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Vol. III of III

NASA CR-2592 Vol-3

RADAR DERIVED SPATIAL STATISTICS OF SUMMER RAIN

APPENDICES

Prepared by

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for Goddard Space Flight Center

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16. Abstract

This is Volume III, Appendices, of the Final Report on rain statistics. It is a collection of selected important memoranda written during the course of the experiment. It contains detailed information on:

a. Frequency Diversity
b. Radar Controller and Radar Video Processor
c. SPANDAR Calibration
d. Meteorological Summaries

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CONTENTS

APPENDIX A

A FREQUENCY DIVERSITY SOURCE
DEVELOPED FOR
RAIN STATISTICS PROGRAM

Memo MED-SR/718

20 June 1973

by

C.H. Ronnenburg, A.J. Bassnett
and H.H. Knapp

Applied Physics Laboratory
The Johns Hopkins University
Laurel, Maryland

APPENDIX A

A FREQUENCY DIVERSITY SOURCE DEVELOPED FOR RAIN STATISTICS PROGRAM

A.1 SUMMARY

The SPANDAR radar located at NASA/Wallops Island is equipped with a frequency source to give a frequency diversity (F.D.) capability to the system. The modification provides outputs of sufficient level to drive the radar local oscillator and transmitter TWT amplifiers in a single frequency mode (frequency center) or one of two F.D. modes (normal and interlace). The normal mode gives outputs of 1, 2 or 4 MHz increments in 8, 16, 24 or 32 steps on a pulse-to-pulse basis, whereas the interlace mode presents the same frequencies so that adjacent steps are separated by alternate increments of approximately 13 MHz and 11 MHz.

Frequency selection is accomplished in digital and analog circuits which develop a control voltage to vary the frequency of a solid state oscillator (S.S.O.).

Figures A.1, A.2 and A.3, respectively, show the front panel, top chassis, and bottom chassis views of the completed unit.

A.2 DESCRIPTION

A block diagram of the F.D. source is shown in Figure A.4. The carrier frequency is generated in the voltage controlled S.S.O. and is divided, filtered, and fed to two, double-balanced mixer/modulators. Modulating frequencies of 240 MHz and 270 MHz are generated in the local oscillator (L.O.), filtered, and applied to the other input of each mixer/modulator to give outputs of:

$$f_{(\text{transmit channel})} = f_{\text{carrier}} \pm 240 \text{ MHz}$$

$$f_{(\text{L.O. channel})} = f_{\text{carrier}} \pm 270 \text{ MHz}.$$

Each of these signals is filtered to obtain the upper sideband and are amplified and presented to the radar TWT amplifiers. Other outputs are provided for test or calibration purposes.

In particular, a transmit sample output from an attenuator to the "From Atten" input is switched to the "Calibration Out" to give a high level receiver calibration on a pulse-to-pulse basis. The avalanche diode noise source is similarly switched into the "Calibration Out" line to give a low level receiver calibration.

A.3 DESIGN

The F.D. source was assembled using components either purchased or designed by the Applied Physics Laboratory. The following items were purchased and are listed with the manufacturers in Table A.1.

a. S.S.O. (Purchased) - The Texscan S.S.O. is voltage controlled and has a measured response and settling time of less than 50 μsecs to the maximum step change in control voltage. The oscillator can be coarse tuned mechanically from 2500 MHz to 2900 MHz and electrically tuned over 200 MHz. A typical voltage vs. frequency curve is shown in Figure A.5. Power output is nominally 100 mW. The harmonic output was measured to be greater than 20 dB below the carrier and spurious signals were 70 dB below the carrier.

b. Filters - S.S.O. Lines - A 2470-2650 MHz stripline filter is inserted in the S.S.O. line to each mixer. These filters and the isolators prevent coupling between the two mixers via the parallel S.S.O. input paths.

c. L.O. - The APL built local oscillator (L.O.) is crystal controlled at 30 MHz. The two modulating signals, 240 MHz and 270 MHz, are developed by X8 and X9 transistor multipliers, respectively. The output levels are approximately 12 mW. Figure A.6 is a schematic of the L.O.

d. L.O. Filters (Purchased) - The outputs of the L.O. contain some of the original 30 MHz at a level 50 or 60 dB below the modulating signals. In the mixing process this generates some undesired output frequency components, and must be filtered before being applied to the mixer.

e. Double Balanced Mixer/Modulators (Purchased) - These units are used as balanced modulators and reduce filtering requirements by suppressing the carrier. The conversion loss is 8 dB.

f. Mixer Filters - The filters following each of the mixers removes the lower sideband and further reduces the carrier component not suppressed by the mixer. Both are eight stage interdigital filters. The passband and insertion loss vs. frequency are shown in Figures A.7 and A.8.

g. Amplifiers (Purchased) - Two transistor amplifiers are used to obtain the needed power to drive the TWT's in the SPANDAR system. These amplifiers have a 20 dB gain (+13 dBm output) over a frequency range from 2.6 GHz to 3.0 GHz.

h. F.D. Logic, Board #3 (Figure A.9) - The basic timing information for the frequency shift and calibrate signal triggers is derived in Board No. 3 from the positive system trigger, a 10 MHz gated oscillator and a 16-bit synchronous counter (U14 through U17). The counters and buffer flip-flop are cleared by a 1.6 μsec pulse generated by a one shot (U18) from the system trigger.

The 8 input NAND gates (U12, U13) decode counts of 9332 and 9940, respectively, and trip the output flip-flops (U10) and gate inverters (U11) which supply positive going voltage changes to one shots U5, U6 and U7 on Board No. 2. The output flip-flop holds the output voltage positive until reset by the next system trigger. This eliminates the ambiguities which exist in the output decoders and allows only one output level change per input trigger.

The positive going change occurs on output 5 of U10 at 934.6 μsec after the system trigger and on output 3 of U10 at 995.6 μsec after the system trigger.

i. F.D. Logic, Board #2 (Figure A.9) - Positive going edges from the flip-flops of U10, Board No. 3, initiate one-shots U5, U6 and U7 having delays of 3.5 μsec, 9 μsec and 27.7 μsec, respectively. Pulses of 4 μsec (U10) and 15 μsec (U9) are generated following the delays of U7 and U6 and give overall delays and widths with respect to the trigger input to Board #3 of:

F.D. Counter Input (Pin 13)	939.1 μsec delay
Noise Trigger (Pin M)	1023.3 μsec delay
Pulse Trigger (Pin N)	1005.3 μsec delay
Pulse-to-Noise Source (Pin 9)	15.0 μsec width
Cal. Pulse (Pin R)	4.0 μsec width
Noise Pulse (Pin L)	15.0 μsec width
PIN Switch Driver (Pin 18)	4.0 μsec width

The F.D. counter contains 5 bits which can be preset to binary 31, 27, 23 and 19. The countdown is decoded to obtain the preset pulse at

0, 4, 8 and 12, respectively, to give counts of 32, 24, 16 and 8 about binary 16. When the F.D. mode switch is set to F_c the counter is held at binary 16.

U11 (B, C and D), and U12 (A, B and C) comprise an Exclusive-OR circuit having the most significant bit (MSB) and least significant bit (LSB) of the counter as inputs. The output of this circuit is used in the interlace mode only.

j. <u>F.D. Logic, Board #1, (Figure 9)</u> - A d.c. voltage to control the S.S.O. is developed in these circuits from the 5 bit F.D. counter input. One of the two F.D. modes is selected from the front panel switch.

In the normal mode the four LSB's are summed with binary "0" from U1 and U2. The outputs of U2 and the MSB of the counter are applied to Digital to Analog Converter (DAC) U3 to give an analog output for shaping in the succeeding operational amplifiers.

When the interlace mode is selected, the four LSB's of the F.D. counter are summed with binary 0, 4 or 12 according to the rules:

1. When LSB is "1" add "0000"

2. When LSB is "0" and MSB is "1" add "0100"

3. When LSB is "0" and MSB is "0" add "1100"

4. In every case ignore the carry and derive the MSB to the DAC from the Exclusive-OR of Board #2, i.e., MSB and LSB alike, make $MSB_{(DAC)}$ "1,"

   MSB and LSB different, make $MSB_{(DAC)}$ "0."

The sequence of steps obtained (for number of steps = 24) is 27, 14, 25, 12, 23, 10, 21, 8, 19, 6, 17, 4, 15, 26, 13, 24, 11, 22, 9, 20, 7, 18, 5, 16. Interlace outputs are valid only for this condition.

The current output of the DAC is converted to voltage in U4A which also serves to adjust the step size and to provide a d.c. offset to make the four slopes pivot about zero volts. Center frequency is adjusted by a d.c. voltage summed with the output of U4A in U4B.

U4B drives a shaping circuit where six diode breakpoints are set to provide increasing gain in U5A as the output of U4B goes more negative.

The breakpoints and gain are adjusted to match the curve of the frequency vs. control voltage of the S.S.O. in use. Shaping and gain adjustments are made with the step size switch in TEST.

k. <u>F.D. Logic Adjustment Procedure - Board #1 Shaping Circuits</u>

1. Switch set up

   a. Power On

   b. F.D. Mode - Normal

   c. No. of Steps - 32

   d. Step Size - Test

   e. Cal. Function - Normal

2. Current - Voltage Converter (U4A)

   a. Adjust R-17 (gain) and R-13 (bias) to obtain a 32 step, positive going ramp of -5V to +5V at U4A-12.

3. Shaping Network Driver

   a. Adjust R-18 (gain) and C.F. Adjust (bias) for a 32 step negative going ramp of -10V to -18V (or maximum negative) at U4B-10.

4. Shaping Network and Amplifier

   a. Six breakpoints and gain adjustments are possible. The number used is determined by the shaping requirements. Shaping is done by adjusting breakpoints to ground (CCW) and input gain to minimum (CW). The shaping process is one of increasing the gain at selected points. When adjusting, the most negative is accomplished first. As each breakpoint and gain is adjusted the amplifier gain (R-20) and bias (R-19) may have to be adjusted to keep the S.S.O. drive voltage within amplifier limits.

No definite procedure can be described as the operation is one of "tweaking" and "retweaking" until the desired shape is obtained.

Proper shaping is confirmed by measuring equal steps using a frequency counter and a spectrum analyzer.

b. R - 1, 3, 5, 7, 9 and 11 set breakpoints.

c. R - 2, 4, 6, 8, 10 and 12 adjust the gain after the input passes the corresponding breakpoint.

5. Step Size - R - 14, 15 and 16 adjust ramp gains for three step sizes. These adjustments are made after shaping is accomplished and are measured with a frequency counter and spectrum analyzer.

l. Noise Source (Purchased) - The noise source is pulse-modulated to provide a low level receiver calibration signal. The source provides 39.2 dB excess noise over a frequency range of 2.7 GHz to 2.9 GHz. The noise source is biased to approximately 23V from an internal power supply and is gated on by a 5V pulse supplied from the F.D. logic and timing circuits.

m. Switch Driver (Figure A.10) - The RF switch driver consists of a 2N2907A pulse amplifier and a 2N2222A emitter follower and is required to supply -30 mA to hold the RF switch open and a +15V pulse to close switch. A negative input pulse is required; therefore the .1 μF input capacitor is necessary to couple the negative going input pulse from the F.D. logic. The -30 mA is supplied by the -20V power supply through the one watt resistors at the output and the transistors only operate during the 4 μsec pulse to overcome the negative bias. Operation of the switch driver is controlled by the Cal. Function switch on the panel.

n. R.F. Switch - The APL built PIN diode switch is used to pulse-modulate a sample of the transmit channel power to provide a receiver calibration signal which is usable in the F.D. mode. The PIN diode switch has an on/off ratio of 90 dB and an insertion loss less than 1 dB.

o. Power Supplied (Purchased) - Three power supplies, furnishing dual +20 Vd.c. and +5.5 Vd.c., a single -20 Vd.c. and a single +5.5 Vd.c. satisfy the requirements of the F.D. source. Two +5.5 Vd.c. power suppliers are used to ensure decoupling of the digital and analog circuits and to minimize noise on the S.S.O. control voltage.

Wiring diagrams for power and control switches are shown in Figures A.11 and A.12.

A.4 TYPICAL POWER AND FREQUENCY CHARACTERISTICS

Data was taken in the normal and interlace mode over the full range of operation of the F.D. unit to assure proper operation. The data presented here is for the normal mode, 32 frequency steps and a 2 MHz step size.

Figure A.13 shows the measured frequency output vs. step numbers. The solid line is a plot of the theoretical values with the center frequency set at 2840 MHz. Figures A.14, A.15 and A.16 show the power outputs for the R.F. channels. The power output of the "S.S.O. TEST" port over the operating frequency band is +0.5 dBm $\pm$.25 dB.

TABLE A.1

MANUFACTURERS OF PURCHASED ITEMS

Solid State Oscillator, Model MTO-180ET	Texscan Corporation Indianapolis, Indiana
240 MHz Filter, Model FBT/20-240/10-6/50-28A/28B 270 MHz Filter, Model FBT/20-270/20-6/50-28A/28A	Cir-Q-Tel, Inc. Kensington, Maryland
Double Balanced Mixer/Modulators, Model MX4001 20 dB Amplifier, Model A5827	Aertech Industries Sunnyvale, California
Noise Source, Model NC1-2729-36-CDP	International Microwave Corp. Cos Cob, Connecticut
Power Supply, Model 105	R.O. Associates Menlo Park, California
Power Supply, Model LCD-4-13 Power Supply, Model LCS-A-20	Lambda Electronic Corp. Melville, New York

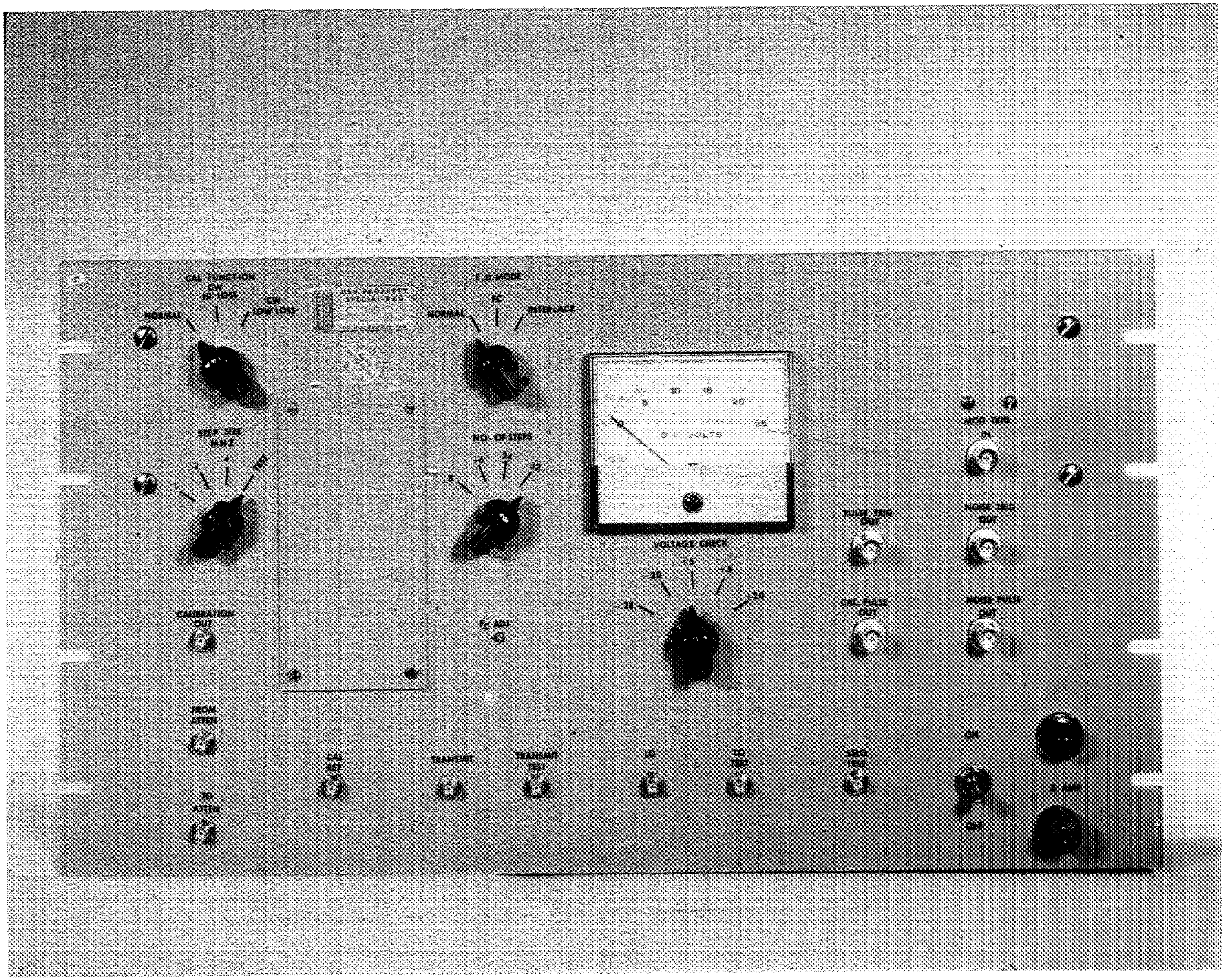

FIGURE A.1. FREQUENCY DIVERSITY SOURCE FRONT PANEL

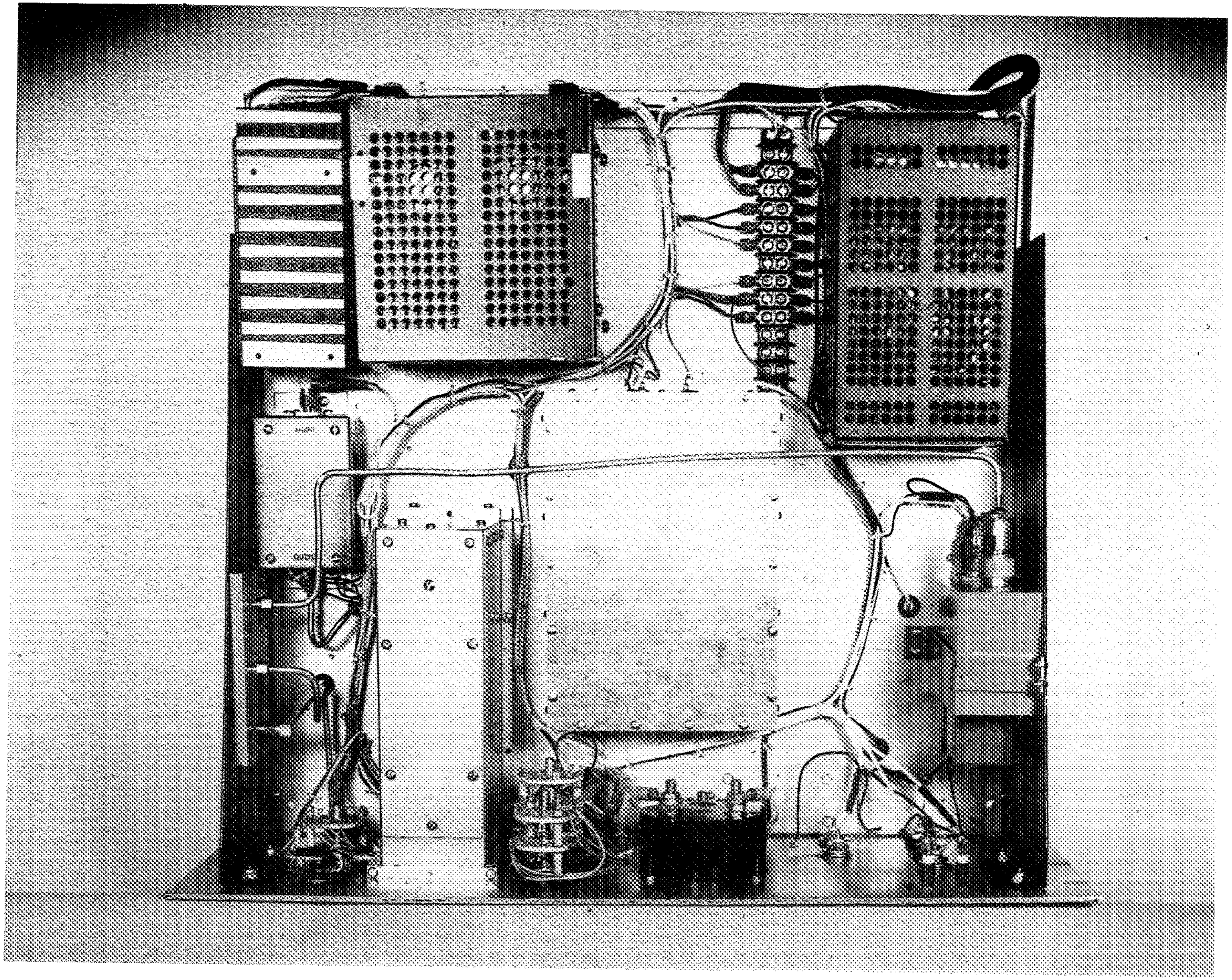

FIGURE A.2. FREQUENCY DIVERSITY SOURCE TOP CHASSIS

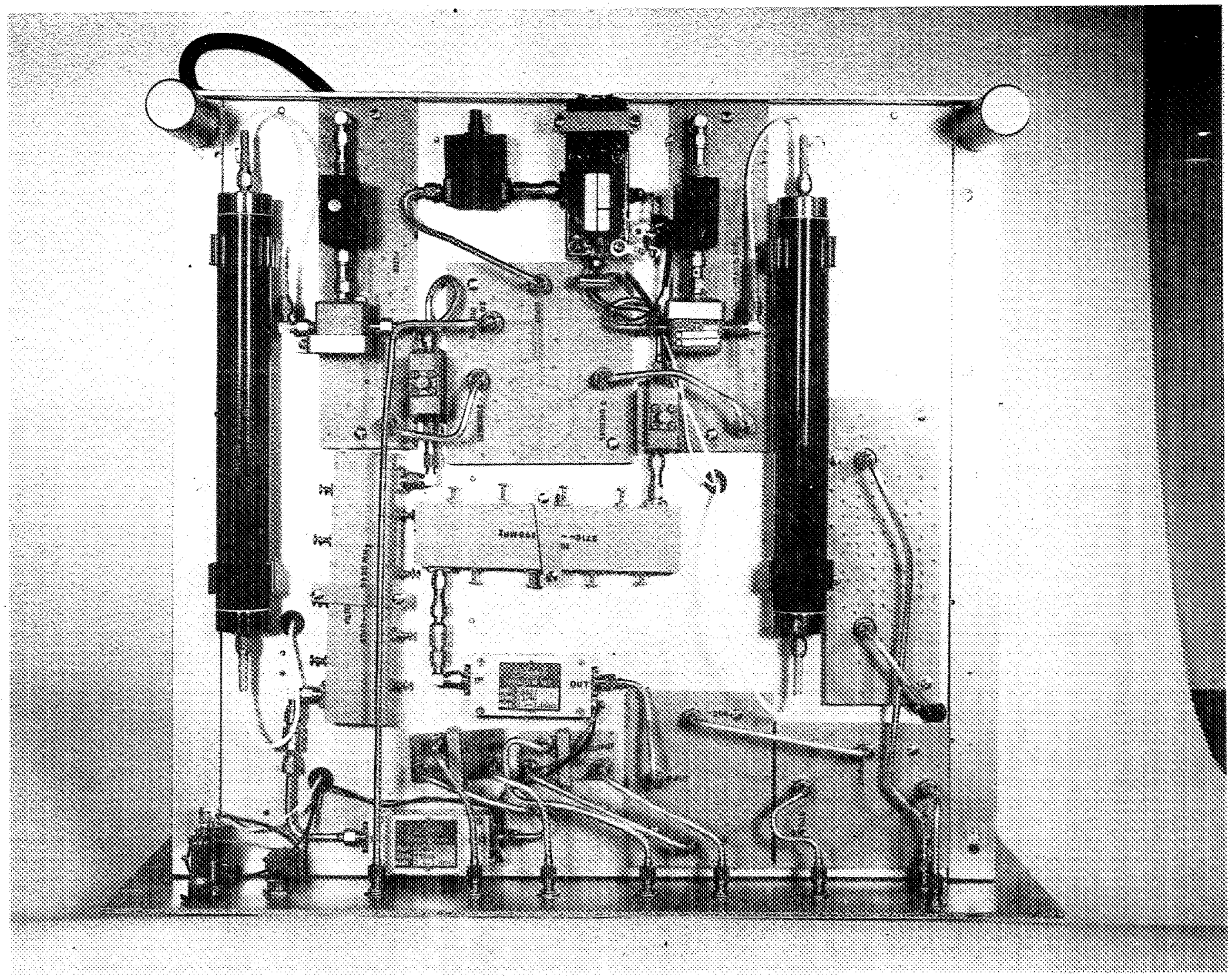

FIGURE A.3. FREQUENCY DIVERSITY SOURCE BOTTOM CHASSIS

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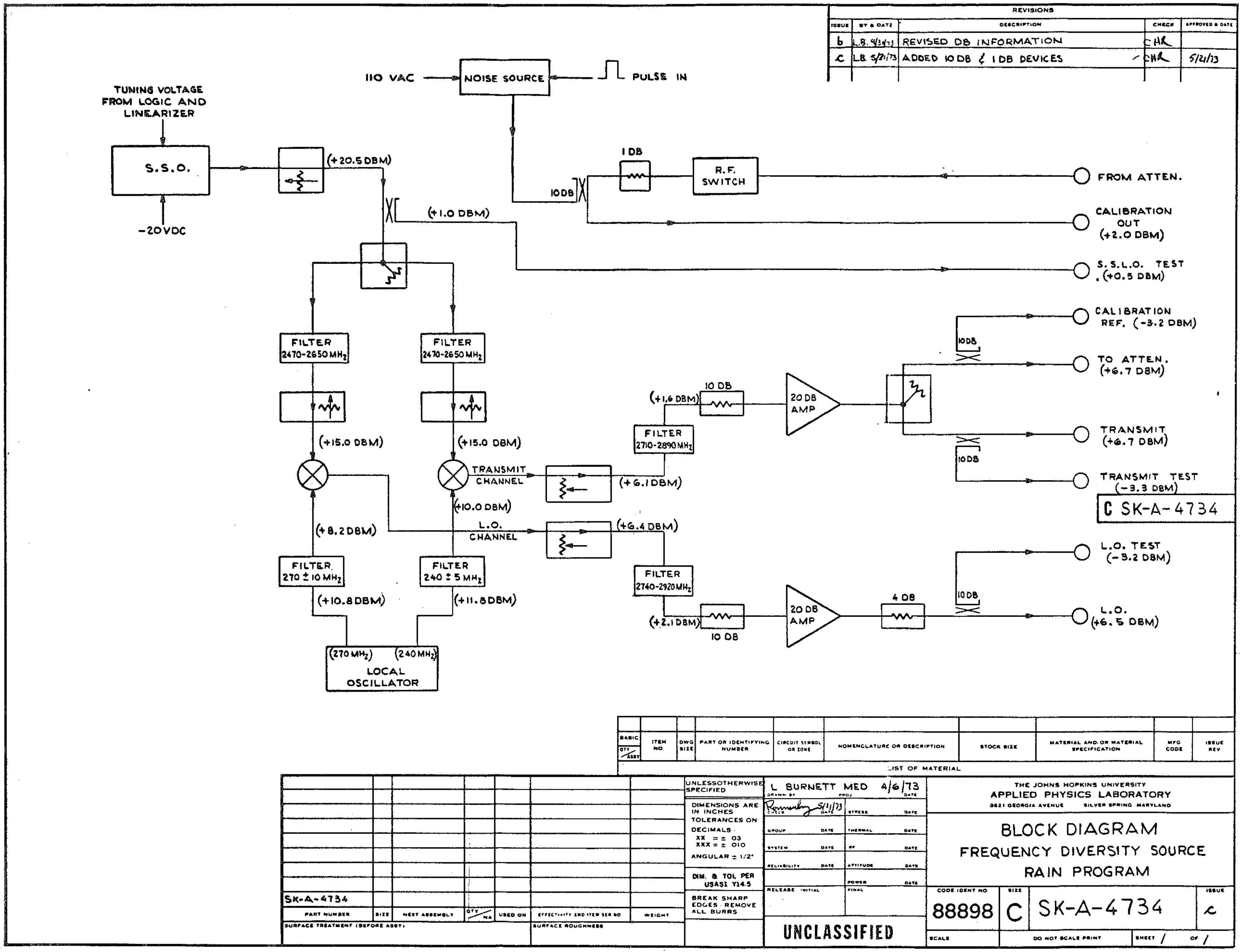
REVISIONS
b L.B. REVISED DB INFORMATION
c LB 5/21/73 ADDED 10 DB & 1 DB DEVICES 5/21/73
110 VAC
NOISE SOURCE
PULSE IN
TUNING VOLTAGE FROM LOGIC AND LINEARIZER
S.S.O.
-20VDC
(+20.5 DBM)
(+1.0 DBM)
1 DB
10 DB
R.F. SWITCH
FROM ATTEN.
CALIBRATION OUT (+2.0 DBM)
S.S.L.O. TEST (+0.5 DBM)
CALIBRATION REF. (-3.2 DBM)
FILTER 2470-2650 MHz
FILTER 2470-2650 MHz
(+15.0 DBM)
(+15.0 DBM)
TRANSMIT CHANNEL
(+10.0 DBM)
L.O. CHANNEL
(+8.2 DBM)
(+6.1 DBM)
(+6.4 DBM)
(+1.6 DBM)
10 DB
FILTER 2710-2890 MHz
20 DB AMP
10 DB
TO ATTEN. (+6.7 DBM)
TRANSMIT (+6.7 DBM)
TRANSMIT TEST (-3.3 DBM)
C SK-A-4734
FILTER 270 ± 10 MHz
FILTER 240 ± 5 MHz
(+10.8 DBM)
(+11.8 DBM)
(270 MHz)
(240 MHz)
LOCAL OSCILLATOR
FILTER 2740-2920 MHz
(+2.1 DBM)
10 DB
20 DB AMP
4 DB
10 DB
L.O. TEST (-3.2 DBM)
L.O. (+6.5 DBM)
LIST OF MATERIAL
SK-A-4734
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
L BURNETT MED 4/6/73
THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY
8621 GEORGIA AVENUE SILVER SPRING MARYLAND
BLOCK DIAGRAM
FREQUENCY DIVERSITY SOURCE
RAIN PROGRAM
88898 C SK-A-4734 c
UNCLASSIFIED
DO NOT SCALE PRINT
SHEET 1 OF 1

FIGURE A.4.

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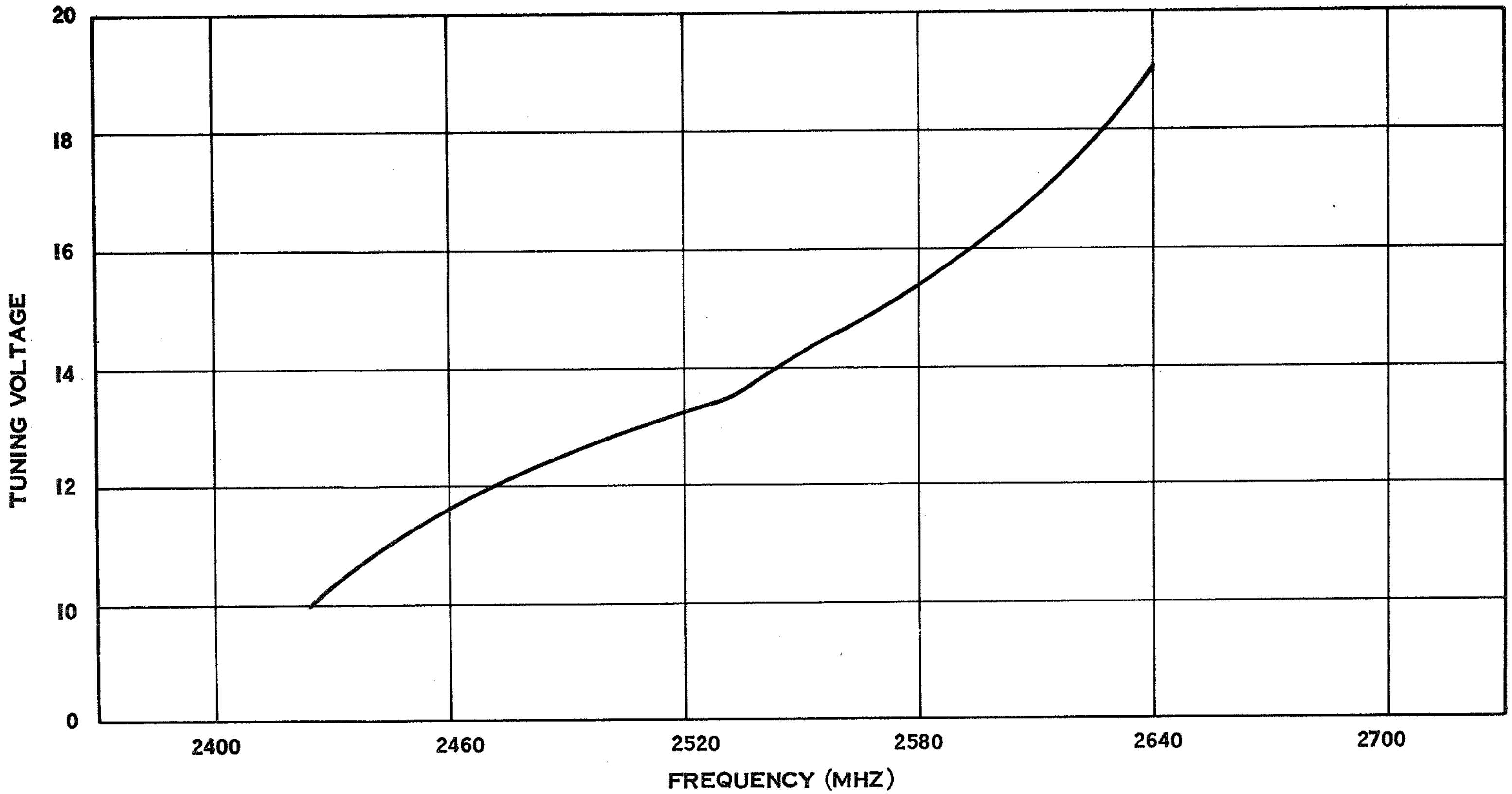

FIGURE A.5. FREQUENCY VS TUNING VOLTAGE

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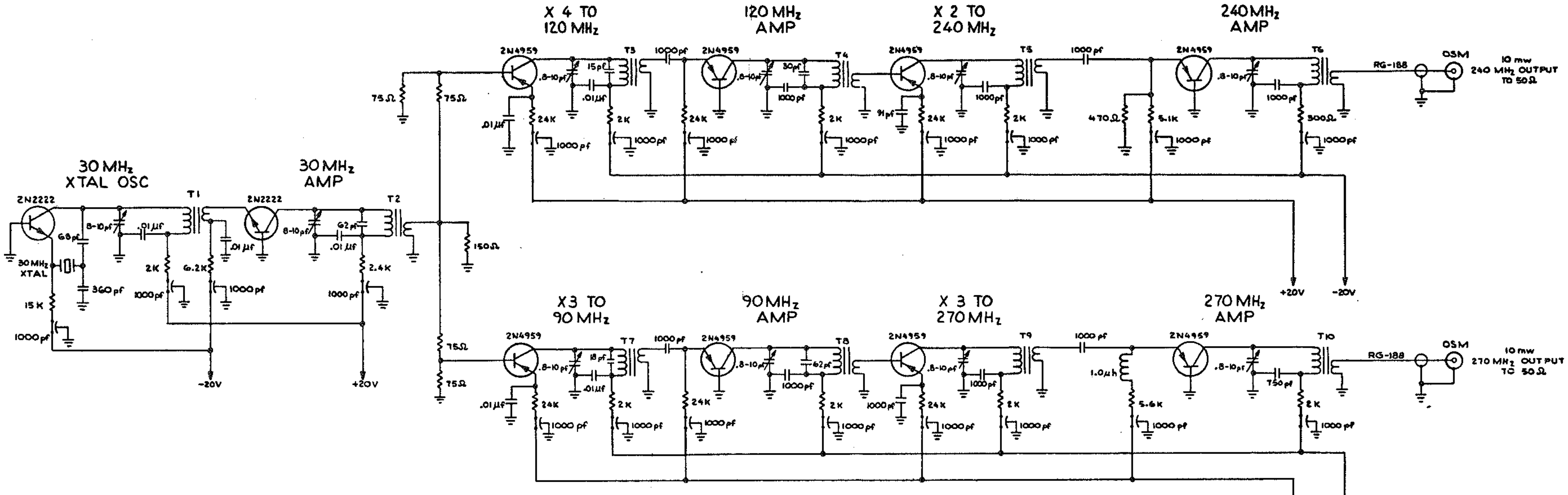

NOTES;

1. ALL PRIMARY WINDINGS SPREAD EQUALLY AROUND TOROIDS
   TOTAL PRIMARY POWER +20V @ 17 ma
   -20V @ 17 ma

T1 — T25-10	TOROID,	PRI - 14 TURNS #26	SEC-3 TURNS #24
T2 — T25-10	TOROID,	PRI - 14 TURNS #26	SEC-5 TURNS #24
T3 — T25-13,	TOROID,	PRI - 7 TURNS #24	SEC-1 TURN #22
T4 — T25-13	TOROID,	PRI - 4 TURNS #24	SEC-1 TURN #26
T5 — T25-13	TOROID,	PRI - 6 TURNS #24	SEC-1 TURN #22
T6 — T25-13	TOROID,	PRI - 6 TURNS #24	SEC-2 TURNS #24
T7 — T25-12	TOROID,	PRI - 9 TURNS #24	SEC-2 TURNS #24
T8 — T26-12	TOROID,	PRI - 5 TURNS #24	SEC-1 TURN #24
T9 — T25-12	TOROID,	PRI - 5 TURNS #24	SEC-1 TURN #22
T10 — T25-12	TOROID,	PRI - 5 TURNS #24	SEC-2 TURNS #22

2. ALL FIXED CAPACITORS ARE DM-5, DM-10, OR DM-15 (EXCEPT FEED-THRUS)
3. .8-10 pf TUNING CAPACITORS ARE JOHANSON
4. ALL .01 μf CAPACITORS ARE MYLAR
5. FEED-THRU CAPACITORS ARE AROVOX TYPE EF-3
6. ALL RESISTORS ARE 1/8 W, 5%

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS
DM & TOL PER USASI Y14.5
BREAK SHARP EDGES REMOVE ALL BURRS

L. BURNETT MED 5/11/73

THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY
SILVER SPRING, MARYLAND

SCHEMATIC
LOCAL OSCILLATOR
(240 MHz & 290 MHz)
RAIN PROGRAM

88898 D SK-A-4766 a

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SHEET 1 OF 1

FIGURE A.6.

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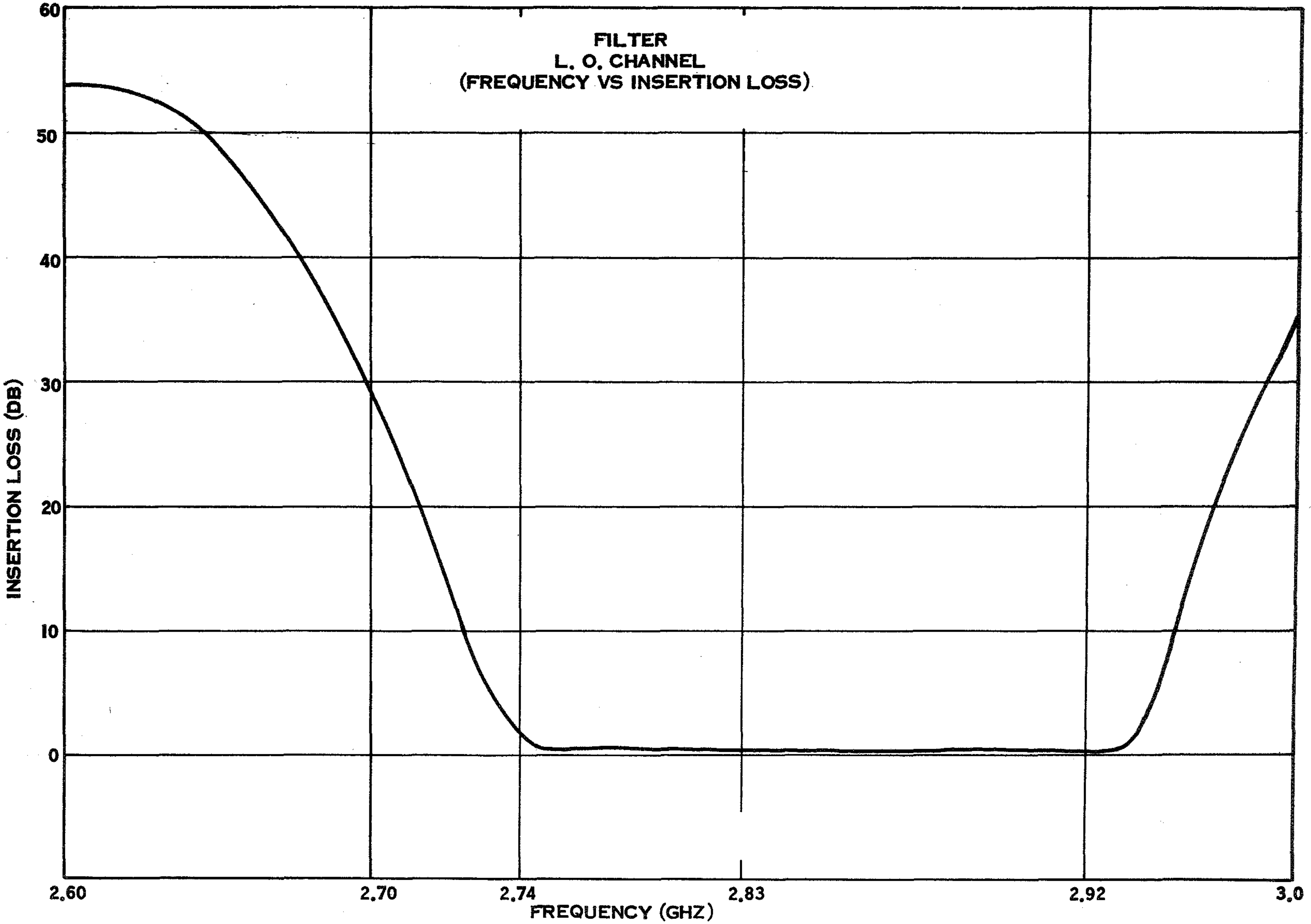

FIGURE A.7. L. O. CHANNEL
(FREQUENCY VS INSERTION LOSS)

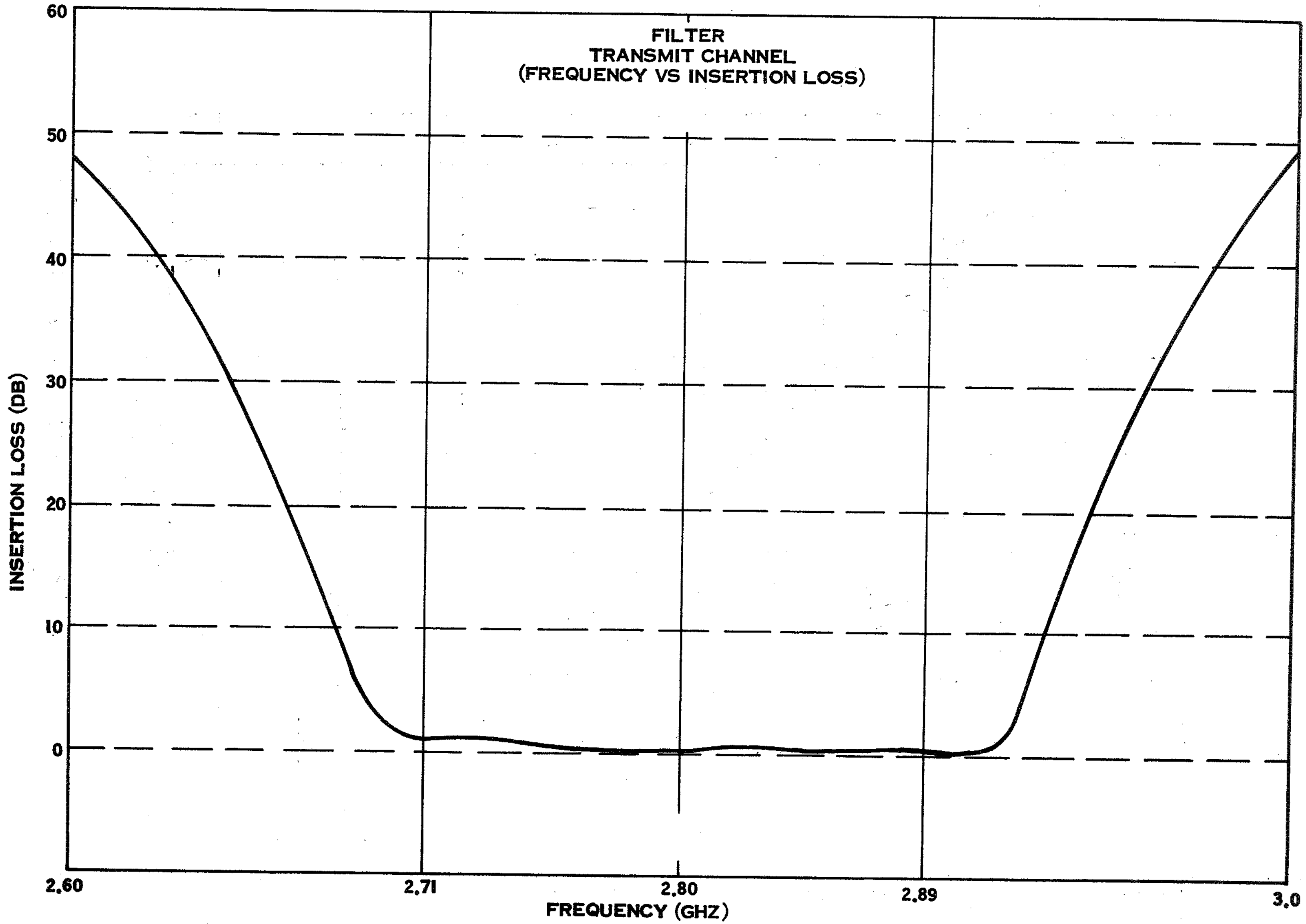

FIGURE A.8. TRANSMIT CHANNEL
(FREQUENCY VS INSERTION LOSS)

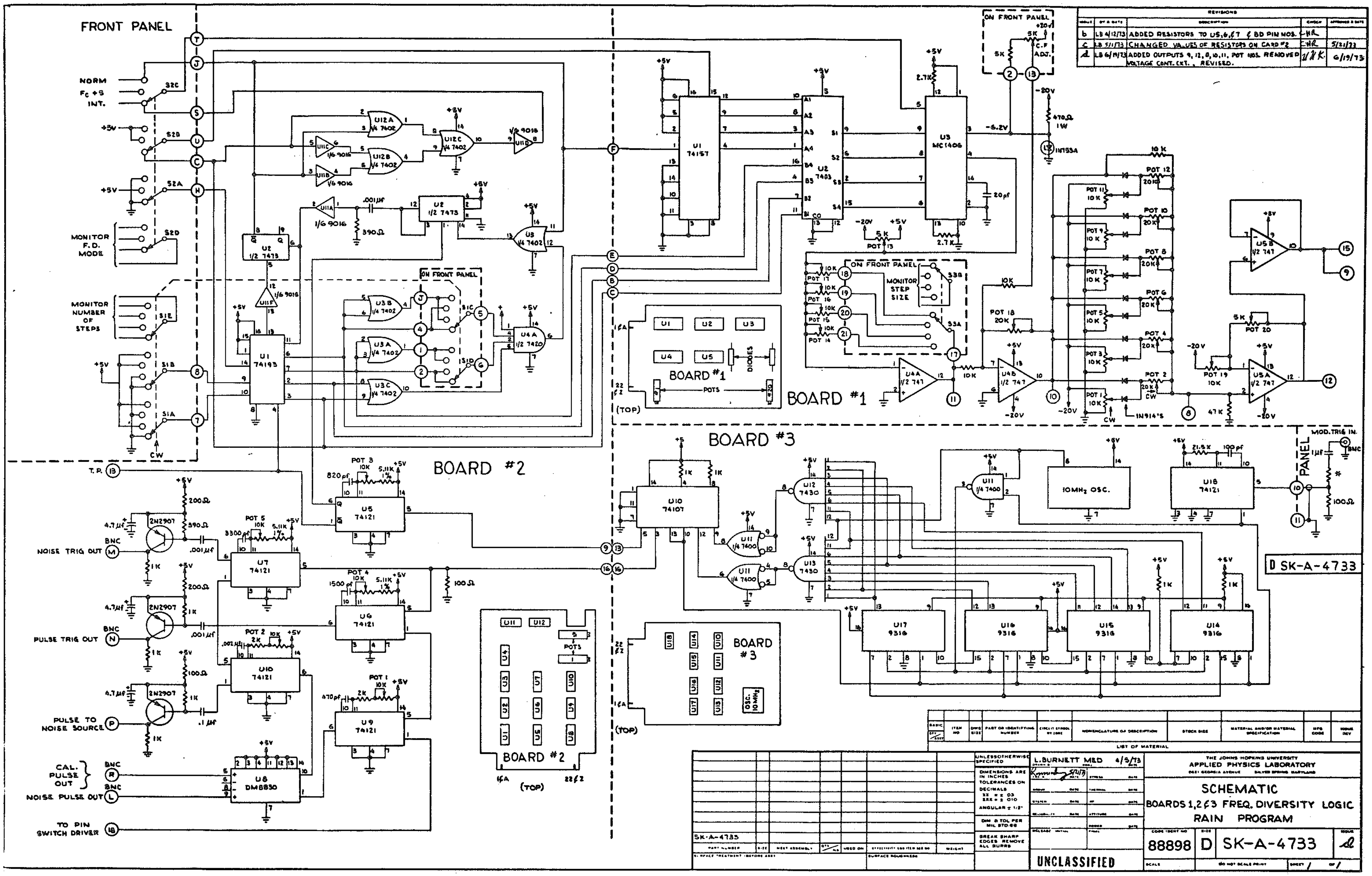
FRONT PANEL
BOARD #1
BOARD #2
BOARD #3
ON FRONT PANEL
NORM
INT.
MONITOR F.D. MODE
MONITOR NUMBER OF STEPS
MONITOR STEP SIZE
T.P.
NOISE TRIG OUT
PULSE TRIG OUT
PULSE TO NOISE SOURCE
CAL. PULSE OUT
NOISE PULSE OUT
TO PIN SWITCH DRIVER
10MHz OSC.
MOD. TRIG IN
PANEL
b LB 4/12/73 ADDED RESISTORS TO U5,6,&7 & BD PIN NOS.
c LB 5/1/73 CHANGED VALUES OF RESISTORS ON CARD #2
d LB 6/19/73 ADDED OUTPUTS 9, 12, 8, 10, 11, POT NOS. REMOVED VOLTAGE CONT. CKT., REVISED.
D SK-A-4733
LIST OF MATERIAL
L. BURNETT M&D 4/5/73
THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY
SCHEMATIC
BOARDS 1,2 & 3 FREQ. DIVERSITY LOGIC
RAIN PROGRAM
88898 D SK-A-4733 d
SK-A-4733
UNCLASSIFIED

FIGURE A.9.

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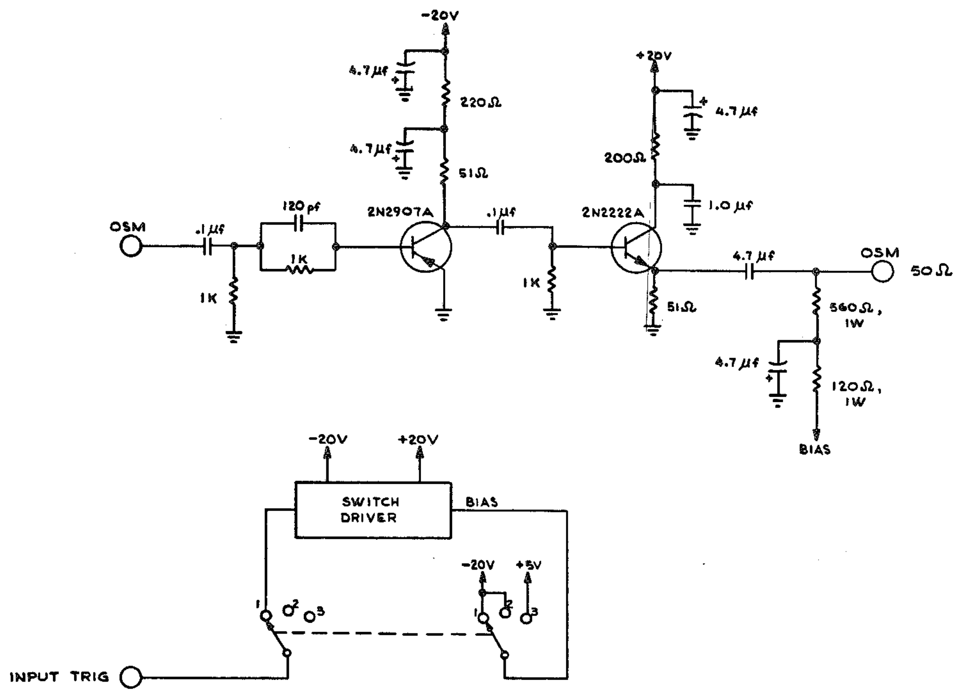

C SK-A-4767

REVISIONS				
ISSUE	BY & DATE	DESCRIPTION	CHECK	APPROVED & DATE

LIST OF MATERIAL

BASIC QTY ASSY	ITEM NO	DWG SIZE	PART OR IDENTIFYING NUMBER	CIRCUIT SYMBOL OR ZONE	NOMENCLATURE OR DESCRIPTION	STOCK SIZE	MATERIAL AND/OR MATERIAL SPECIFICATION	MFG CODE	ISSUE REV

PART NUMBER	SIZE	NEXT ASSEMBLY	QTY NA	USED ON	EFFECTIVITY-END ITEM SER NO	WEIGHT

SURFACE TREATMENT (BEFORE ASSY) | SURFACE ROUGHNESS

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS.
XX = ± .03
XXX = ± .010
ANGULAR ± 1/2°
DIM. & TOL PER USASI Y14.5
BREAK SHARP EDGES. REMOVE ALL BURRS

L. BURNETT MED 5/11/73
DRAWN BY | PROJ | DATE
CHECK | DATE | STRESS | DATE
GROUP | DATE | THERMAL | DATE
SYSTEM | DATE | RF | DATE
RELIABILITY | DATE | ATTITUDE | DATE
POWER | DATE
RELEASE INITIAL | FINAL

UNCLASSIFIED

THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY
8621 GEORGIA AVENUE SILVER SPRING, MARYLAND

SCHEMATIC
RF SWITCH DRIVER
RAIN PROGRAM

CODE IDENT NO	SIZE		ISSUE
88898	C	SK-A-4767	a

SCALE | DO NOT SCALE PRINT | SHEET 1 OF 1

FIGURE A.10.

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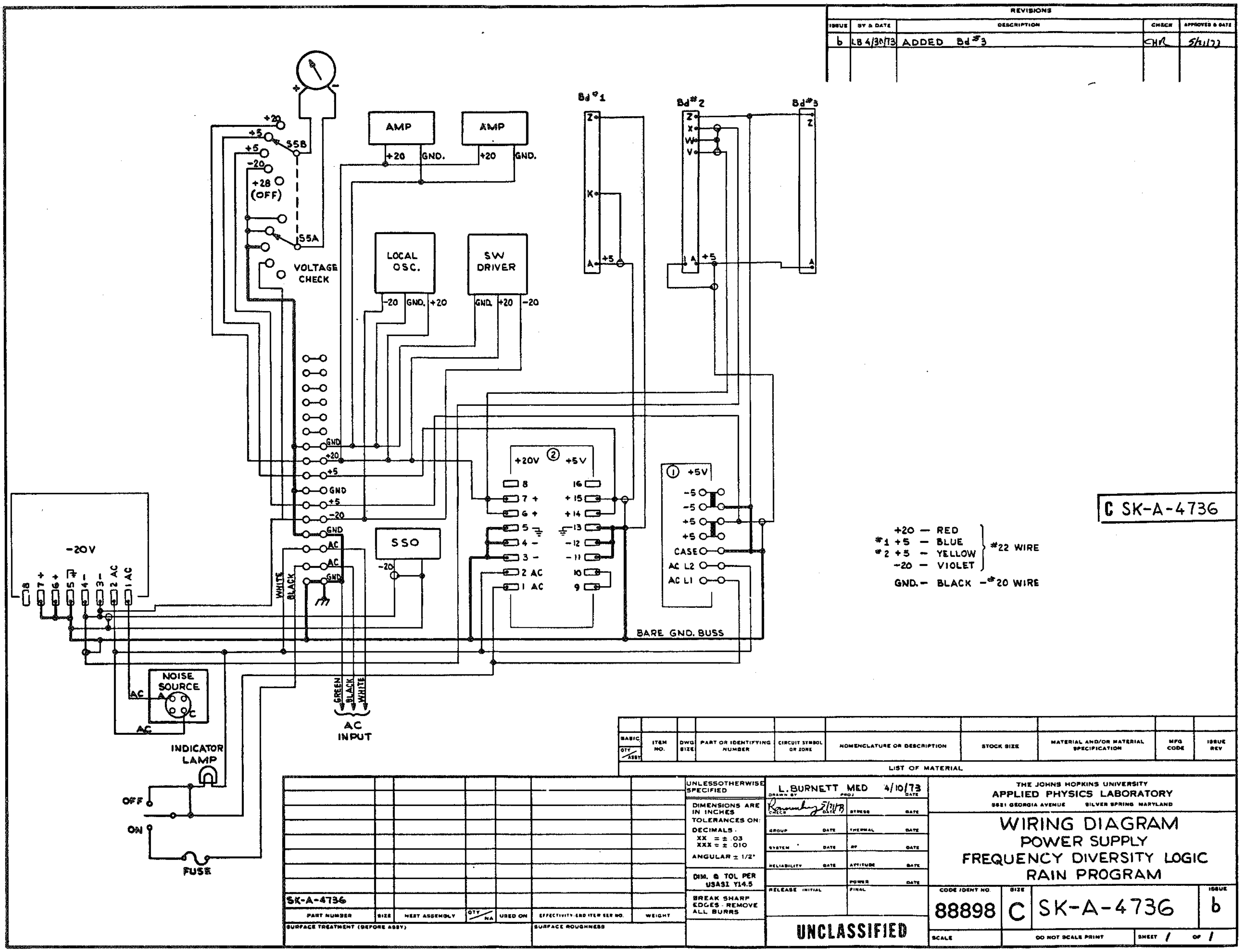

REVISIONS
b LB 4/30/73 ADDED Bd #3
AMP
AMP
+20
GND.
S5B
+20
+5
-20
+28 (OFF)
S5A
VOLTAGE CHECK
LOCAL OSC.
SW DRIVER
Bd #1
Bd #2
Bd #3
Z
X
W
V
K
A
+5
GND
+20
+5
GND
+5
-20
GND
AC
AC
GND
-20V
SSO
+20V
+5V
BARE GND. BUSS
CASE
AC L2
AC L1
+20 — RED
#1 +5 — BLUE
#2 +5 — YELLOW
-20 — VIOLET
#22 WIRE
GND. — BLACK — #20 WIRE
C SK-A-4736
WHITE
BLACK
GREEN
NOISE SOURCE
AC
INPUT
INDICATOR LAMP
OFF
ON
FUSE
LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS XX = ± .03 XXX = ± .010
ANGULAR ± 1/2°
DIM. & TOL PER USASI Y14.5
BREAK SHARP EDGES · REMOVE ALL BURRS
L. BURNETT MED 4/10/73
THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY
8621 GEORGIA AVENUE SILVER SPRING MARYLAND
WIRING DIAGRAM
POWER SUPPLY
FREQUENCY DIVERSITY LOGIC
RAIN PROGRAM
SK-A-4736
88898 C SK-A-4736 b
UNCLASSIFIED
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FIGURE A.11.

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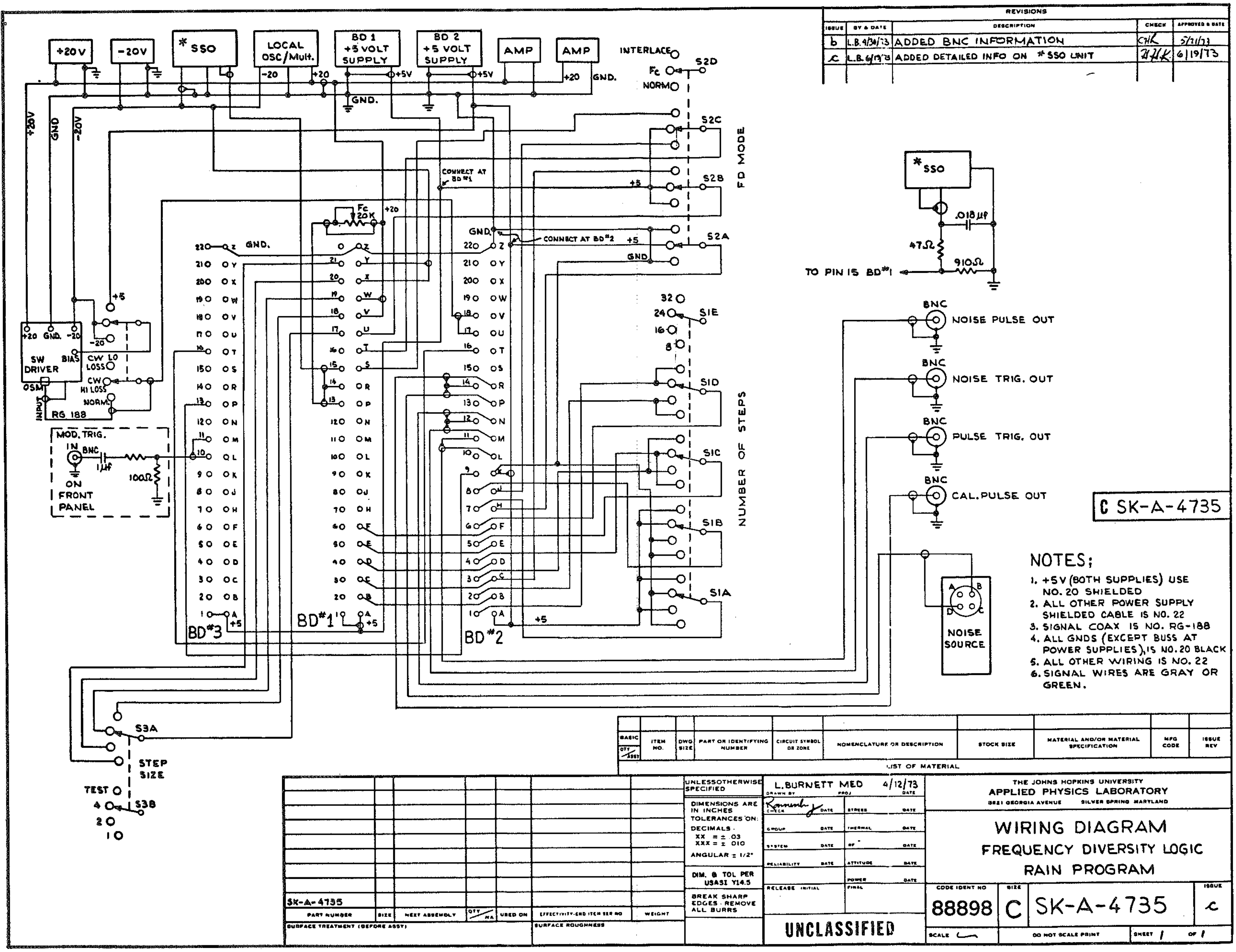
REVISIONS
b L.B. 4/30/73 ADDED BNC INFORMATION CHK 5/21/73
c L.B. 6/19/73 ADDED DETAILED INFO ON *SSO UNIT 6/19/73
+20V
-20V
*SSO
LOCAL OSC/Mult.
BD 1 +5 VOLT SUPPLY
BD 2 +5 VOLT SUPPLY
AMP
AMP
INTERLACE
Fc
NORM
S2D
S2C
S2B
S2A
FD MODE
CONNECT AT BD#1
CONNECT AT BD#2
S1E
S1D
S1C
S1B
S1A
NUMBER OF STEPS
SW DRIVER
CW LO LOSS
CW HI LOSS
NORM
RG 188
MOD. TRIG. IN BNC
ON FRONT PANEL
BD#3
BD#1
BD#2
TO PIN 15 BD#1
BNC NOISE PULSE OUT
BNC NOISE TRIG. OUT
BNC PULSE TRIG. OUT
BNC CAL. PULSE OUT
NOISE SOURCE
C SK-A-4735
NOTES;
1. +5V (BOTH SUPPLIES) USE NO. 20 SHIELDED
2. ALL OTHER POWER SUPPLY SHIELDED CABLE IS NO. 22
3. SIGNAL COAX IS NO. RG-188
4. ALL GNDS (EXCEPT BUSS AT POWER SUPPLIES), IS NO. 20 BLACK
5. ALL OTHER WIRING IS NO. 22
6. SIGNAL WIRES ARE GRAY OR GREEN.
S3A
STEP SIZE
S3B
TEST
LIST OF MATERIAL
L.BURNETT MED 4/12/73
THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY
8621 GEORGIA AVENUE SILVER SPRING MARYLAND
WIRING DIAGRAM
FREQUENCY DIVERSITY LOGIC
RAIN PROGRAM
88898 C SK-A-4735 c
UNCLASSIFIED
DO NOT SCALE PRINT

FIGURE A.12.

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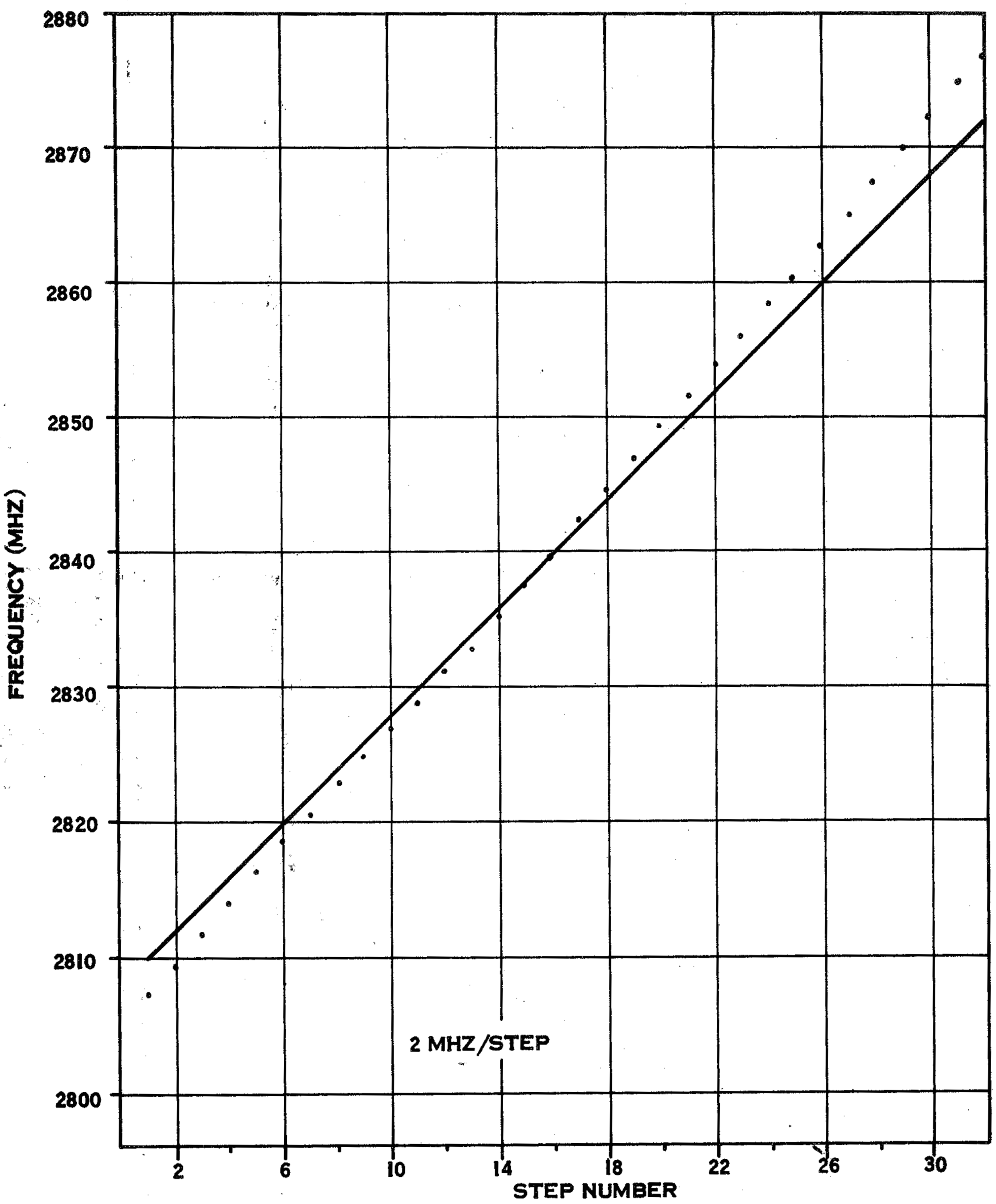


FIGURE A.13. STEP NUMBER VS OUTPUT FREQUENCY

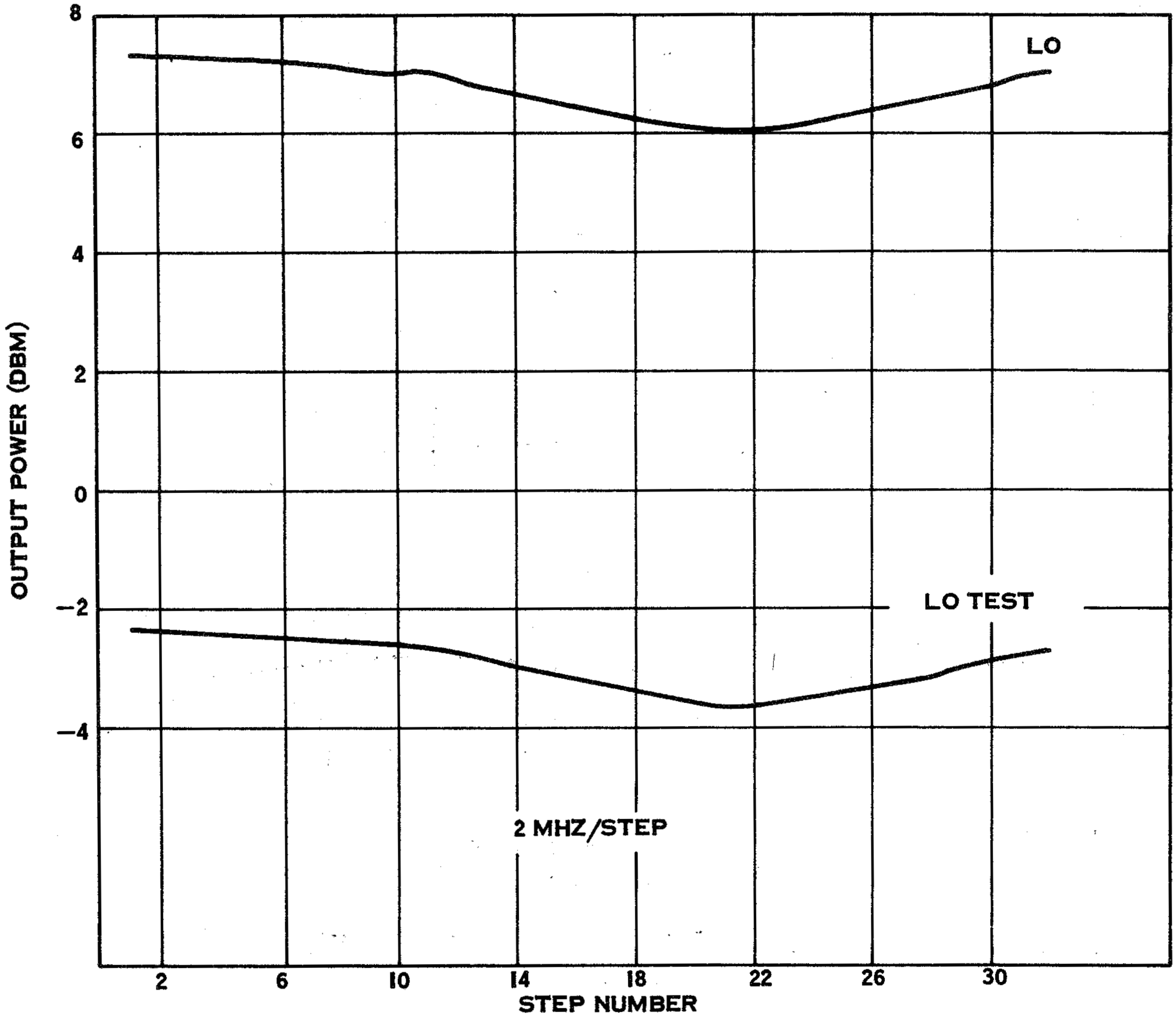


FIGURE A.14. STEP NUMBER VS POWER OUTPUT
L.O. CHANNEL

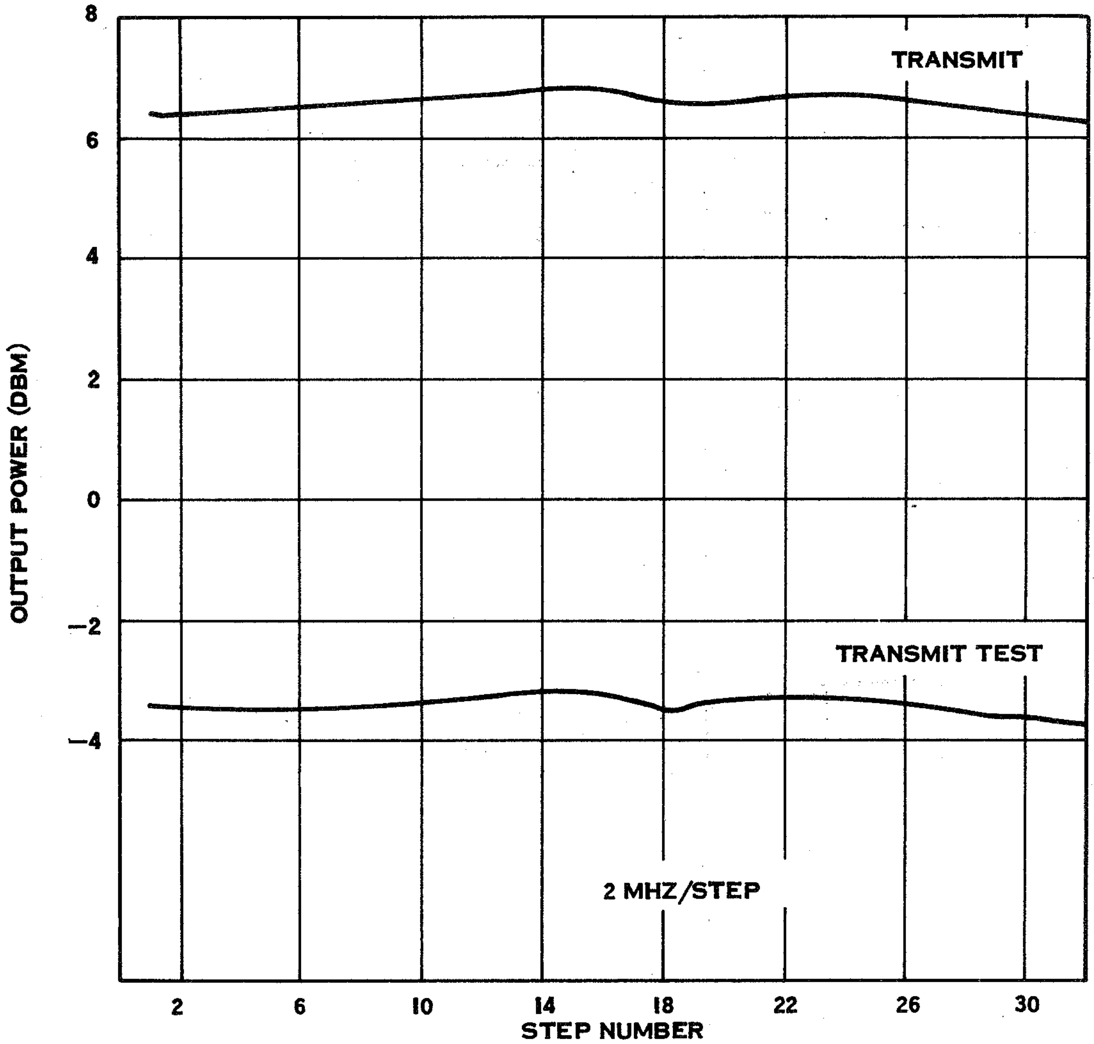


FIGURE A.15. STEP NUMBER VS POWER OUTPUT
TRANSMIT CHANNEL

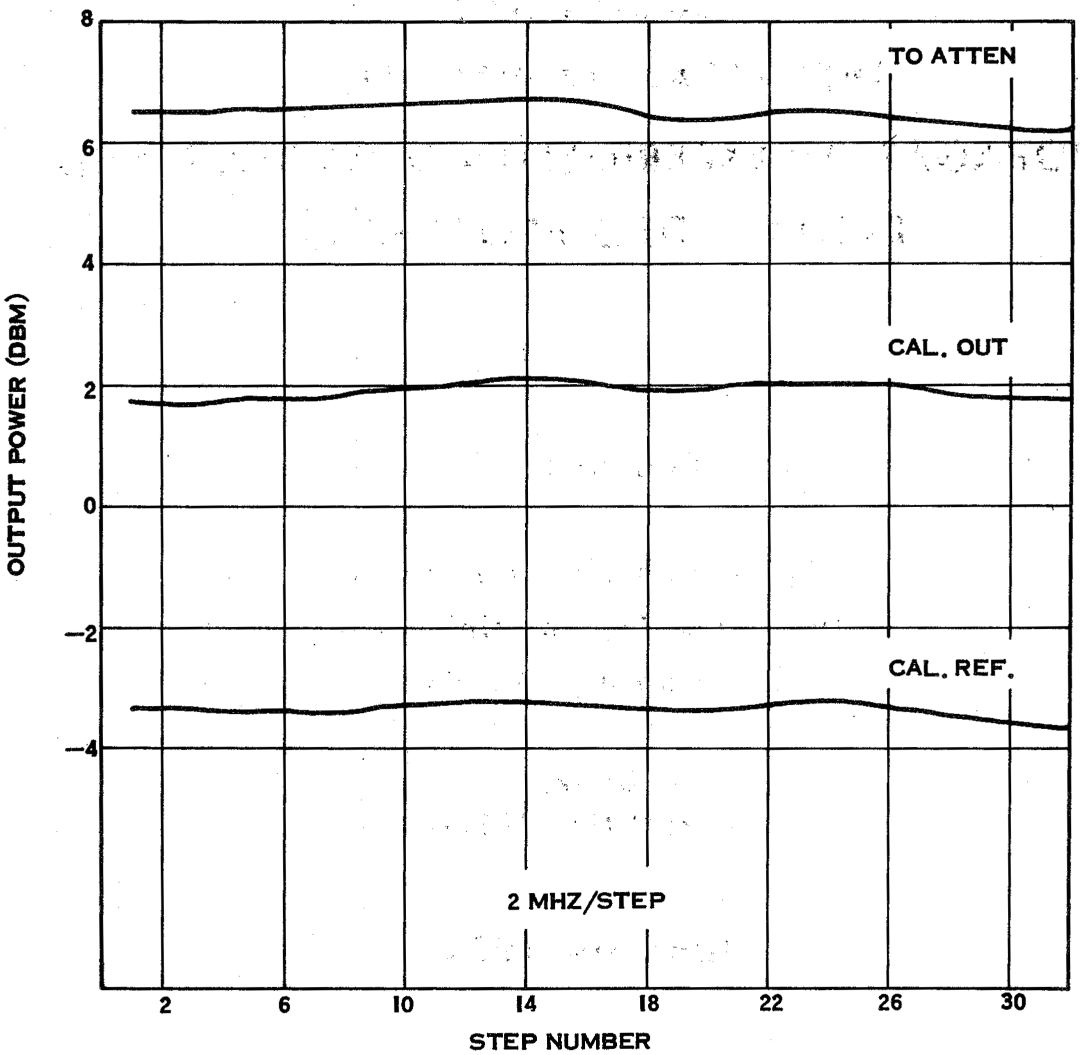


FIGURE A.16. STEP NUMBER VS POWER OUTPUT
CALIBRATION CHANNEL

APPENDIX B

CSC-74-852

TECHNICAL MANUAL FOR PROPAGATION EXPERIMENT CONTROLLER AND RADAR VIDEO PROCESSOR

Prepared for

Applied Physics Laboratory
The Johns Hopkins University
Silver Spring, Maryland

Under
Contract No. 372176

January 1974

by

Computer Sciences Corporation
Paramus, New Jersey 07652

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 SCOPE

This manual covers the description, theory of operation, external connections, and maintenance of the Propagation Experiment Controller and Radar Video Processor.

2.0 GENERAL DESCRIPTION

2.1 PURPOSE OF SYSTEM

The "Propagation Experiment Controller and Radar Video Processor" is a computer-based control system for acquiring statistics on the spacial distribution of rain and has been specially tailored to meet the requirements of the experiment being conducted at Wallops Island by the Applied Physics Laboratory (APL) of Johns Hopkins University.

The system provides for computer-controlled positioning of the weather radar in accordance with scan parameters entered by the experimenter and for processing the returns in a digital sweep integrator. Processed data is output in digital form on magnetic tape together with time, position, and header information for future analysis. In addition, the processed data is converted to analog form and can be displayed on a PPI or A-Scope for convenient monitoring of the experiment.

Another feature of the system is that it can operate in a playback mode in which it processes radar video that has been prerecorded on a video tape recorder.

2.2 SYSTEM CONFIGURATION

The system configuration is shown in block diagram form in Figure 1. As shown, the heart of the control system is a PDP-8/I minicomputer. This is a 12-bit machine and is equipped with 16K of memory and the following main frame options: memory parity control, power failure detection, and extended arithmetic. System software will be stored on the DF32 disk file system which has a 32K capacity and permits rapid experiment initialization. Operator interaction with the control system is via the ASR-35 teletypewriter.

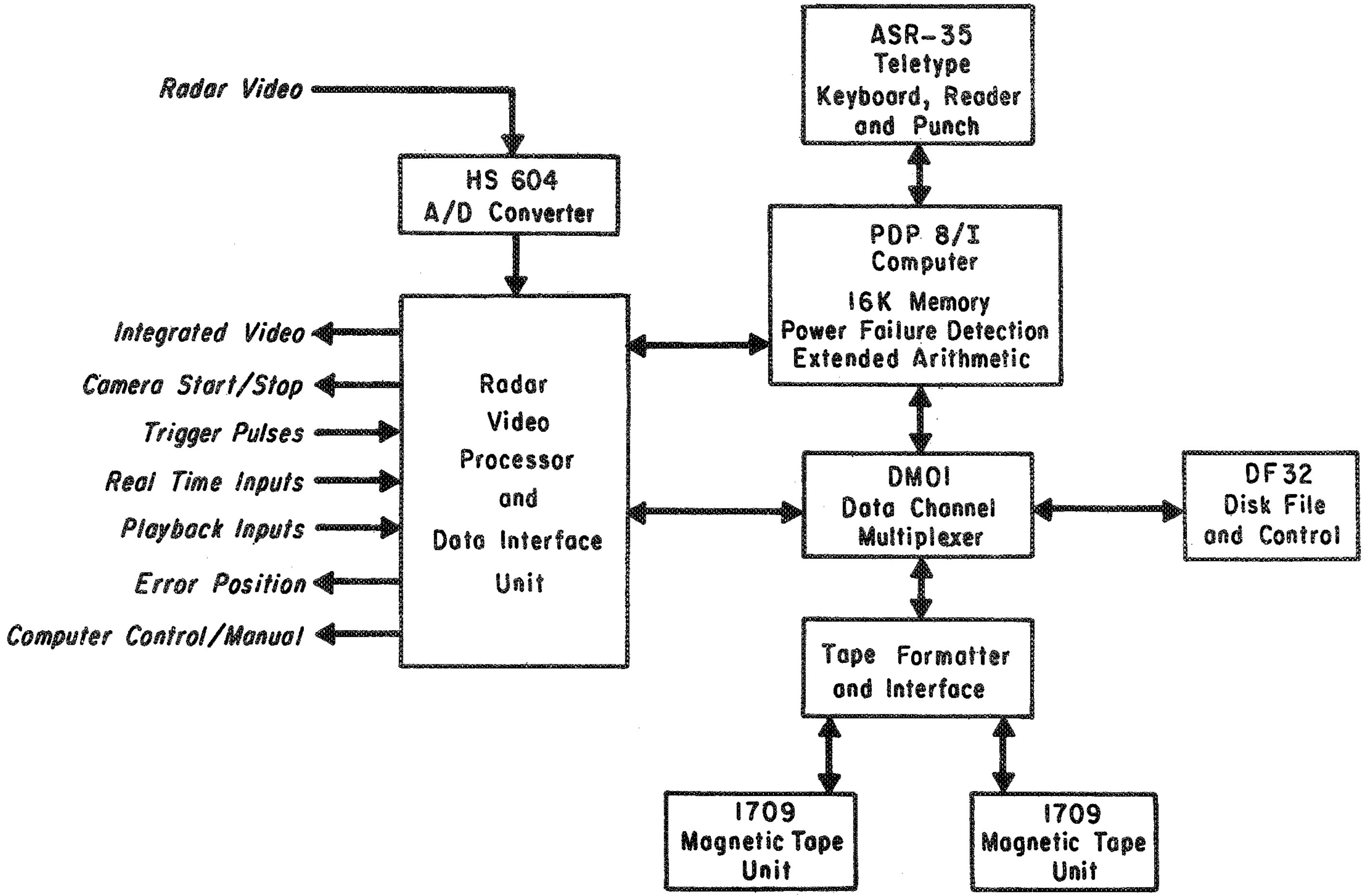


Figure 1. Control System Configuration

The digital data output from the system will be stored on either of two synchronous magnetic tape units which interface with the computer through the tape formatter and interface. The tape units are 9-track units and have a bit density of 1600 bpi and a tape speed of 45 ips.

A specially designed radar video processor is used to process the weather radar returns. Data transfers between the APL interface hardware and the control signals are made via the CSC data interface unit.

A data channel multiplexer (DM01) is also provided to permit several devices to transfer data with the computer using a high-speed direct memory access mode of transfer. The system is also equipped with a multiple channel A/D conversion system (not shown in the configuration diagram) which is not used in the current configuration but is included for future system expansion.

A complete list of the equipment comprising the control system is given in Table 1. The radar video processor and data interface unit are described in detail in another section of this manual. The other equipment is described in detail in the appropriate technical manuals provided as part of the system documentation.

Detailed subsystem interconnections are shown in the CSC equipment schematics provided as part of the system documentation (see Appendix A).

2.3 PHYSICAL CONFIGURATION

The equipment comprising the control system is housed in three adjoining equipment cabinets which are bolted together to form one consolidated unit. The cabinets are mounted on heavy-duty casters and are equipped with full rear doors. The end cabinets are also provided with side panels. Equipment cooling is provided by air fans located at the top of each cabinet. The approximate housing dimensions are 72 inches high by 66 inches wide by 30 inches deep. The door swing is approximately 22 inches. Overall floor space required for the cabinets is thus approximately 66 inches wide by 52 inches deep.

Table 1. Control System Equipment

Manufacturer	Model No.	Description
Digital Equipment Corporation (DEC)	PDP-8/I	Minicomputer with 4K of memory and cabinet
	MC8/I B	Memory extension control 4096 words of memory with parity
	MM8/I D	Memory module - 8K - with parity
	KP8/I	Power failure detection and restart
	KE8/I	Extended arithmetic element
	DM01	Data channel multiplexer
	DF32	Disc file and control system (32K words)
	H961-A	Cabinet (2)
	AF01A*	Analog digital converter with multiplexer control system
	A121*-	4-channel FET multiplexer switch (6)
Digital Equipment Corporation (DEC)	AH03*	Scaling amplifier $\pm$10V voltage swing
Teletype	ASR-35	Teletypewriter keyboard, reader, and punch
Digit-Data Corp.	1709/1600 (R/W)	Digital Magnetic Tape Unit (2)
	—	Read/write phase encoded formatter
Digit-Data Corp.	—	PDP-8/I negative bus computer interface
Computer Labs	HS-604	A/D converter - 6-bit
CSC		Radar Video Processor and Data Interface Unit

*Not used in present system configuration but available for future system expansion.

The ASR-35 teletypewriter is mounted on its own pedestal and can be located up to 10 feet away from the cabinets. Floor space required for the teletypewriter is approximately 44 inches wide by 19 inches deep.

The cabinets contain standard 19-inch mounting frames which allow convenient mounting of the various equipments. The placement of the equipments within the cabinets is illustrated in Figure 2.

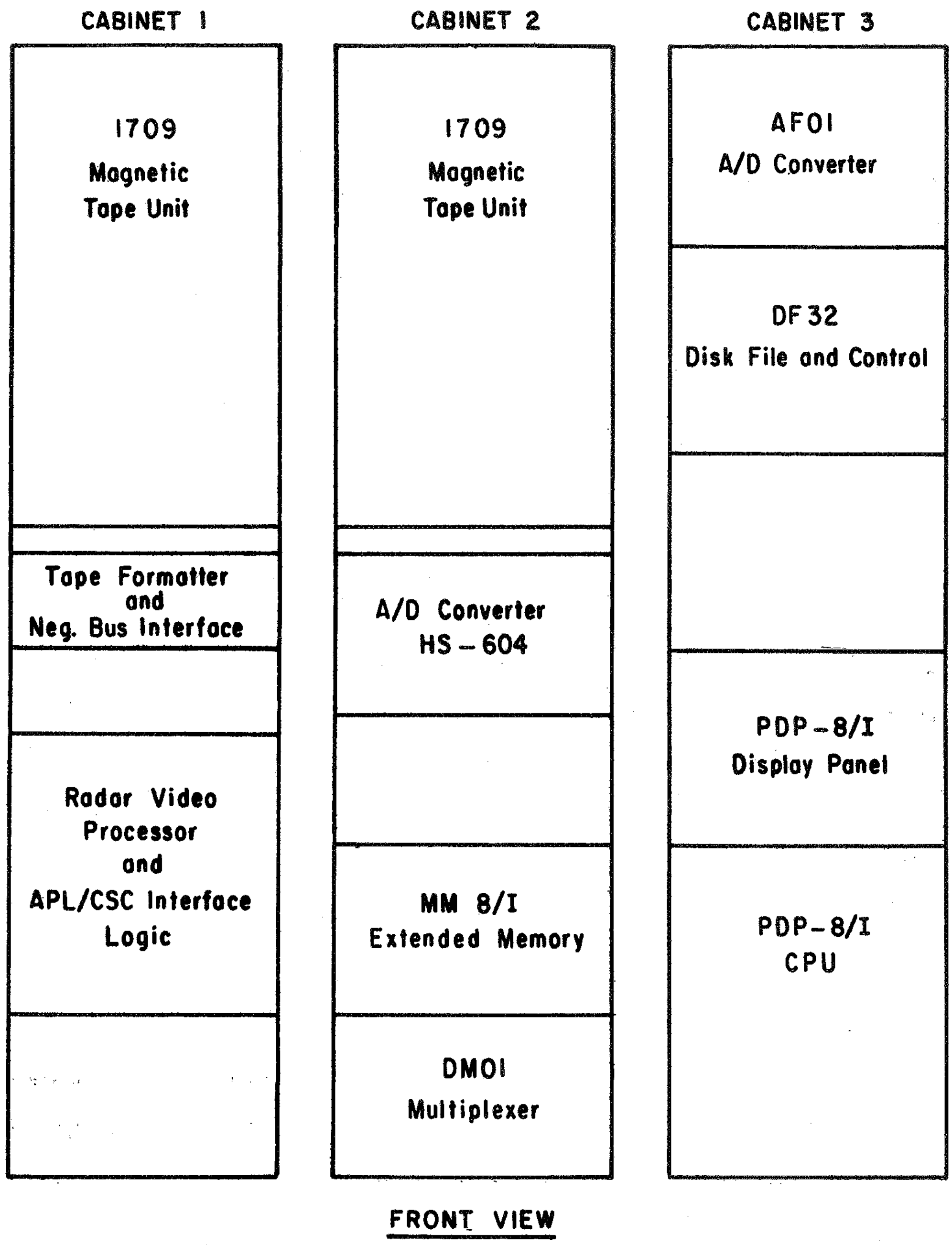


Figure 2. Cabinet Layout

2.4 INTERFACE SPECIFICATIONS (ELECTRICAL)

Inputs

AC Power	Voltage: 115 ± 17 volts (single phase) Frequency: 60 ± .5 Hz Current: 20 amperes
Radar Video Input	Input voltage: 0-2048 milliwatts Input impedance: 50 ohms
Data Inputs	# of signals: 20
RT Data (0-11) PB Data (0-7)	Input Load: DM7820 line receiver shunted by 220 ohms Logic "1": Positive differential voltage Logic "0": Negative differential voltage Differential threshold: 3.0 volts min
Pulse Inputs	# of signals: 7
RT Data Ready PB Data Ready Error Data Received High Calibration Trigger Low Calibration Trigger Main Bang Trigger 64 Hz Trigger	Pulse width: 1.0 ± .2 microseconds Levels: same as data inputs

Outputs

Data Outputs	# of signals: 12
Error Data (0-11)	Output source: DM7830 line driver Logic "1": Positive differential voltage Logic "0": Negative differential voltage Minimum differential voltage: 3.0 volts into 100 ohms
Pulse Outputs	# of signals: 3
Data Received RT Acknowledge PB Acknowledge	Pulse width: .6 ± .12 microseconds Output source: same as data outputs Levels: same as data outputs
Scope Trigger Outputs	# of signals: 4
Main Bang Scope Trigger High Calibration Scope Trigger Low Calibration Scope Trigger Integration Scope Trigger	Pulse width: .6 ± .12 microseconds Polarity: positive Amplitude: 3.6 volts min Baseline: .4 volts max Output source: TTL gate (7400 series)

Camera Start/Stop	Output source: TTL gate Logic levels: "1" = start "0" = stop
Comp/Manual	Output source: DM7830 line driver Comp: negative differential voltage Manual: positive differential voltage Differential voltage: 30 volts min into 100 ohms
Integrated Video	Output voltage: 2.5 volts Max current out: 20 milliamperes Resolution: 8 bits Offset: ±1/8 LSB Linearity: .0125% min

3.0 CSC DESIGNED EQUIPMENT

3.1 RADAR VIDEO PROCESSOR

3.1.1 General Description

The radar video processor (RVP) is a high-speed digital integrator that has been specially designed to process the weather radar returns obtained during the APL experiment. Processed data is transferred to the PDP-8/I minicomputer where it is formatted, combined with a header, and then output to IBM-compatible magnetic tape for future analysis.

The processing performed by the RVP consists in measuring the average radar return strength in discrete range bins, covering the radar range of interest, by integrating over consecutive radar pulses. Range bins of .5 or 1.0 microsecond may be selected corresponding to the basic radar pulse width used. A total of 871 range bins is provided starting from a minimum range of 62 microseconds, thereby allowing data acquisition out to a range of 933 microseconds when a 1-microsecond pulse width is used. Range accuracy of 125 nanoseconds is obtained through the use of a highly stable 8 MHz clock internal to the RVP. The RVP also provides the capability for integrating high-level and low-level calibration signals, as well as noise, which are present on the video input at prescribed times following the maximum radar range of interest.

The input video is quantized with 6-bit resolution while the processed data is output as 8-bit binary words. In addition to a digital output, the RVP also provides an analog output allowing the processed data to be displayed on an A-Scope or PPI.

The RVP is also equipped with a "self-check feature" through the inclusion of simulator logic which allows verification of RVP operation without the need for external signals.

During normal operation, the external signals required for RVP operation are as follows:

1. The input video containing the "raw" radar video, the high-level and low-level calibration signals, and noise.
2. A "main bang" trigger pulse whose leading edge is coincident with radar pulse transmission.
3. High-level and low-level trigger pulses whose leading edges are coincident with the high-level and low-level calibration signals, respectively.

The operation of the RVP is controlled by the experiment control program through the use of IOT instructions which are used to set the RVP processing parameters, enable, disable, and monitor the RVP operation, and to initiate data transfer to the computer.

3.1.2 Theory of Operation

A block diagram of the RVP is shown in Figure 3. As shown, the input video interfaces directly with a 6-bit A/D converter where it is sampled and digitized at intervals of the radar pulse width, thereby preserving the basic radar range resolution. Each sample obtained per range bin is added to the accumulated sum of previous samples of the same range bin in a digital adder. The accumulated sums are stored in a 960-word circulating shift register which is updated by shifting the adder output into the register as each new sample is obtained. The contents of the shift register are circulated once every radar pulse, thus keeping the range bins

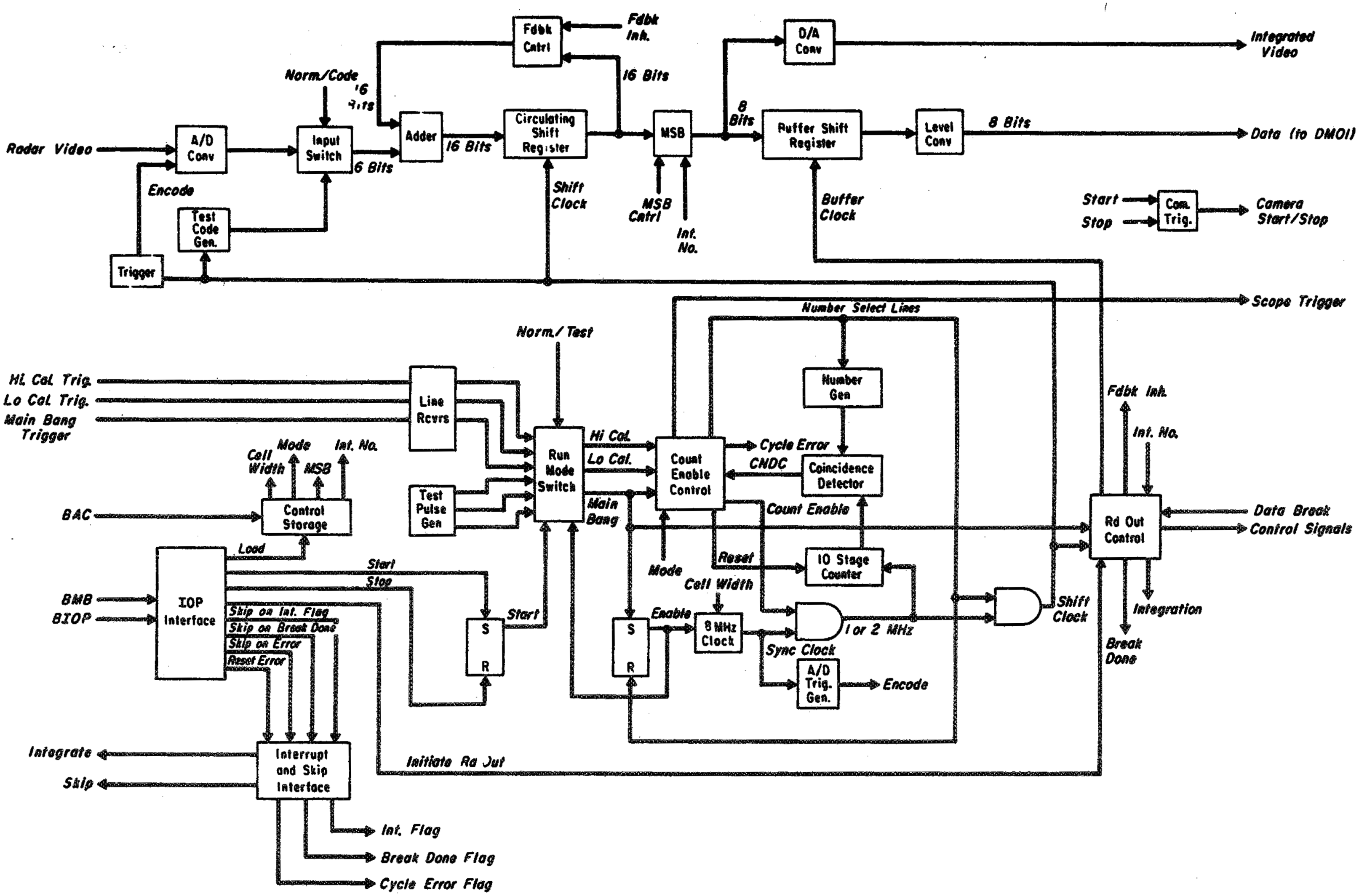


Figure 3. Block Diagram of Radar Video Processor

aligned from pulse to pulse. Both the adder and the circulating shift register are 16-bit devices in order to allow up to 1024 (2^{10}) samples to be accumulated.

When the number of samples required per integration has been obtained (i.e., 128, 256, 512 or 1024 samples as previously selected), the eight most significant bits of the shift register are selected and shifted into a second 960-word shift register which serves as a temporary storage facility prior to the transfer of the processed data to the minicomputer. The loading of the temporary storage takes place as new samples are being shifted into the circulating shift register from the digital adder. During this time, the feedback path from the circulating shift register to the digital adder is inhibited, thereby "rezeroing" the shift register for each new integration cycle. Also, as the buffer storage is being loaded, the eight bits of integrated video are applied to an 8-bit D/A converter where it is converted to analog form allowing convenient driving of scope displays which may be used to monitor RVP operation.

After the buffer register has been loaded, the RVP generates a computer interrupt requesting data transfer to the computer. At the proper time the control program issues an IOT instruction to initiate the data transfer via the 3-cycle data break facility of the computer. In this mode of transfer which is fully described in the DEC "Small Computer Handbook", words are transferred one at a time directly into the computer memory. by utilizing the memory cycles of the computer. During data transfer the processor is stalled; however, the major registers of the computer are undisturbed by the data transfer and processing is resumed immediately upon transfer completion. The RVP readout control logic has been designed to limit the data transfer rate to only three quarters of the computer's capability, thus avoiding completely tying up the machine during the transfer of the RVP data, and enabling the computer to respond to other computer interrupts. At the completion of the data transfer the RVP generates another computer interrupt to notify the control program to resume normal processing.

The circuit shown in the schematic diagram (Figure 8 of Appendix A), stores the RVP control word. Data is entered into the register on the leading edge of the load pulse, which is generated by instruction 6152.

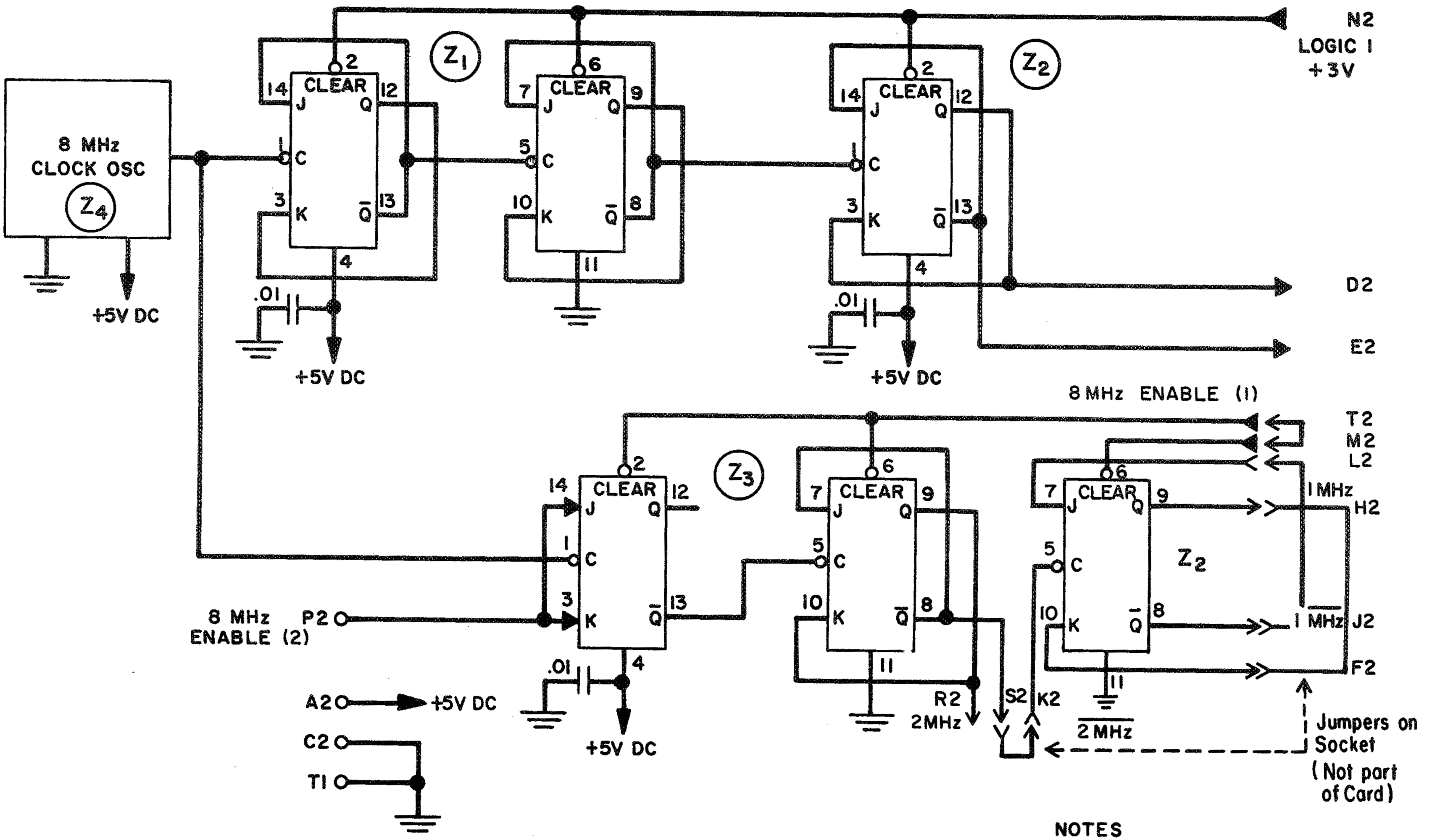
The RVP clock circuit provides the pulse trains used for the internal timing of the RVP. A schematic is given in Figure 4. An 8-MHz crystal oscillator with a stability of $\pm 10 \times 10^{-6}$ over a temperature range of 20°C to 30°C is used as the basic frequency source. The 8-MHz signal is divided by 8 in Z2 and Z3 when the 8-MHz enable line is high. It goes high when a main bang pulse is received and goes low when the STOP command, which is generated by instructions 6154, is issued from the computer. All flip-flops change state on the negative going transition of the C inputs. Clock timing is shown in Figure 5.

The sixteen bit adder circuit sums the radar video samples using two's complement arithmetic. In this arithmetic, the two numbers to be added are complemented and incremented by one to yield the complement of the sum of the original number. The preceding statement can be expressed by the following identity:

$$\overline{(A + B)} = \overline{A} + \overline{B} + 1$$

A schematic of the adder is given in Figure 6. The circuit is comprised of four 4-bit full adders. As shown, the first six "A" inputs of the 16-bit adder are the A/D output while the "B" inputs are the stored sum. Both the A and B numbers are complemented; that is, the all 1's condition represents zero volts while the all 0's condition represents maximum voltage. The addition of one to the A and B inputs is accomplished by setting Carry C_o to a logic "1". The worst case propagation delay of the adder is 48 nanoseconds.

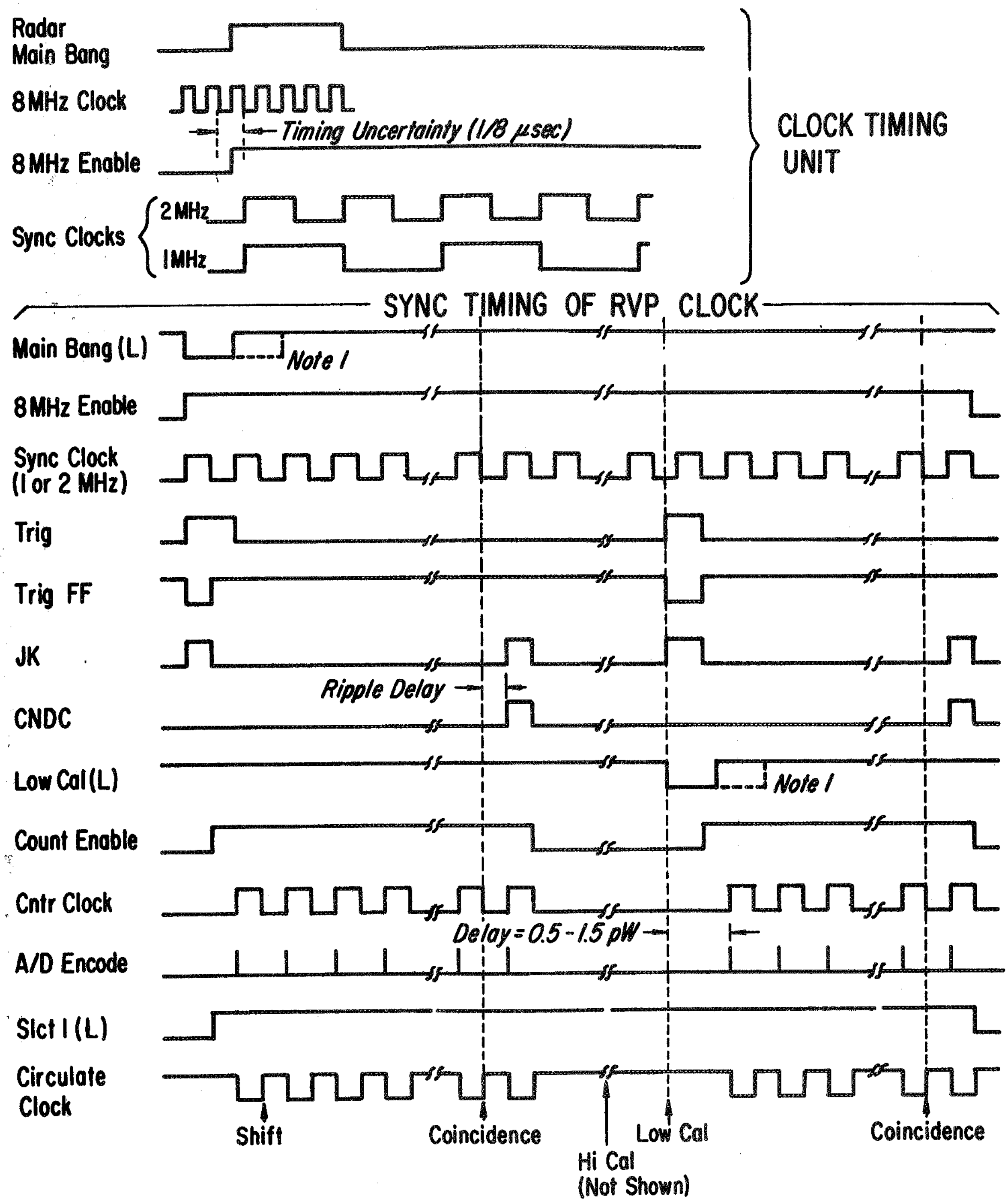
The feedback circuit controls the feedback of the stored sum to the 16-bit adder. A schematic is given in Figure 4 of Appendix A. The outputs of the circulating shift register indicated by Σ^1 xy are inverted by the M111 card and then applied to a set of two input NAND gates. When the FEEDBACK



NOTES

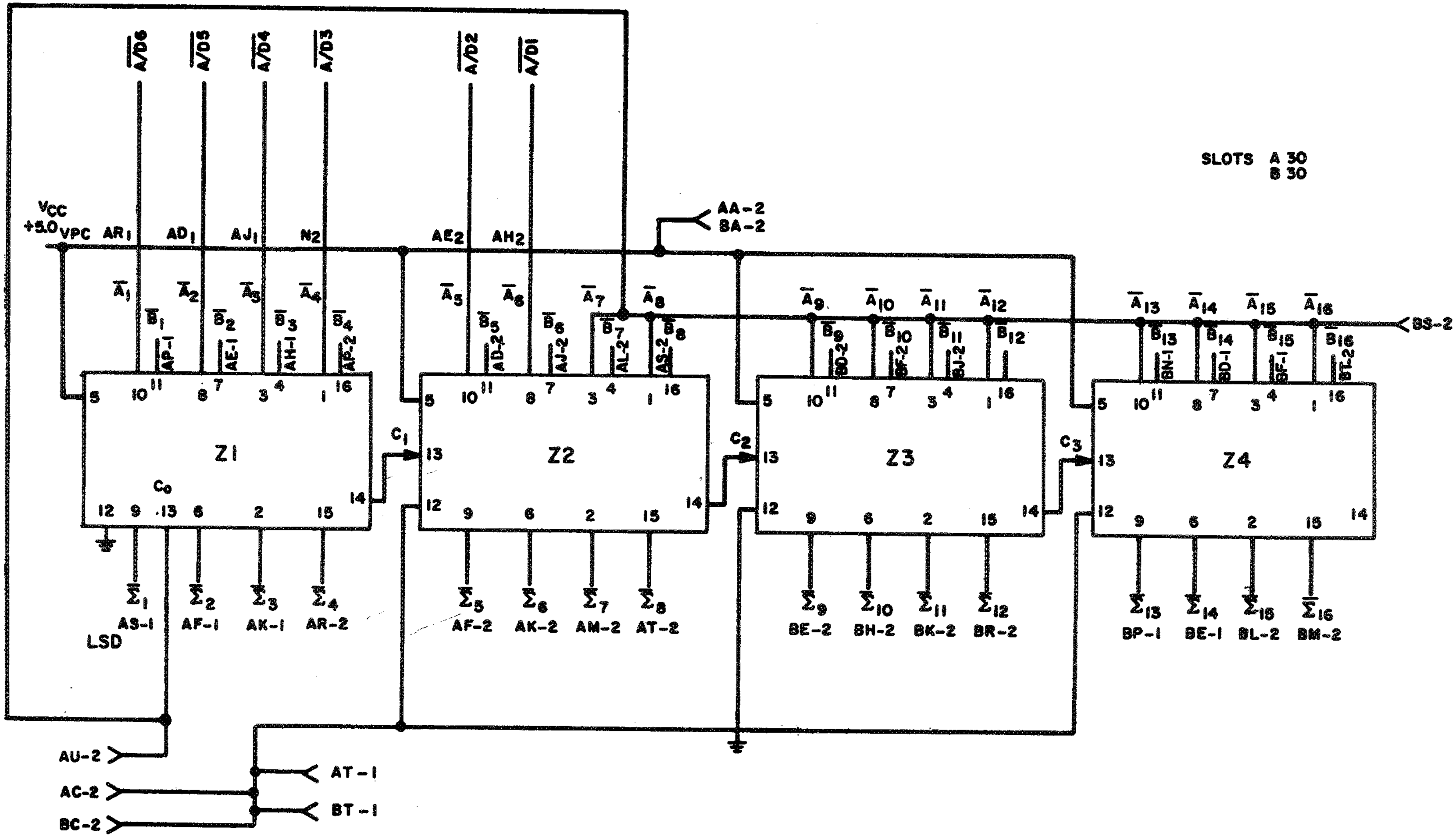
1. V_{CC} = +5V DC
2. USE GND PLANING
3. Z_1, Z_2, Z_3 SN7473N
4. Z_4 MOTOROLA K1035A (8 MHz)

Figure 4. Radar Video Processor Clock



Note 1. These pulses are always 1 μsec. The drawing is scaled to sync clock which may be 1 or 2 MHz.

Figure 5. Count Enable, Encode, and Circulate Timing



Notes:
Z1 = Z2 = Z3 = Z4 = National Semiconductor, DM-8283.
Double Height Double Clad DEC Card
NC = No Connection

Figure 6. 16 Bit Adder

INHIBIT*(2) is a logic 1 these inputs are reinverted; however, when the FEEDBACK INHIBIT*(2) is a logic 0 the outputs of the NAND gates are driven to logic 1's.

The circulating shift register stores the partial sums of the radar video samples. A schematic is given in Figure 7. The shift register is comprised of dual 240 bit static MOS shift registers. Two ICs are connected in series to provide 960 storage elements. The shift register shifts one bit to the right on the rising edge of the circulate clock. Circulate timing is shown in Figure 8.

The output storage register circuit stores the eight most significant bits of the circulating shift register. Data is shifted into the register during the first video scan of each new set of radar samples and is shifted out of the register during the readout mode which is initiated by IOT instructions 6162. A schematic is given in Figure 7. The circuit is identical to the circulating shift register with the exception that it has a 8-bit capacity instead of 16 bits.

Internal timing for the RVP is derived from an 8-MHz clock which is gated on at the start of radar pulse transmission by the "main bang" trigger pulse, thus assuring 125 nanosecond range accuracy. This clock is counted down to provide A/D sampling pulses at the desired rate of 1 or 2 MHz. Control circuitry within the RVP assures that samples are taken at the proper time during a range scan. Clock and control circuitry timing is shown in Figure 5.

Three sets of timing apply to RVP operation. The first corresponds to the processing of radar data previously recorded on video tape, referred to as tape mode 1, while the last two correspond to the processing of the weather returns either directly from the radar or from a video tape recording which also contains all the necessary timing signals, referred to as tape mode 2, and which from the RVP's point of view is indistinguishable from the real-time mode.

In tape model 1, sampling is initiated with the main bang trigger pulse and continues until 960 samples have been taken at which time further sampling is inhibited until the receipt of the next main bang trigger pulse. The significant timing relationships for this mode are shown in Figure 9.

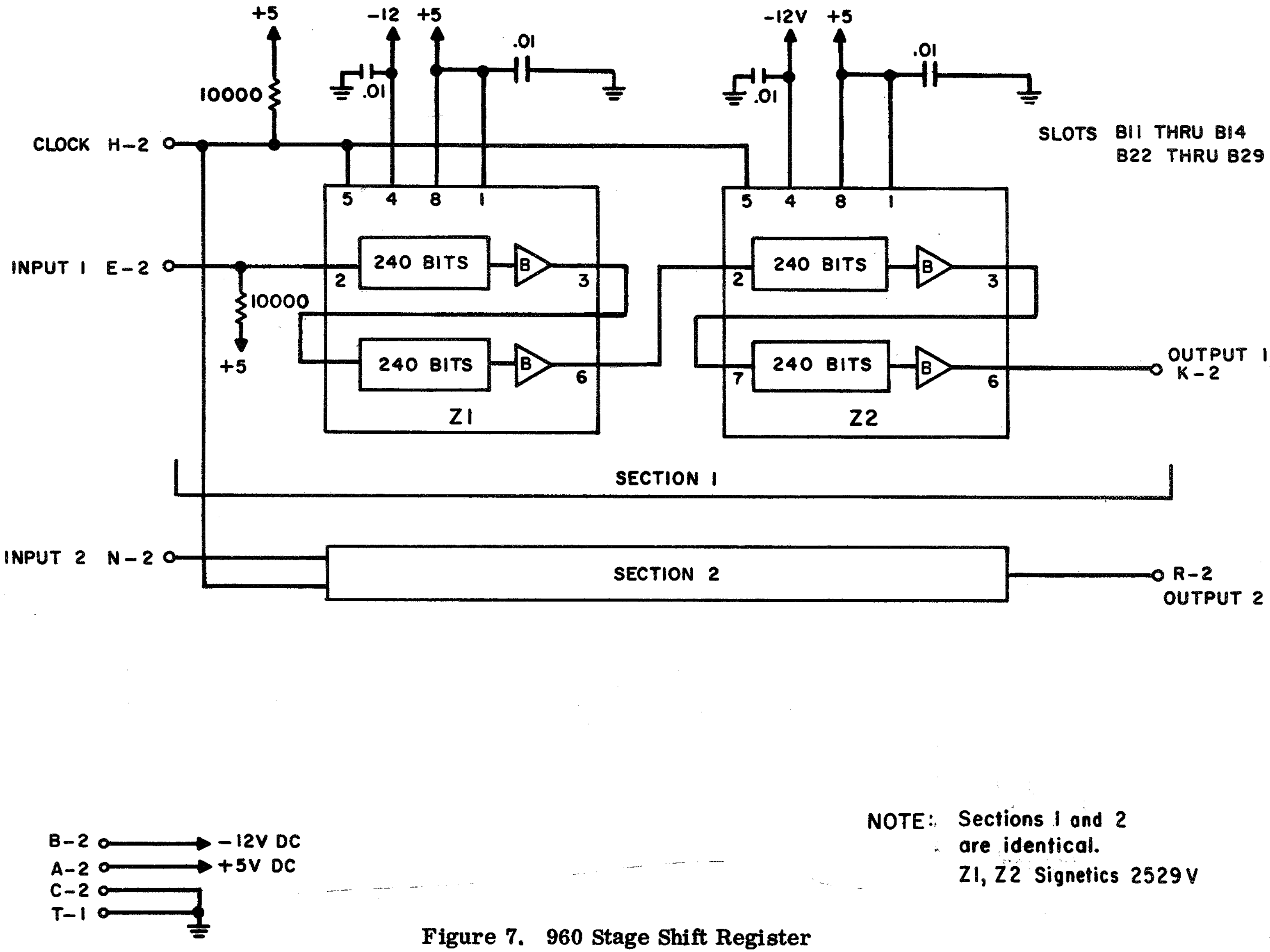
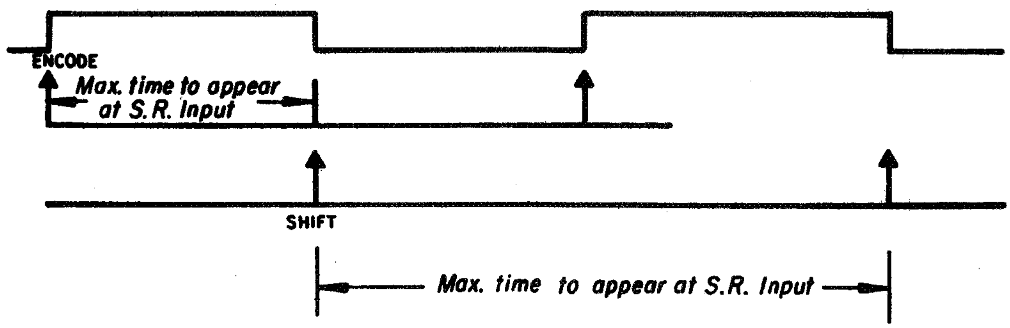


Figure 7. 960 Stage Shift Register



A/D DELAY	95 nsec		
ADDER 4 x 12	48		
DATA SET UP.	50		
	193	< 250 nsec	Margin 57
SHIFT REGISTER DELAY .	330		
FD BK DELAY.	20		
ADDER DELAY.	48		
SET UP	50		
	448	< 500	Margin 52

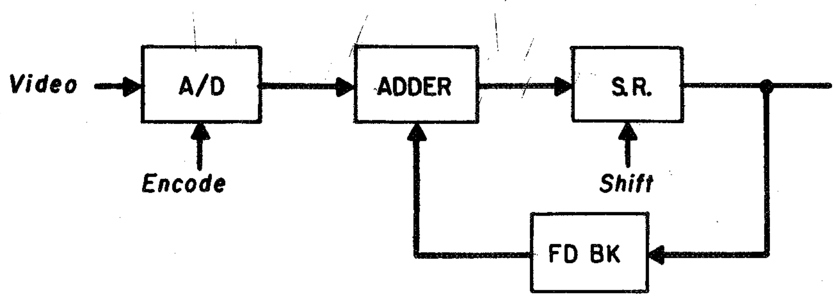


Figure 8. Circulate Timing Diagram

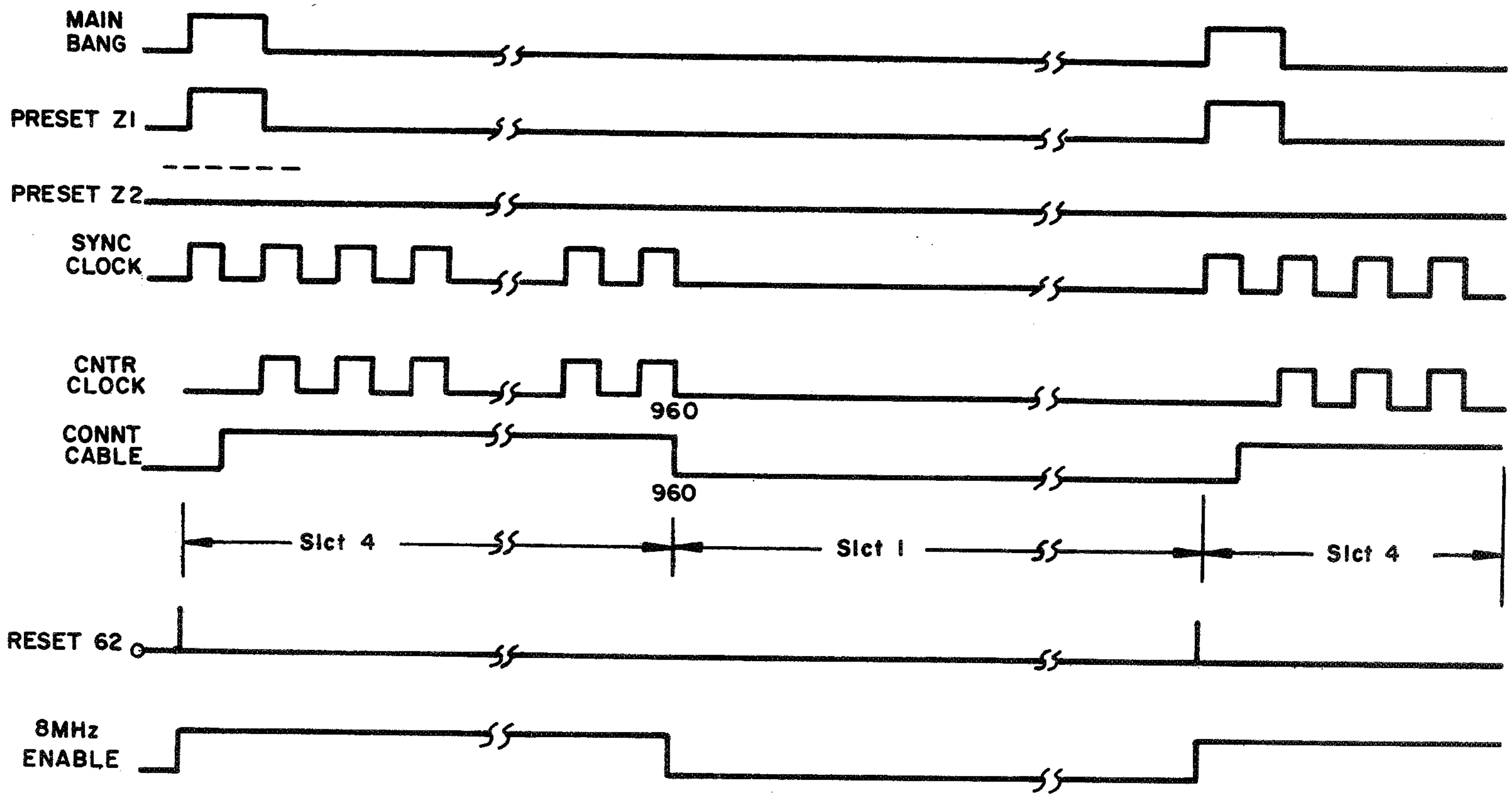


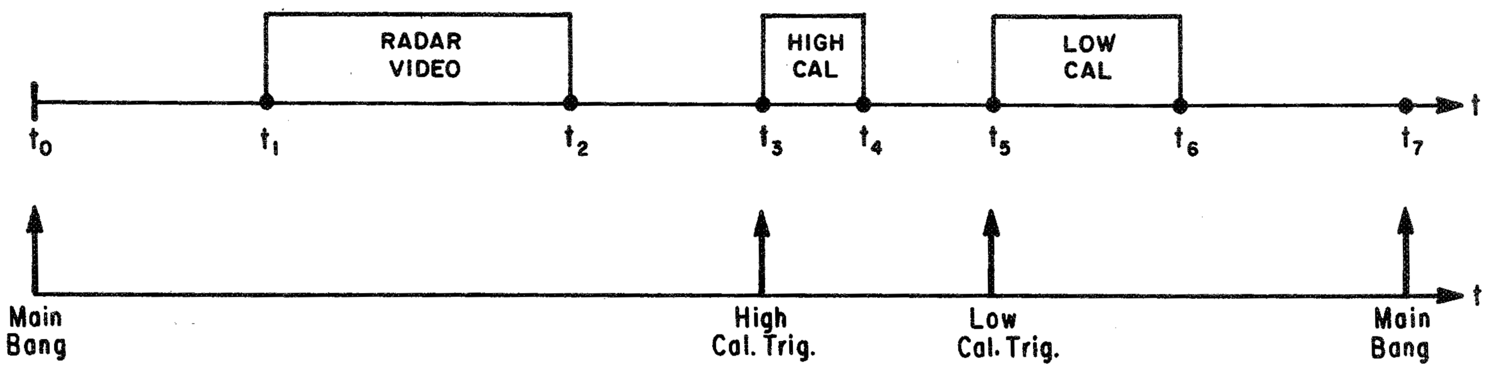
Figure 9. Tape Mode 1 Timing Diagram

The other RVP timing, corresponding to the real-time mode and tape mode 2, is more involved due to the presence of high-level and low-level calibration signals which are gated onto the video input following the maximum range of interest. The significant timing relationships for these modes are illustrated in Figure 10.

As shown in the figure, the minimum range at which data acquisition is desired is 62 microseconds. When 1-microsecond range bins (pulse widths) are used, the sample corresponding to the minimum range will be the sixty-third word in the circulating shift register. The timing for this mode is shown in Figure 11. This follows since a discrete sample of the input video actually represents a space average which for the particular case of the minimum range bin covers the range from 62 to 63 microseconds. Likewise, when 0.5-microsecond range bins (pulse widths) are used, the minimum range sample is taken at 62.5 microseconds which covers the range from 62.0 to 62.5 microseconds. The timing for this mode is shown in Figure 12. For both range bin widths, the RVP logic ensures that the sixty-third word in the circulating shift register is the minimum range bin. The first 62 words corresponding to samples prior to the minimum range are not used and are discarded in the computer prior to being written to magnetic tape. A total of 871 range bins are taken at which time further sampling is inhibited until the receipt of a high calibration trigger pulse. The time at which the maximum range sample is taken is 933 microseconds for 1-microsecond range bins and 497.5 microseconds for 0.5 microseconds range bins.

As shown, the high calibration signal will be applied at 1002 microseconds and will last for approximately 4.25 microseconds.

The first high to low transition of the sampling clock after the leading edge of the high calibration trigger pulse re-enables A/D sampling. The first sample taken will be used as a guard bin while the next two will be valid samples of the high calibration signal level. For the worse case timing, this will ensure that the high calibration samples are taken a minimum of 0.75 microsecond from the leading



t_0 = Main Bang = 0 μsec

t_1 = Min Range = 62 μsec

t_2 = Max. Range = $\left.\begin{array}{l} 933\ \mu\text{ sec} \\ 497.5\ \mu\text{ sec} \end{array}\right\}$ PW = $\begin{array}{l} 1.0 \\ 0.5 \end{array}$

t_3 = High Cal. Trig. Pulse = 1002 μsec

$t_y - t_3$ = Duration of High Cal. Signal = 4.25 μsec

t_5 = Low Cal. Trig. Pulse = 1020 μsec

$t_6 - t_5$ = Duration of Low Cal. Signal Pulse = 11 μsec min.
20 μsec max.

t_7 = Next Main Bang = $\dfrac{1}{PRF} + t_0$

Figure 10. Timing Relationships for Real Time Mode or Tape Mode 2

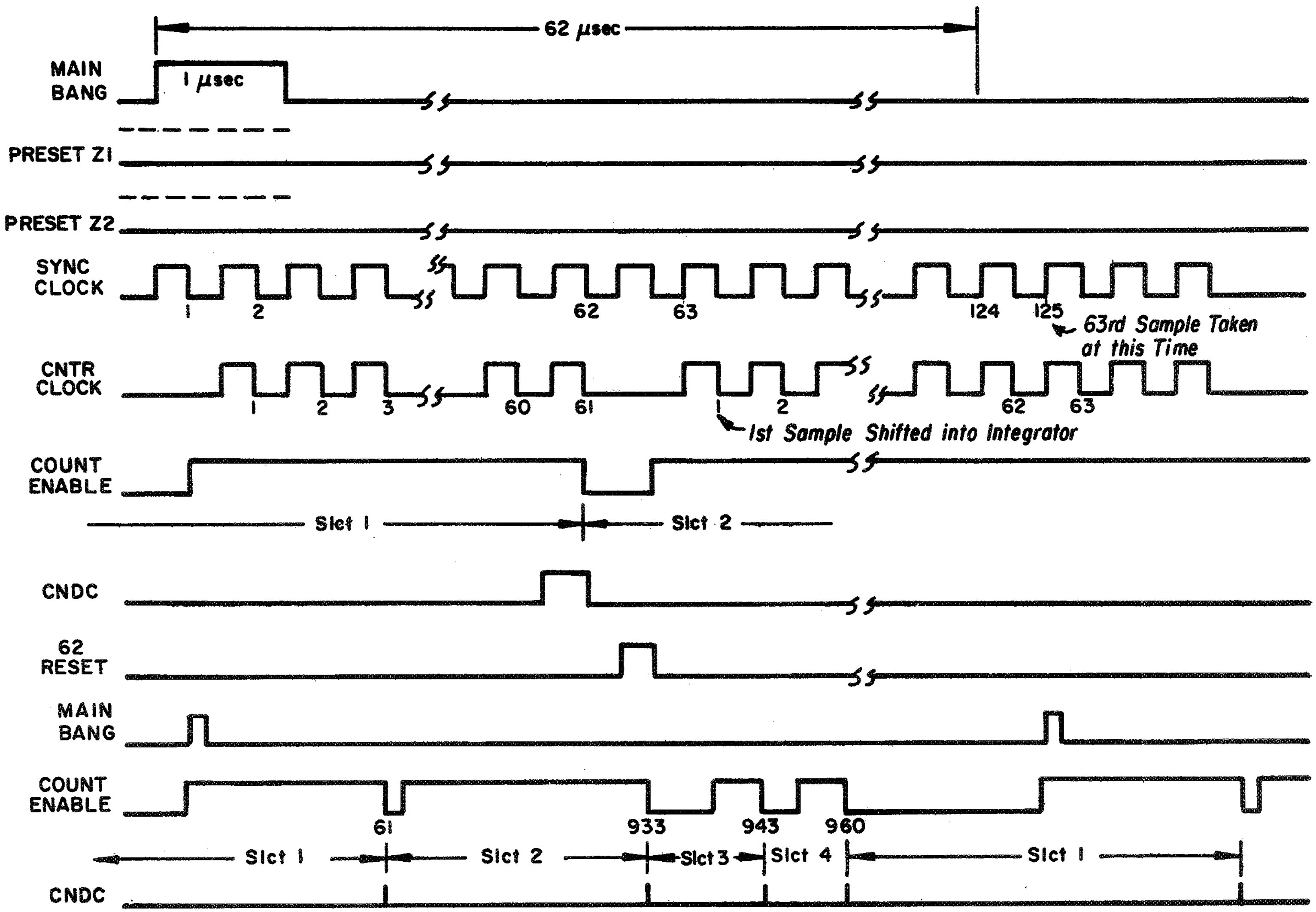


Figure 11. Real Time or Tape Mode 2, Timing Diagram (1/2 sec PW)

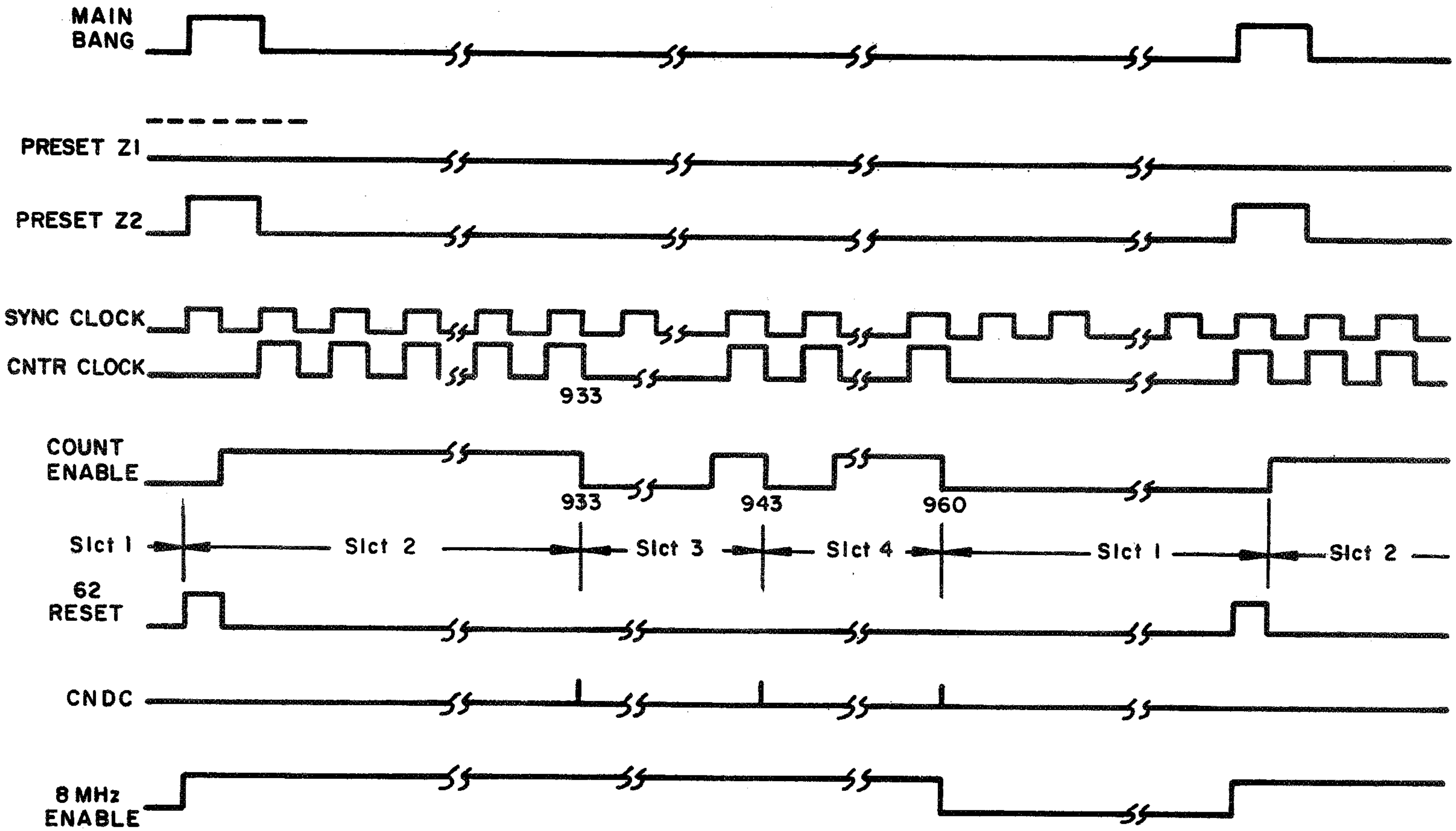


Figure 12. Real Time or Tape Mode 2 Timing Diagram (1 μsec PW)

and trailing edges of the high calibration signal. The next six range bins following the high calibration bins are used as guard bins to wait out the high calibration pulse when 0.5 microsecond-range bins are used, after which four samples of noise will be taken and then sampling inhibited until the receipt of a low calibration trigger pulse. Worse case timing ensures that the first noise sample will be taken a minimum of 0.75 microsecond after the high calibration signal.

As shown in the timing diagram, the low calibration signal will be applied at 1020 microseconds at which time sampling will be re-enabled as was done for the high calibration signal. The first sample taken will be a guard bin after which nine samples of the low calibration signal level are taken, followed by three additional samples to completely fill the circulating shift register. Sampling is then inhibited until the receipt of the next main bang trigger pulse. The contents of the circulating shift register for the real-time or tape mode 2 operations are summarized in Table 2.

Table 2. Contents of the Circulating Shift Register for Real-Time or Tape Mode 2

Shift Register Word	Contents
1-62	Not used
63-933	Video
934	Guard byte
935-936	High calibration
937-942	Guard bytes
943-946	Noise
947	Guard byte
948-956	Low calibration
957-960	Not used

The RVP also includes error detecting circuitry to detect the occurrence of trigger pulses while A/D sampling is in process indicating an RVP or radar interface malfunction. If such a condition is detected, the RVP raises a flag and generates a computer interrupt to signal the control program.

3.1.3 RVP Operation

The RVP operates completely under computer control with the exception of toggle switches mounted on the left side of the RVP mounting blocks. Table 3 outlines the function of these switches.

Table 3. RVP External Switches

Video/Code	This switch selects the source of the RVP input which is either the A/D output or the internal code generator. During normal operation, this switch is set to video.
960/Off 640/Off 320/Off	These switches select the desired main bang PRF when operating the RVP in the test mode. When any switch is switched out of the Off position, the RVP is placed in the test mode. Only one switch should be out of the Off position at any given time. During normal operation these three switches are set to the Off position.

The IOT instructions used to control RVP operation are listed below.

Instruction	Mnemonic	Description
6151	Stop	Disables the RVP by gating off successive radar "main bang" pulses. Processing of the current radar return is completed.
6152	Load	Strobes the control word held in the PDP-8/I accumulator into a buffer register in the RVP. The format of the control word is as follows:

0	1	2 3 4 5	6 7	8 9 10 11 ← AC bits
	Cell Width	Integration Number	Mode	MSB Select

(a) Cell Width - specifies the width of a range bin as follows:

Cell Width (Microseconds)	1.0	.5
AC 1	0	1

(b) Integration Number - specifies the number of pulses integrated per RVP record.

Integration Number	128	256	512	1024
AC 2	1	0	0	0
AC 3	0	1	0	0
AC 4	0	0	1	0
AC 5	0	0	0	1

(c) Mode - specifies the RVP mode of operation.

Mode	Real-Time	Tape Mode 1	Tape Mode 2
AC 6	1	0	0
AC 7	0	1	0

Instruction	Mnemonic	Description
		(d) *MSB Select - specifies the number of bits that the most significant bit (MSB) of the RVP output data is shifted from the MSB of the adder (i.e., 16th). When S_0 is selected the most significant bits of the integration are selected. When S_X is selected the MSB of the output will be 16-x. For example S_4 selects the 12th bit.

MSB Select	S_0	S_2	S_4	S_6
AC 8	1	0	0	0
AC 9	0	1	0	0
AC 10	0	0	1	0
AC 11	0	0	0	1

*This option is not provided for in the current control program and is intended for future expansion of RVP processing capability.

Instruction	Mnemonic	Description
6154	Start	Enables the RVP by gating on the radar "main bang" pulse and resets all control counters. Data stored in the readout buffer is retained.
6161	Skip on Integration Flag (SIF)	Interrogates the integration cycle flag internal to the RVP. If the flag is set the next instruction is skipped. The integration flag will be set by the second radar return in an integration cycle and, when set, causes a program interrupt by activating the interrupt bus.
6162	Initiate Readout (IRD)	Enables the RVP to output data to the computer using the three-cycle data break mode. The readout will be initiated at the latter of the following: (a) The readout buffer is loaded. (This is accomplished by the second main bang in an integration cycle.) (b) This instruction (IRD) is received.

Instruction	Mnemonic	Description
6164	Skip on Readout Done Flag (SRD)	Interrogates the Readout Done Flag internal to the RVP. If the flag is set, the next instruction is skipped. The Readout Done Flag, when set, also causes a program interrupt by activating the interrupt bus. The Readout Done Flag is set by the word count overflow pulse generated by the computer in the data break mode when the prescribed number of words has been transferred.
6171	Skip on Cycle Error Flag (SCE)	Interrogates the cycle error flag internal to the RVP. If the flag is set, the next instruction is skipped. The cycle error flag when set causes a program interrupt by activating the interrupt bus. The cycle error flag is set when the RVP internal monitoring circuitry detects that a trigger pulse has been received while A/D sampling is in progress.
6172	Clear Cycle Error Flag (CEF)	Resets the cycle error flag.
6174	Clear Integration Flag (CIN)	Resets the integration flag.
6144	Clear Readout Done Flag (CRD)	Resets the readout done flag.

3.2 CSC DATA INTERFACE

3.2.1 Description and Theory of Operation

The CSC data interface unit contains the necessary logic and buffer circuitry for transferring data between the PDP-8/I computer and the APL interface in both the real-time and playback modes of operation. In the real-time mode, data transfers are used to position the antenna mount under computer control as well as to input time of day information to the computer for inclusion on the magnetic tape output. In the playback mode the data transfers are used to read in the digital data prerecorded on the audio channel of the video tape to the computer for inclusion on the magnetic tape output.

Data transfers occur at a basic 64-Hz rate as determined by a 64-Hz timing pulse supplied to the CSC data interface. Data is transferred in parallel form as a sequence of several words with timing for individual word transfers derived from the computer clock.

In the real-time mode each data input transfer consists of five 12-bit words which contain pedestal azimuth and elevation, as well as time of day. The formats of these five words are illustrated in Figure 13. Timing control for the transfer of these words is as follows.

When data is ready for input, a data ready pulse is applied to the CSC data interface, where it is used to generate a computer interrupt to inform the control program that data is ready for transfer. The computer will then issue five IOT instructions to read in the data. Each IOT results in an acknowledge pulse being sent to the APL interface which is used to update the word being transferred to the computer.

In the playback mode, 21 twelve-bit words are read into the computer. The contents and formats of these words are illustrated in Figure 14. Timing control for data transfer is identical to that used for the real-time input transfer except 21 words are transferred instead of five.

In the real-time mode the CSC data interface will supply position control information to the APL interface as two 12-bit words (see Figure 15). The contents of the error word output are as follows:

1. ED 11 for angle identity AZ or EL; Ø for AZ, 1 for EL.
2. ED (0-10) for desired minus actual position in two's complement binary coded with the LSB (ED0) equal to the LSB input to the controller from the shaft encoders (i.e., 1 bit = .005; $180 \div 2^{15}$).

The CSC interface also supplies a control signal indicating whether the computer is generating position control signals. Each time position control information is output a retriggerable one-shot with an approximate one-second

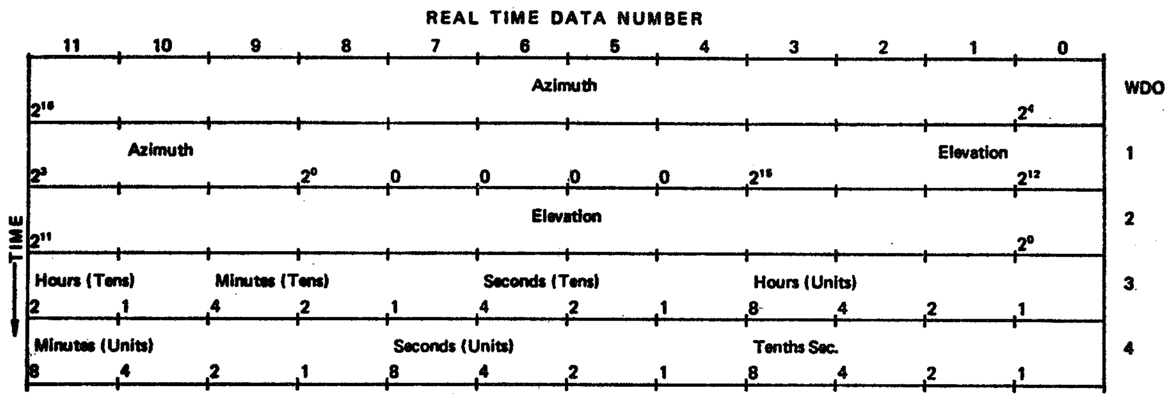


Figure 13. Real-Time Data Format

Word Format	PB Data Bit 0	1	2	3	4	5	6	7
0	Data Valid 1	Pulse Width 1	PRF 1	2	Scan Rate 1	2	4	0
1	Par-Amp 1	Power Ref. (Units) 1	2	4	8	Power Ref. (Tens) 1	2	4
2	Number in Sequence 1	2	4	8	1	2	4	0
3	ΔAz/ΔEl 1	2	Type of Run 1	2	Cal Level 1	2	4	8
4	Azimuth (8 LSB) 2^0							2^7
5	Azimuth (8 MSB) 2^8							2^{15}
6	Elevation (8 LSB) 2^0							2^7
7	Elevation (8 MSB) 2^8							2^{15}
8	Hours (Tens) 1	2	Minutes (Tens) 1	2	4	Seconds (Tens) 1	2	4
9	Hours (Units) 1	2	4	8	Minutes (Units) 1	2	4	8
10	Seconds (Units) 1	2	4	8	Tenths (Sec.) 1	2	4	8
11	Spare							
12	Spare							
13	Elevation Start 2^0							2^7
14	Elevation Stop 2^0							2^7
15	Azimuth Start 2^0							2^7
16	Azimuth Stop 2^0							2^7
17	Days (Tens) 1	2	4	8	Days (Units) 1	2	4	8
18	ID (Tens) 1	2	4	8	ID (Units) 1	2	4	8
19	Days (Hund.) 1	2	Year 1	2	4	ID (Hund.) 1	2	4
20	Spare							

TIME ↓

PB DATA BIT

Figure 14. Format 1 - For Tapes Recorded During Summer of '72

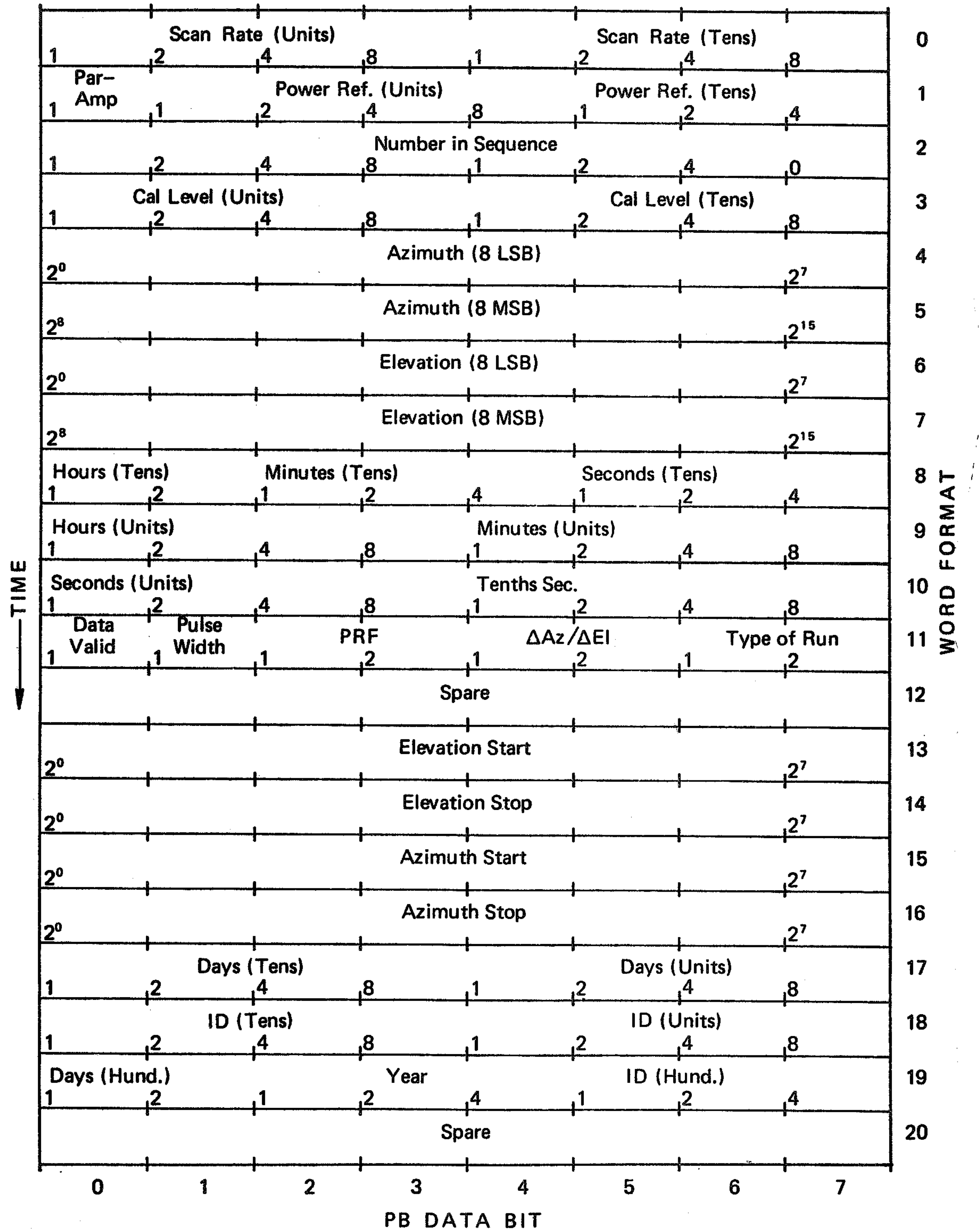


Figure 15. Format 2 - For Tapes Recorded After Summer of '72

(adjustable) time shot is triggered. If position information is not output within the time out period of the one-shot, the control line will indicate the computer is no longer controlling mount position.

Connections to the CSC data interface are made via four multiple twisted-pair cables.

3.2.2 Software Control of Data Interface

The data interface operates under computer control through the use of the IOT instructions listed below.

Octal Code	Name/Mnemonic	Function
6141	Clear Data Acknowledge Flag (CDA)	Resets the data acknowledge flag.
6142	Clear 64-Hz Flag (C64)	Resets the 64-Hz flag.
6144	Clear Readout Done Flag	Resets the readout done flag.
6641	Skip on Data Ready (SDR)	Interrogates the data ready flag. If the flag is set, the next instruction is skipped. The data ready flag is set by the appropriate data ready pulse in either the real-time mode or the tape playback mode (1 or 2). The data ready flag, when set, activates the interrupt bus.
6642	Read Data and Acknowledge (RDA)	Strobes the data from the APL video tape interface unit (real-time or playback) into the AC. It is not necessary to clear the AC prior to this instruction because RDA generates an AC clear pulse which clears the AC during the instruction. This instruction is also gated through to the APL interface (acknowledge pulse) to cause the next data word to appear at the CSC interface.
6644	Clear Data Ready Flag (CDR)	Resets the data ready flag.

Octal Code	Name/Mnemonic	Function
6651	Read Error Data (RED)	Gates the contents of the AC (error word) to the APL interface. This instruction is also gated through to the APL interface where it is used to strobe the error word into a buffer register. The instruction also triggers a resettable one shot which drives the computer/manual control signal. If the time interval between RED instructions exceeds 0.5 second (nominal), the manual mode will be indicated.
6652	Skip on Data Acknowledge Flag (SDA)	Interrogates the data acknowledge flag. If the flag is set, the next instruction is skipped. The data acknowledge flag is set by the data received pulse (real-time mode only) which should occur within 10 microseconds following an RED instruction. The data acknowledge flag, when set, activates the interrupt bus.
6654	Skip in 64 Hz Received (S64)	Interrogates the 64-Hz flag. If the flag is set the next instruction is skipped. The 64-Hz flag is set by the 64-Hz timing pulse in both the real-time and tape playback modes. When set, the 64-Hz flag activates the interrupt bus.

4.0 EXTERNAL CONNECTIONS

External connections to the control system are made via the interface cables listed in Table 4.

The four multiple twisted-pair cables designated J1-J4 are supplied with the control system and are brought out through the fan part at the top of cabinet #1 and are approximately forty feet long. The control system end of the cable is connected to a DEC M908B cable connector which plugs directly into a connector block module in cabinet #1. The APL end of these cables is equipped with a 50-pin #57-30500 (micro-ribbon) plug and shell designed to mate with a #57-40500 receptacle. Plug pin assignments for each of these cables are listed in Table 5.

Table 4. Interface Cables

Name	Designation	Description
Real Time	J1	15 - Multiple twisted pairs individually shielded
Tape Playback	J2	11 - Multiple twisted pairs individually shielded
Error Position	J3	11 - Multiple twisted pairs individually shielded
Trigger Pulses	J4	11 - Multiple twisted pairs individually shielded
Radar Video		Coaxial cable (50 ohms)
Integrated Video		Coaxial cable (90 ohms)
Main Bang Scope Trigger		Coaxial cable
High Calibration Scope Trigger		Coaxial cable
Low Calibration Scope Trigger		Coaxial cable
Integration Scope Trigger (MB)		Coaxial cable
Camera Start/Stop		Coaxial cable

Table 5. Plug Pin Assignments for Interface Cables

REAL-TIME CABLE – J1		
Pin No.		Function
J1 – 1 (+)	J1 – 26 (-)	Data Line – 2^0
J1 – 2	J1 – 27	2^1
J1 – 3	J1 – 28	2^2
J1 – 4	J1 – 29	2^3
J1 – 5	J1 – 30	2^4
J1 – 6	J1 – 31	2^5
J1 – 7	J1 – 32	2^6
J1 – 8	J1 – 33	2^7
J1 – 9	J1 – 34	2^8
J1 – 10	J1 – 35	2^9
J1 – 11	J1 – 36	2^{10}
J1 – 12	J1 – 37	2^{11}
J1 – 13	J1 – 38	Data Ready
J1 – 14	J1 – 39	ACKNOWLEDGE

TAPE PLAYBACK CONNECTOR – J2		
Pin No.		Function
J2 – 1 (+)	J2 – 26 (-)	Date Line – 2^0
J2 – 2	J2 – 27	2^1
J2 – 3	J2 – 28	2^2
J2 – 4	J2 – 29	2^3
J2 – 5	J2 – 30	2^4
J2 – 6	J2 – 31	2^5
J2 – 7	J2 – 32	2^6
J2 – 8	J2 – 33	2^7
J2 – 9	J2 – 34	N.C.
J2 – 10	J2 – 35	N.C.
J2 – 11	J2 – 36	N.C.
J2 – 12	J2 – 37	N.C.
J2 – 13	J2 – 38	Data Ready
J2 – 14	J2 – 39	ACKNOWLEDGE

Table 5 (Continued)

ERROR POSITION CABLE – J3		
Pin No.		Function
J3 – 1 (+)	J3 – 26 (-)	Data Line – 2^0
J3 – 2	J3 – 27	2^1
J3 – 3	J3 – 28	2^2
J3 – 4	J3 – 29	2^3
J3 – 5	J3 – 30	2^4
J3 – 6	J3 – 31	2^5
J3 – 7	J3 – 32	2^6
J3 – 8	J3 – 33	2^7
J3 – 9	J3 – 34	2^8
J3 – 10	J3 – 35	2^9
J3 – 11	J3 – 36	2^{10}
J3 – 12	J3 – 37	ID Bit
J3 – 13	J3 – 38	Read Data
J3 – 14	J3 – 39	Data Received
J3 – 15	J3 – 40	Comp/Manual

TRIGGER PULSES CABLE – J4		
Pin No.		Function
J4 – 1 (+)	J4 – 26 (-)	High Calibration
J4 – 2	J4 – 27	Low Calibration
J4 – 3	J4 – 28	Not used
J4 – 4	J4 – 29	64-Hz Trigger
J4 – 5	J4 – 30	PRF (Main Bang)

The control system provides BNC jacks for the remaining coaxial cables. The radar video jack is located at the rear of the HS-604 A/D converter mounted in cabinet #2. The coaxial cable can be brought in through the fan port at the top of the cabinet. The remaining jacks are mounted on a panel at the front of cabinet #1.

AC power is brought into the control system via a single 20 amp line cord, located at the rear of cabinet #2, and equipped with a 20A twist-lock plug.

5.0 MAINTENANCE

Under normal usage the control system will require only a minimum of maintenance as follows:

1. Regrease the magnetic tape unit read/write heads regularly.

2. Lubricate the muffin fans and the teletypewriter reader at intervals of 1000 operating hours or a year whichever occurs first.

3. Clean the equipment card racks with a soft brush or rag to prevent dust build up as required.

Drawings for the radar video processor and data interface as well as a subsystem interconnection cabling diagram have been provided as part of the system documentation. These drawings and the various technical manuals for the system components contain the necessary information for troubleshooting and repairing the control system in the event of a system malfunction. Conventions used in the CSC supplied drawings conform to those used by the Digital Equipment Corporation in their documentation.

APPENDIX C

SPANDAR CALIBRATION ACTIVITIES

Final Memo Report
MMS-1348, 12 September 1973

by

W.L. Vann

Applied Physics Laboratory
The Johns Hopkins University
Laurel, Maryland

APPENDIX C

SPANDAR CALIBRATION ACTIVITIES

C.1 INTRODUCTION

The calibration/characterization programs undertaken on the SPANDAR radar were oriented toward determining the operating characteristics of the system and toward a system of monitoring that would maintain a high level of accuracy during the experiment period. To accomplish the first objective a large number of measurements were made covering the transmitter, antenna, and receiver along with associated waveguide transmission lines, monitoring couplers, coax lines and attenuators. The measurements were performed initially to determine the general condition of the microwave system and to identify any component that should be replaced because of high VSWR or insertion loss. The measurements were then repeated after replacing several sections of waveguide.

Of some concern was the second and third time around rejection of radar returns caused by the frequency separation between adjacent pulses. To provide this information the radar preamp response was measured and the entire receiver chain was measured over an extended frequency range at signal levels covering the full dynamic range of the system.

The Frequency Diversity (F.D.) chassis was a key element in the experiment. Many tests were performed on the unit while it was at the Applied Physics Laboratory to determine the unit's stability, frequency linearity, power output variations across the frequency band, and the stability of the timing system. Some problems observed in the timing system stability were resolved by modifying the circuitry to a counter controlled delay generator giving a much improved stability. Circuit changes to improve the stability and the output power distribution were made by MED personnel. Neither the calibration effort or the resulting modifications were part of the group design-and-build commitments.

Extensive antenna patterns were measured covering the principal planes at several frequencies, along with backlobe and spillover lobe responses. Measured also were a set of stepped elevation patterns from which antenna contours were generated. Antenna gain measurements were made by MED personnel and have been separately reported in References 1 and 3.

Pedestal servo response tests were conducted by MCS personnel and the results reported separately (Reference 7). The results of the servo tests were supplied to Computer Services Corporation as design constraints in the antenna scan pattern generating program (see Appendix B).

A system of continuous monitoring and calibration was devised for the SPANDAR radar which consists of continuous measurement and recording of certain parameters, periodic measurement of other parameters, periodic injection of a known level signal from a source external to the radar, continuous injection of noise samples and samples of the transmit frequency timed to occur in the radar dead times, and occasional calibrated sphere tracking tests.

The interrelation and use of these calibration techniques are not discussed in this Appendix. However, the method of deriving and injecting the continuous receiver calibration signals are addressed in Section C.4, on the F.D. chassis calibration.

Simplified block diagrams of the radar system, measuring system and the continuous calibration system are included at the end of this appendix.

C.2 WAVEGUIDE MEASUREMENTS

The waveguide system tests were accomplished over a period of 4 months and consisted of several hundred individual measurements. The initial measurements (Reference 4) were devoted to calibration of waveguide couplers, measurement of isolators, circulators, a spare rotary joint and a first cut at the VSWR and insertion loss of the entire waveguide run. These early waveguide tests resulted in higher VSWR and insertion loss responses than anticipated and additional tests were made to identify and replace the components with excessive VSWR and/or insertion loss. The azimuth and elevation rotary joints were measured separately to determine their VSWR, insertion loss, and wow. Tests were also performed on the paramp circulator and on several of the transmitter components.

Subsequent to the completion of the waveguide tests and the replacement of several sections of waveguide, the entire waveguide run was retested for VSWR, insertion loss and return loss (see Figures C.1 and C.2); the results are summarized in Table C.1. From the paramp circulator to the antenna, the total insertion loss/return loss is broken into its transmit loss and receive loss components to reflect the additional receive loss when the parametric amplifier is bypassed and additional loss is incurred in the circulator. The location numbers in 1a of Table C.1 refer to the key numbers in Figure C.1.

Each of the measurements of insertion loss for the main waveguide run are tabulated as average loss and by a peak-to-peak (p-to-p) value as taken from the x/y plotter record. The p-to-p values refer to apparent variations in insertion loss with frequency. The apparent variations are because of several effects including: (1) change in loss from VSWR (reflective loss); (2) power variation in the measuring instruments not corrected by the leveling circuitry; (3) incomplete regulation in the ratio meter circuitry. These variations were not investigated in depth since they were small and their contribution to the error budget is negligible in the F.D. mode.

The measurements given in 1b through 1f of Table C.1 refer to individual component tests and are letter-keyed where pertinent to Figure C.1. The summary loss value in 1b refers to the total receiver line losses from the transmitter room reference location to the mixer preamp input terminal location 9 in Figure C.1.

Copies of the VSWR and loss calibration records are on file at the MDP RARF project office, the Applied Physics Laboratory, and the originals are on file at the Wallops Island radar site (SPANDAR records).

C.3 ANTENNA MEASUREMENTS

The antenna gain and pattern measurements were made using a power source and a horn located on a tower 10,200 ft from the radar with the intervening terrain consisting mostly of tidal marsh. The horn was placed 225 ft above MSL level on the tower. The SPANDAR antenna centerline is about 100 ft above MSL. These numbers result in a look-up angle from the radar of 0.8^0 to the radar beam center and an angle of 2.5^0 from the radar beam center to the specular reflection region. An ambiguity factor of $\pm$ 0.4 dB results from reflected energy entering the radar side lobes. As previously reported, the antenna gain was measured by breaking the waveguide run at point 6 (Figure C.1) and attaching a TWT amplifier, precision attenuator, and power meter. The measured power was then compared with a calibrated reference horn that was moved up and down to establish the maxima and minima of the interference lobe structure which was incident on the antenna. This was done to account for multipath. These measurements were then resolved to determine the antenna gain of 50.75 dB at center frequency (Reference 3).

Antenna patterns were measured by connecting precision attenuators, a TWT amplifier, and a detector in place of the receiver mixer terminals. The video detector output and mount synchro outputs were used to drive a Scientific Atlanta recorder to obtain the patterns presented in Figures C.3, C.4 and C.5. The principal plane (azimuth and elevation) patterns were measured at three frequencies and, in addition, a full 360^0

pattern was taken at center frequency with the elevation angle reduced in steps (to correct for the slightly tilted range geometry) to search for wide-angle sidelobes, spillover lobes, and back lobes. None of these was found in the 40 dB range of the instrumentation.

The SPANDAR antenna fed mechanism is a turnstile junction (circular waveguide fed by crossed rectangular waveguides) that was incorporated in the original design to permit the use of linear vertical, linear horizontal, or circular polarization. This polarization flexibility is a source of error in a measurement where frequency agility is to be used and high axial ratio linear polarization is required. Measurements were made on the antenna feed to determine the polarization ratio (ellipticity) over the F.D. band when the feed is set for linear vertical at the center frequency. The measured ellipticity was greater than 34 dB at center frequency and decreased to approximately 15 dB at the band edges (see Figure C.6).

C.4 F.D. CHASSIS TESTS

In addition to the initial installation, modification and use of the F.D. chassis during the 1972 measurement effort, a measurement program was initiated after logic changes were incorporated to provide a frequency interlace mode; the noise source was installed, and a general cleanup and repackaging was accomplished. Tests were performed to validate the frequency interlace logic, and to determine the output power variation as a function of frequency, frequency linearity, warmup stability and the accuracy/stability of the calibrate signal timing pulses. Much of this engineering test data is reported in Reference 2; however, selected tests and supplementary data are included here for reference. Table C.2 gives a typical set of measurements where, for a given frequency step size (2 MHz) and number of steps (32), the output frequency and all the output power levels were measured. Table C.3 is the result of an earlier test and shows the interlace frequency select pattern for 24 steps at $\sim$ 1 MHz per step. The power levels at several of the output ports were subsequently changed to the values in Table C.2 before the unit was installed in SPANDAR.

Figure C.7 shows the nominal linearity over a bandwidth of 140 MHz and reflects a successful attempt to compensate for the solid state oscillator (S.S.O.) tuning in that the step sizes are nearly constant. Absolute uniformity of the steps was not a requirement but the ability to obtain 24 steps of nominal 1 MHz per step within the power bandwidth of the FPS-18 transmitter (see Figure C.8) was a requirement.

Figure C.9 shows the frequency step pattern obtained in the normal and the interlace mode when 24 and 32 steps are selected. Since the interlace logic was designed for the 24 step mode and was based on a frequency separation between adjacent pulses of 12 steps (12 to 15 MHz in the 1 MHz/step mode) this logic becomes somewhat invalid when other than 24 steps are selected (Reference 2). The 32 step pattern shows several large steps and one very small step (frequency 32 to frequency 1).

Selection of 24 steps results in the portion of the curve from step 5 to step 28 inclusive being selected. During this interval the pattern is 13 steps when the frequency is increasing and 11 steps where decreasing including the pattern reset from frequency 28 to frequency 5. The selection of 8 or 16 steps results in numbers 13 through 20 and 9 through 24, respectively, being selected. These step combinations are valid except for the reset condition where the frequency separation between 20 and 13 or 24 and 9 does not meet the criteria established for the frequency separation between adjacent pulses. The logic was validated for the 24 step mode, and while other numbers of steps can be selected in the interlace mode there will be a resulting penalty in second-time-around storm signal rejection.

A test was conducted to determine the warm-up time (frequency settling) from a cold start and the results are shown in Figure C.10. From this test 1 to 2 hours was selected as the nominal warm-up time for a frequency tolerance of $\pm$ 1 MHz.

Delay multivibrator timing circuits were used in the initial design to generate both the PIN diode modulator and noise source triggers and/or the pulse width control. Measurements of the delay with PRF and with temperature changes indicated that variations of 10 μsec or more were present. At this point a design change was initiated where the large delays would be generated by a counter/decoder driven by a 10 MHz crystal oscillator. The delay multivibrators were still used for vernier delay control and for pulse-width control. After the installation and debugging of this design change the delay and pulse width variations were reduced to $\pm$ 0.1 to 0.2 μsec.

Subsequent to installation of the F.D. chassis in SPANDAR the power distribution in the calibrate channel was changed to that shown in Figure C.11. Higher losses than anticipated in the coaxial cables and in the attenuator network were compensated for by changing the noise source coupler from 3 dB to 10 dB. The calibrate output pulse was then set for -10 dBm peak at the mixer terminal (no attenuation inserted) and an attenuator was removed from the noise source line to maintain the proper level.

The noise source delivers -39 dB excess noise (above kt) which translates to -75 dBm per MHz of receiver bandwidth. An IF bandwidth of 4 MHz is used with no image rejection resulting in an effective receiving aperature of 4 MHz signal and 4 MHz image, or an 8 MHz total bandwidth for calculating the total power from the noise source accepted and processed by the receiver. The noise source power (8 MHz Bw) at the mixer terminals was estimated to be

-75.	dBm/MHz
+ 9.	dBm (8 MHz)
-19.3	dB coupling loss
- 2.7	dB cable loss
-88.	dBm (8 MHz) net

The high level calibrate signal was set for -10 dBm and the step attenuator provided greater than 100 dB attenuation range. This test signal was used for all receiver calibrations and was the reference by which the external tower source signal was measured.

C.5 RECEIVER MEASUREMENTS

The receiver preamp frequency response is shown in Figure C.12. This response was measured after adjustments were made to eliminate distortions in the wideband response. The complete receiver was measured to obtain the wideband frequency response and the log response. These results are given in Figures C.13 and C.14. The wideband frequency response curve shows a pronounced hump at 15 MHz at stronger signal levels. This is assumed to be caused by frequency multiplying action resulting from the nonlinear response of the log IF strip.

C.5.1 Transmitter Power Gain

The FPS-18 transmitter was adjusted for broadband response and the data shown in Figure C.8 plotted. The output power variation of less than 1.5 dB includes any contribution because of the F.D. chassis and the driver TWT and will not result in significant error in the processed video returns when averaged over the F.D. range.

C.5.2 Additional Measurements

Many additional measurements were made on various parts of the system but have not been presented here. Some of these measurements were published in the material referenced and other measurements were redundant. The data presented here represents (with minor exceptions) the radar status at the beginning of the 1973 CLC experiment program. The principal exceptions are the preamp response and the log IF slope curves which were made after some retuning and gain adjustment was performed on June 6 and 7, 1973. The log IF gain and offset was re-adjusted along with the gain and offset in the interface unit and the video recorder. Improved stability in the recorder system and improved linearity of the log IF at low signal outputs were the results of the changes.

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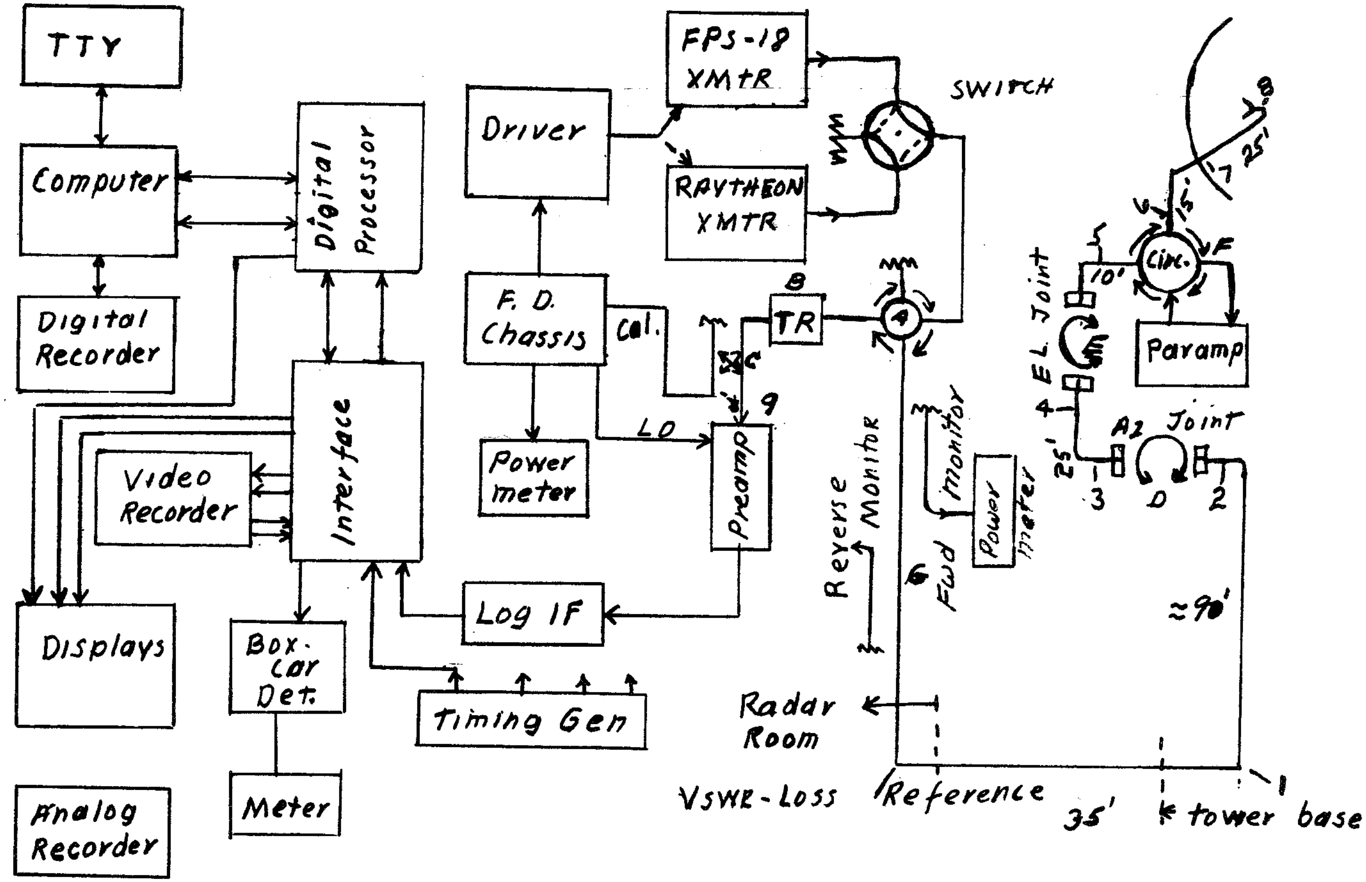

FIGURE C.1. SPANDAR RADAR SIMPLIFIED DIAGRAM

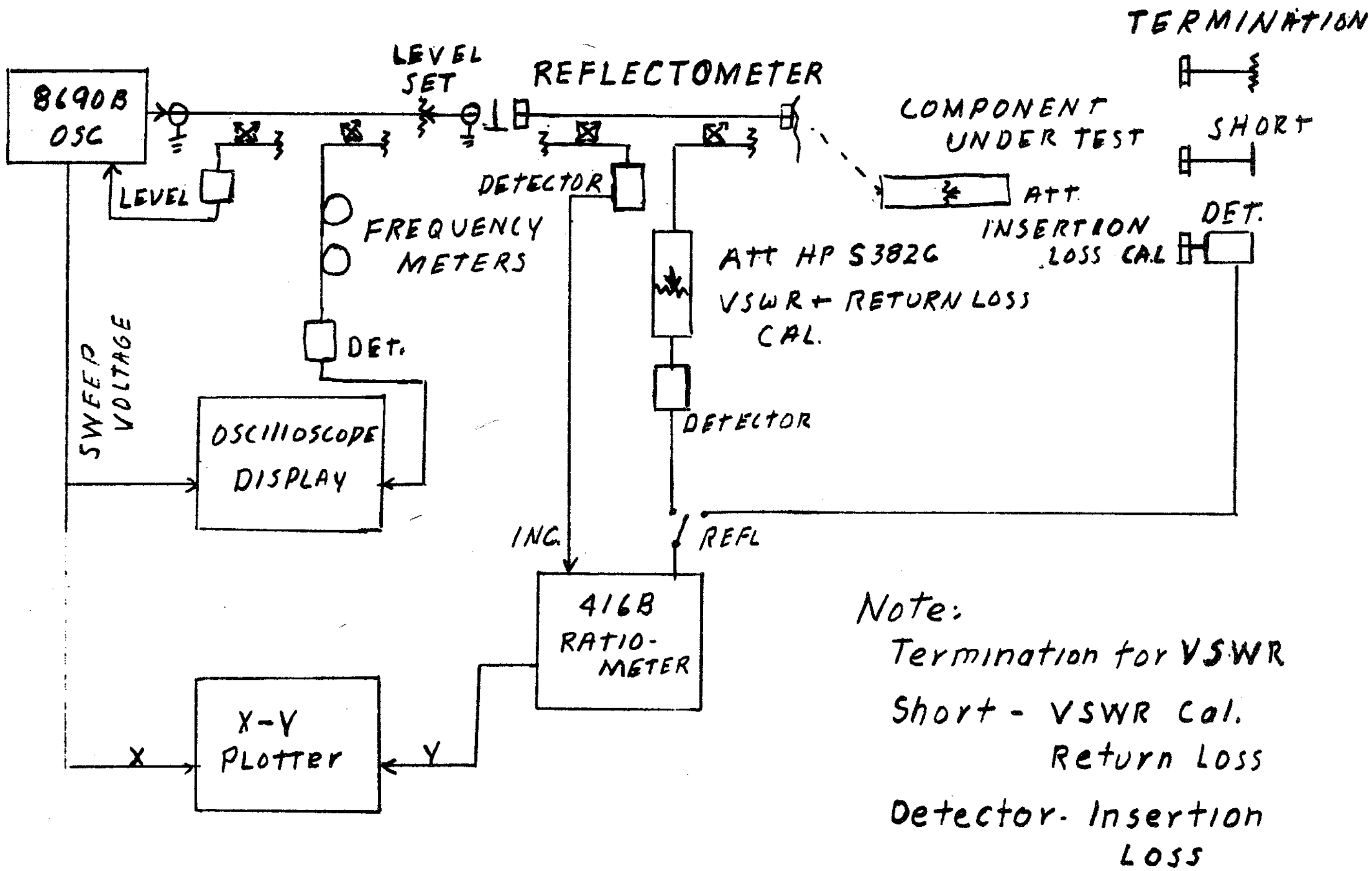

FIGURE C.2. SIMPLIFIED MICROWAVE DIAGRAM
VSWR - RETURN LOSS - INSERTION LOSS

TABLE C.1

WAVEGUIDE TEST RESULTS

1a. Losses in Waveguide Run to Antenna

Location (Figure)	Transmitter room to:	VSWR	INS. LOSS		RETURN LOSS	
			AVG.	Pk/Pk	AVG.	Pk/Pk
1.	Base of tower	< 1.07:1	0.4 dB	0.1 dB	0.35 dB	0.15 dB
2.	Input to azimuth joint	1.18	0.9	0.15	0.9	0.15
3.	Output of azimuth joint	1.19/1.23	1.10/1.15	0.2	1.10/1.15	0.2
4.	Input to elevation joint	1.28	1.20	0.2	1.20	0.2
5.	Input to paramp circ.	1.29	1.45	0.3	1.40	0.25
			TRANSMIT LOSS		RECEIVE LOSS	
6.	Output of paramp circulator (antenna gain reference)	1.37:1	1.75	0.3	2.50	0.4
7.	Inside dish	1.50	1.80	0.3	2.55	0.5
8.	Scanner input	1.48:1.53	2.0	0.6	2.75	0.7
	Scanner (inclusive)	1.60/1.65	–		–	

1.b. Losses in Receiver Line Components

Circulator/Duplexer (a)	0.35 dB	
TR Tube (b)	0.55 dB	
Switch/flex guide, etc.	0.2	
Coax. isolator	0.1	
Signal injection coupler (c)	0.5	
Total additional receive loss	1.7 dB	Reference to point 9.

TABLE C.1 (Continued)

1c. Rotary Joints (D &E)

	VSWR	INS. LOSS	WOW
Azimuth (D)	1.04/1.08:1	0.1 dB	< 0.5 dB
Elevation (E)	1.07	0.12 dB	< 0.5 dB

1d. Paramp Circulator (F)

Port.	VSWR	INSERTION LOSS
1 → 2	< 1.07:1	0.2 dB (transmit direction)
2 → 3	< 1.05	0.35 dB
3 → 4	< 1.10	0.3 dB
4 → 1	1.13	0.3
2 → 1	< 1.12	0.95 dB (receive direction short on 3 &4)

1e. Receiver Duplexer Circulator (A)

Port.	VSWR	INSERTION LOSS
1 → 2	1.10:1	.25 dB transmit
2 → 3	1.12:1	.35 dB receive
1 → 3		>25 dB isolation

1f. Directional Couplers (not shown on diagram unless noted)

Coupler No.	Coupling	Directivity
10	62.3 dB	24 dB
15	30.5 dB	23 dB
14	30.6 dB	24 dB
33	19.6 dB	26 dB
50	19.4 dB	18 dB
FPS-18 Power Monitor (G)		
Port 1	36.0 dB	>20 dB
2	36.1 dB	>20 dB
FPS-14 (S Band)	37.0 dB	>20 dB

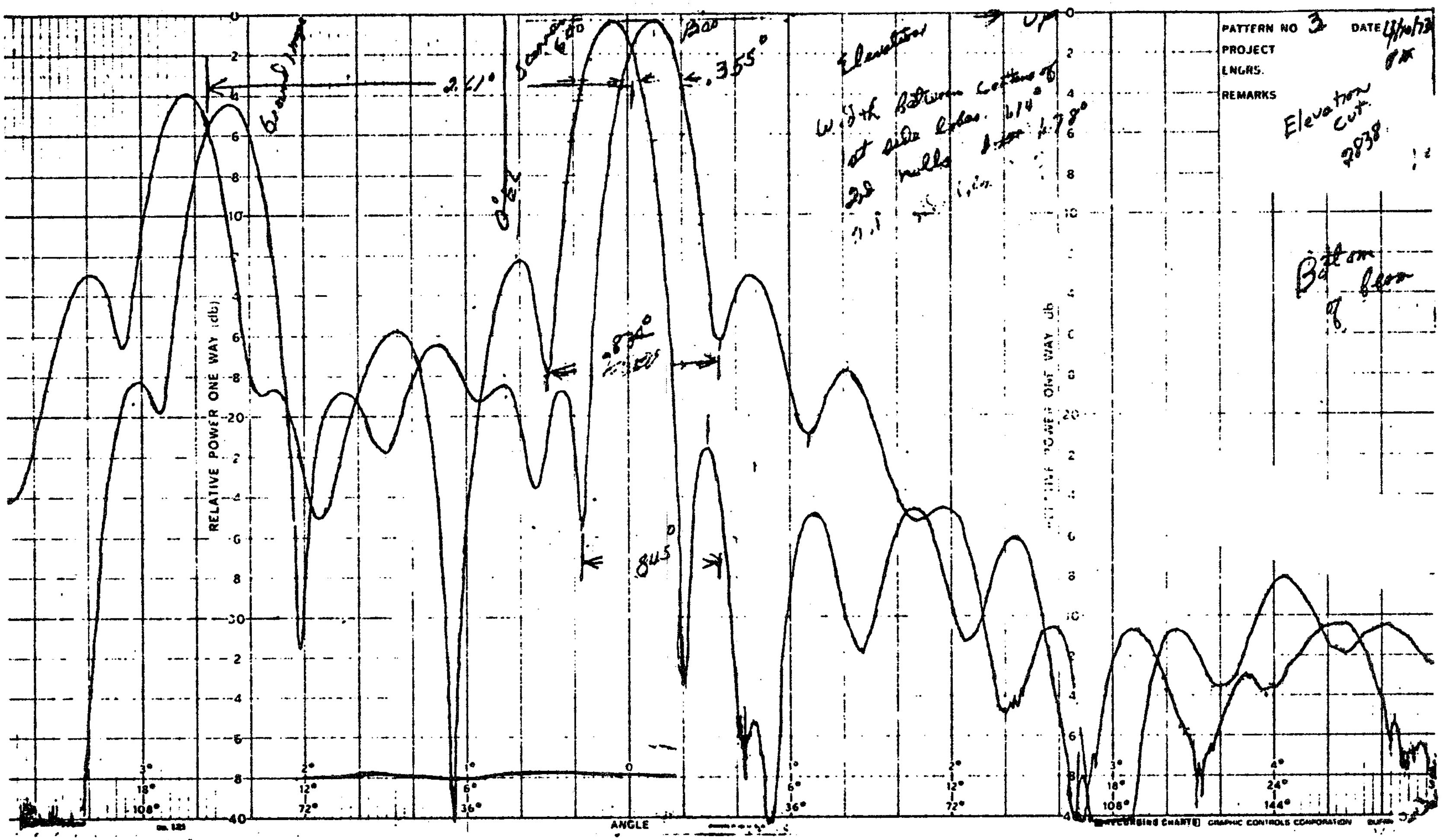

FIGURE C.3. VERTICAL ANTENNA PATTERN, 2838 MHz

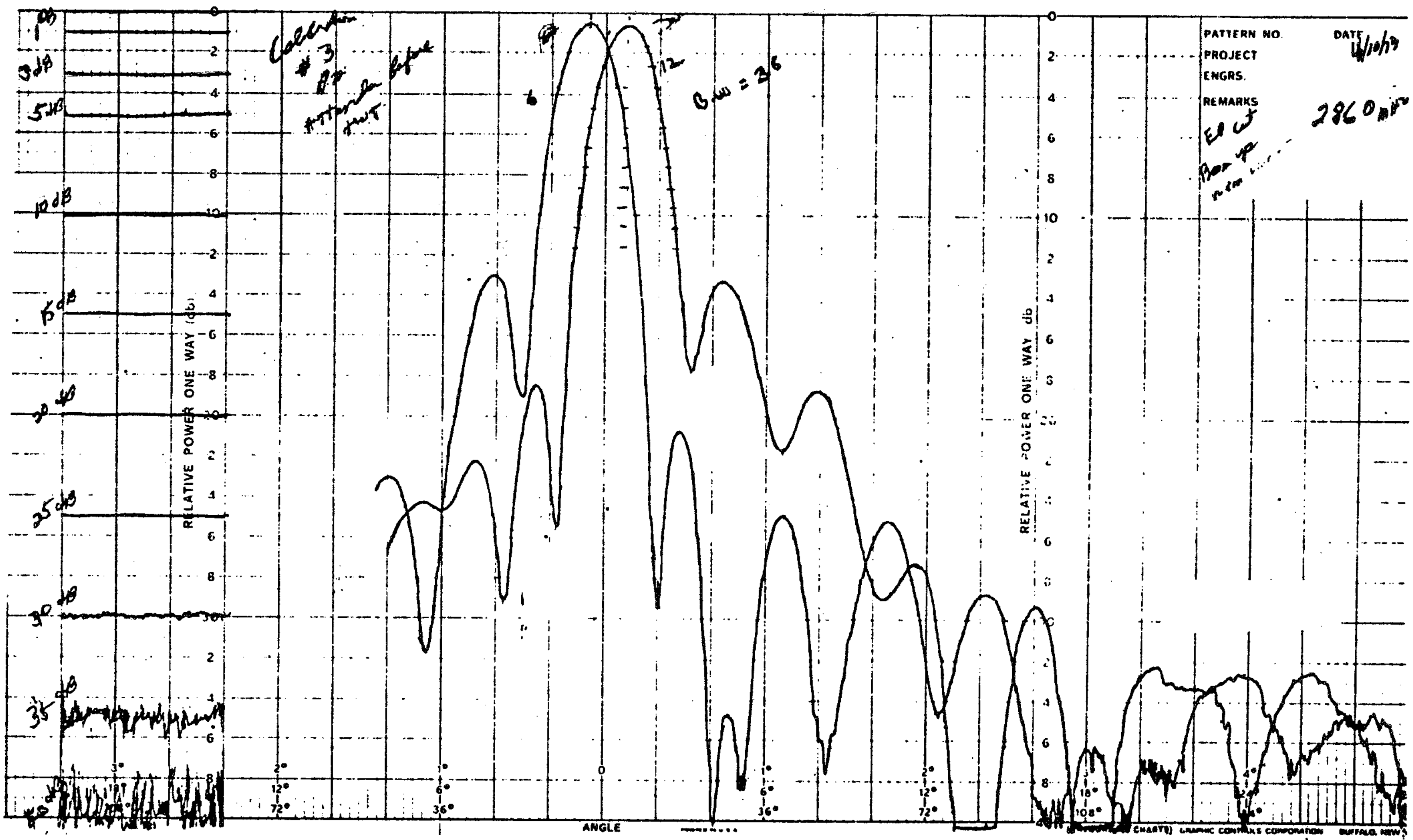

FIGURE C.4. VERTICAL ANTENNA PATTERN, 2860 MHz

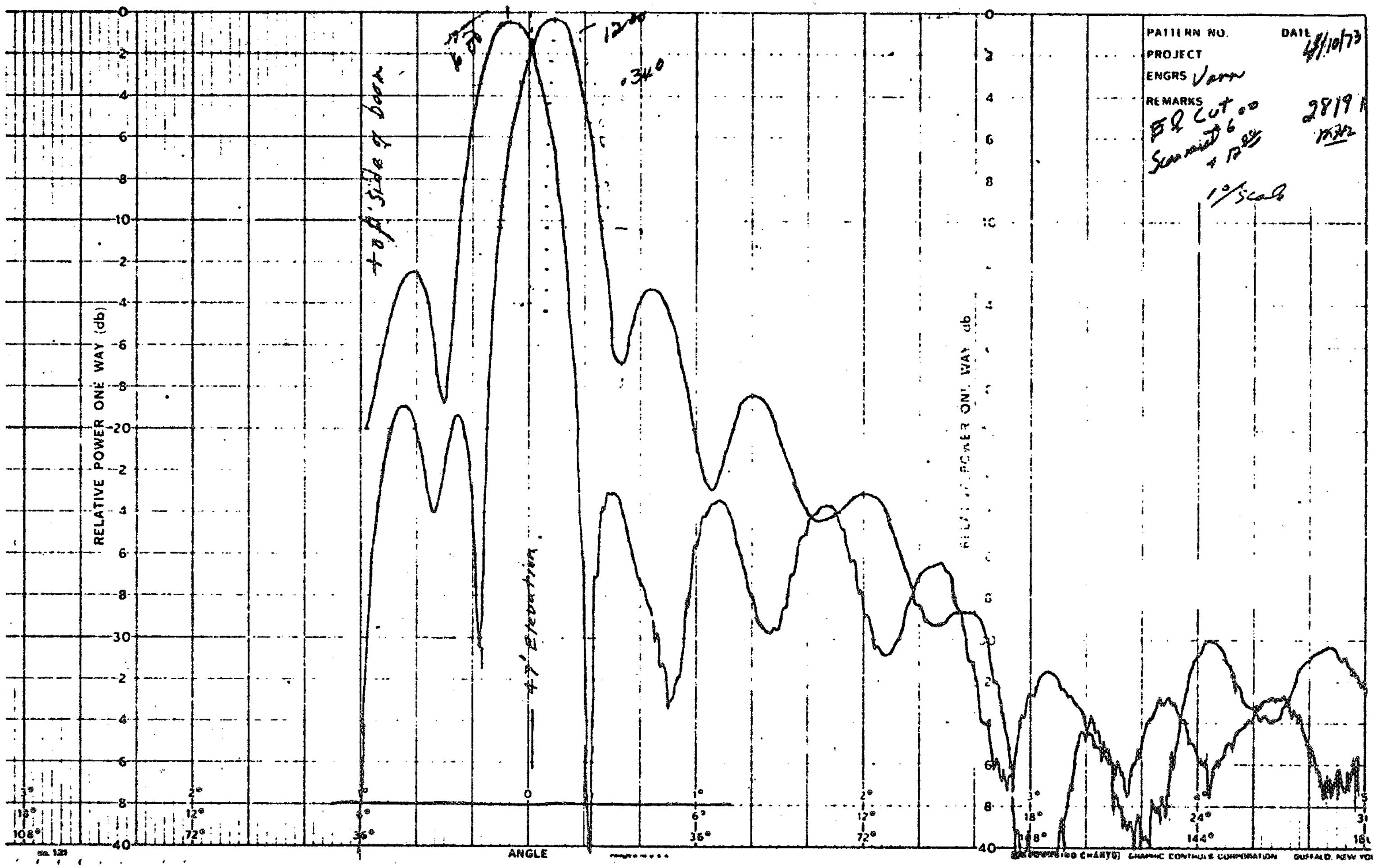

FIGURE C.5. VERTICAL ANTENNA PATTERN, 2819 MHz

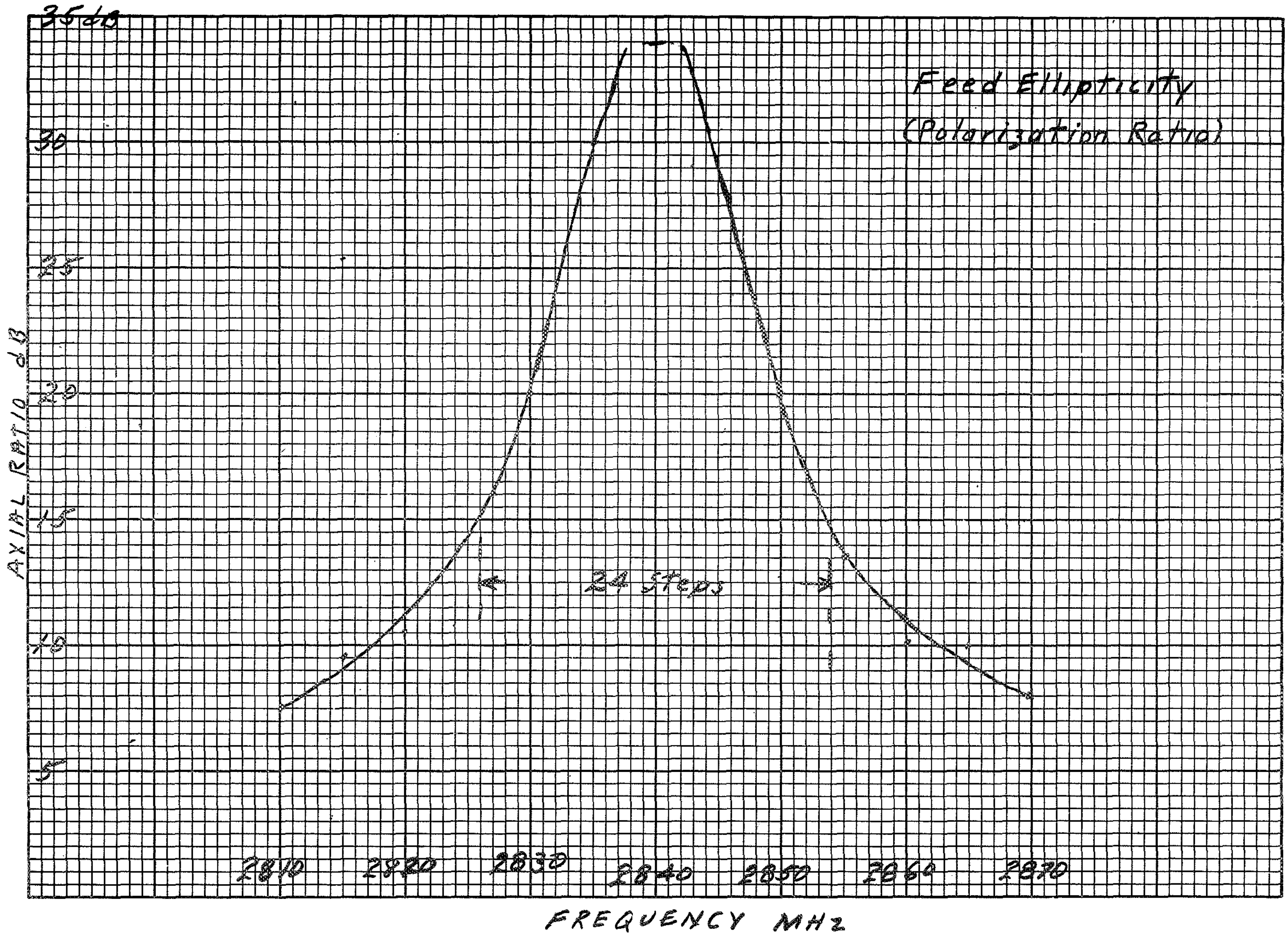

FIGURE C.6. ANTENNA FEED ELLIPTICITY OVER THE FREQUENCY DIVERSITY BAND

TABLE C.2

NORMAL MODE - 2 MHz/STEP - 32 STEPS CENTER FREQUENCY 2840 MHz - ALL PORTS

Freq No.	Freq MHz	Power Output - dBm							
		P_{LO} dBm	P_{LO} Test	P_T	P_T Test	Cal/out	Cal Ref	Cal to ATTEN	SSLO Test
1	2807.36	7.35	-2.35	6.40	-3.45	1.75	-3.45	6.50	0.25
2	09.35	7.35	-2.35	6.40	-3.45	1.75	-3.45	6.50	0.25
3	11.60	7.30	-2.40	6.40	-3.45	1.75	-3.45	6.50	0.30
4	13.95	7.25	-2.40	6.45	-3.45	1.80	-3.40	6.60	0.30
5	16.04	7.25	-2.45	6.50	-3.45	1.80	-3.40	6.60	0.35
6	18.45	7.20	-2.50	6.50	-3.45	1.80	-3.40	6.60	0.35
7	20.57	7.20	-2.50	6.50	-3.40	1.80	-3.40	6.60	0.35
8	22.72	7.15	-2.55	6.55	-3.40	1.85	-3.40	6.65	0.40
9	24.70	7.10	-2.60	6.60	-3.40	1.90	-3.30	6.65	0.40
10	26.90	7.05	-2.60	6.60	-3.35	2.00	-3.30	6.65	0.40
11	28.83	7.05	-2.70	6.65	-3.30	2.05	-3.25	6.70	0.45
12	31.08	6.90	-2.75	6.70	-3.25	2.10	-3.20	6.70	0.45
13	33.08	6.80	-2.85	6.75	-3.25	2.10	-3.20	6.70	0.45
14	35.19	6.70	-2.95	6.80	-3.20	2.10	-3.20	6.70	0.50
15	37.35	6.60	-3.05	6.80	-3.20	2.10	-3.20	6.70	0.50
16	39.63	6.50	-3.15	6.75	-3.25	2.05	-3.25	6.65	0.50
17	42.03	6.40	-3.30	6.70	-3.30	2.00	-3.30	6.55	0.55
18	44.65	6.30	-3.40	6.60	-3.40	1.95	-3.35	6.45	0.55
19	47.03	6.20	-3.50	6.60	-3.40	1.90	-3.40	6.40	0.60
20	49.51	6.10	-3.60	6.60	-3.40	1.95	-3.35	6.45	0.60
21	51.79	6.05	-3.65	6.60	-3.35	2.00	-3.30	6.50	0.60
22	54.13	6.05	-3.60	6.70	-3.30	2.05	-3.25	6.55	0.60
23	56.19	6.10	-3.60	6.70	-3.30	2.05	-3.25	6.55	0.60
24	58.50	6.20	-3.50	6.70	-3.30	2.05	-3.25	6.55	0.65
25	60.49	6.30	-3.40	6.65	-3.35	2.00	-3.30	6.50	0.65
26	62.79	6.35	-3.35	6.60	-3.40	2.00	-3.30	6.45	0.65
27	65.26	6.45	-3.25	6.55	-3.45	1.95	-3.40	6.40	0.65
28	67.76	6.55	-3.15	6.50	-3.50	1.85	-3.45	6.35	0.65
29	70.08	6.65	-3.00	6.45	-3.60	1.80	-3.50	6.30	0.65
30	72.49	6.75	-2.90	6.40	-3.60	1.80	-3.55	6.30	0.65
31	74.79	6.90	-2.80	6.35	-3.65	1.75	-3.60	6.25	0.65
32	77.12	7.00	-2.70	6.30	-3.70	1.75	-3.60	6.25	0.65

TABLE C.3

INTERLACE MODE - 1 MHz - 24 STEPS - CENTER FREQUENCY 2840 MHz

Freq No.	Freq MHz	Power Output - dBm - All Ports							
		P_{LO} dBm	P_{LO} Test	P_T	P_T Test	Cal/out	Cal Ref	Cal to ATTEN	SSLO Test
1	2828.03	8.20	-1.70	6.55	-3.20	+4.35	-0.75	8.95	0.50
2	43.01	7.50	-2.35	6.70	-3.10	+4.50	-0.65	8.90	0.60
3	30.23	8.10	-1.75	6.60	-3.20	+4.40	-0.70	8.95	0.50
4	45.46	7.40	-2.40	6.70	-3.10	+4.50	-0.65	8.85	0.60
5	32.37	8.00	-1.85	6.60	-3.15	+4.45	-0.70	8.95	0.50
6	47.85	7.40	-2.45	6.70	-3.15	+4.50	-0.60	8.85	0.65
7	34.53	7.90	-1.95	6.65	-3.20	+4.45	-0.70	8.95	0.55
8	50.19	7.40	-2.50	6.80	-3.10	+4.60	-0.60	8.90	0.70
9	36.75	7.80	-2.05	6.65	-3.15	+4.50	-0.70	8.95	0.60
10	52.39	7.40	-2.45	6.85	-3.00	+4.65	-0.50	8.95	0.70
11	39.29	7.65	-2.20	6.70	-3.15	+4.50	-0.65	8.90	0.60
12	54.60	7.40	-2.40	6.85	-3.00	+4.70	-0.50	8.95	0.70
13	41.75	7.55	-2.30	6.70	-3.15	+4.50	-0.65	8.90	0.60
14	29.17	8.10	-1.70	6.60	-3.25	+4.40	-0.75	8.95	0.50
15	44.19	7.45	-2.40	6.70	-3.15	+4.50	-0.65	8.85	0.60
16	31.35	8.00	-1.80	6.60	-3.20	+4.45	-0.70	8.95	0.50
17	46.63	7.40	-2.45	6.70	-3.15	+4.50	-0.65	8.85	0.65
18	33.45	7.95	-1.90	6.60	-3.20	+4.45	-0.70	8.95	0.55
19	48.99	7.40	-2.45	6.75	-3.10	+4.55	-0.60	8.85	0.65
20	35.62	7.85	-2.00	6.65	-3.15	+4.50	-0.70	8.95	0.60
21	51.23	7.40	-2.50	6.80	-3.10	+4.60	-0.55	8.90	0.70
22	38.02	7.70	-2.10	6.70	-3.15	+4.50	-0.65	8.90	0.60
23	53.47	7.40	-2.45	6.85	-3.00	+4.70	-0.50	8.95	0.70
24	40.57	7.60	-2.25	6.70	-3.15	+4.50	-0.65	8.90	0.60

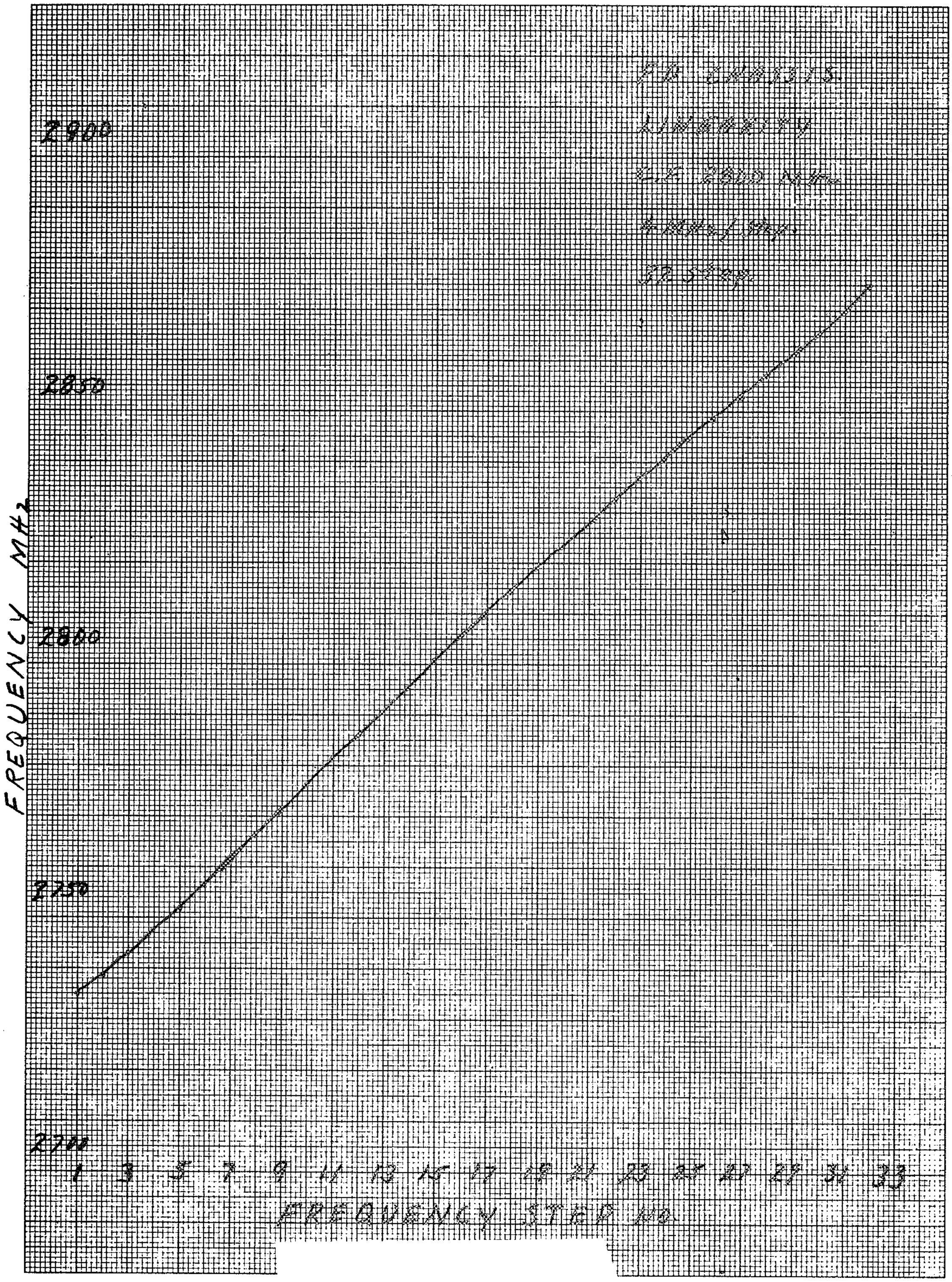

FIGURE C.7. FREQUENCY DIVERSITY
CHASSIS LINEARITY

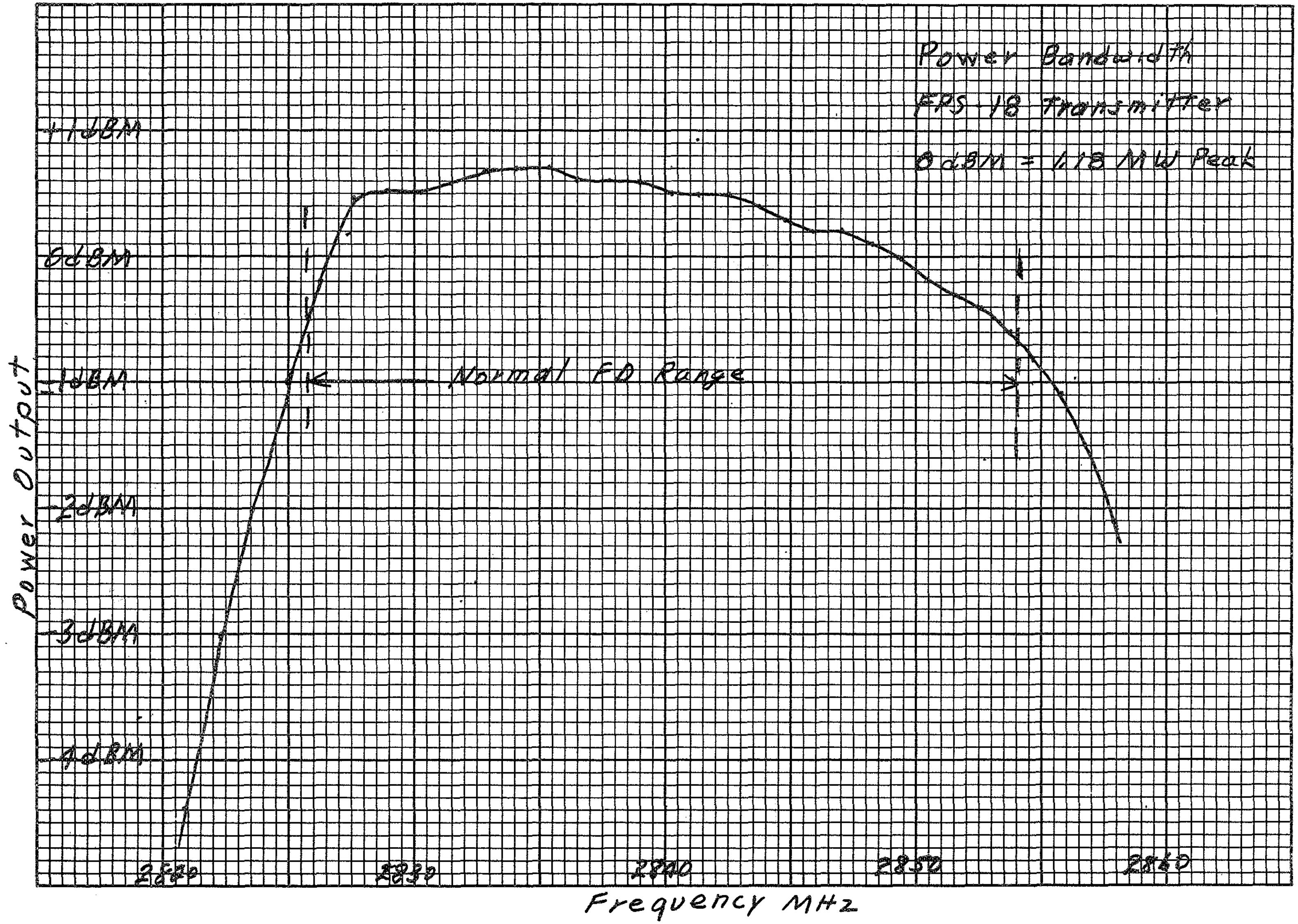

FIGURE C.8. POWER BANDWIDTH OF FPS-18 TRANSMITTER

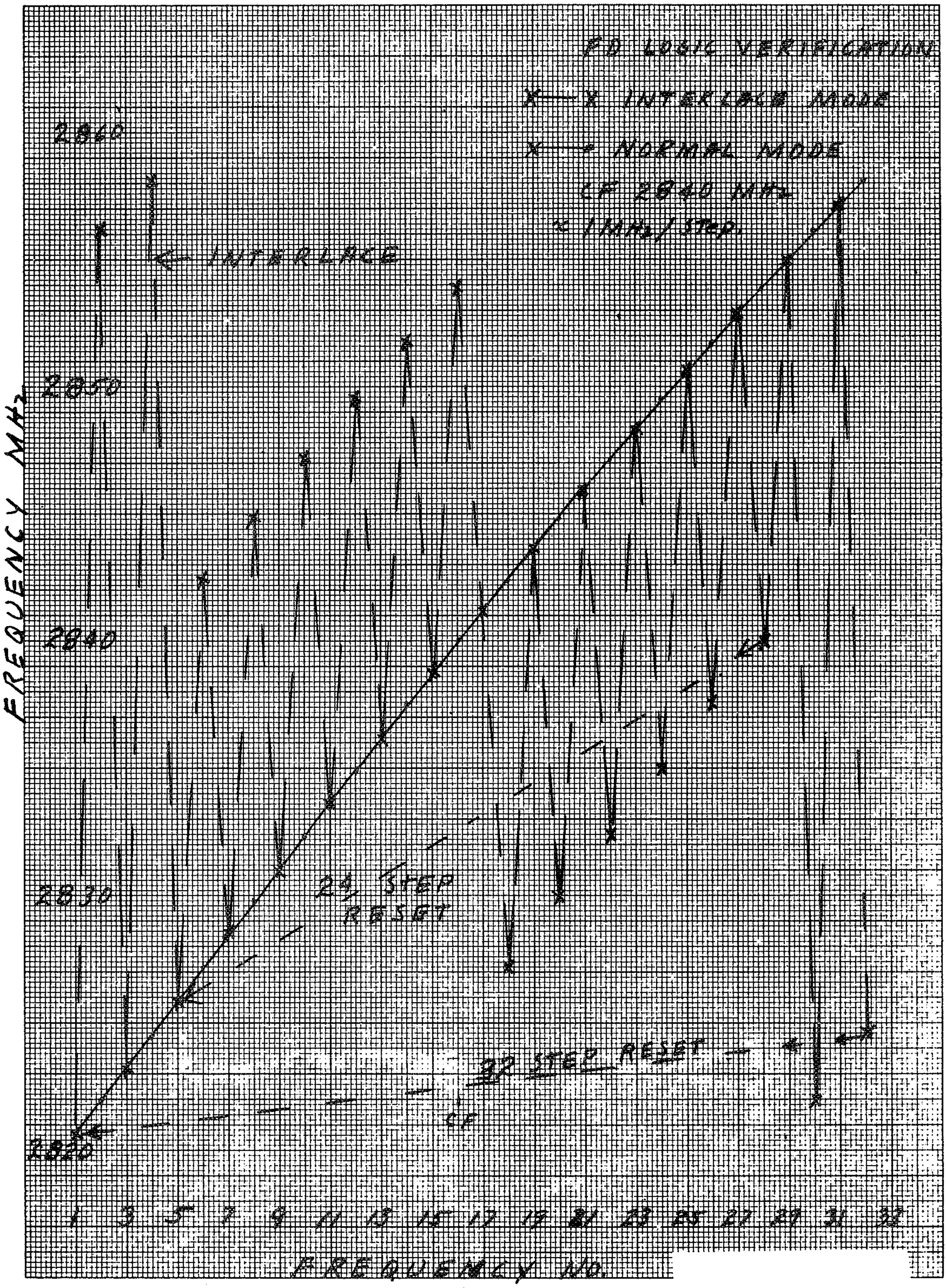

FIGURE C.9. FREQUENCY DIVERSITY STEPPING LOGIC

FIGURE C.10. FREQUENCY SETTLING TIME FOR FREQUENCY DIVERSITY CHASSIS

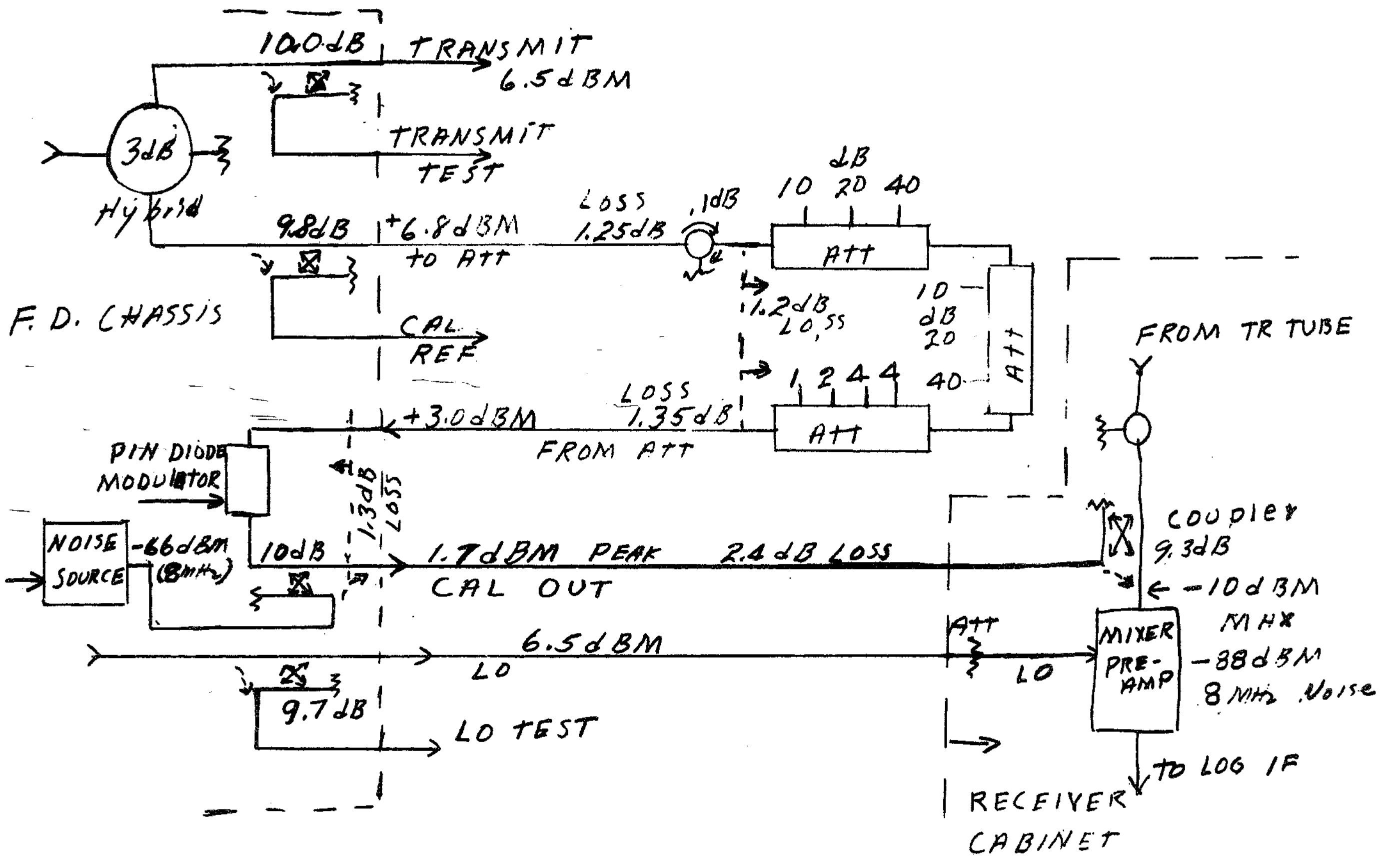

FIGURE C.11. RECEIVER CALIBRATION AND MONITORING

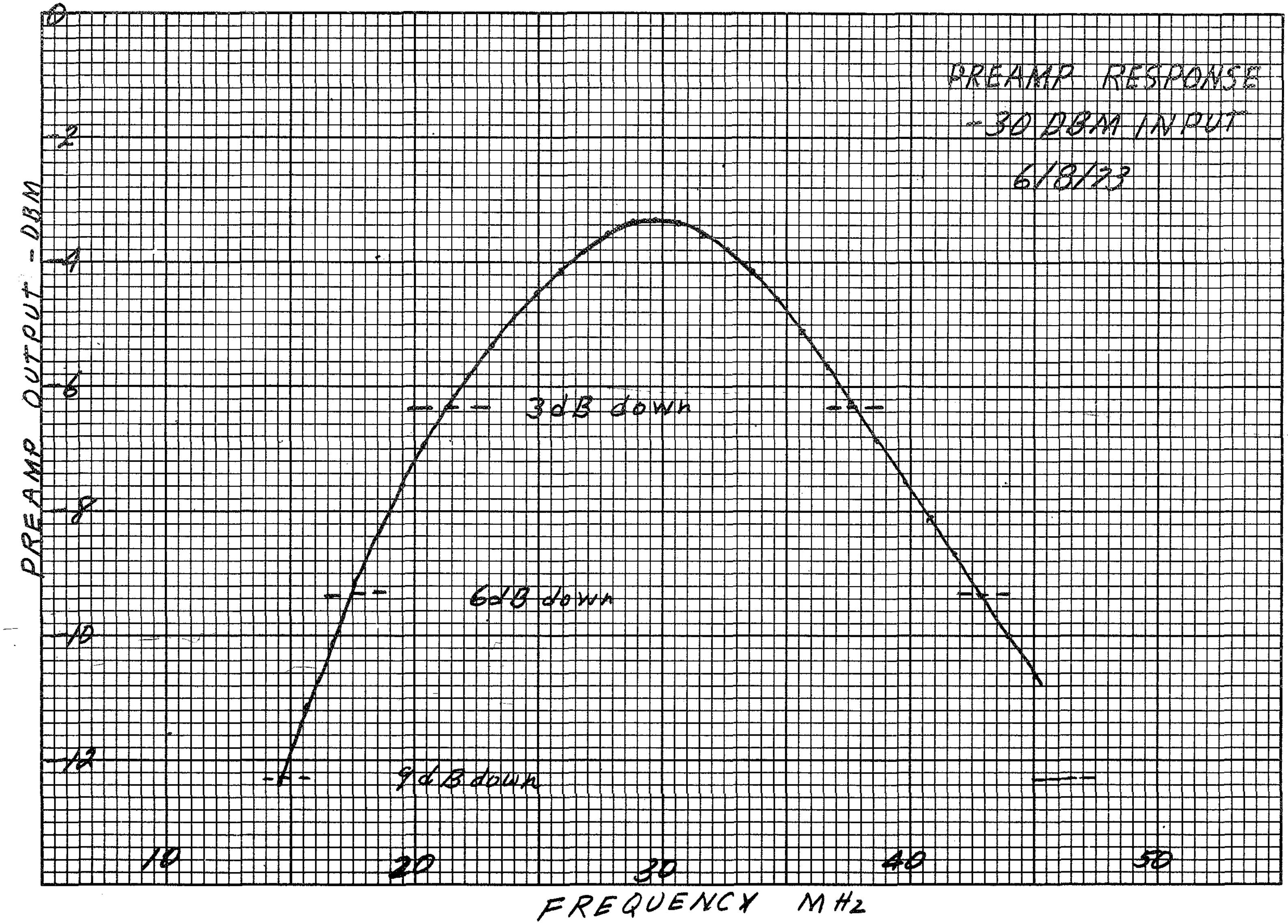

FIGURE C.12. PREAMPLIFIER FREQUENCY RESPONSE CHARACTERISTICS

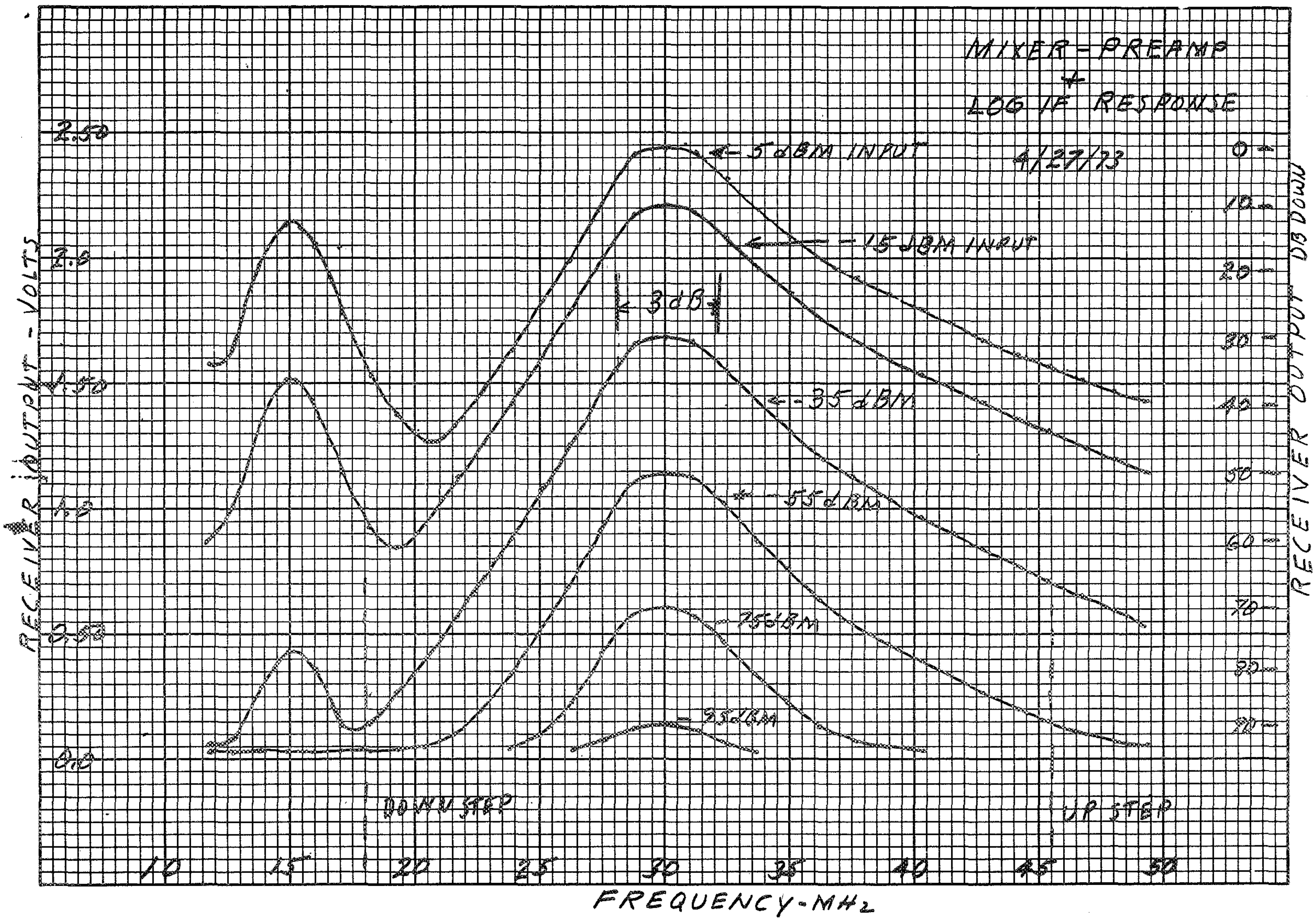

FIGURE C.13. MIXER, PREAMPLIFIER AND LOG IF
RESPONSE CHARACTERISTICS

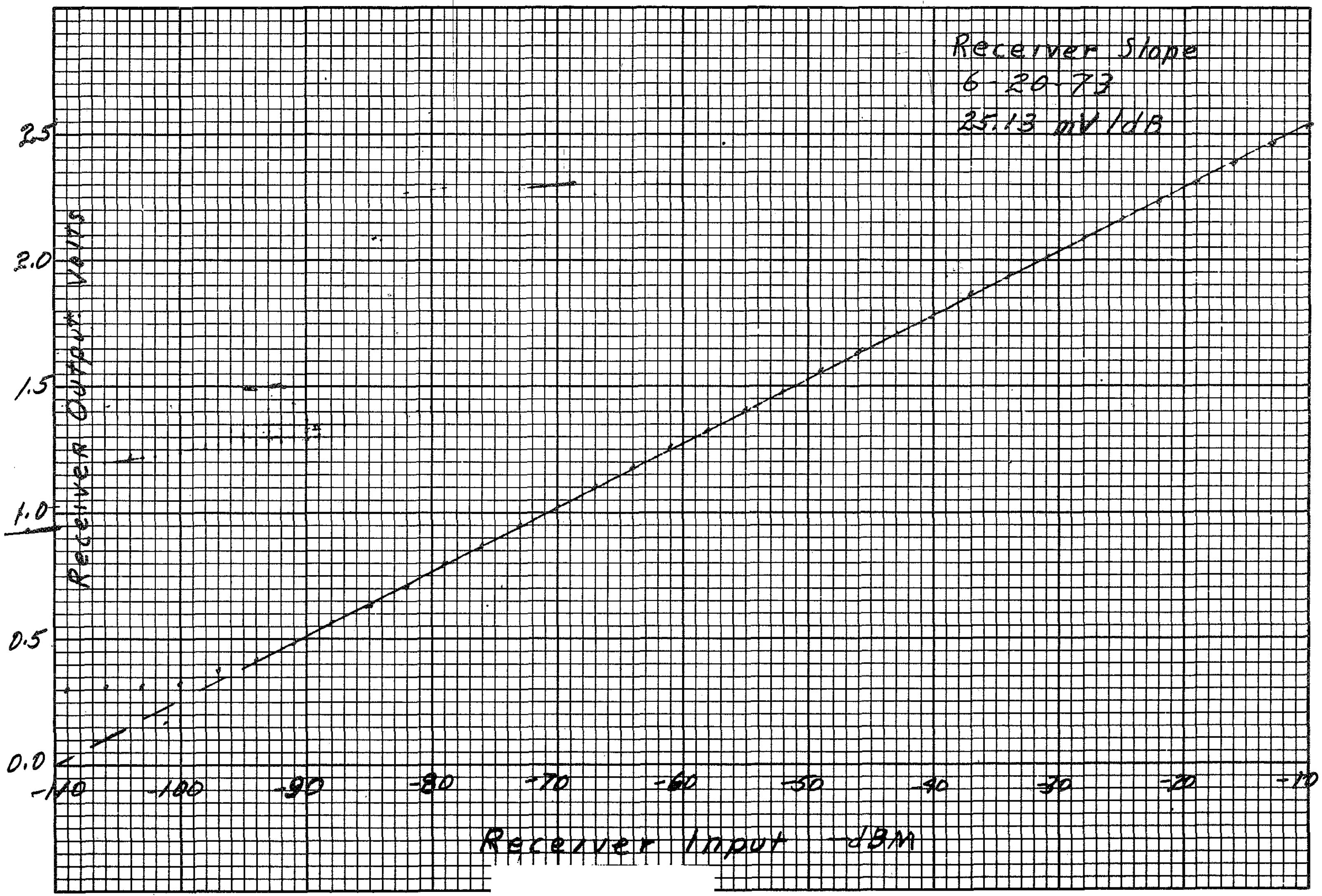

FIGURE C.14. RECEIVER CHARACTERISTIC

APPENDIX D

METEOROLOGICAL SUMMARIES FOR PERIODS OF SPANDAR RAIN OBSERVATION MAY THROUGH AUGUST 1973

by

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APPENDIX D

METEOROLOGICAL SUMMARIES FOR PERIODS OF SPANDAR RAIN OBSERVATION, MAY 1973 THROUGH AUGUST 1973*

Meteorological data reductions for May 1973 through August 1973 are presented for use in the analyses for the CLC program. The sources of information are: Assessment by the Wallops Island Staff Meteorologist, supplementary assessment by A. Arnold, facsimile weather charts, surface weather observations, transmitted by teletype Service A, taken at airports within the SPANDAR observing area and taken at Wallops Island, the rain gage installed at the Snow Hill VOR, the rain gage at Wallops Island, and the evaluation of data from the radiosonde released at approximately 2300Z (Z = Greenwich Meridian Time) at Wallops Island. Further reductions are possible; these can be undertaken as the analyses indicate the need.

A summary was kept of the precipitation and thunder information and is tabulated in Table D.1 for each of the 4 months. The sources of information are the reports from the airways observing stations. Information from the Weather Service radars, as the one at Patuxent River, Md., was not used for this summary. Hence, the times of the observed precipitation are limited. In some cases no observing station reported precipitation for a given hour; this was disregarded in the "Time" column if there was rain at the preceding and following hour - only a period of two or more hours of nonrain is shown in the summary. Further, no distinction was made on rain types and intensities; thus drizzle and sprinkles which may not be visible on radar are included in the summary. In general, there was a lack of data from the airways stations for weekends and holidays. These are shown as dashes. The summary also includes the periods when SPANDAR took digital data of rain echoes and a Remarks column. The dates refer to the day that the observing tour starts.

Reports for the separate times when SPANDAR observed rain are also shown. For each day there is given the rain type, a brief description of the meterological situation, rain reports and a graph of the radiosonde evaluation. Observations from nearby airport stations are included in the rain reports. These stations routinely report on the hour - the observation itself is made a few minutes before the hour. Additional

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* A. Arnold, Memo MPD 73U-053, 29 June 1973; MDP 73U-066, 11 September 1973; MPD 73U-070, 26 September 1973, and FIE 73U-006, 3 December 1973.

reports are given for events that occur between hourly observations. Table D.2 lists the symbols for use with these reports. Table D.3 gives the location of stations relative to SPANDAR. In the graph of the radiosonde values, the temperature is shown as a solid line, the dew-point temperature as a dashed line. Where the relative humidity is recorded as below 20 percent, an artificial dew-point temperature 30°C less than the measured temperature is shown; this portion of the dew-point temperature is shown dotted.

TABLE D.1

SUMMARY OF OBSERVED RAINS OR THUNDER

Date	Time (Z)	Spandar Time (Z)	Remarks*
MAY 1973			
7	None		
8	1130-1500 1700-0500		
9	0500-1300 1600-1730 2200-0030	 2200-0230	
10	None		
11	1800-1830		Local, at Wallops WSO
12	-		No data
13	-		No data
14	0000-0500	0100-0315	No data before 1900Z
15	0500-2000	2030-2100 0200-0330	
16	None		
17	2000-0500	2200-0200	
18	None		
19	-		No data
20	1200-2000 0100-0400		From Wallops WSO From Wallops WSO
21	None		No data before 2000Z
22	None		
23	1030-2200	2030-2330	No 1000Z report
24	0500-1200 1630-0500	 2030-0330	Large data gaps
25	0500-0500		Record gap 0600Z-1000Z and after 0400Z
26	0500-1400		From Wallops WSO

TABLE D.1 (Continued)

Date	Time (Z)	Spandar Time (Z)	Remarks*
MAY 1973 (cont.)			
27	1400-1600		From Wallops WSO
28	1000-1600		From Wallops WSO
29	1300-1730 1930-0330	 2030-0230	No data prior to 1000Z
30	probably.		Salisbury, at approximately 1700Z, reported aircraft observed heavy thunderstorm 25 miles northwest.
31	possibly		Patuxent Naval Station reported light shower ended 0514.
JUNE 1973			
1	None		No Service A after 2000Z
2	-		No Data
3	0030 - ?		Wallops Island Data
4	None	0055-0105	No Service A Before 1100Z
5	None		
6	0830-0910 1304-1309		Local at Salisbury Local at Wallops Island
7	1500-0100		
8	1800-1930		
9	-		No data
10	-		No data
11	None		No Service A before 1000Z
12	0023-0040 0340-0500		Norfolk Reported a Trace Newport News had a Trace

TABLE D.1 (Continued)

Date	Time, (Z)	Spandar Time (Z)	Remarks*
JUNE 1973 (cont.)			
13	0500-1500 1700-2230 0130-0230 0430-0500	2030-0140	
14	0500-0530		Thunder Report, Langley AFB ended at 0520
15	None		No Service A after 2000Z
16	0200-0500		VOR Rain gage
17	0500-0600		VOR and Wallops Island Rain gages
18	1000-0035	2030-0330	Same as 17th, No Service A Data
19	0800-1100 1630-0430	2055-2110	VOR Rain gage Service A and Wallops Island No Service A before 1900Z
20	None	0305-0340	
21	About 0600Z 1900-0130	2050-0335	Newport News Report
22	0500-0630 1300-0500	2030-0330	Patuxent NAS Report
23	0500-1200?		No Service A Data after 1200Z
24	-		No Data
25	None		
26	0800?-1240		
27	1100?-0100	2110-2355	No Service A Data 0700Z to 1100Z
28	1945-2030	2040-2115	Thunder Report, Patuxent NAS
29	0500-2230	2055-0340	
30	None		No Service A Data After 1300Z

TABLE D.1 (Continued)

Date	Time, (Z)	Spandar Time (Z)	Remarks*
JULY 1973			
1	-		No Data
2	0600-1745		No Service A before 1015Z
3	1045-1145 1456-1908 0100-0500	 2135-0335	 No Service A after 0400Z
4	0500-0800 0457-0500		Form 10B and VOR Gage VOR Gage
5	0500-0503 0015-0115	 0105-0210	VOR Gage No Service A before 1000Z
6	None		No Service A after 1730Z
7	-		No Data
8	-		No Data
9	None		No Service A before 1100Z
10	<2000-2200 0215-0500	 2115-0355	Service A 1900Z Data Not Received
11	0500-1730 2045-0500	 2250-0240	
12	0500-0730		
13	None		
14	-		No Data
15	1520-2030 2345-0347		Form 10B and VOR Gage Form 10B and VOR Gage
16	0600-0800 1000-1430		Form 10B and VOR Gage No Service A before 1000
17	1115-1945		
18	None	2120-2245	

TABLE D.1 (Continued)

Date	Time, (Z)	Spandar Time (Z)	Remarks*
JULY 1973 (cont.)			
19	None		
20	0200-0230	0000-0145	No Service A after 0400
21	0232-0500		Form 10B and VOR Gage
22	0500-0800		Form 10B
23	About 0530 1930?-2015		VOR Gage No Service A before 1000Z Some 2000Z Data not Received
24	None		
25	None		
26	None		
27	2115-2200	2040-0025	
28	About 1200 1732-1825 About 2300		VOR Gage VOR Gage VOR Gage
29	-		No Data
30	None		No Service A Data before 1000Z
31	0200-0430	0020-0350	
AUGUST 1973			
1	1700-0430	2110-0345	
2	0600-0800 1330-0500	 2100-0340	
3	0500-1100 1600-0300	 2055-0340	
4	0600-1200		Form 10B and VOR gage
5			No data
6	No rain		

TABLE D.1 (Continued)

Date	Time, (Z)	Spandar Time (Z)	Remarks*
AUGUST 1973 (cont.)			
7	No rain		
8	No rain		
9	No rain		
10	No rain		
11	2130-2330		Form 10B
12			No data
13	2230-2330 0200-0500	2115-0350	
14	0500-0900 1830-0500	 2120-0335	
15	0500-1100 1330-1430 0200-0400	 2315-0335	
16	about 1800	2055-0315	
17	about 0000	2150-2155	
18	1000-2200		Form 10B and VOR gage
19	1900-2230		Form 10B and VOR gage
20	1530-2100 2300-0030 0230-0500	 2035-0335	
21	0500-0500	2110-0330	
22	0500-1930 2330-0330		
23	No rain		
24	No rain		
25			No Data
26			No Data
27	No rain		
28	No rain		

TABLE D.1 (Continued)

Date	Time, (Z)	Spandar Time (Z)	Remarks*
AUGUST 1973 (cont.)			
29	No rain		
30	No rain		
31	No rain		

* No Data = No Service A Data Received and No Rain at Either VOR or Wallops Island

Form 10B (or Wallops Island Gage) = No Service A Data Received. Information from Form 10B

VOR Gage = No Service A Data Received. Information From Gage at VOR

TABLE D.2

DECODING REPORTS FROM NEARBY STATIONS

STATIONS:	
SBY	Salisbury - Wicomico County Airport, Salisbury, Md.
NHK	Patuxent Naval Air Station, Patuxent River, Md.
PHF	Patrick Henry Airport, Newport News, Va.
LFI	Langley Air Force Base, Hampton, Va.
NGU	Chambers Field (Naval Air Station), Norfolk, Va.
ORF	Norfolk Regional Airport, Norfolk, Va.
WAL	Wallops Station NASA Airport, Chincoteague, Va.
SYMBOLS:	
N	No precipitation. Shown mostly on the hour.
-	No report. Shown only on the hour.
T	Thunder
R	Rain
RW	Rain Shower
L	Drizzle
A	Hail
PRECIPITATION INTENSITY	
- -	Very Light
-	Light
	Moderate
+	Heavy

At any particular station, the precipitation or nonprecipitation is generally regarded as continuing between reports. This is not always true, however, because of missing reports or nonreporting of a change in condition.

TABLE D.3

LOCATIONS OF STATIONS RELATIVE TO SPANDAR

Station	Location	Range (nmi)	Azimuth (deg.)
NHK	Patuxent, Maryland	50	302
SBY	Salisbury, Maryland	28	360
PHF	Newport News, Virginia	64	228
LFI	Hampton, Virginia	62	221
NGU	Norfolk, Virginia	66	214
ORF	Norfolk, Virginia	67	210
WAL	Wallops Island Station, Virginia	1.7	112

The ranges and azimuths were scaled from a map of the area. Since the precise locations of the weather observation points are not known, the values are approximate. It is estimated that the range may be in error by one mile and the azimuths by one or two degrees.

METEOROLOGICAL SITUATION REPORT, MAY 9, 1973

PERIOD: 2200Z May 9 to 0230Z May 10

1. RAIN TYPE:

Frontal Thundershower. (Source: A. Arnold using Facsimile Surface Weather Map for 0000Z; Teletype Service A.)

2. GENERAL DESCRIPTION:

There was a period of thundershowers south of SPANDAR from about 2230Z onward. The 0000Z weather map showed a (weak) cold front passing New York, New Jersey, Delaware and Maryland coastline to Norfolk and cutting into eastern North Carolina. (Source: Same as above.)

3. RAIN REPORTS:

a. Rain gage at VOR: No rain (Source: Chart record)

b. Wallops Island Gage: No rain (Source: Form 10B)

c. Nearby Observing Stations: Appended. (Source: Service A)

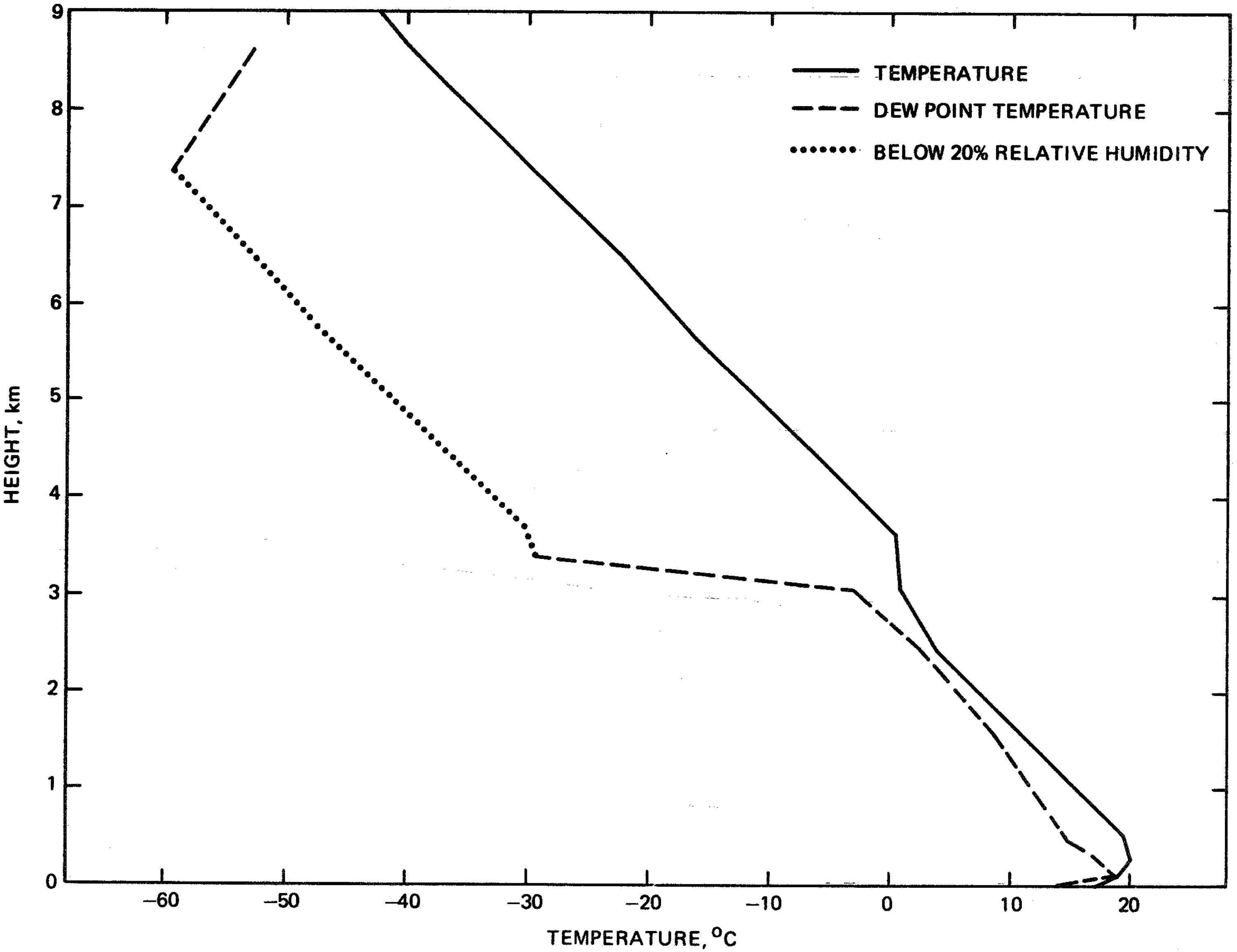
4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
MAY 9, 2200Z TO 0400Z, MAY 10, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2200	N	N	N	N	N	N	–
2223				TRW–			
2300	N	N	N	TRW–	N	N	–
2302				T			
2308					T		
2318						T	
2330					ENDED		
2336				ENDED			
2343					T		
0000	N	N	N	N	T	N	–
0001						RAIN BEGAN	
0010						ENDED	
0100	N	N	N	N*	N	N	–
0200	N	N	N	N	N	N	–

*THERE WAS DISTANT LIGHTNING TO THE SOUTH EAST



WALLOPS RADIOSONDE DATA FOR
MAY 9, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, MAY 14, 1973

PERIOD: 0100Z-0315Z May 15

1. RAIN TYPE:

a. Widely scattered small and light convective showers. (Source: Wallops Island Staff Meteorologist)

b. Convergence Rain - intermittent and scattered. (Source: A. Arnold from 0000Z and 0300Z facsimile weather maps; Teletype Service A.)

NOTE: The principal difference, above, is that a. says the rain is convective, while the b. says it is not convective.

2. GENERAL DESCRIPTION:

A stationary front extended from just off the Carolina Capes. (Source: as a. above.) To this A. Arnold adds: There is a wave on this front producing a wide, scattered rain area to the north extending to Southern Virginia. The surface air flow is easterly. The 0300 map shows a closed Low on the wave.

3. RAIN REPORTS:

a. Rain gage at VOR: No rain (Source: Chart Record)

b. Rain gage at Wallops Island (Source: Form 10B)

Time (hr ending) Z	Amount Precipitation (mm)
0200	Trace
0300	Trace
0400	Trace

c. Nearby Observing stations. Appended (Source: Service A)

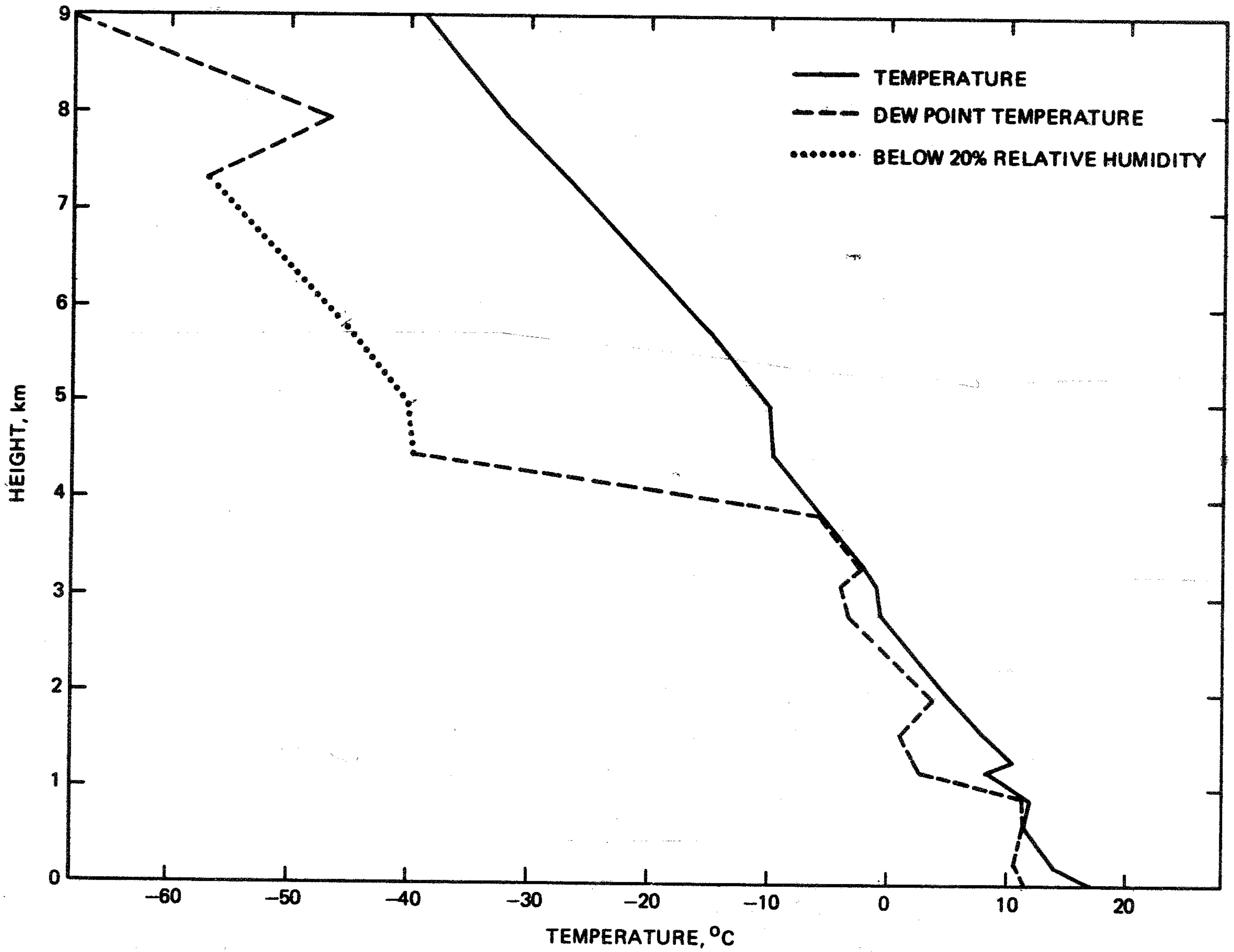
4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation.)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
0100Z TO 0400Z, MAY 15, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
0100	N	N	N*	N	N	N	–
0105				RW–			
0140					RAIN BEGAN		
0200	N	N	RW–	R–	R	N	–
0236				INTMT R–			
0300	N	–	–	–	–	–	–
0400	N	N	N	N	N	N	–

*SHOWERS TO NORTH



WALLOPS RADIOSONDE DATA FOR
MAY 14, 1973 RELEASED AT 2230Z

METEOROLOGICAL SITUATION REPORT, MAY 15, 1973

PERIOD: 2030Z-2100Z May 15 and 0200Z-0330Z of the 16th

1. RAIN TYPE:

a. Period 2030Z-2100Z - Convergence rain (intermittent)

b. Period 0200Z-0330Z - (slight) Instability Showers (Source: A. Arnold, using surface weather maps for 2100Z, 0000Z, and 0300Z: Teletype Service A airways report.)

2. GENERAL DESCRIPTION:

There was a Low center near Nantucket, Mass., with a front off-shore cutting inland in Florida. During the period of observations an occlusion formed. At 2100Z, the map shows a wave on the front about 100 miles off the VA. - N.C. coast. By 0000 and 0300Z the front was considerably off the coast. During the early observation, the precipitation was regarded as due to convergence at low levels. For the later observation, with the front well to the east, the precipitation was regarded as showery due to slight instability. (Source: Same as above.)

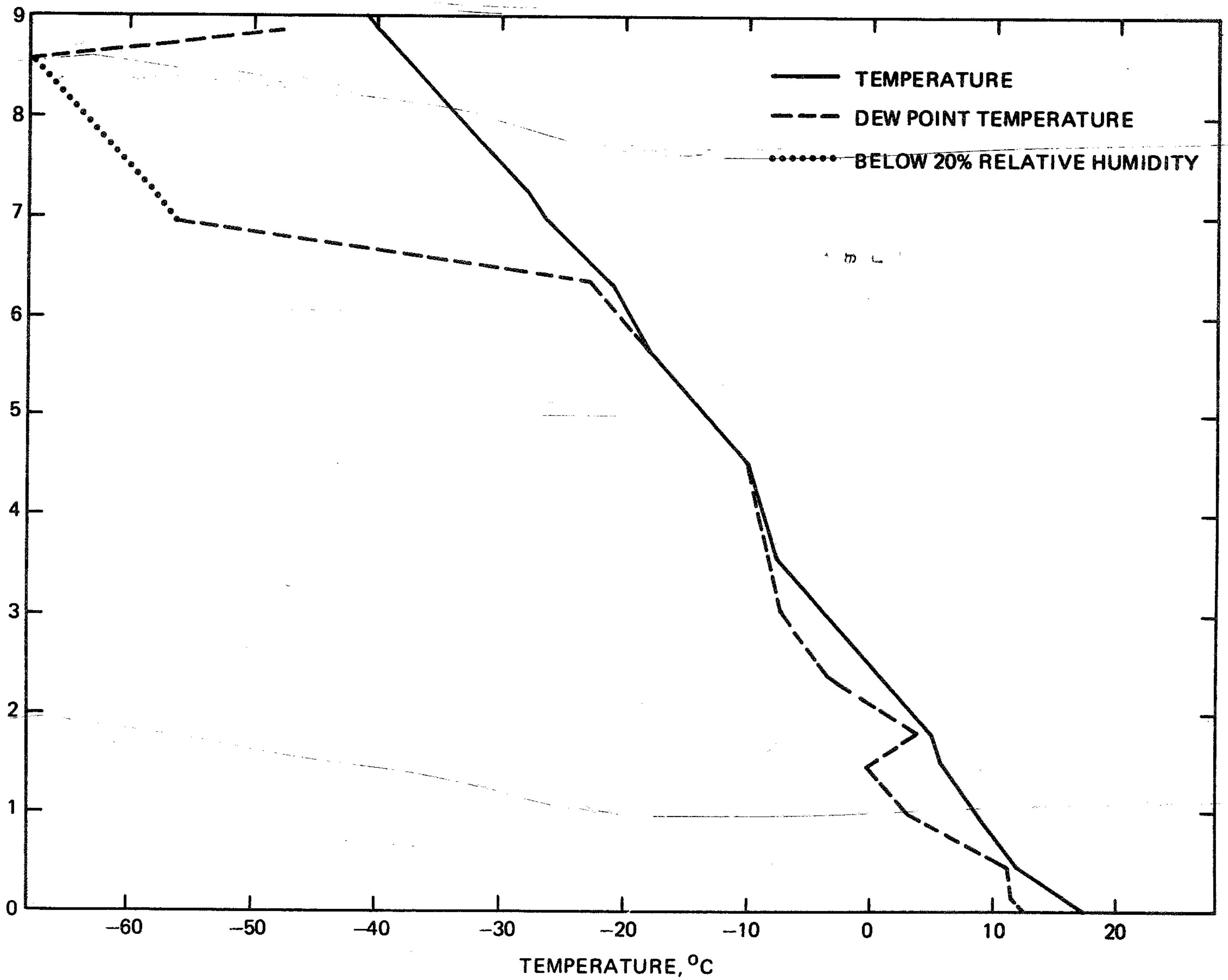
3. RAIN REPORTS:

There was no rain measured by gage at VOR, nor at Wallops Island.

None of the airways stations reported rain.

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation.)



WALLOPS RADIOSONDE DATA FOR MAY 15, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, MAY 17, 1973

PERIOD: 2200Z May 17 to 0200Z of the 18th

1. RAIN TYPE:

Frontal thundershowers (Source: Wallops Island Staff Meteorologist)

2. GENERAL DESCRIPTION:

Shower and thundershower activity accompanied a cold front. The front which nearly paralleled the coast was in the area of observation at the beginning of the period and passed through during observation period. The showers were mostly with the frontal passage and after passage. The wind shift accompanying frontal passage was marked. There were showers throughout the area of observation. (Source: Same as above with additions from airways observing stations.)

3. RAIN REPORTS:

a. Rain gage at VOR (Source: Chart Record)

Time (hr ending) Z	Amount Precipitation (mm)
2300	2.2
2400	None
0100	None
0200	0.2

b. Rain gage at Wallops Island (Source: Form 10B)

Time (hr ending) Z	Amount Precipitation (in.)
2300	0.17
2400	None
0100	None
0200	None

c. Five minute rain totals

(1) Wallops Station (Source: Wallops Island Weather Service Office)

Ending Time (Z)	Amount Precipitation (in.)
2205	.008
2210	.007
2215	.005
2220	.008
2225	.007
2230	.006
2235	.032
2240	.038
2245	.024
2250	.006
2255	.005
2300	.005

(2) Rain gage at VOR (Source: Chart Record, absolute time is approximate)

Ending Time (Z)	Amount Precipitation (mm)
2205	-
2210	0.2
2215	-
2220	-

Ending Time (z)	Amount Precipitation (mm)
2225	-
2230	0.2
2235	0.6
2240	0.2
2245	0.2
2250	0.2
2255	0.4
2300	0.2

d. Nearby airways stations. Appended. (Source: Service A.)

4. RADIOSONDE GRAPH:

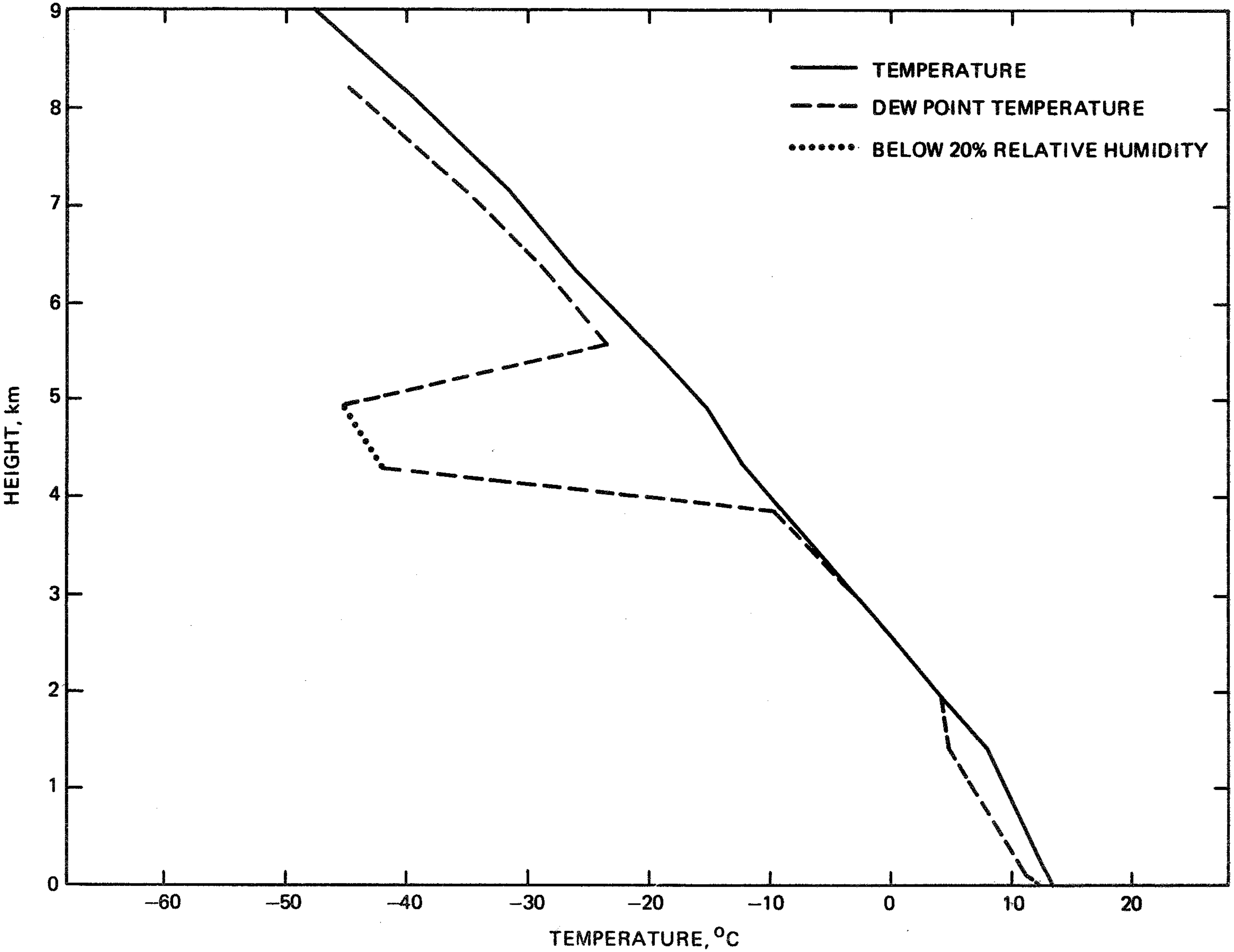
Appended. (Source: Wallops Island Sonde Evaluation.)

5. REMARKS:

Peak rainfall rate at VOR at about 2252Z was approximately 8.6mm/hr.

OBSERVATIONS FROM LOCAL WEATHER STATIONS
MAY 17, 2200Z TO 0200Z, MAY 18. 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2200	N	RW––	N	N	RW–	RW–	
2226	TR–						
2244	R–						
2300	R–	RW––	RW––	RW–	RW––	RW––	
2326				ENDED			
0000	N	RW–	N	N	RW––	RW––	
0025					RAIN BEGAN		
0030	RAIN BEGAN		RAIN BEGAN				
0044					THUNDER BEGAN		
0100	R––	N	RW–	RW–	TRW–	TRW–	
0110	ENDED						
0120						RW–	
0125					ENDED		
0129			ENDED				
0135						ENDED	
0147				ENDED			
0200	N	N	N	N	N	N	



WALLOPS RADIOSONDE DATA FOR MAY 17, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, MAY 23, 1973

PERIOD: 2030Z - 2330Z

1. RAIN TYPE:

Squall line Thundershowers. (Source: Wallops Island Staff Meteorologist.) Also, see Description.

2. GENERAL DESCRIPTION:

a. Weak complex trough of low pressure extended from the Great Lakes to the Mid-Atlantic coast. Apparent squall line developed over Virginia and intensified as it moved eastward over the Chesapeake Bay and Eastern Shore. (Source: Wallops Island Staff Meteorologist.)

b. There was a complex frontal system that passed through the area, with a Low within our observation area. On this basis, it may be called "frontal thundershowers." The only squall line shown on weather maps was in southwest Va. on the 12Z map, but not on subsequent maps; however, the squall line might have been there. Rain showers and thunder during this period were reported in the Norfolk area; it is expected that there was activity over the ocean. (Source: A. Arnold.)

3. RAIN REPORTS:

a. Rain gage at VOR: Malfunction

b. Rain gage at Wallops Island (Source: Form 10B.) None

c. Nearby airways stations: Appended. (Source: Service A.)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation.)

5. REMARKS:

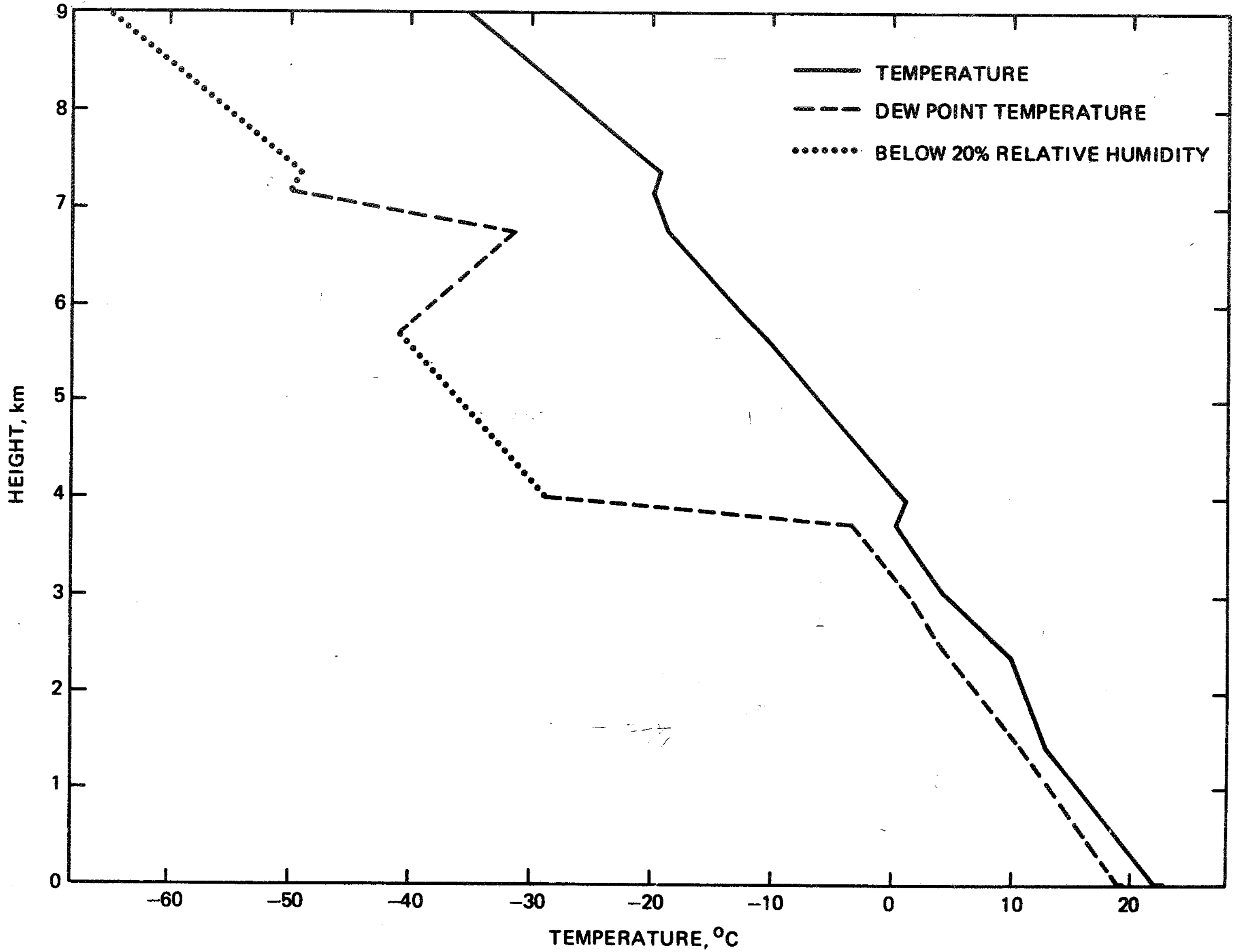
There is the possibility that there was hail. A report from PHF, Newport News, Va. at 2300Z states: Thunderstorm hail indicated, at 30 miles northwest of PHF. This is believed to be an aircraft report. It is not clear that this location is within the SPANDAR observation area.

OBSERVATIONS FROM LOCAL WEATHER STATIONS
2000Z TO 2200Z, MAY 23, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2000	N	N	N	N	N	N	
2020			RAIN BEGAN				
2035				TRW–			
2047			ENDED				
2100	N*	N	N	TRW–	N	N	
2103					THUNDER BEGAN		
2104				THUNDER ENDED			
2111				N			
2120					RAIN BEGAN		
2126					TRW+		
2134						RAIN BEGAN	
2137				RW–		THUNDER BEGAN	
2143					TRW––		
2145					ENDED	THUNDER ENDED	
2146						RAIN ENDED	
2200	N	N	N	N	N	N	

NO RAIN REPORTED AFTER THIS HOUR

*THERE WAS A RAIN SHOWER OBSERVED TO THE EAST



WALLOPS RADIOSONDE DATA FOR
MAY 23, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, MAY 24, 1973

PERIOD: 2030Z May 24 to 0330Z May 25

1. RAIN TYPE:

a. Warm front rain (coupled with onshore flow). (Source: Wallops Island Staff Meteorologist)

b. (1) For all but southern part, see 1a. above.

(2) Southern part. Showers and thundershowers associated with stationary front. (Source: A. Arnold using surface weather maps.)

2. DESCRIPTION:

A Low was located near the western Va. - N.C. border with a stationary (may be termed "warm") front extending eastward near the border. In the vicinity of the front the additional lifting produced showers and thundershowers, while farther north there was rain. (Source: A. Arnold using weather maps.)

3. RAIN REPORTS:

a. Rain gage at VOR: Malfunction

b. Wallops Island gage: (Source: Form 10B)

Time (hr ending) Z	Amount Precipitation (in.)
2100	.01
2200	.02
2300	.01
0000	Trace
0100	Trace
0200	Trace
0300	Trace
0400	.18

METEOROLOGICAL SITUATION REPORT, MAY 24, 1973 (continued)

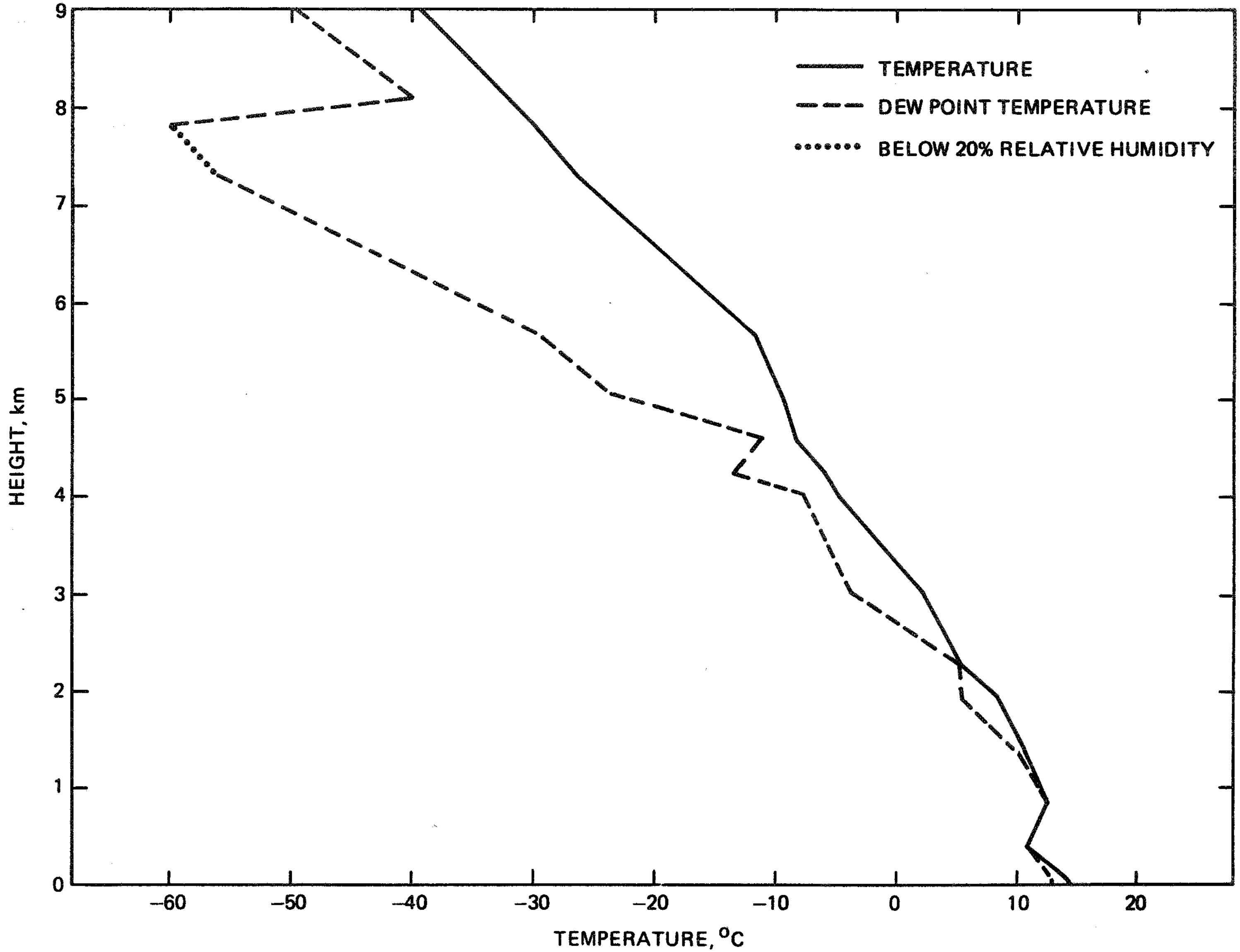
c. Nearby airways stations. Appended. (Source: Service A.)

4. RADIOSONDE GRAPH:

Appended (Source: Wallops Island sonde evaluation.)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
MAY 24, 2000Z TO 0400Z, MAY 25, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2000	R––	R–	RW––	N	N	N	–
2010			ENDED				
2025	R–						
2100	R––	R––	N	N	N	N	RW–
2135	ENDED						
2140		ENDED					
2200	N	N	N	N	N	N	–
2300	N	N	N	N	R–	N	–
0000	N	N	N	N	–	N	–
0031			RAIN BEGAN				
0041				RW–			
0042			THUNDER BEGAN				
0100	N	N	TRW–	RW–	–	N	–
0102						RAIN BEGAN	
0119				TRW			
0132						THUNDER BEGAN	
0141				TRW–			
0200	N	N	TRW–	TRW–	–	TRW+	–
0206						TRW–	
0210						RW–	
0213				T			
0225			RW–				
0227				ENDED			
0250					RAIN BEGAN		
0300	N	R–	RW–	RW–	RW–	TRW	–
0400	N	R–	R–	R–	RW–	TRW–	–



WALLOPS RADIOSONDE DATA FOR
MAY 24, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, MAY 29, 1973

PERIOD: 2030Z May 29 to 0230Z May 30

1. RAIN TYPE:

a. Convective thundershowers of moderate to heavy intensity. (Source: Wallops Island Staff Meteorologist.)

b. For the very early part of the period and for the Norfolk area: Squall line thunderstorms. For the remainder: Pre-frontal thunderstorms. (Source: A. Arnold using the 2100 and 0000 surface weather map.)

2. GENERAL DESCRIPTION:

a. An ill-defined cold front stretched from northern Delaware southwestward across the Chesapeake Bay and Tidewater Virginia and on to southern Georgia at 1700Z and moved slowly east/southeastward during the evening. (Source: Wallops Island Staff Meteorologist.)

b. To the preceding description, A. Arnold adds: The 2100Z map shows a squall line in the Norfolk area.

3. RAIN REPORTS:

a. Rain gage at VOR: No rain (Source: Chart Record)

b. Rain gage at Wallops Island: No rain (Source: Form 10B)

c. Nearby airways stations: Appended (Source: Service A)

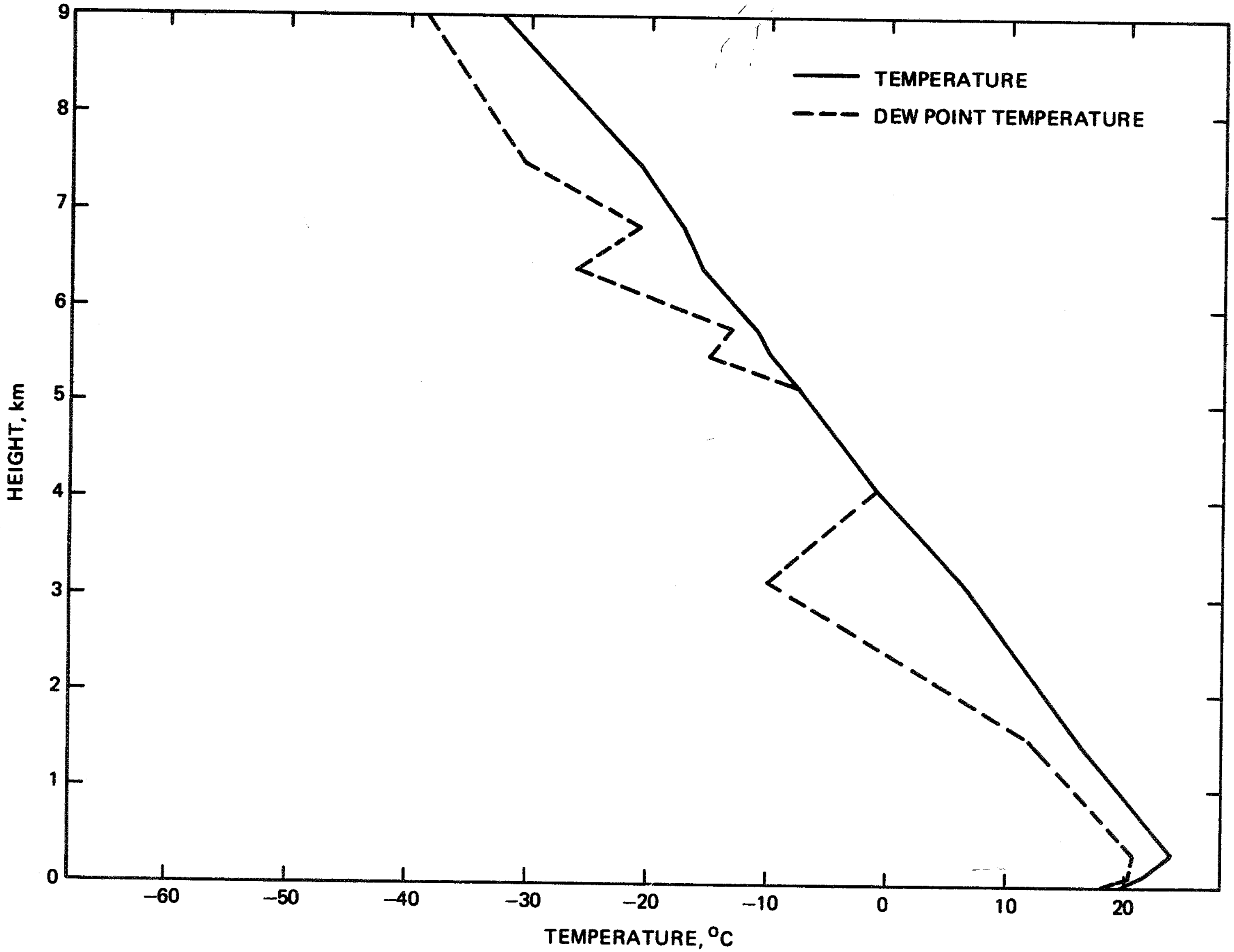
4. RADIOSONDE GRAPH:

Appended (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
MAY 29, 2000Z TO 0300Z, MAY 30, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2000	N	N	N	T	TRW+	T	N
2005						RAIN BEGAN	
2007				TRW–			
2010					RAIN ENDED		
2018			THUNDER BEGAN				
2022				T			
2025					RAIN BEGAN		
2042				TRW–			
2050			THUNDER ENDED				
2056					N		
2100	N	N	N	T	N	TRW–	N
2105						THUNDER ENDED	
2110						RAIN ENDED	
2155		RAIN BEGAN					
2200	N	RW–	N	N	N	N	–
2208		TRW–					
2240		T					
2300	N	T	N	–	–	N	–
2310		N					
2323	T						
2325		T					
2340		TRW–					
2345	TRW–						
0000	TRW–	TRW–	N	N	N	N	–
0005		T					
0008	TRW+						
0015		N					
0020	T						
0050	RAIN BEGAN	RAIN BEGAN					
0056	TRW						
0100	TRW	RW–	–	–	–	–	–
0128	THUNDER ENDED						
0131	RAIN ENDED						
0200	N	RW–	N	N*	–	N	–
0300	–	RW–	N	N	–	N	–

*DISTANT LIGHTNING TO NORTH



WALLOPS RADIOSONDE DATA FOR
MAY 29, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JUNE 4, 1973

PERIOD: 0055Z to 0105Z, June 5

1. RAIN TYPE:

Squall line thundershowers (Source: A. Arnold, using Surface Weather Map for 0000Z, and Teletype Service A airways reports.)

2. GENERAL DESCRIPTION:

SPANDAR observed a group of cells to the north and northwest, at 60 to 75 nmi. These appear to be the southern limit of activity associated with a squall line located north and northwest beyond the range of the radar. The identification above, that there was thunder associated with the cells is indirect and is based largely on the reports of thundershowers by Dover AFB, about 80 miles north of SPANDAR. (Source: Same as above.)

3. RAIN REPORTS:

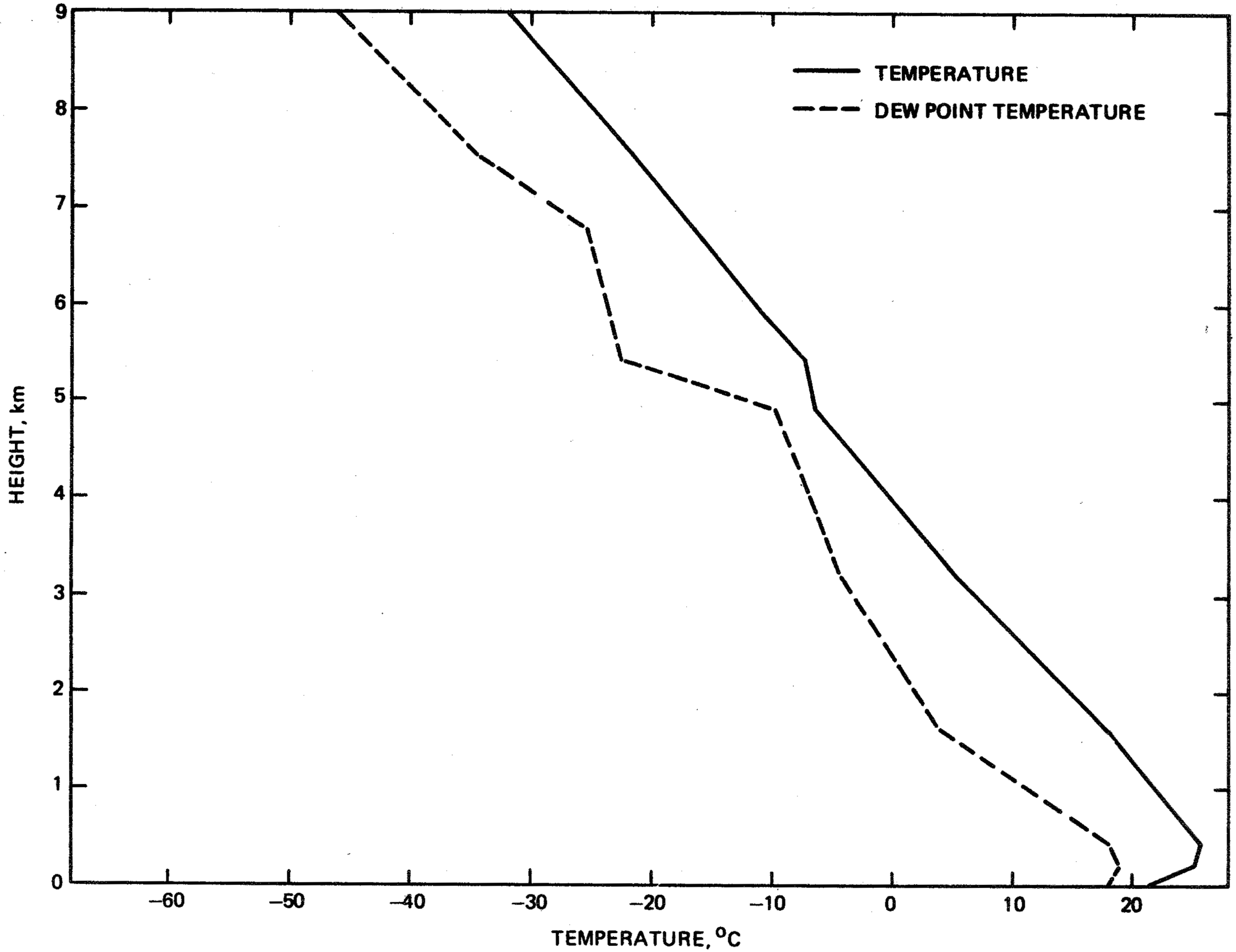
a. Rain gage at VOR: No rain (Source: Chart record)

b. Wallops Island gage: No rain (Source: Form 10B)

c. Nearby Airport Stations: No rain reported (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)



WALLOPS RADIOSONDE DATA FOR JUNE 4, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JUNE 13, 1973

PERIOD: 2030Z June 13 to 0140Z June 14

1. RAIN TYPE:

Thunderstorms due to convergence along a trough. (Source: Wallops Island Staff Meteorologist and A. Arnold.)

2. GENERAL DESCRIPTION

A flat trough of low pressure lay over the coastal plain from New Jersey to North Carolina. A poorly-organized cold front stretched from New England across eastern Pennsylvania to West Virginia and Kentucky at 1700Z and was moving east-southeastward. (Source: Wallops Island staff meteorologist.)

The Weather Service issued severe thunderstorm watch number 358, at 1615Z covering the SPANDAR observing area. (Source: Teletype Service A.)

3. RAIN REPORTS:

a. Rain gage at VOR: No rain (Source: Chart record)

b. Wallops Island Gage: No rain (Source: Form 10B)

c. Nearby Airport Stations: Appended (Source: Service A)

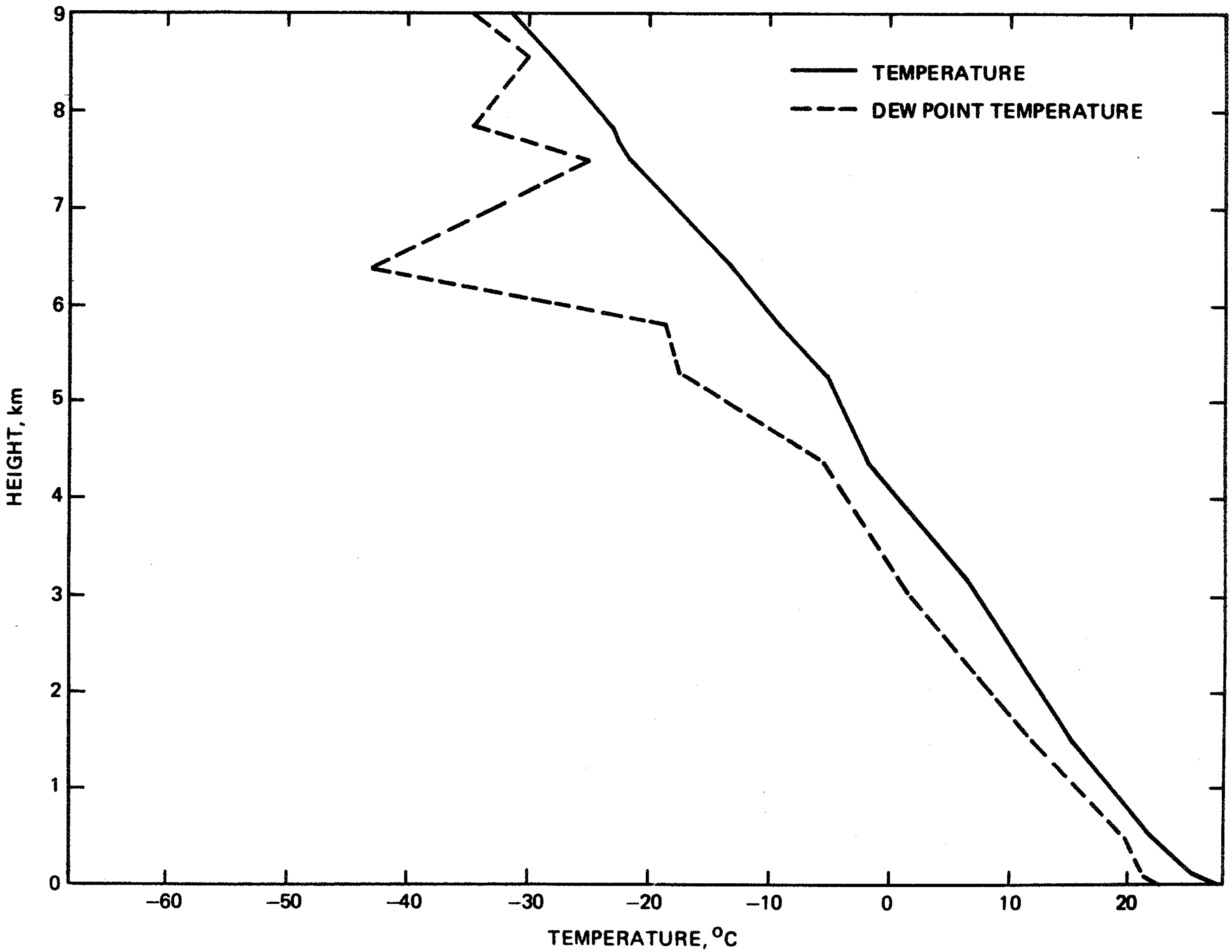
4. RADIOSONDE GRAPH:

Appended (Source: Wallops Island sonde evaluation.)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
JUNE 13, 2000Z TO 0200Z, JUNE 14, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2000	N	N	N	N	N	N	N
2020					RW–	RW–	
2030						TRW+	
2040					ENDED		
2100	N	N	N	N	N	TRW+	N
2200	N	N	N	N	N	T	–
2225						ENDED	
2300	N	N	N	N	N	N	–
0000	N	N	N	N	N	N	–
0100	N	N	N	N*	N*	N	–
0145				RW–			
0200	N	N	N	RW–	N	N	–

*LIGHTNING OBSERVED



WALLOPS RADIOSONDE DATA FOR
JUNE 13, 1973 RELEASED AT 2320Z

METEOROLOGICAL SITUATION REPORT, JUNE 18, 1973

PERIOD: 2030Z June 18 to 0330Z June 19

1. RAIN TYPE:

Showers. There may have been thundershowers toward southern portion early in the period, but considerable data are missing. (Source: A. Arnold.)

2. GENERAL DESCRIPTION:

Lines of showers formed over Chesapeake Bay and moved eastward. A nearly stationary front extended from N. Carolina coast to western Virginia. (Source: Wallops Island staff meteorologist for early in the period.)

A Low in the vicinity of Cape Hatteras, N.C., along the stationary front is shown on the 0000Z map. (Source: A. Arnold using surface map.)

3. RAIN REPORTS:

a. Rain gage at VOR. Summary for period 2000Z to 0400Z. (Source: Chart Record)

Time (hr ending) Z	Amount Precipitation (mm)
2100	1.4
2200	2.6
2300	6.6

b. Rain gage at Wallops Island. (Source: Form 10B)

Time (hr ending) Z	Amount Precipitation (mm)
2100	.34
2200	.82
2300	.01

b. Rain gage at Wallops Island (continued)

0000	.01
0100	.01

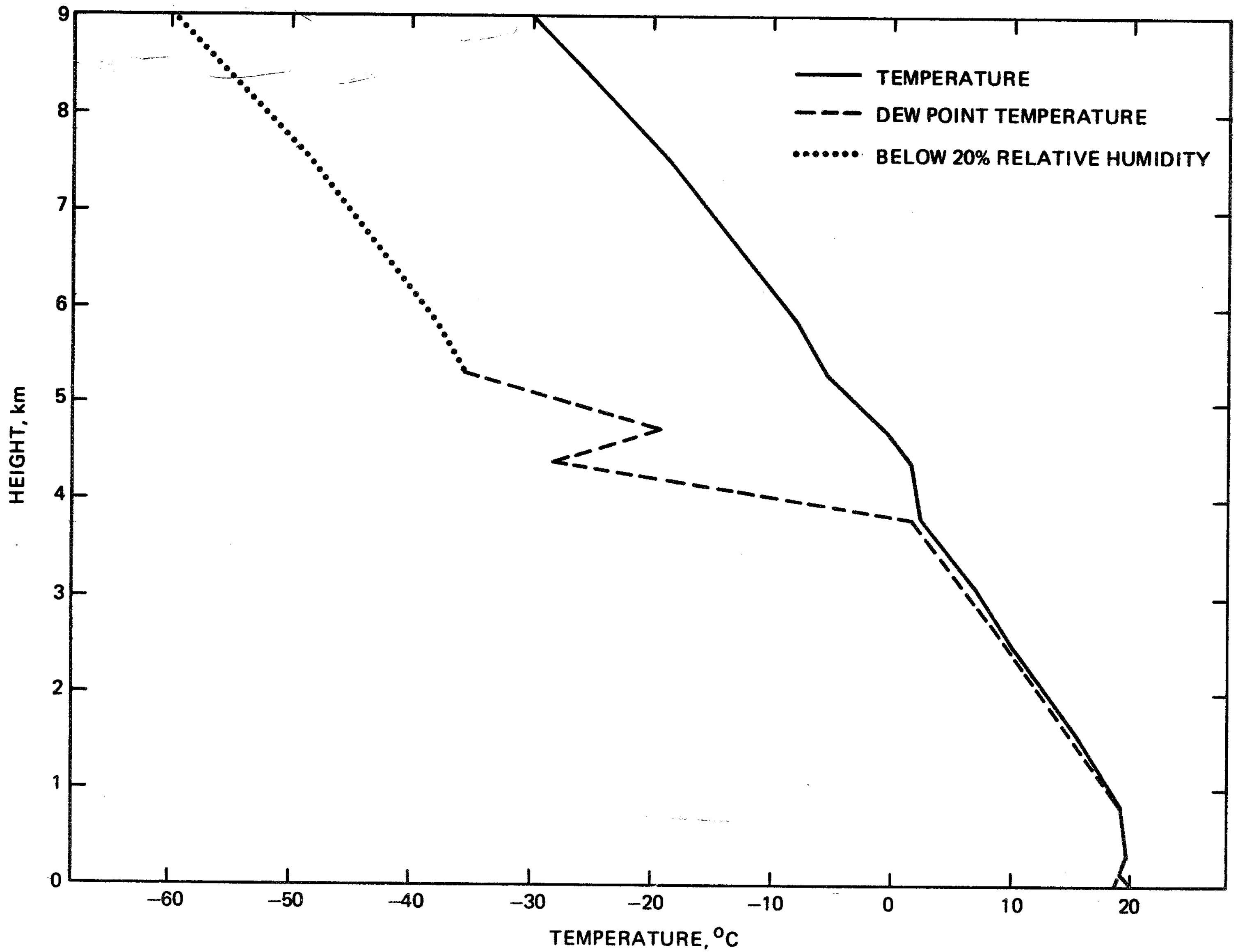
c. Some peak rain intensities observed by rain gage at VOR. (Source: Chart Record)

Rain Rate (mm/hr)	Approximate Time, Z
9	2109
11	2133
10-20	2200-2205
17	2225

d. Nearby Airport Stations: No data received.

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)



WALLOPS RADIOSONDE DATA FOR JUNE 18, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JUNE 19, 1973

PERIOD: 2055Z to 2110Z

1. RAIN TYPE:

Widely scattered showers due to convergence. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

A Low was located about 200 miles east of Wallops Island. The shower observed was in relatively cool air along the coast and behind the Low in a region of converging flow. (Source: Same as above)

3. RAIN REPORTS:

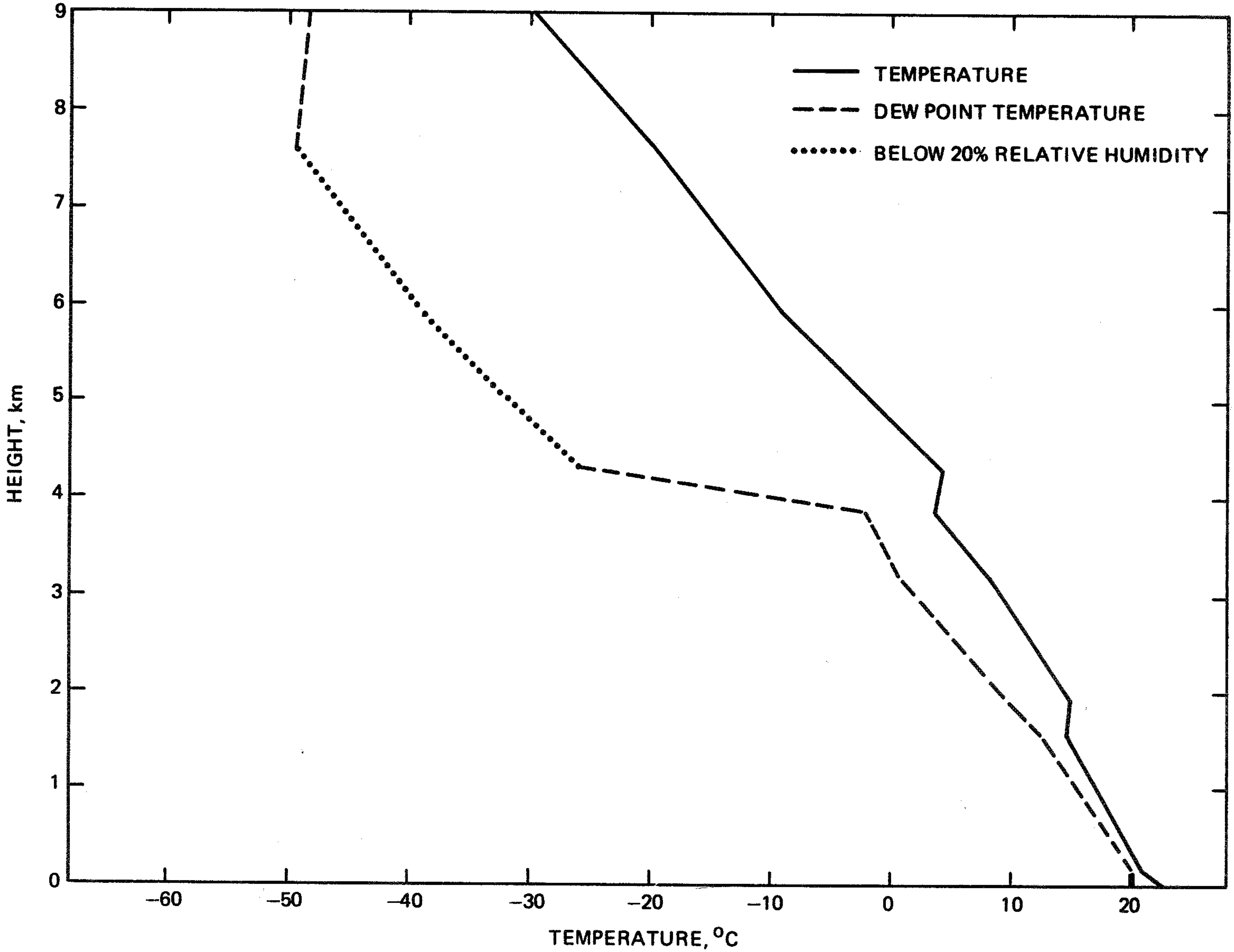
a. Rain gage at VOR: No rain. (Source: Chart Record)

b. Wallops Island gage: No rain. (Source: Form 10B)

c. Nearby Airport Stations: No rain reported

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation.)



WALLOPS RADIOSONDE DATA FOR
JUNE 19, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JUNE 20, 1973

PERIOD: 0305Z to 0340Z June 21

1. RAIN TYPE:

Thundershowers, trough induced. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

A weak trough (a stationary front) was located South of our area of observation in north and central N. Carolina. An area of scattered showers and/or thundershowers north of the trough reached within range of SPANDAR.

3. RAIN REPORTS:

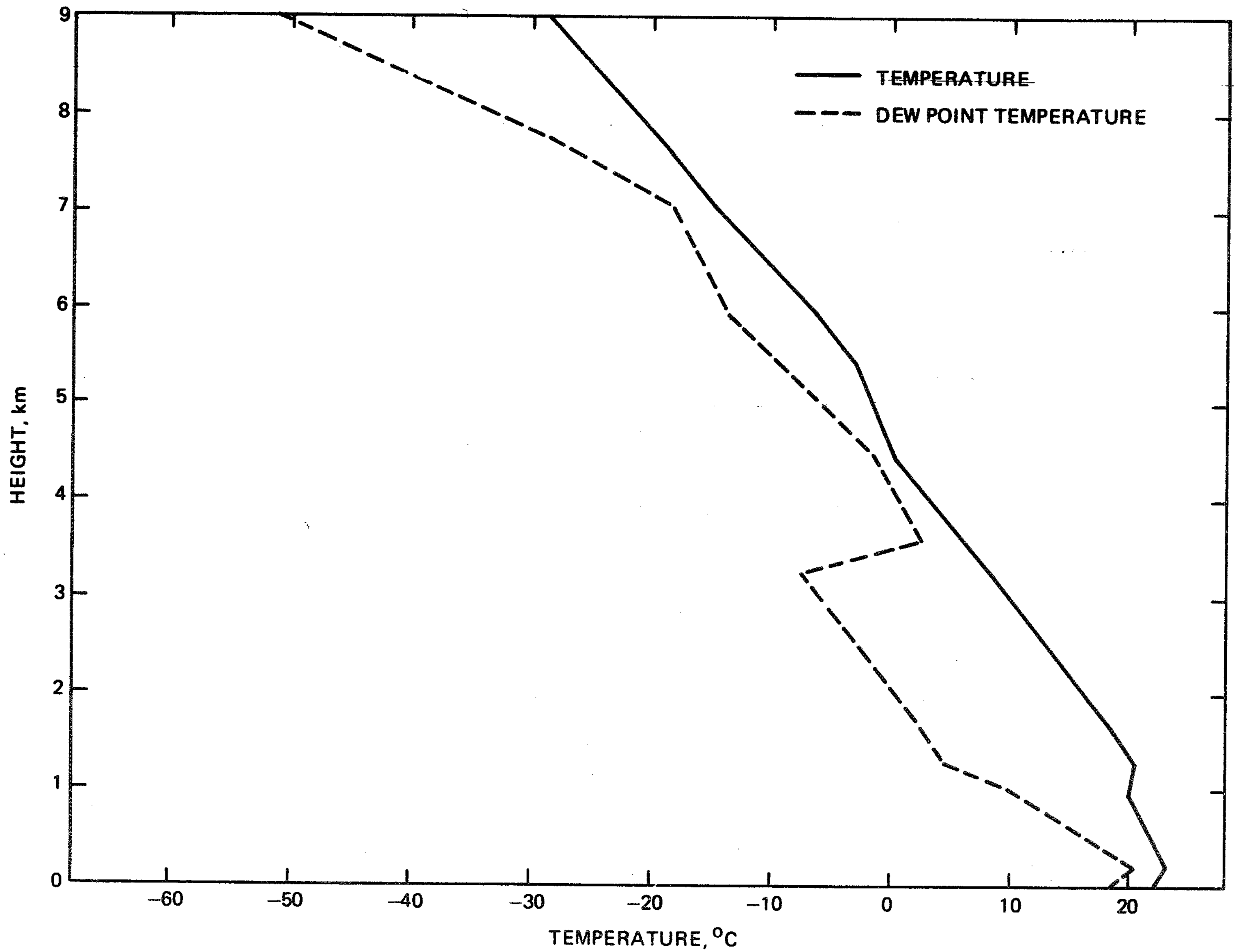
a. Rain gage at VOR: No rain. (Source: Chart Record)

b. Wallops Island gage: No rain. (Source: Form 10B)

c. Nearby Airport Stations: No rain reported, but Norfolk (both Regional Airport and Naval Air Station) and Langley AFB reported distant lightning at 0300Z. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)



WALLOPS RADIOSONDE DATA FOR
JUNE 20, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JUNE 21, 1973

PERIOD: 2050Z June 21 to 0335Z June 22

1. RAIN TYPE:

Pre-frontal scattered air mass thundershowers. (Source: Wallops Island staff meteorologist)

2. GENERAL DESCRIPTION:

Very slow moving weak cold front over the Appalachians. Warm moist air to east of front. The 2100Z, 0000Z, and 0300Z surface weather maps show a squall line approximately 100 miles east of the cold front. (Source: Wallops Island staff meteorologist and A. Arnold.)

3. RAIN REPORTS:

a. Rain gage at VOR: No rain. (Source: Chart Record)

b. Wallops Island gage: No rain. (Source: Form 10B)

c. Nearby Airport Stations: Appended. (Source: Service A)

4. RADIOSONDE GRAPH:

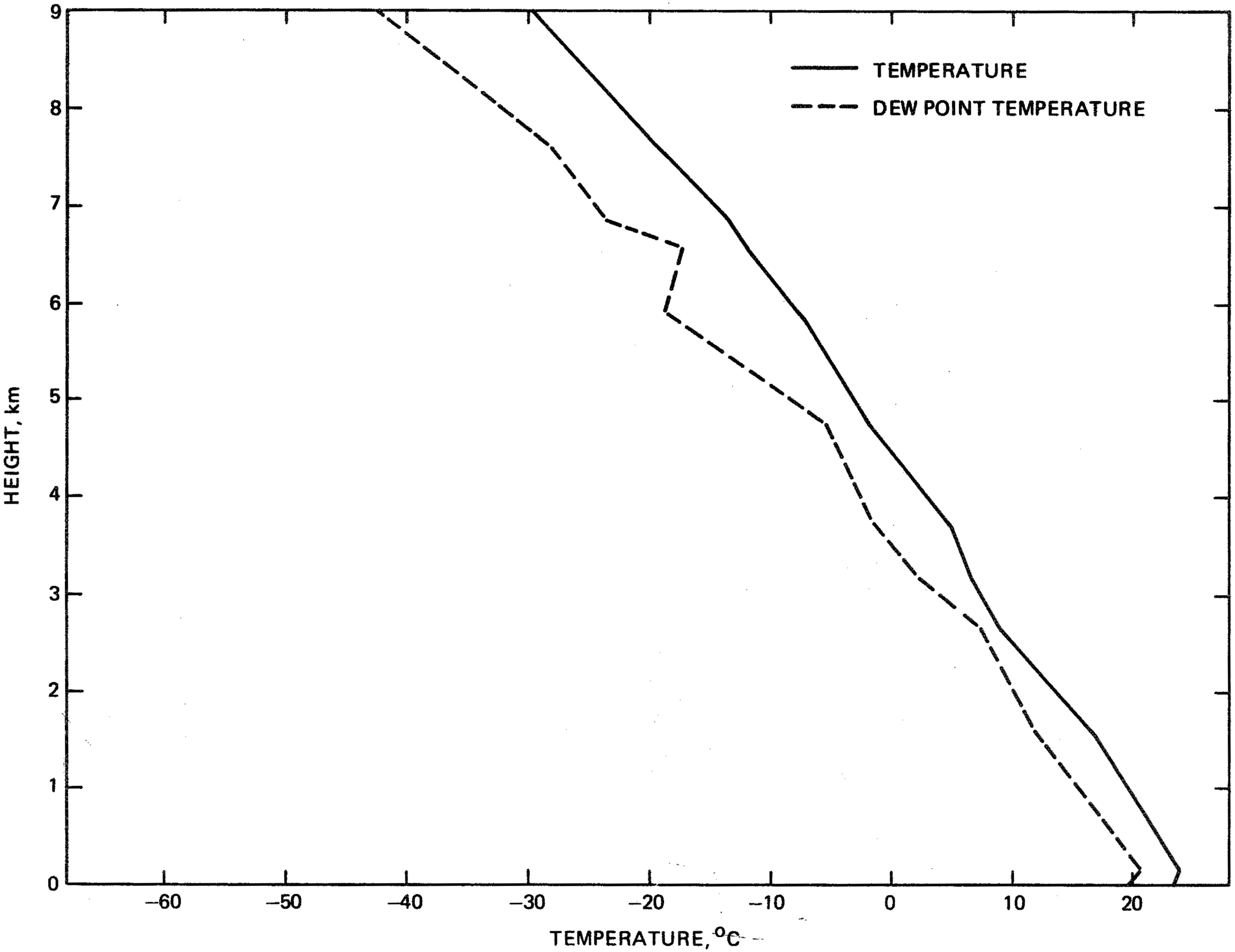
Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
JUNE 21, 2000Z TO 0400Z, JUNE 22, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2000	N	N	N	N	N	TRW--	
2006					RAIN BEGAN		
2012				THUNDER BEGAN			
2016					ENDED		
2020						THUNDER ENDED	
2040					RAIN BEGAN		
2041					TRW-		
2045				TRW-			
2047			RAIN ENDED				
2100	N	N	N*	TRW-	TRW-	RW--	
2105					THUNDER ENDED		
2110				ENDED			
2125					RAIN ENDED		
2200	–	N	N	N	N	N	
2300	N	N	N	N	N	N	
0000	N	N**	N	N	N	N	
0035		RAIN BEGAN					
0100	N	RW	N	N	N	N	
0110		ENDED					
0200	N	N	N	N	N	N	
0300	N	N	N	N	N	N	
0400	N	N	N	N	N	N	

*RW+ MOVING TO NE

**LIGHTNING TO WEST



WALLOPS RADIOSONDE DATA FOR
JUNE 21, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JUNE 22, 1973

PERIOD: 2030Z June 22 to 0330Z June 23

1. RAIN TYPE:

Thundershowers along a front and vicinity of weak frontal wave. (Source: Wallops Island staff meteorologist)

2. GENERAL DESCRIPTION:

A very slow moving cold front, oriented SW-NE, was in our area of observation. A weak wave on the front over the Va.-N. Carolina border moved over the Va. capes which had the effect of enlarging and prolonging the rain over the lower shore. (Source: Wallops Island staff meteorologist and A. Arnold.)

3. RAIN REPORTS:

a. Rain gage at VOR: Summary for period 2000Z to 0400Z (Source: Chart Record)

Time (hr ending) Z	Amount Precipitation (mm)
2100	2.8
2200	not measurable
2300	not measurable
0000	0.8
0100	1.2
0200	0.8
0300	0.2
0400	not measurable

b. Rain gage at Wallops Island: (Source: Form 10B)

Time (hr ending) Z	Amount Precipitation (in.)
2100	.06

b. Rain gage at Wallops Island (continued)

Time (hr ending) Z	Amount Precipitation (in.)
2200	.01
2300	.06
0000	.10
0100	.06
0200	.01
0300	.05
0400	.04

c. Nearby Airport Stations: Appended. (Source: Service A)

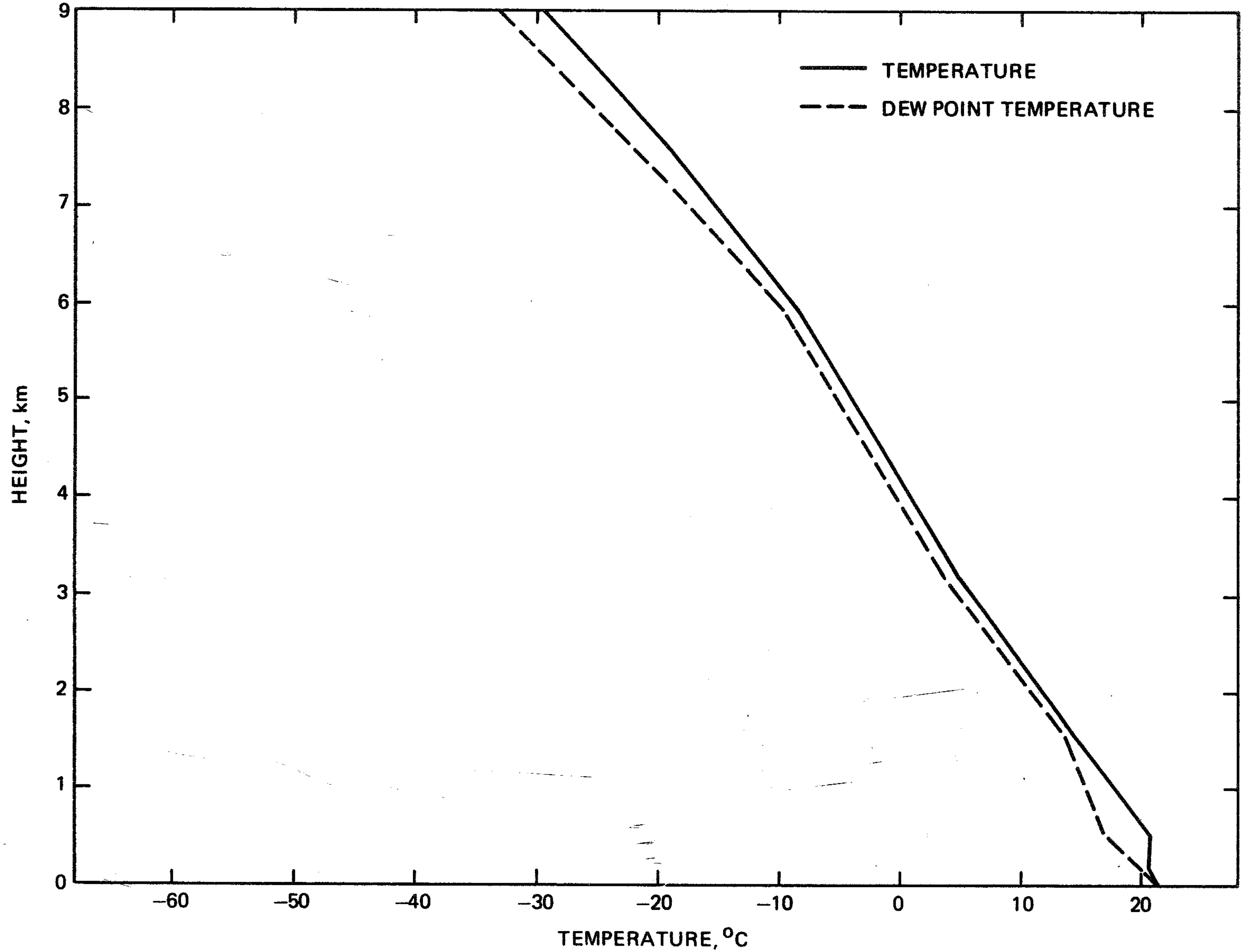
d. Heavy rain report. At 0000Z, Hampton, Va. (LFI) reported a rainfall of 3.55 in. - all of which fell in the preceding 4 hours. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
JUNE 22, 2000Z TO 0400Z, JUNE 23, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2000	R–	N	N	N	RW–	T	RW
2012				RW–			
2013					THUNDER BEGAN		
2027						TRW+	
2036				TRW–			
2045					THUNDER ENDED		
2047				TRW			
2049					RAIN ENDED		
2100	R–	N	N	TRW+	N	–	RW–
2109			TRW––				
2125					RAIN BEGAN		
2130	ENDED						
2137					RW–		
2146			THUNDER ENDED				
2200	N	N	RW––	TRW+	RW–	RW–	
2300	N	N	RW––	RW–	RW–	RW–	
2312				TRW–			
2337						R–	
0000	N	N	R–	TRW–	RW–	R–	
0027						R	
0034						THUNDER BEGAN	
0036				RW–			
0040					RW+		
0050					THUNDER BEGAN		
0100	N	N	R–	RW–	TRW+	TRW+	
0130		RAIN BEGAN				TRW	
0135		ENDED					
0147						THUNDER ENDED	
0153	RAIN BEGAN						
0200	RW––	N	R–	RW–	TRW–	RW–	
0215	ENDED						
0230					THUNDER ENDED		
0300	N	N	R––	L–	R–	RW–	
0326						ENDED	
0340		RAIN BEGAN			ENDED		
0400	N	R–	R––	N	N	N	



WALLOPS RADIOSONDE DATA FOR JUNE 22, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JUNE 27, 1973

PERIOD: 2110Z to 2355Z

1. RAIN TYPE:

Massive thundershowers. (Source: Wallops Island staff meteorologist)

2. GENERAL DESCRIPTION:

The pressure pattern over the eastern U.S. was ill-defined. A poorly organized, flat trough of low pressure was along the coastline from Delmarva to South Carolina. (Source: Same as above)

3. RAIN REPORTS:

a. Rain gage at VOR: No rain. (Source: No rain catch measured)

b. Wallops Island gage: A trace of a rain shower occurred between 2310 and 2330Z. (Source: Form 10B)

c. Nearby Airport Stations: Appended. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

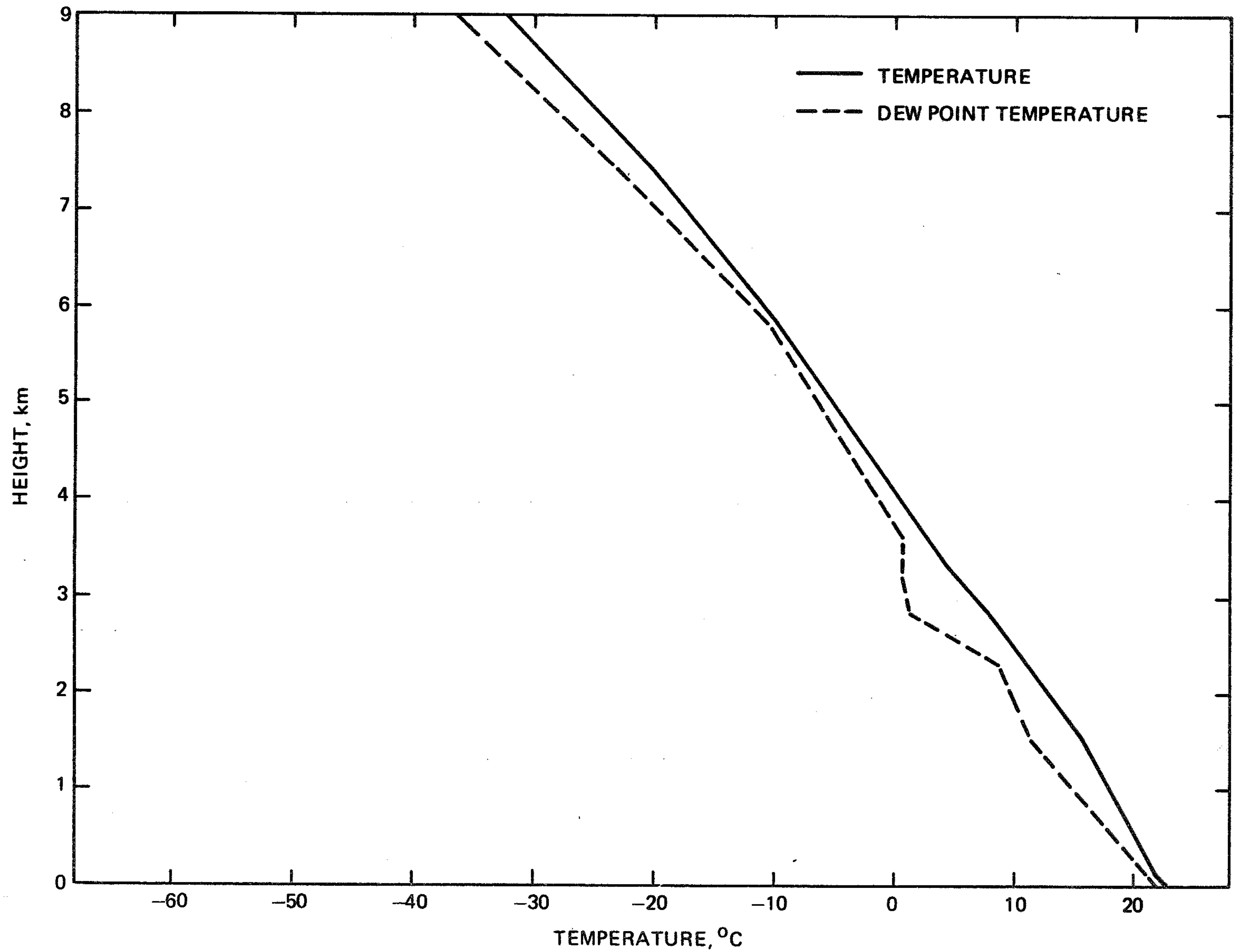
OBSERVATIONS FROM LOCAL WEATHER STATIONS
2100Z TO 2400Z, JUNE 27, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2100	T	N*	TRW--	N	RW-	N	
2126		THUNDER ENDED					
2130	THUNDER ENDED						
2132				RW-			
2135					ENDED		
2145			THUNDER ENDED				
2200	N	N**	RW-	RW-	N	N	
2245			ENDED				
2300	N	N***	N	N	N	N	
2336						RAIN BEGAN	
2340	RAIN BEGAN						
2400	RW-	N	N	N	N	R--	

*SHOWER TO EAST

**SHOWER TO WEST

***SHOWER TO EAST AND SOUTH



WALLOPS RADIOSONDE DATA FOR
JUNE 27, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JUNE 28, 1973

\- PERIOD: 2040Z to 2115Z

1. RAIN TYPE:

Convergence thundershowers. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

There was a slow moving cold front in east-central Ohio and a trough located about 200 mi. to the east. There were scattered thunderstorms in advance of these. The identification of thunder is based on the report by Patuxent NAS just prior to the 2040 start of SPANDAR measurements. (Source: Same as above.)

3. RAIN REPORTS:

a. Rain gage at VOR: No rain. (Source: Chart Record)

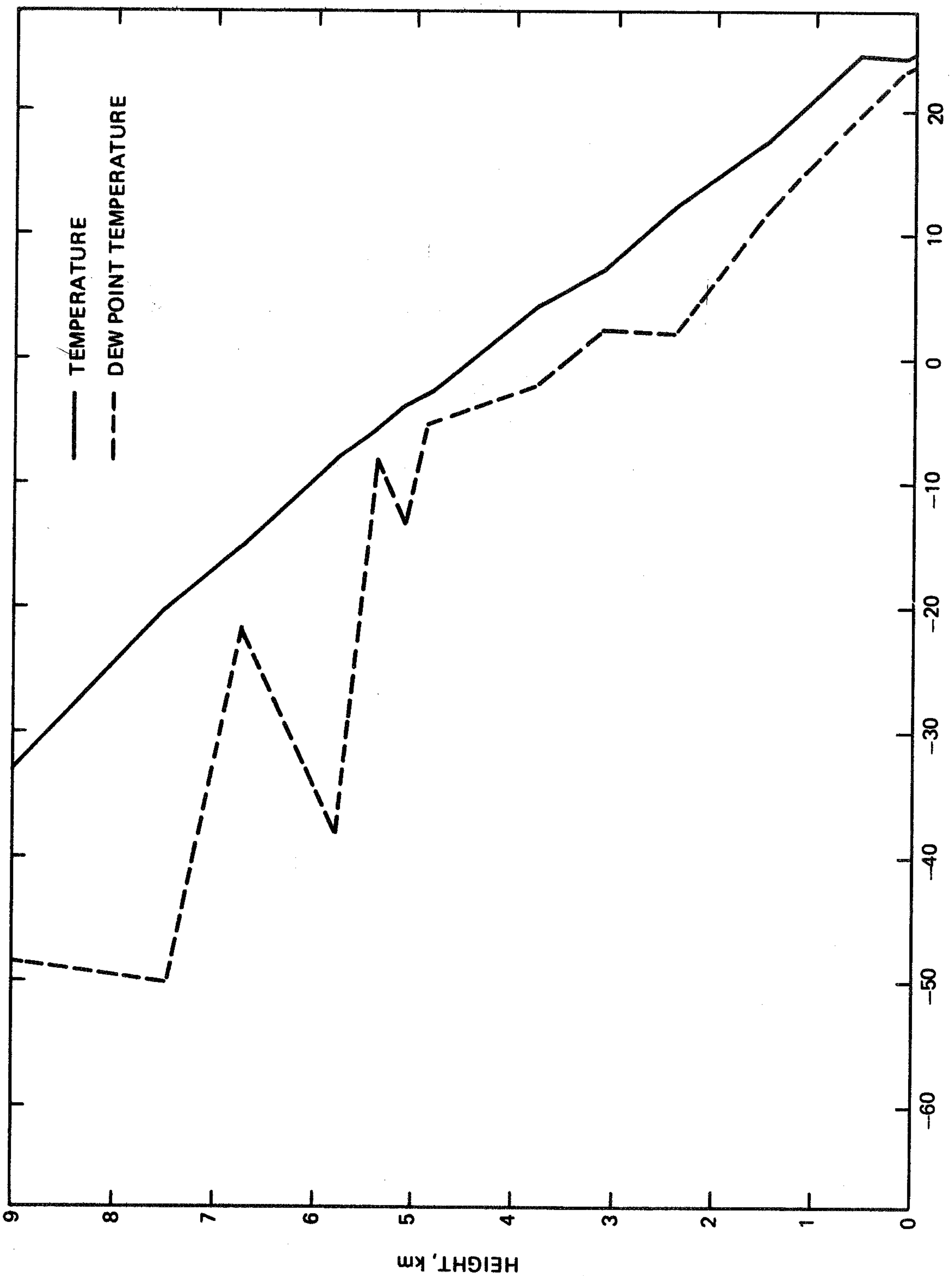
b. Wallops Island gage: No rain.

c. Nearby Airport Stations: No rain reported.

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

WALLOPS RADIOSONDE DATA FOR
JUNE 28, 1973 RELEASED AT 2315Z



METEOROLOGICAL SITUATION REPORT, JUNE 29, 1973

PERIOD: 2055Z June 29 to 0340Z June 30

1. RAIN TYPE:

Frontal showers and thundershowers. (Source: Wallops Island staff meteorologist).

2. GENERAL DESCRIPTION:

A very slow moving cold front was in eastern Pennsylvania and eastern Virginia. There was a Low on this front in eastern Virginia. (Source: Same as above and A. Arnold.)

3. RAIN REPORTS:

a. Rain gage at VOR: (Source: Chart Record)

Time (hr ending) Z	Amount Precipitation (mm)
2100	0.4

b. Wallops Island gage: (Source: Form 10B)

Time (hr ending) Z	Amount Precipitation (in.)
2100	.01
2200	.01
2300	.01

c. Nearby Airport Stations: Appended. (Source: Service A)

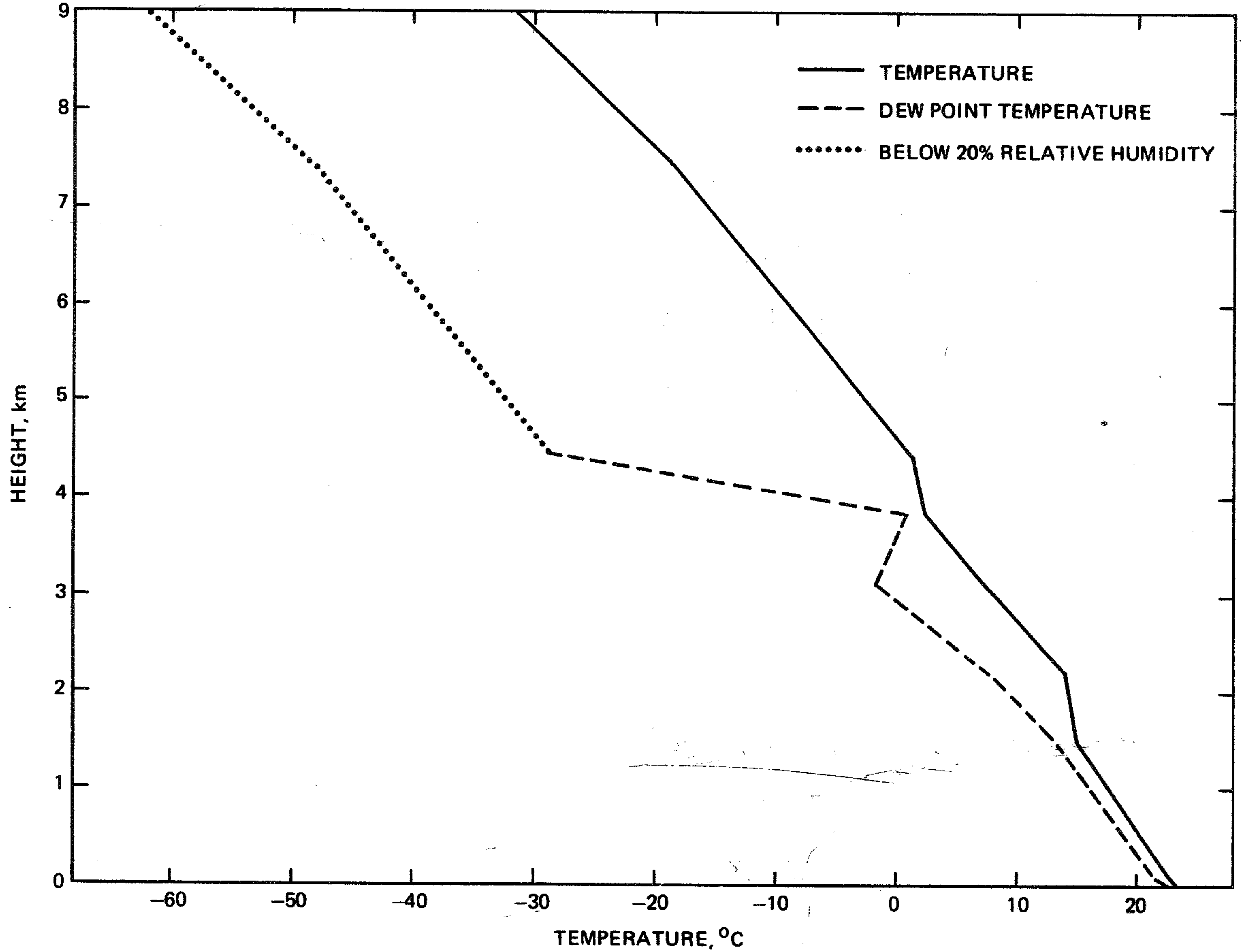
4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
JUNE 29, 2000Z TO 0400Z, JUNE 30, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2000	N	N	N	T	N	RW–	N
2004				N			
2040	RAIN BEGAN						
2042							RAIN BEGAN
2046						ENDED	
2100	N	N	N	N	N	N	RW––
2131	RW––						
2145	ENDED						
2200	N	N	N	N	N	N	N

THERE WERE NO REPORTS OF RAIN FROM THESE STATIONS FOR THE BALANCE OF THE PERIOD.



WALLOPS RADIOSONDE DATA FOR
JUNE 29, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JULY 3, 1973

PERIOD: 2135Z July 3 to 0335Z July 4

1. RAIN TYPE:

a. To about 0000Z. Convergence showers.

b. After about 0000Z. Squall line thunderstorms. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

A moderate squall line was located west to north advancing southeastward and coming within the range of SPANDAR near 0000Z. A cold front was about 75 mi. beyond the squall line. For the early part of the observation period, the showers are regarded as separate and distinct and due to convergence in advance of the cold front and squall line. These have not been identified as thundershowers as information on this is lacking. For the later part of the observation period there is a line of thunderstorms associated with the squall line.

The Weather Service issued severe thunderstorm watch number 421 at 2255Z, and replaced it with number 423 at 0143Z. These included threats of hail.

The Salisbury airport relayed aircraft reports of interest: (a) 0127Z: a line of thunderstorms 15 mi. wide was located 25 mi. northwest of the airport; (b) 0200Z: there was severe turbulence with 2000 ft. per min. updrafts located 30 mi. northwest of the airport. (Source: A. Arnold)

3. RAIN REPORTS:

a. Rain gage at VOR: No rain measured between 2100Z and 0300Z. For the time between 0300Z and 0330Z there was 6.2 mm of rain and between 0330Z and 0400Z there was 4.0 mm of rain. (Source: Chart Record)

b. Rain gage at Wallops Island: No rain reported between 2100Z and 0400Z. (Source: Form 10B)

c. Some peak rain intensities observed by rain gage at VOR.

METEOROLOGICAL SITUATION REPORT, JULY 3, 1973 (continued)

:. Rain gage at VOR (continued)

Rain Rate (mm/hr)	Approximate Time, Z
60	0316
80	0320
30	0321-0327

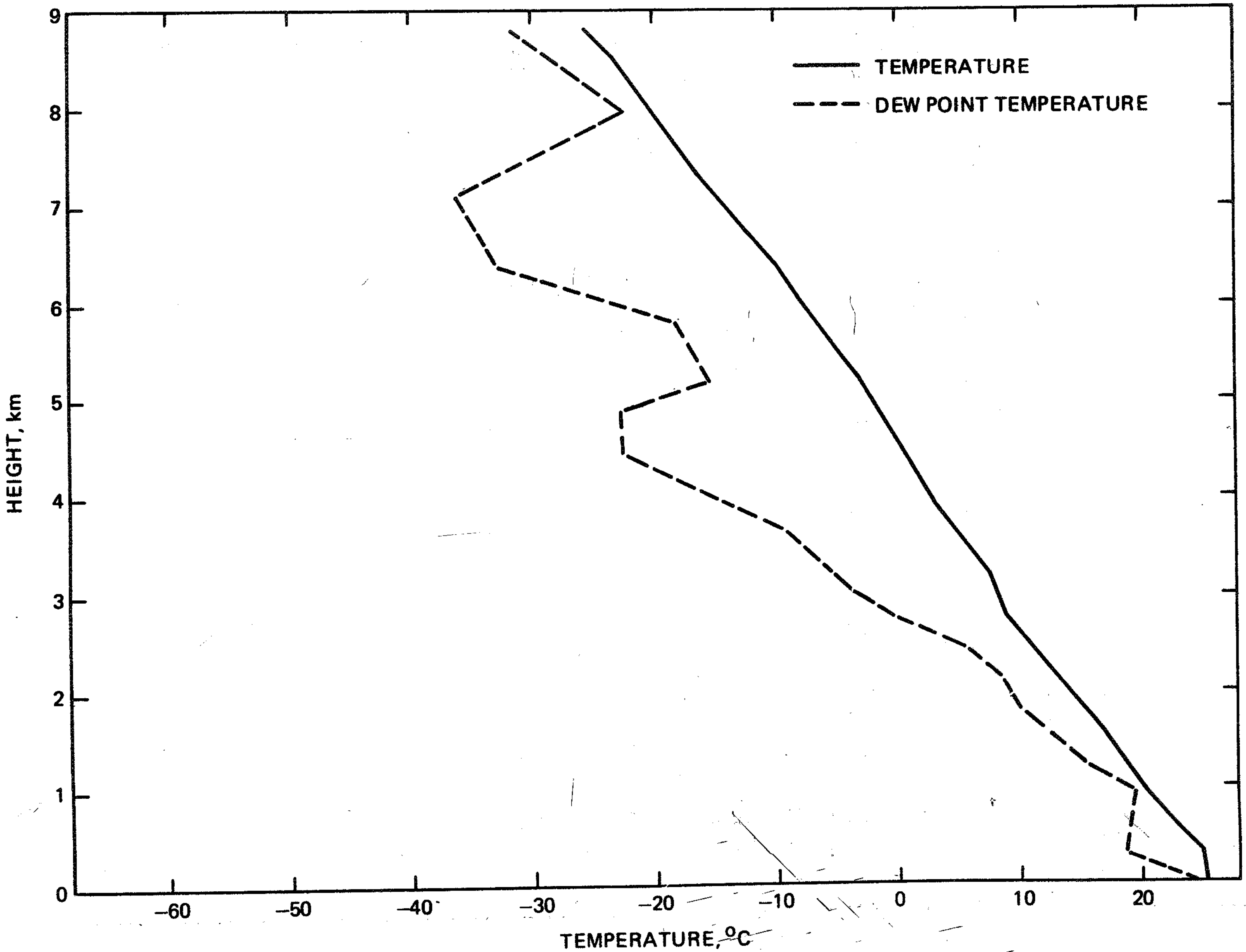
d. Nearby airport stations. Appended. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
JULY 3, 2100Z TO 0400Z, JULY 4, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
	NO RAIN REPORTED BY ABOVE STATIONS BETWEEN 2100Z AND 0000Z						
0058		THUNDER BEGAN					
0100	N	T*	N	N	N	N	
0135		RAIN BEGAN					
0200	N**	TRW–	N	N	N	N	
0208	THUNDER BEGAN						
0235	RAIN BEGAN						
0236		RAIN ENDED					
0246		N**					
0300	TRW+	N**	N	N	N	N	
0400	TRW–	–	N	–	–	N	
*RAIN SHOWER NORTH TO NORTHWEST OF NHK							
**LIGHTNING							



WALLOPS RADIOSONDE DATA FOR JULY 3, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JULY 5, 1973

PERIOD: 0105Z to 0150Z July 6

1. RAIN TYPE:

Cold frontal showers (Source: A. Arnold)

2. GENERAL DESCRIPTION:

A weak cold front lay off the coast of Delaware and northward and cut inland through Delaware. The rain type is not identified as including thunder since Norfolk did not report any, nor were there reports of thunder or even rain earlier in the day from any local station. However, there may have been thundershowers; Elizabeth City, North Carolina, 40 mi. south of Norfolk, reported thunder during our observation period. (Source: A. Arnold)

3. RAIN REPORTS:

a. Rain gage at VOR: No rain (Source: Chart Record)

b. Rain gage at Wallops Island: No rain (Source: Form 10B)

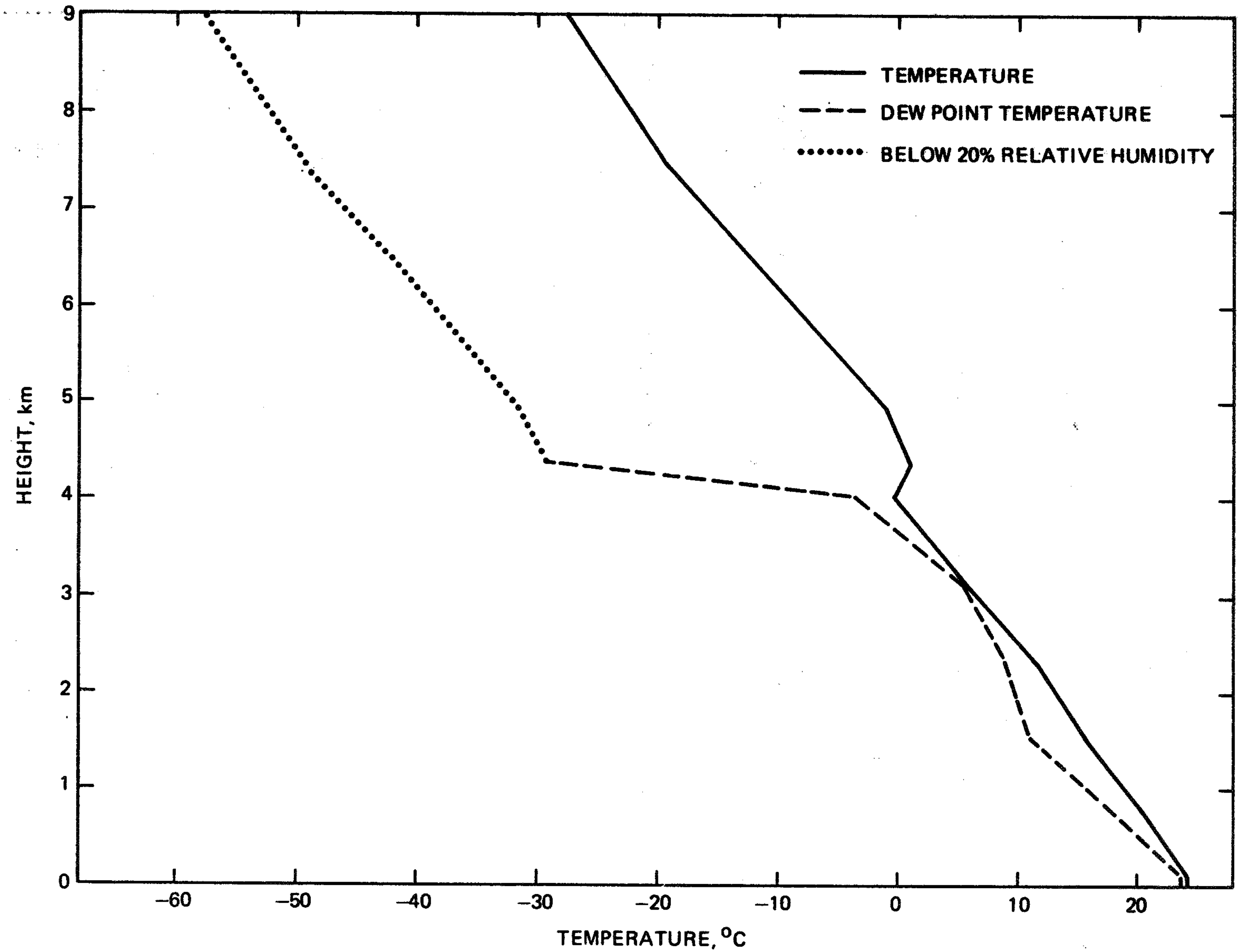
c. Nearby Airport Stations: Appended. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Teletype Service C, Reports TTAA and TTBB for nominal time 0000Z)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
0100Z TO 0200Z, JULY 6, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
0100	N	N	N	N	N	RW–	
0107						ENDED	
0200	N	N	N	N	N	N	



WALLOPS RADIOSONDE DATA FOR
JULY 5, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JULY 10, 1973

PERIOD: 2115Z July 10 to 0355Z July 11

1. RAIN TYPE:

Trough - induced thundershowers (Source: A. Arnold)

2. GENERAL DESCRIPTION:

A cold front with a wave extended from southern New England westward through Pennsylvania. A squall line from the vicinity of Washington, D.C. extended southwestward through Virginia. There was a trough southeast of the frontal-squall line system in the SPANDAR observation area. (Source: A. Arnold)

3. RAIN REPORTS:

a. Rain gage at VOR: None recorded (Source: Chart Record)

b. Rain gage at Wallops Island: None (Source: Form 10B)

c. Nearby Airport Stations: Appended (Source: Service A)

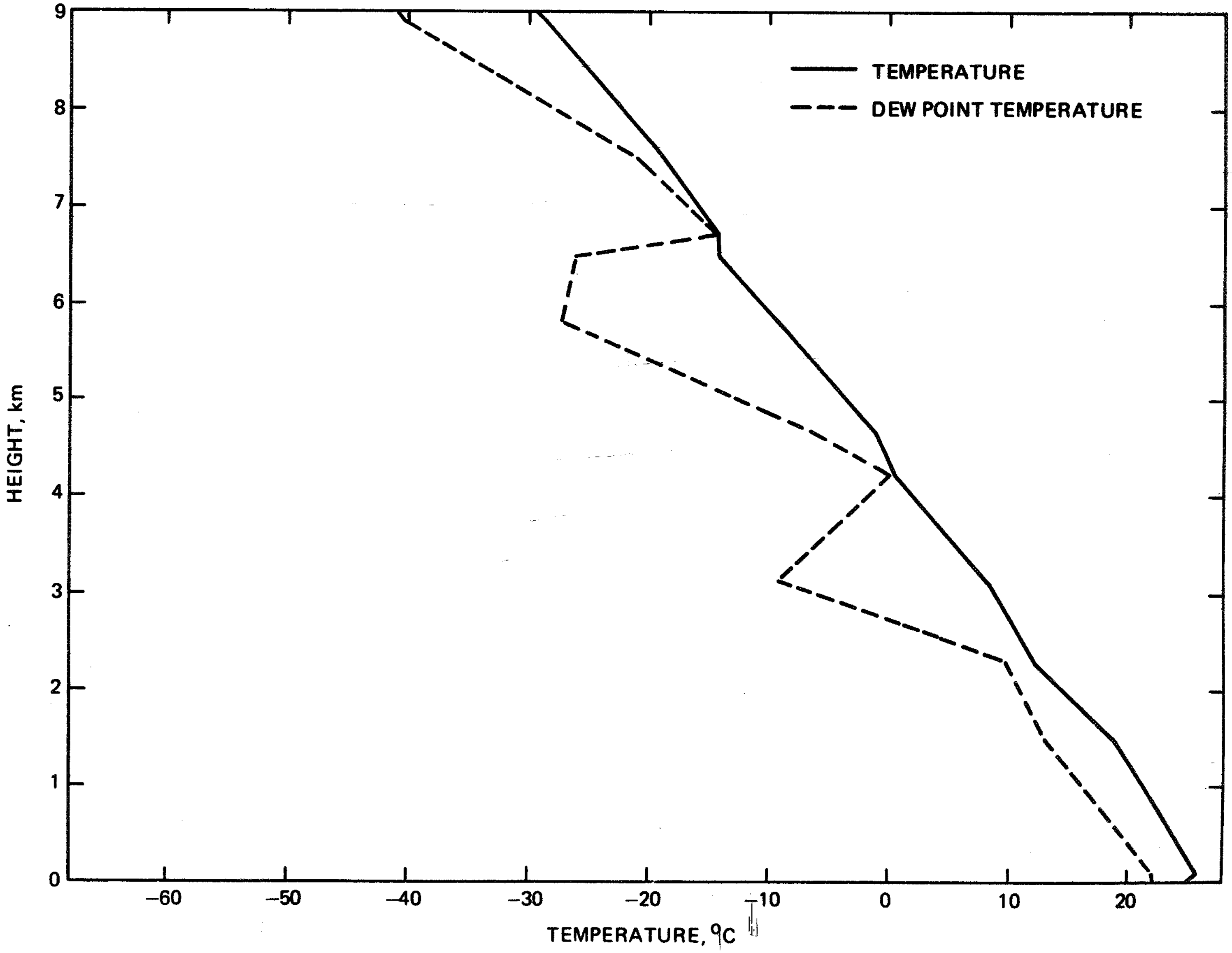
4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
JULY 10, 2100Z TO 0400Z, JULY 11, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2100	N	N	N	N	T	TRW	
2123						TRW–	
2130					ENDED		
2135						THUNDER ENDED	
2150						RAIN ENDED	
2200	N	N	N	N	N	N	
2300	N*	N	N	N	N	N	
0000	N	–	N	N	N	N	
0100	N	N	N	N	N	N	
0125		THUNDER BEGAN					
0200	N	T	N	N	N	N	
0225		RAIN BEGAN					
0300	N	TRW–	N	N	N	N	
0335	THUNDER BEGAN						
0400	T	TRW–	N	N	N	N	

*AIRCRAFT REPORT TRW+ 22 MILES NORTHEAST OF SBY



WALLOPS RADIOSONDE DATA FOR
JULY 10, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JULY 11, 1973

PERIOD: 2250Z July 11 to 0240Z July 12

1. RAIN TYPE:

Thundershowers in advance of cold front (Source: Wallops Island Staff Meteorologist)

2. GENERAL DESCRIPTION:

A cold front oriented southwest-northeast was located from the southern tip of New Jersey to southeastern Virginia at 2100Z, moved southeastward during the observation period and by 0300Z was over the ocean cutting inland at the Virginia-North Carolina border. (Source: A. Arnold)

3. RAIN REPORTS:

a. Rain gage at VOR: Malfunction. Rain amount for this period was approximately 15 mm. (Source: P.D. Visit)

b. Rain gage at Wallops Island: (Source: Form 10B)

Time (hr ending) Z	Amount Precipitation (in.)
2300	.45
0000	.08
0100	.01
0200	Trace
0300	Trace

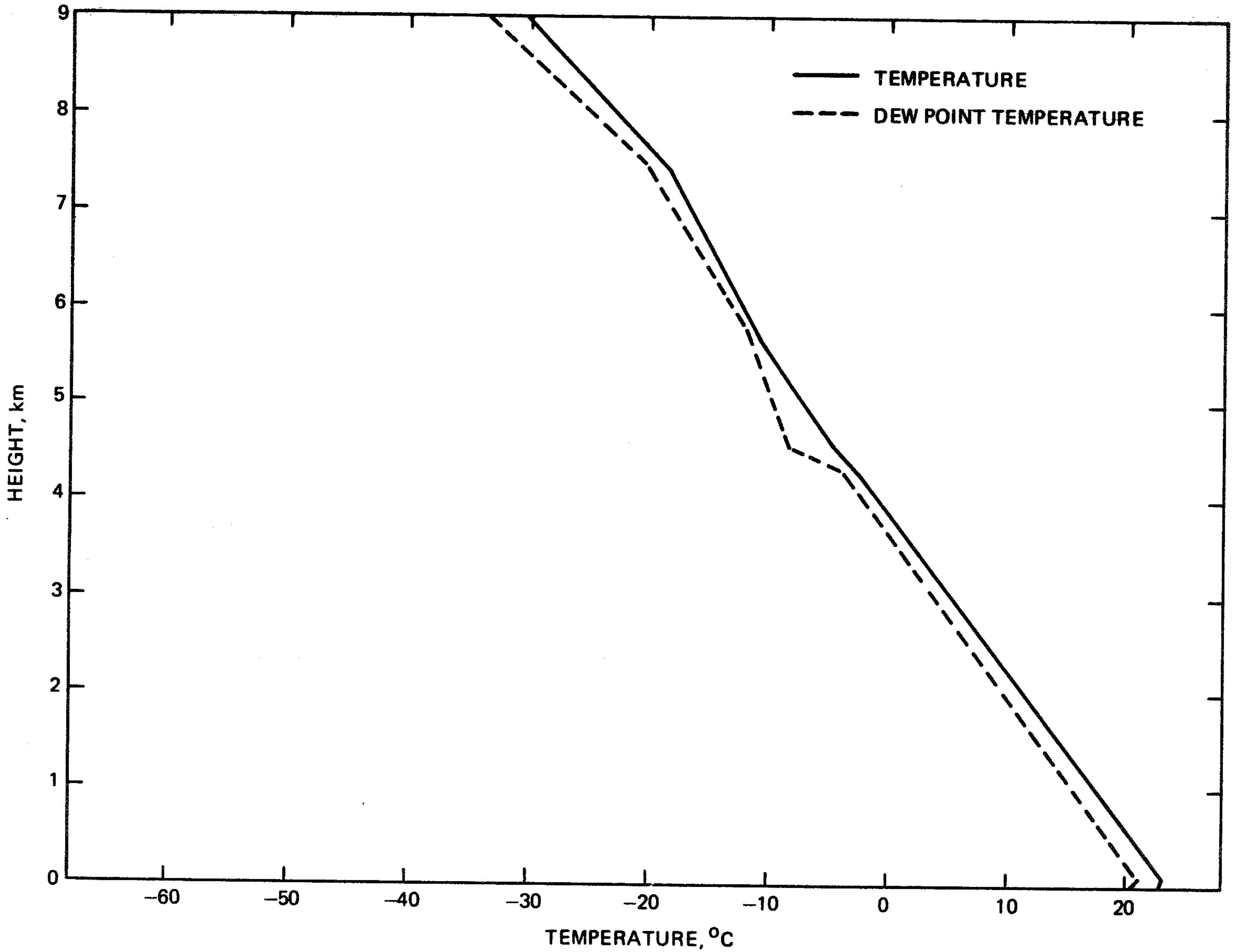
c. Nearby Observing Stations: Appended. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. Note this routine flight was in a thundershower. The evaluation contains interpolation. (Source: Wallops Island sonde evaluation.)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
JULY 11, 2200Z TO 0100Z, JULY 12, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2200	T	N	N	N	N	N	
2253	ENDED						
2300	N	N	N	N*	N	N	
2301			THUNDER BEGAN				
2313				TRW–			
2319				TRW			
2321			THUNDER ENDED				
2331				TRW+			
2342				TRW			
2346				RW–			
2348						RAIN BEGAN	
2350				N			
0000	N	N	N	N	–	RW–	
0012						ENDED	
0100	N	N	N	N	N	N	
NO FURTHER REPORTS OF PRECIPITATION FROM ABOVE STATIONS							
*RAIN SHOWER TO NORTHWEST							



WALLOPS RADIOSONDE DATA FOR
JULY 11, 1973 RELEASED AT 2300Z

METEOROLOGICAL SITUATION REPORT, JULY 18, 1973

PERIOD: 2120Z to 2245Z

1. RAIN TYPE:

Convergence showers (Source: Wallops Island Staff Meteorologist)

2. GENERAL DESCRIPTION

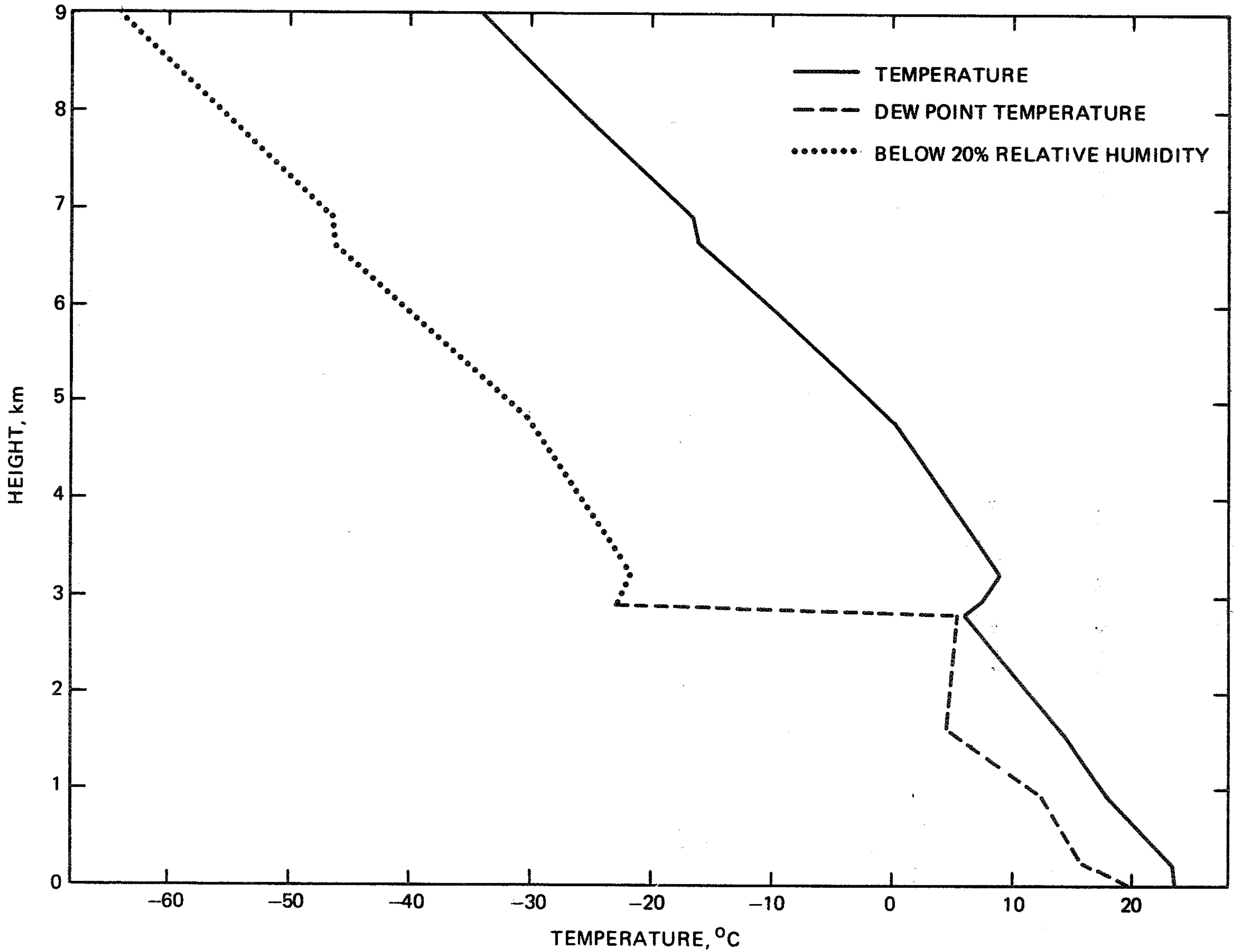
A flat, extensive area of high pressure lay stationary over the eastern seaboard. The light showers were isolated and apparently related to the convergence of the low level wind field. (Source: Wallops Island Staff Meteorologist)

3. RAIN REPORTS:

There was no rain measured by gage at VOR, nor at Wallops Island. None of the nearby airport stations reported rain.

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)



WALLOPS RADIOSONDE DATA FOR
JULY 18, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JULY 20, 1973

PERIOD: 0000Z to 0145Z July 21

1. RAIN TYPE:

Scattered showers, trough induced (Source: A. Arnold.)

2. GENERAL DESCRIPTION:

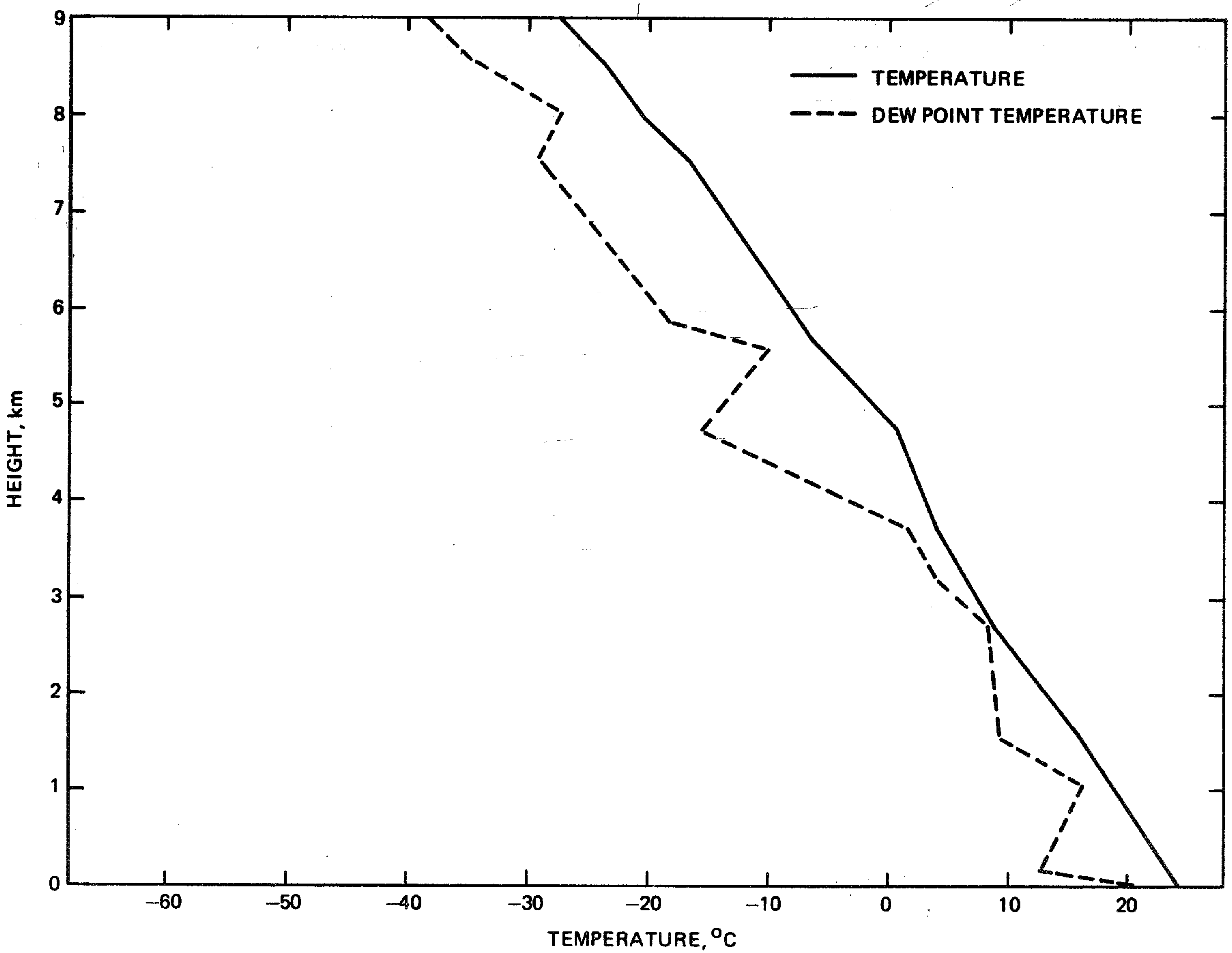
A ridge of high pressure extended from the Carolinas northeastward over the ocean. A cold front extended from northern Indiana to northern Maine. Just northwest of SPANDAR and in our coverage area there was a trough of lower pressure. Our northern view was of the southernmost part of the showers. While there were reports of thunder farther toward the trough line, it is believed that the showers we observed were outside the region of thunder activity. (Source: A. Arnold)

3. RAIN REPORTS:

There was no rain measured by gage at VOR, nor at Wallops Island. None of the nearby airport stations reported rain during the period.

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)



WALLOPS RADIOSONDE DATA FOR
JULY 20, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JULY 27, 1973

PERIOD: 2040Z July 27 to 0025Z July 28

1. RAIN TYPE:

Scattered thundershowers, trough induced (Source: A. Arnold)

2. GENERAL DESCRIPTION:

There was a rapidly moving cold front, at 0000Z oriented SW-NE, extended from near Philadelphia, Pennsylvania through central Virginia. There was also a trough east of front closer to the SPANDAR range of observations. (Source: A. Arnold)

3. RAIN REPORTS:

a. Rain gage at VOR: No rain (Source: Chart Record)

b. Rain gage at Wallops Island: No rain (Source: Form 10B)

c. Nearby Airport Stations: Appended. (Source: Service A)

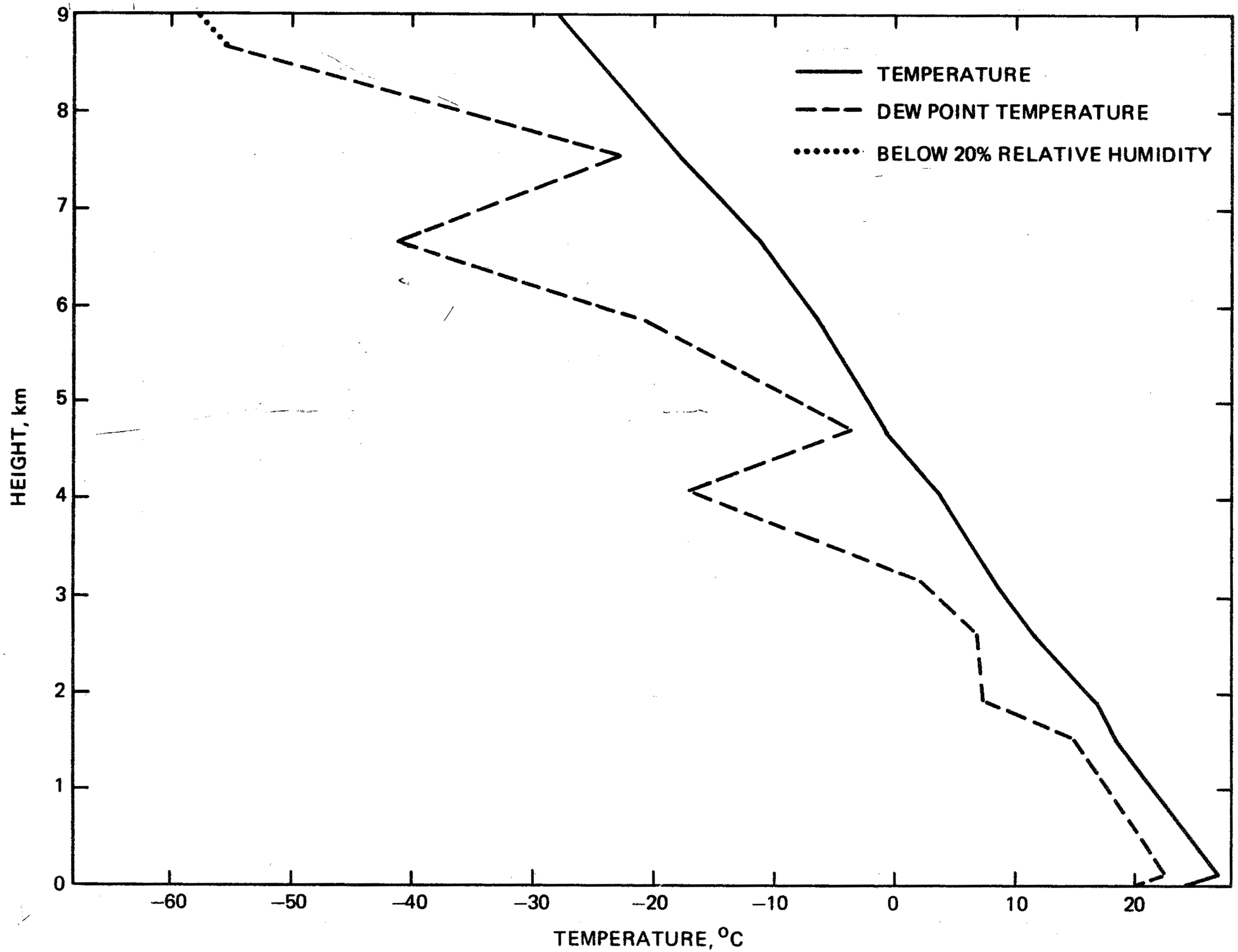
4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
JULY 27, 2000Z TO 0100Z, JULY 28, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2000	N	N	N	N	N	N	
2100	N	N	N	N	N	N	
2105		T					
2125		TRW					
2140		TRW–					
2147		RAIN ENDED					
2200	N	T	N	N	N	N	
2214		THUNDER ENDED					
2300	N	N	N	N	N	N	
2305			*				
0000	N	N	N	N	N	N	
0100	N	N	N	N	N	N	

*THUNDERSTORM REPORTED 20 MILES NNW OF PHF



WALLOPS RADIOSONDE DATA FOR
JULY 27, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, JULY 31, 1973

PERIOD: 0020Z to 0350Z August 1

1. RAIN TYPE:

Convergence thundershowers (Source: A. Arnold)

2. GENERAL DESCRIPTION:

A frontal system with waves cut diagonally across Indiana and produced showers in its advance. The general air flow at the lower levels was offshore. Reference to the 850 mbar map suggests convergence of air in the area of our observations. The identification that there was thunder associated with the observed showers is based on the report of thunder by Richmond, Virginia, about 90 mi. to the west of SPANDAR and about 25 mi. from the observed echoes. (Source: A. Arnold)

3. RAIN REPORTS:

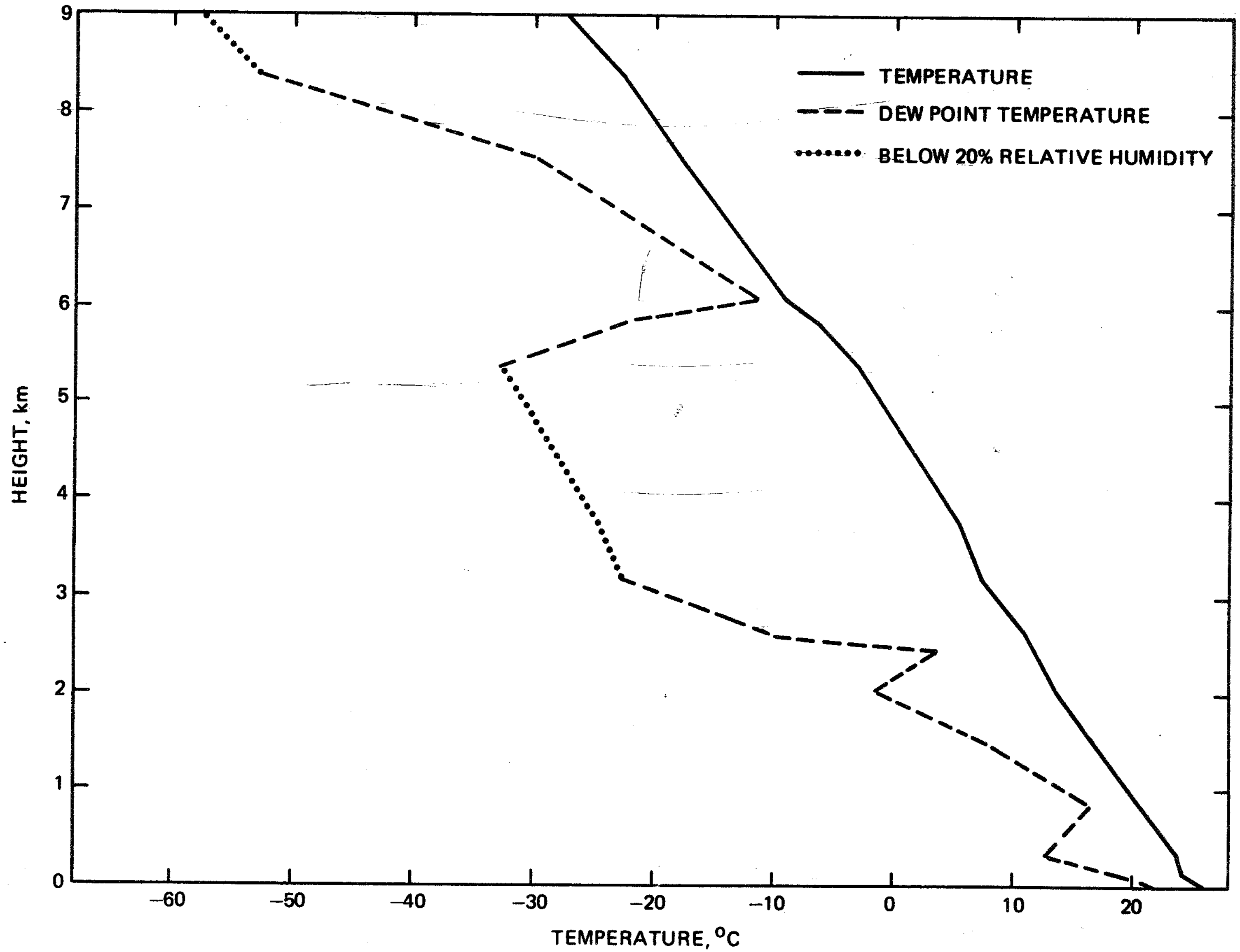
a. Rain gage at VOR: No rain (Source: Chart Record)

b. Rain gage at Wallops Island: No rain (Source: Form 10B)

c. Nearby Observing Stations: The only rain report came from Patuxent Naval Air Station. It reported a trace of rain between 0202Z and 0218Z, and again a trace starting before 0400Z and continuing at 0400Z. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)



WALLOPS RADIOSONDE DATA FOR
JULY 31, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, AUGUST 1, 1973

PERIOD: 2110Z August 1 to 0345Z August 2

1. RAIN TYPE:

Pre-frontal thundershowers. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

A cold front extended from northwest Pennsylvania across eastern Tennessee with evidence of an additional disturbance in central North Carolina. There were scattered showers and thundershowers. (Source: A. Arnold)

3. RAIN REPORTS:

a. Rain gage at VOR: No rain. (Source: Chart Record)

b. Rain gage at Wallops Island: No rain. (Source: Form 10B)

c. Nearby airport stations: Appended. (Source: Service A)

4. RADIOSONDE GRAPH:

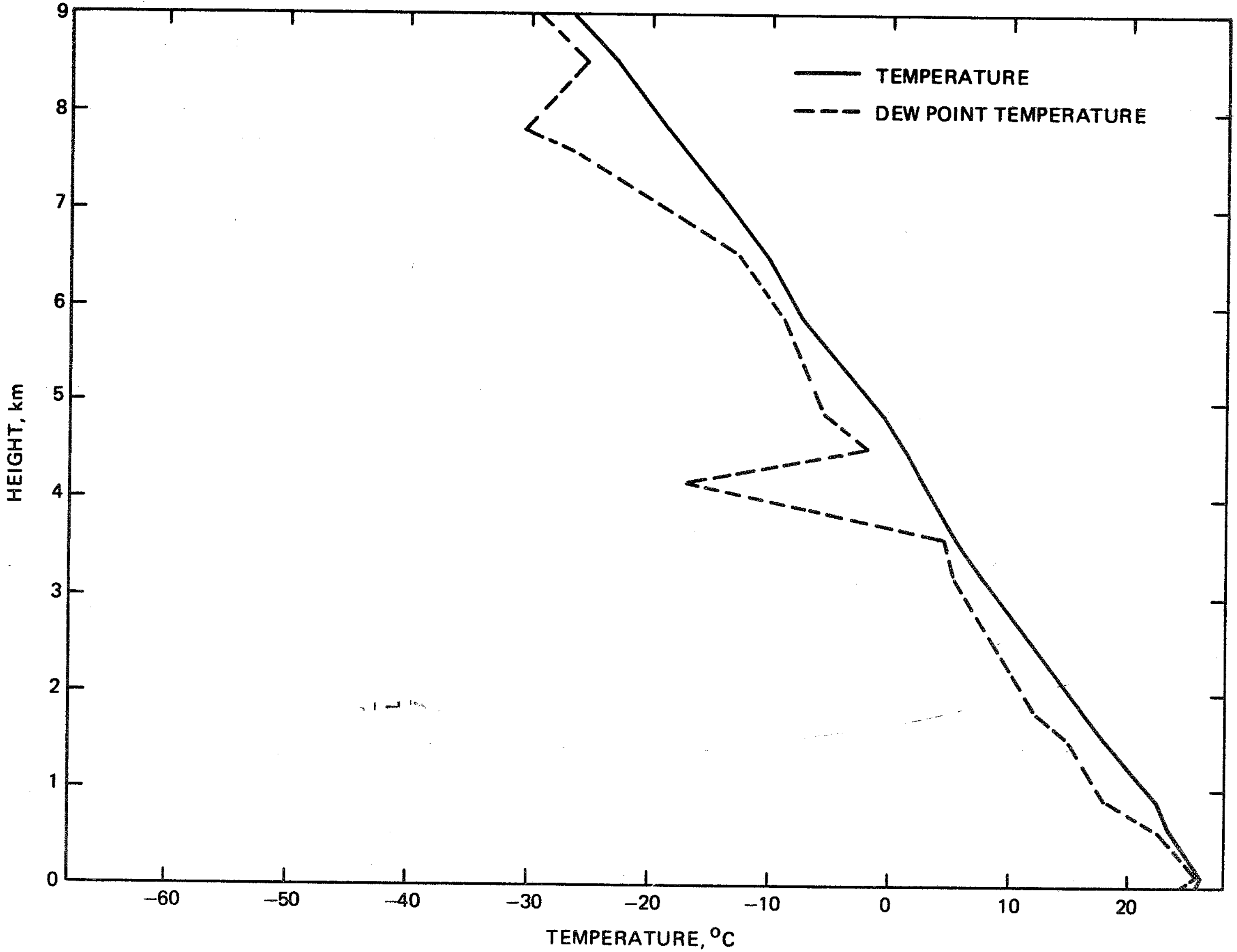
Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
AUG. 1, 2100Z TO 0400Z, AUG. 2, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2100	N	N	N**	RW–	RW–	T	
2109				TRW–			
2111						ENDED	
2122				T			
2131						RAIN BEGAN	
2135			RAIN BEGAN				
2142						ENDED	
2144				ENDED			
2145			ENDED				
2200	N	N	N	N	N	N	
2300	N	–	N	N	N	N	
0000	N	TRW–	N	N	N	N	
0052	RAIN BEGAN						
0054				THUNDER ENDED			
0100	RW––	–	N*	N	N*	N*	
0114				RW–			
0130				N			
0158		THUNDER ENDED					
0200	RW––	RW–	N	N	N	N*	
0221	ENDED						
0230		ENDED					
0230		THUNDER BEGAN					
0300	N	T	N	N	N	N	
0302		TRW					
0358		THUNDER ENDED					
0400	N	RW–	N	N	N	N	

*LIGHTNING

**RAIN SHOWER EAST AND SOUTHEAST OF PHF



WALLOPS RADIOSONDE DATA FOR AUGUST 1, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, AUGUST 2, 1973

PERIOD: 2100Z August 2 to 0340Z August 3

1. RAIN TYPE:

Squall-line thunderstorms and pre-frontal thundershowers. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

A squall line oriented approximately 210^0-30^0, was located approximately 40 mi. west of SPANDAR on the 2100Z map. It was not shown on the 0000Z or 0300Z map. Farther to the west there was a cold front from western Virginia through east-central Pennsylvania. Showers or thundershowers at one time or other appeared in most of the land area within the SPANDAR range. (Source: A. Arnold)

3. RAIN REPORTS:

a. Rain gage at VOR: (Source: Chart Record)

Time (Z)	Amount Precipitation (mm)
2230-2300	9.4
2300-2330	1.2
2330-0030	0.4

b. Rain gage at Wallops Island: (Source: Form 10B)

Time (Z)	Amount Precipitation (in.)
2100-2200	0.04
2200-2335	Trace

c. Some peak rain intensities observed by rain gage at VOR:

Rain Rate (mm/hr)	Approximate Time, Z
60	2232 to 2236
32	2236 to 2240
15	2240 to 2249

METEOROLOGICAL SITUATION REPORT, AUGUST 2, 1973 (Continued)

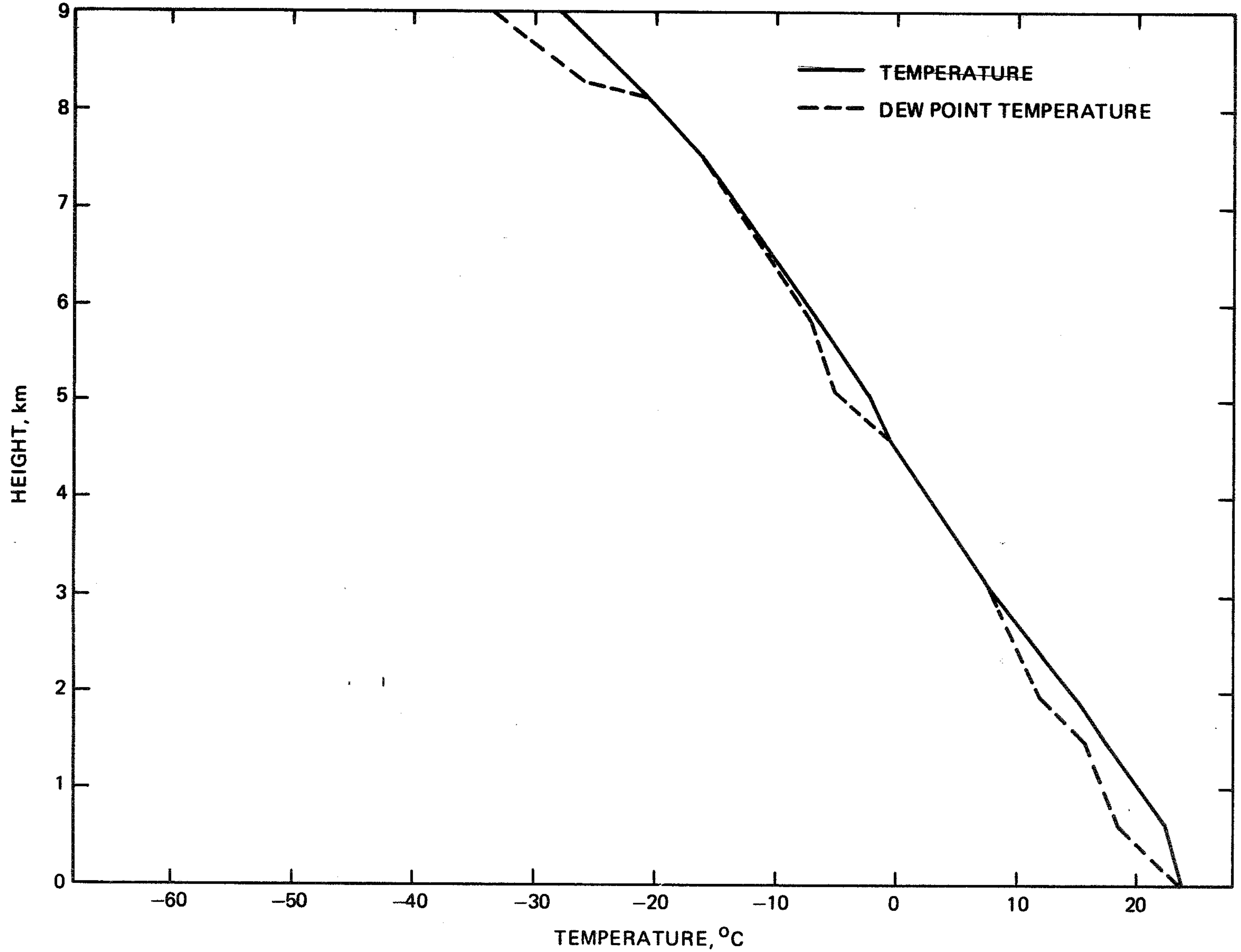
d. Nearby Airport Stations: Appended. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
AUG. 2, 2100Z TO 0400Z, AUG. 3, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2100	RW––	N	RW–	RW–	N	N	
2106				N			
2115			ENDED				
2125						RAIN BEGAN	
2135						ENDED	
2200	RW––	N	N	N	N	N	
2205						RAIN BEGAN	
2215						ENDED	
2256	*						
2300	RW––	N	N	N	N	N	
2325						RAIN BEGAN	
2340				THUNDER BEGAN	RAIN BEGAN		
2350			RAIN BEGAN				
0000	RW–	N	RW	T	RW––	RW–	
0001			TRW+				
0005				TRW–			
0010						ENDED	
0015					ENDED		
0020			THUNDER ENDED				
0023			RW––				
0027				RW–			
0100	RW––	N	RW––	RW–	N	N	
0102				RW			
0112			RW–	RW–			
0115	ENDED						
0133			ENDED				
0200	N	N	N	RW–	N	N	
0226				N			
0300	N	N	N	N	N	N	
0345		RAIN BEGAN					
0350		THUNDER BEGAN					
0400	N	TRW––	N	N	N	N	
*AIRCRAFT REPORTS THUNDERSTORM 22 MILES NORTHWEST OF SBY							



WALLOPS RADIOSONDE DATA FOR
AUGUST 2, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, AUGUST 3, 1973

PERIOD: 2055Z August 3 to 0340Z August 4

1. RAIN TYPE:

Cold frontal thunderstorms to the south in general Norfolk area and to the east. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

A slowly moving cold front that has been influencing the weather in the SPANDAR observation area for the two preceding days has moved off-shore cutting inland at the southeastern corner of Virginia. Copious precipitation that often accompanies a slow moving front was observed. For example, for the 6 hours (1800Z to 0000Z), Hampton reported 4 in., Norfolk 2 in. and Newport News 1 in. (Source: A. Arnold)

3. RAIN REPORTS:

a. Rain gage at VOR: (Source: Chart Record)

Time (hr ending) Z	Amount Precipitation (mm)
2100	0.2
2200	0.8
2300	1.2
0000	0.4
0100	0.2

b. Rain gage at Wallops Island: (Source: Form 10B)

Time (hr ending) Z	Amount Precipitation (in.)
2100	.08
2200	.07
2300	.07
0000	.03

b. Rain gage at Wallops Island (continued)

Time (hr ending) Z	Amount Precipitation (in.)
0100	.03
0200	.01
0300	Trace
0400	Trace

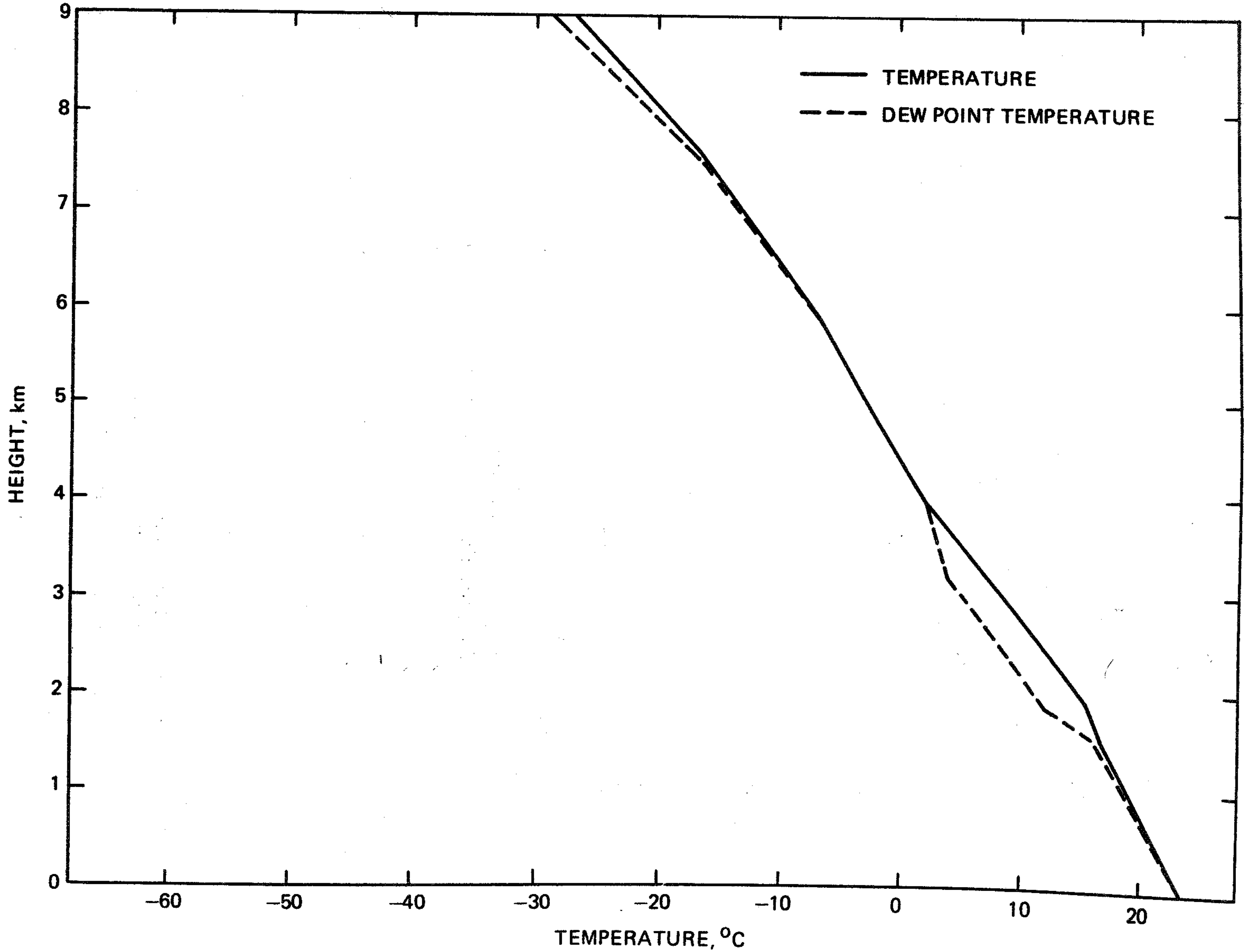
c. Nearby Airport Stations: Appended. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
AUG. 3, 2000Z TO 0400Z, AUG. 4, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2000	N	RW–	R	–	TRW+	TRW+	R–
2010			R		TRW		
2035					TRW–		
2037				TRW–			
2100	N	RW–	R	TRW–	TRW	TRW+	R–
2107				RW			
2110					RW–		
2114			R				
2127						THUNDER ENDED	
2145				RW			
2200	N*	R––	R–	RW–	RW	RW–	–
2216			R–				
2229						THUNDER BEGAN	
2245					THUNDER BEGAN		
2300	N	N	R–	RW–	TRW–	TRW+	–
2316				RW–	R–	THUNDER ENDED	
2340				THUNDER BEGAN	THUNDER ENDED		
0000	N	N	R–	TRW–	RW–	RW–	–
0010				R–			
0017						RW–	
0100	N	N	R–	R–	RW–	R–	
0116						R–	
0139				R–			
0200	N	N	R–	R–	RW––	R–	
0230					ENDED		
0234				N			
0243						ENDED	
0300	N	N	N	N	N	N	
0400	N	N	N	N	N	N	
*INTERMITTENT R––							



WALLOPS RADIOSONDE DATA FOR AUGUST 3, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, AUGUST 13, 1973

PERIOD: 2115Z August 13 to 0350Z August 14

1. RAIN TYPE:

Pre-frontal thundershowers. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

There was a stationary front just beyond the SPANDAR range to the south and west. The front, configured like a warm front, produced scattered showers and thundershowers in our area of observation. (Source: A. Arnold)

3. RAIN REPORTS:

a. Rain gage at VOR: None measured. (Source: Chart Record)

b. Rain gage at Wallops Island: There was 0.04 in. of rain in the hour ending at 0400Z. (Source: Form 10B)

c. Nearby Airport Stations: Appended. (Source: Service A)

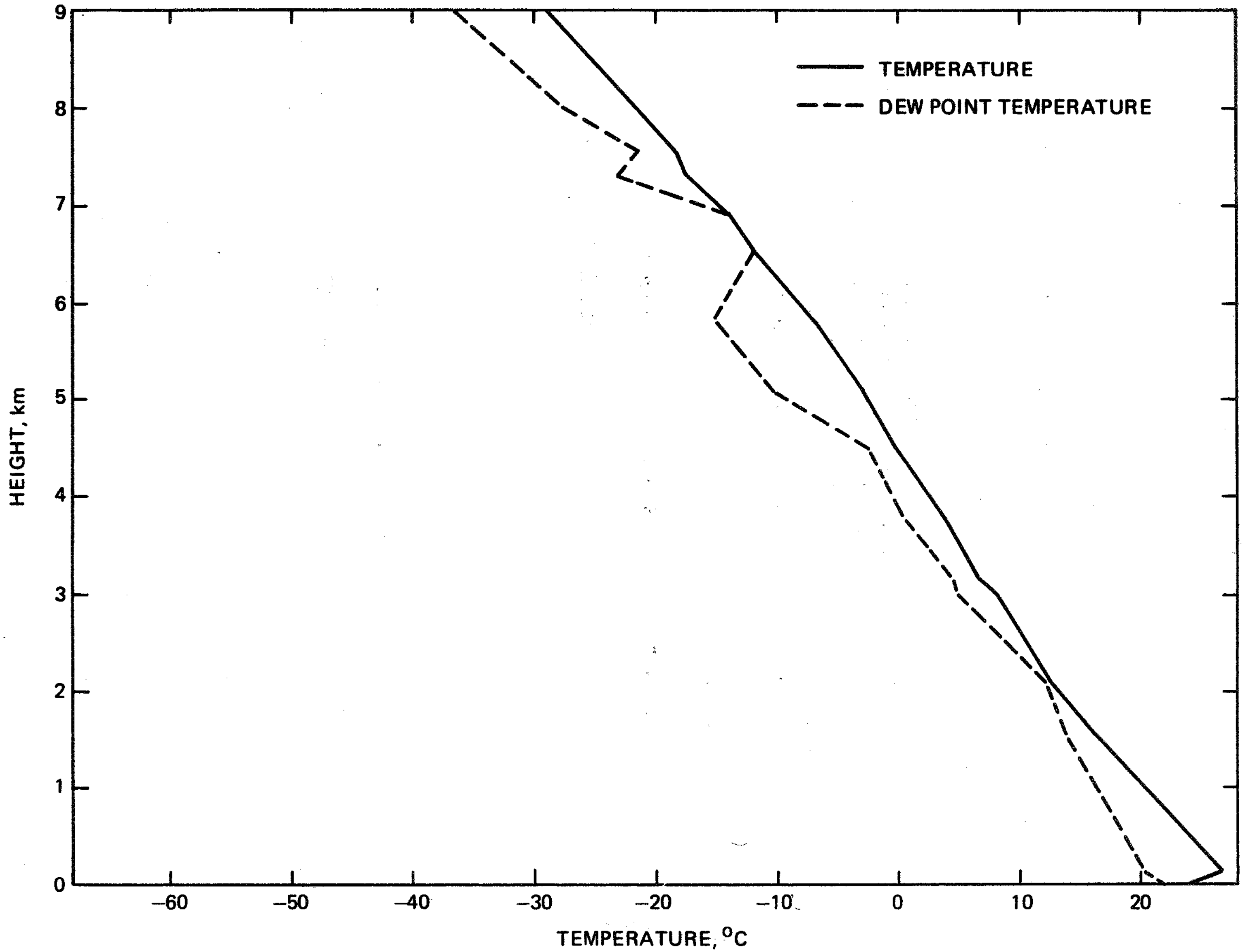
4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS

AUG. 13, 2100Z TO 0400Z, AUG. 14, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2100	N	N	N	N	N	N	
2200	N	N	N	N	N	N	
2246		RAIN BEGAN					
2300	N	RW–	N	N	N	N	
2317		ENDED					
0000	N	N	N	N	N	N	
0100	N	N	N	N*	N*	N*	
0200	N	N	N*	N*	N	N*	
0224			TRW–				
0233				T			
0237					RAIN BEGAN		
0239				TRW–			
0242						RAIN BEGAN	
0243					TRW		
0245		RAIN BEGAN					
0300	N	RW–	TRW	TRW+	TRW	RW–	
0302		TRW–					
0308				TRW–			
0315					RAIN ENDED		
0330			THUNDER ENDED			ENDED	
0335			RAIN ENDED				
0340	RAIN BEGAN						
0342				TRW–			
0348				T			
0356					THUNDER ENDED		
0400	RW	TRW–	N	T	N	N	
*LIGHTNING							



WALLOPS RADIOSONDE DATA FOR
AUGUST 13, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, AUGUST 14, 1973

PERIOD: 2120Z August 14 to 0335Z August 15

1. RAIN TYPE:

Frontal thunderstorms to the north.

Convergence (air mass) thundershowers to the south. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

There was a Low in Ohio with a stationary front extending eastward through southern Delaware. The thundershowers in the SPANDAR range were associated with this front and associated with the warm sector that covered Virginia. The 2100Z map shows a Low within the warm sector centered near Richmond; this may also have contributed to the thundershowers that were reported throughout the area. (Source: A. Arnold)

3. RAIN REPORTS:

a. Rain gage at VOR: (Source: Chart Record)

Time (hr ending) Z	Amount Precipitation (mm)
2400	.06
0100	.16
0200	.10

b. Rain gage at Wallops Island: (Source: Form 10B)

Time (hr ending) Z	Amount Precipitation (in.)
2200	.02
2300	.03
2400	.02
0100	.15

METEOROLOGICAL SITUATION REPORT, AUGUST 14, 1973 (continued)

b. Rain gage at Wallops Island (continued)

Time (hr ending) Z	Amount Precipitation (in.)
0200	.13
0300	Trace
0400	01

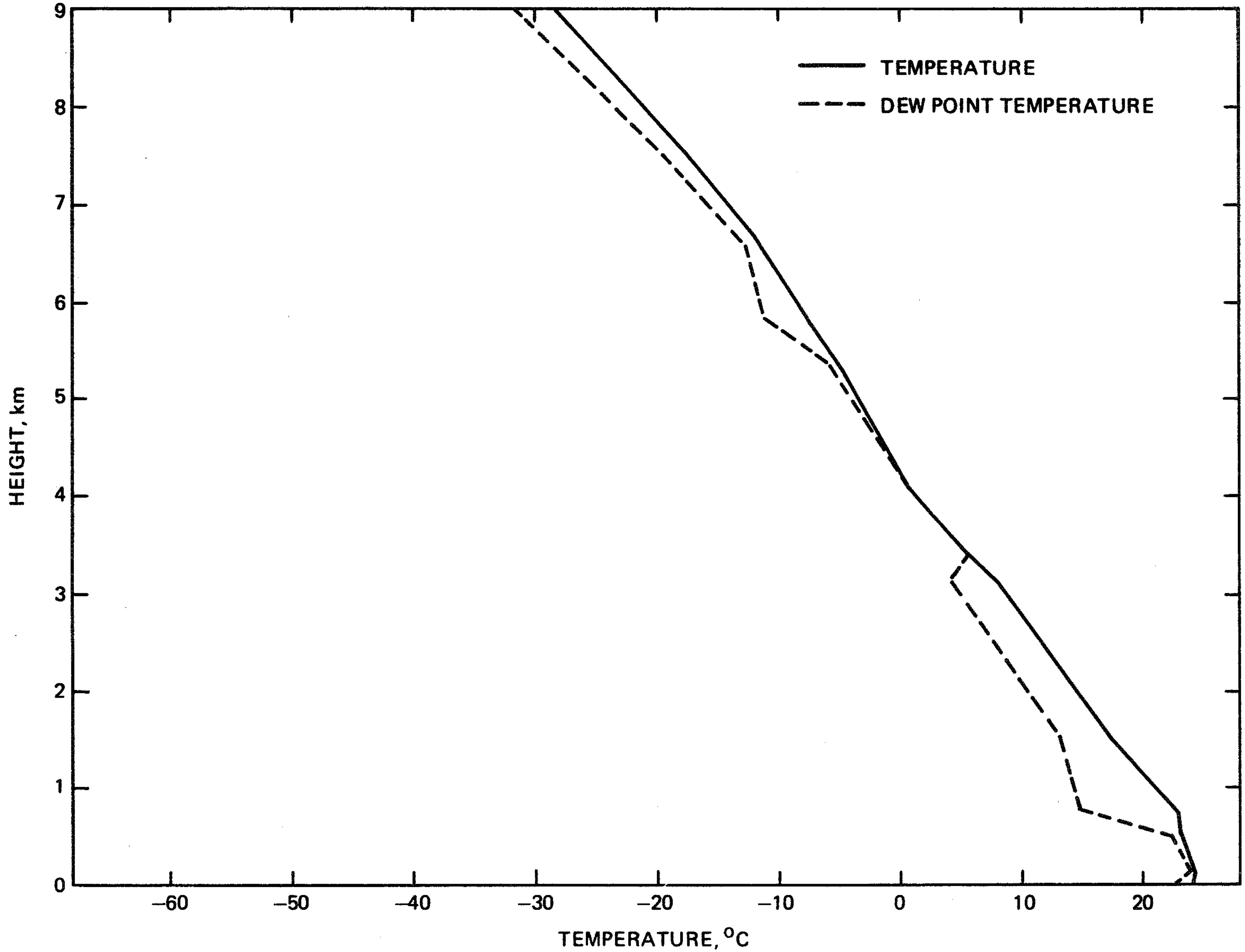
c. Nearby Airport Stations: Appended. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
AUG. 14, 2100Z TO 0400Z, AUG. 15, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2100	N	N	N	N	N	N	
2136						RAIN BEGAN	
2140			RAIN BEGAN				
2142						ENDED	
2150		RAIN BEGAN	THUNDER BEGAN				
2200	N	RW--	TRW-	N	N	N	
2210				THUNDER BEGAN	THUNDER BEGAN		
2214						THUNDER BEGAN	
2215		THUNDER BEGAN			RAIN BEGAN		
2230					RAIN ENDED		
2300	N	TRW-	TRW	TRW-	T	T	
2307				TRW			
2316						TRW--	
2318				TRW+	TRW-		
2320		THUNDER ENDED					
2323					TRW+		
2326				TRW-			
2334						TRW-	
2338					TRW+		
2345			THUNDER ENDED				
0000	N*	RW--	R--	TRW-	T	TRW--	
0020	TR+			RW-			
0026				N			
0030			ENDED				
0056					ENDED		
0100	TR	N	N	N*	N	T	
0110	THUNDER ENDED						
0122						ENDED	
0125	R--						
0140	ENDED						
0200	N*	N	N	N	N	N	
0300	N	N	N	N	N	N	
0330					RAIN BEGAN		
0338					TRW		
0400	N	N	N	N	TRW	N*	
*LIGHTNING							



WALLOPS RADIOSONDE DATA FOR
AUGUST 14, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, AUGUST 15, 1973

PERIOD: 2315Z August 15 to 0335Z August 16

1. RAIN TYPE:

Frontal thundershowers and showers. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

The weak cold front that had been located from central Ohio to eastern Tennessee, 24 hrs before, moved quickly through the area of observation and weakened further. There were scattered showers and thundershowers, before, during, and after frontal passage. The only rain reported by airport stations in our area was at Salisbury, Md., and was post-frontal. (Source: A. Arnold)

3. RAIN REPORTS:

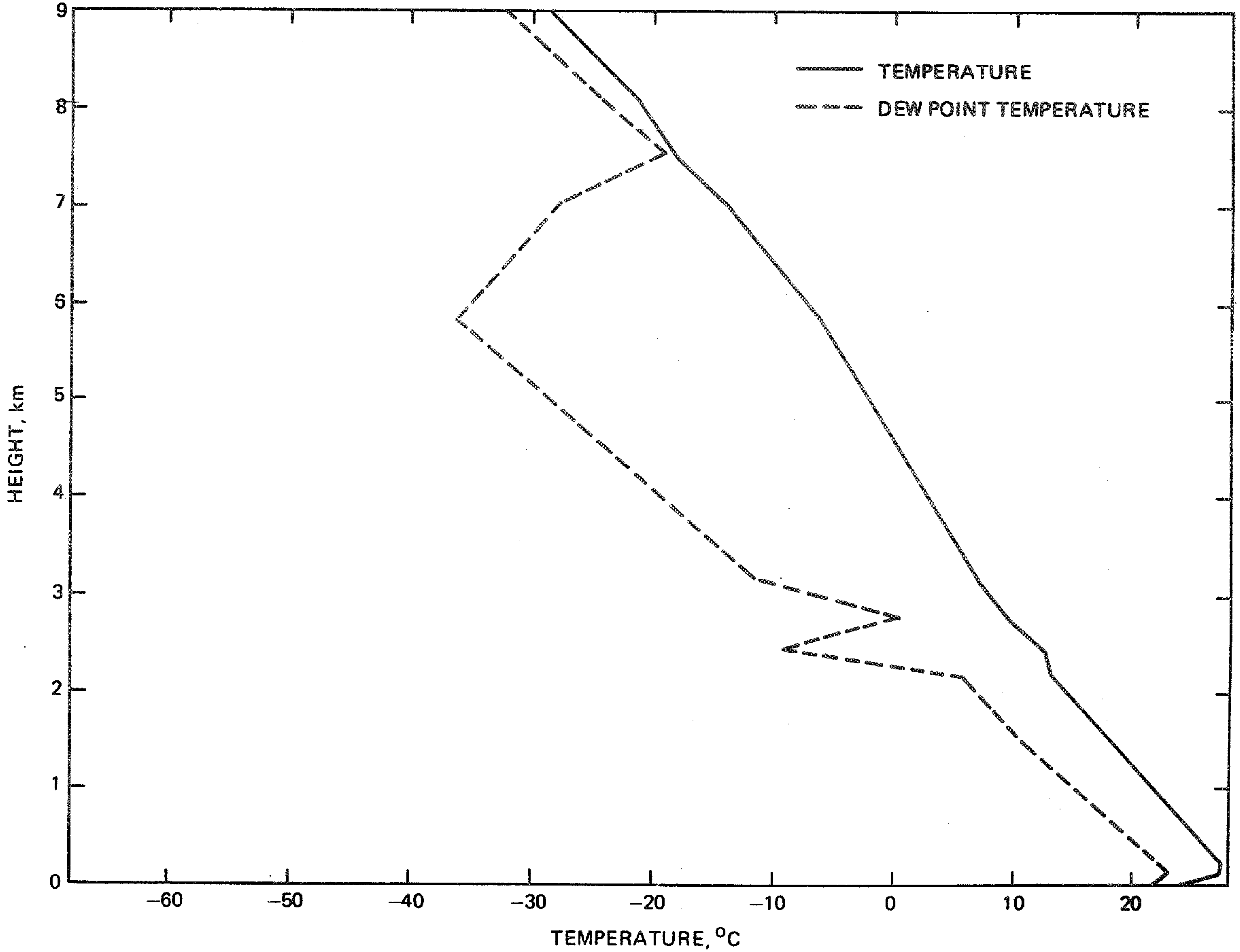
a. Rain gage at VOR: No rain measured. (Source: Chart Record)

b. Rain gage at Wallops Island: No rain reported. (Source: Form 10B)

c. Nearby Airport Stations: Of the several airport stations within the SPANDAR range only Salisbury airport reported a rain shower (between 0227Z and 0345Z) and thunder (between 0225Z and 0340Z). The total rainfall was 0.39 in. However, all the airport stations reported seeing lightning at 0100Z or at 0200Z, or at both hours.

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)



WALLOPS RADIOSONDE DATA FOR AUGUST 15, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, AUGUST 16, 1973

PERIOD: 2055Z August 16 to 0315Z August 17

1. RAIN TYPE:

Scattered (post-frontal) showers. (Source: A. Arnold)

2. GENERAL DESCRIPTION

A cold front extended through North Carolina and east-northeastward over the ocean. There were widely scattered showers. (Source: A. Arnold)

3. RAIN REPORTS:

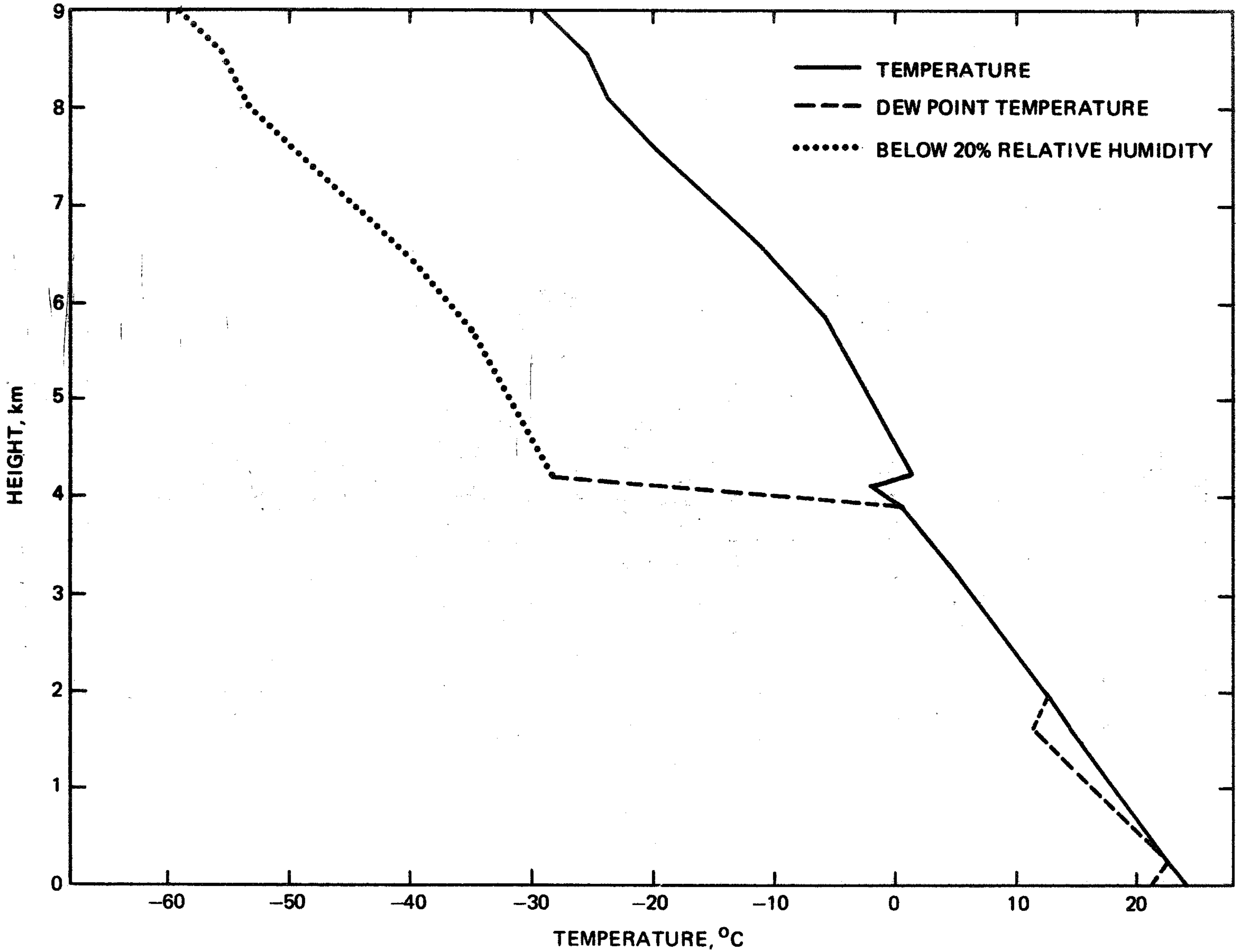
a. Rain gage at VOR: No rain measured. (Source: Chart Record)

b. Rain gage at Wallops Island: No rain reported. (Source: Form 10B)

c. Nearby Airport Stations: None of the nearby airport stations reported rain during the period of SPANDAR observation. However, Salisbury, Md., relayed an aircraft report that at 2135Z there was a heavy rain shower over Tangier, Virginia. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)



WALLOPS RADIOSONDE DATA FOR AUGUST 16, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, AUGUST 17, 1973

PERIOD: 2150Z to 2155Z

1. RAIN TYPE:

Scattered isolated showers due to convergence. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

There was a Low to the southwest near the Tennessee-North Carolina border with a stationary frontal system that contained waves. The observed showers were well in advance of this system and presaged its influence subsequently on the morning of the 18th. The showers observed are ascribed to slight convergence since the frontal system was felt to be too far away to be of immediate influence. (Source: A. Arnold)

3. RAIN REPORTS:

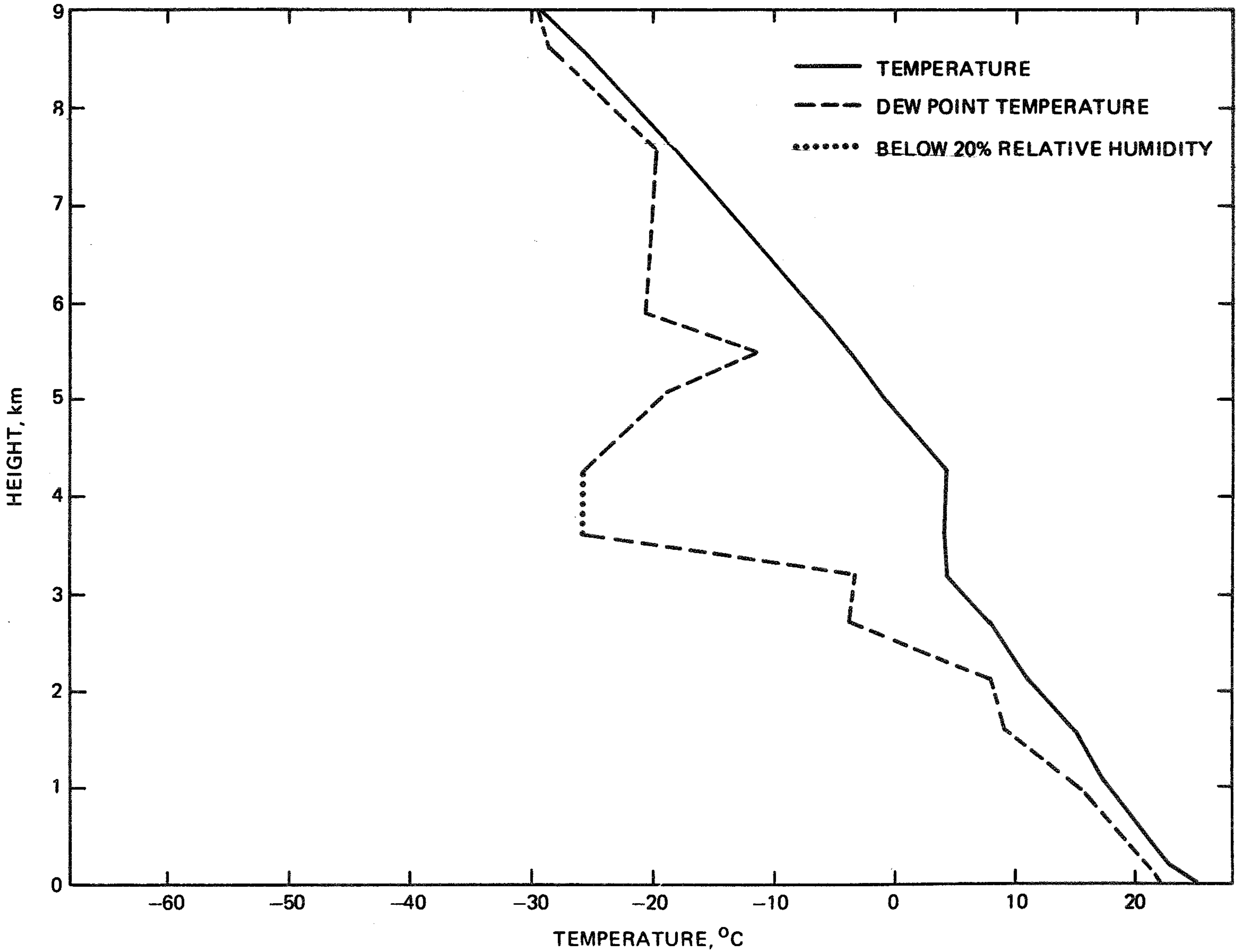
a. Rain gage at VOR: None measured. (Source: Chart Record)

b. Rain gage at Wallops Island: None reported. (Source: Form 10B)

c. Nearby Airport Stations: No station reported rain during the SPANDAR observation period. The Patuxent Naval Air Station reported a brief sprinkle at about 0000Z. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)



WALLOPS RADIOSONDE DATA FOR AUGUST 17, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, AUGUST 20, 1973

PERIOD: 2035Z August 20 to 0335Z August 21

1. RAIN TYPE:

Trough-induced thundershowers. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

A trough of low pressure lay just west of the SPANDAR area. There was a cold front farther to the west from central Pennsylvania to western Virginia. A low formed over southeastern Virginia during the observation period. Showers and thundershowers appeared at scattered locations in the observation area.

3. RAIN REPORTS:

a. Rain gage at VOR: No rain measured. (Source: Chart Record)

b. Rain gage at Wallops Island: No rain reported. (Source: Form 10B)

c. Nearby Airport Stations: Appended. (Source: Service A)

4. RADIOSONDE GRAPH:

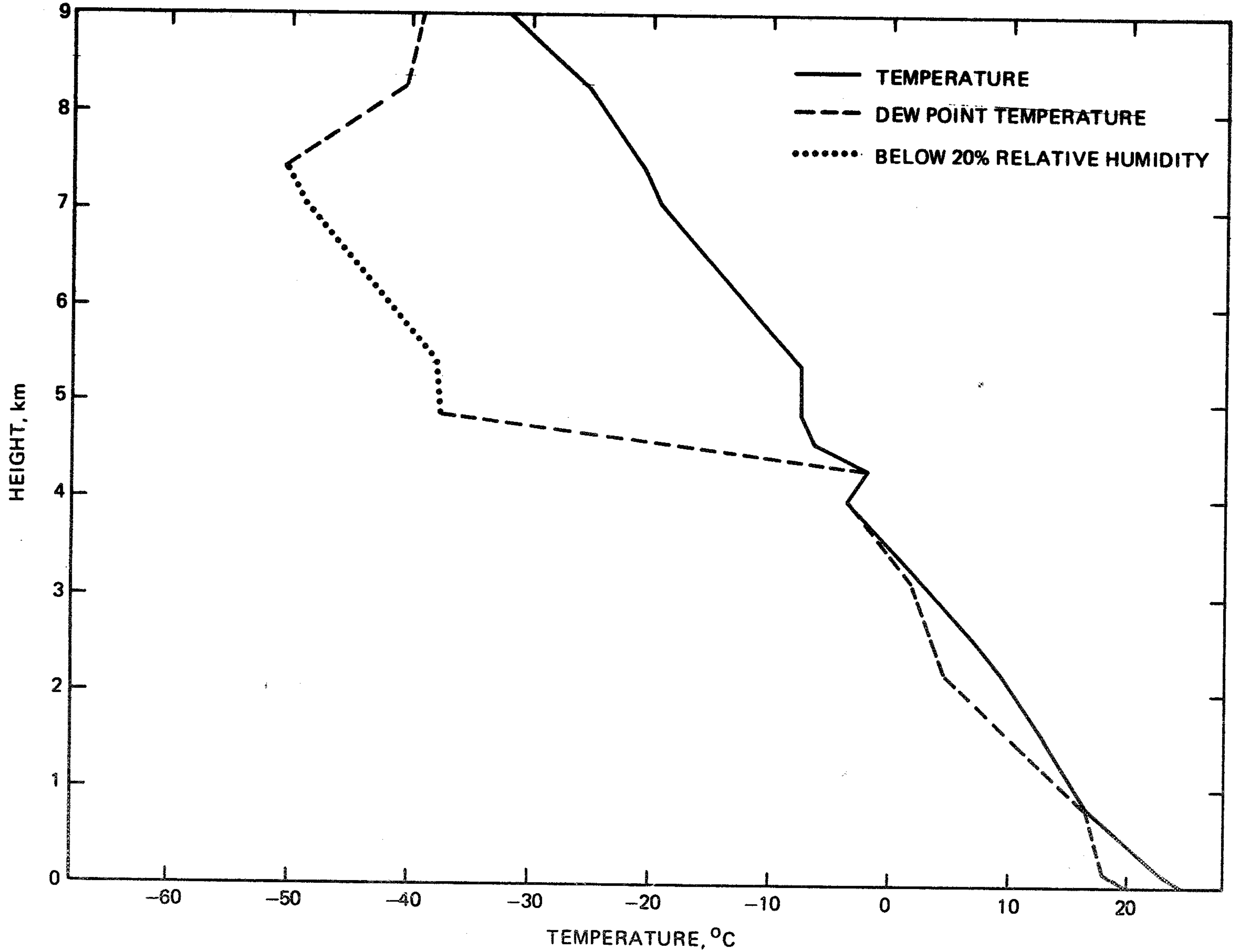
Appended. (Source: Wallops Island sonde evaluation)

OBSERVATIONS FROM LOCAL WEATHER STATIONS
AUG. 20, 2000Z TO 0400Z, AUG. 21, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2000	RW–	N	N		N	N	
2010	ENDED						
2100	N	N	N		N	–	
2200	N	N	N		N	N	
2300	N	–	N		N	N	
2326		N**					
2339		RW+					
0000	N	RW–	N		N	N	
0100	N	N	N		N	N	
0200	N	N	N		N	N	
0235			THUNDER BEGAN				
0240						RAIN BEGAN	
0245					RAIN BEGAN		
0300	N	N	T		RW–	RW–	
0302			RAIN BEGAN				
0320			TRW–				
0337			TRW+				
0356					THUNDER BEGAN		
0400	N	N*	TRW+		TRW–	RW*	

*LIGHTNING

**RAIN SHOWER TO SOUTHEAST OF NHK



WALLOPS RADIOSONDE DATA FOR
AUGUST 20, 1973 RELEASED AT 2315Z

METEOROLOGICAL SITUATION REPORT, AUGUST 21, 1973

PERIOD: 2110Z August 21 to 0330Z August 22

1. RAIN TYPE:

Frontal showers and possible thundershowers. (Source: A. Arnold)

2. GENERAL DESCRIPTION:

A cold front lay just west of the SPANDAR observation area at 2100Z and (to the west) within our observation area from about 2300Z onward. The front was near to and paralleled the coast line. The 0000Z map showed a Low near Hatteras, N.C. There were only occasional scattered reports of thunder, none during the period of SPANDAR operation - so the typing, above, emphasizes the showers. (Source: A. Arnold)

3. RAIN REPORTS:

a. Rain gage at VOR: (Source: Chart Record)

Time (quarter hr ending) Z	Amount Precipitation (mm)
2115	0.8
2130	1.6
2145	1.0
2200	1.0
2215	3.5
2230	16.1
2245	9.3
2300	11.7
2315	1.2
2315 - 0030	no measurable rain
0045	2.2

METEOROLOGICAL SITUATION REPORT, AUGUST 21, 1973 (continued)

a. Rain gage at VOR (continued)

Time (quarter hr ending) Z	Amount Precipitation (mm)
0045 - 0145	no measurable rain
0200	0.8
0215	10.7
0230	0.4
0245	7.0
0300	0.4
0315	0.2
0330	no measurable rain

b. Rain gage at Wallops Island; (Source: Form 10B)

Time (hr ending) Z	Amount Precipitation (in.)
2200	0.61
2300	0.29
2400	Trace
0100	Trace
0200	Trace
0300	Trace
0400	0.02

c. Some peak rain intensities observed by rain gage at VOR:

Rain Rate (mm/hr)	Approximate time, Z
84	2221 (for 1.0 min.)

c. Some peak rain intensities observed by rain gage at VOR (continued)

Rain Rate (mm/hr)	Approximate Time, Z
78	2223 (for 1.7 min.)
80	2226 (for 1.8 min.)
102	2228 (for 1.3 min.)
72	0237 (for 1.0 min.)
70	0238 (for 1.2 min.)

d. Heavy rainfall at nearby weather stations:

Salisbury, Md. had 1.50 in. for 6 hours ending 0600Z August 22.

Pocomoke City, Md. had 7.2 in. of rain between 2100Z August 11 and 1100Z August 22.

Pocomoke City also had the greatest 24 hr precipitation, 7.39 in. for all stations in Maryland, Delaware, and Virginia for the months May to August 1973 (for the day ending at 2100Z, August 22).

Nelsonia, Va. had 6.20 in. of rain for August 21.

Wallops Station, Va. had 4.77 in. of rain for the 24 hrs ending 1100Z August 22. Rain gage at VOR had 120 mm (4.74 in.) of rain for the period 1910Z August 21 to 1400Z August 22.

e. Nearby Airport Stations: Appended. (Source: Service A)

4. RADIOSONDE GRAPH:

Appended. (Source: Wallops Island sonde evaluation)

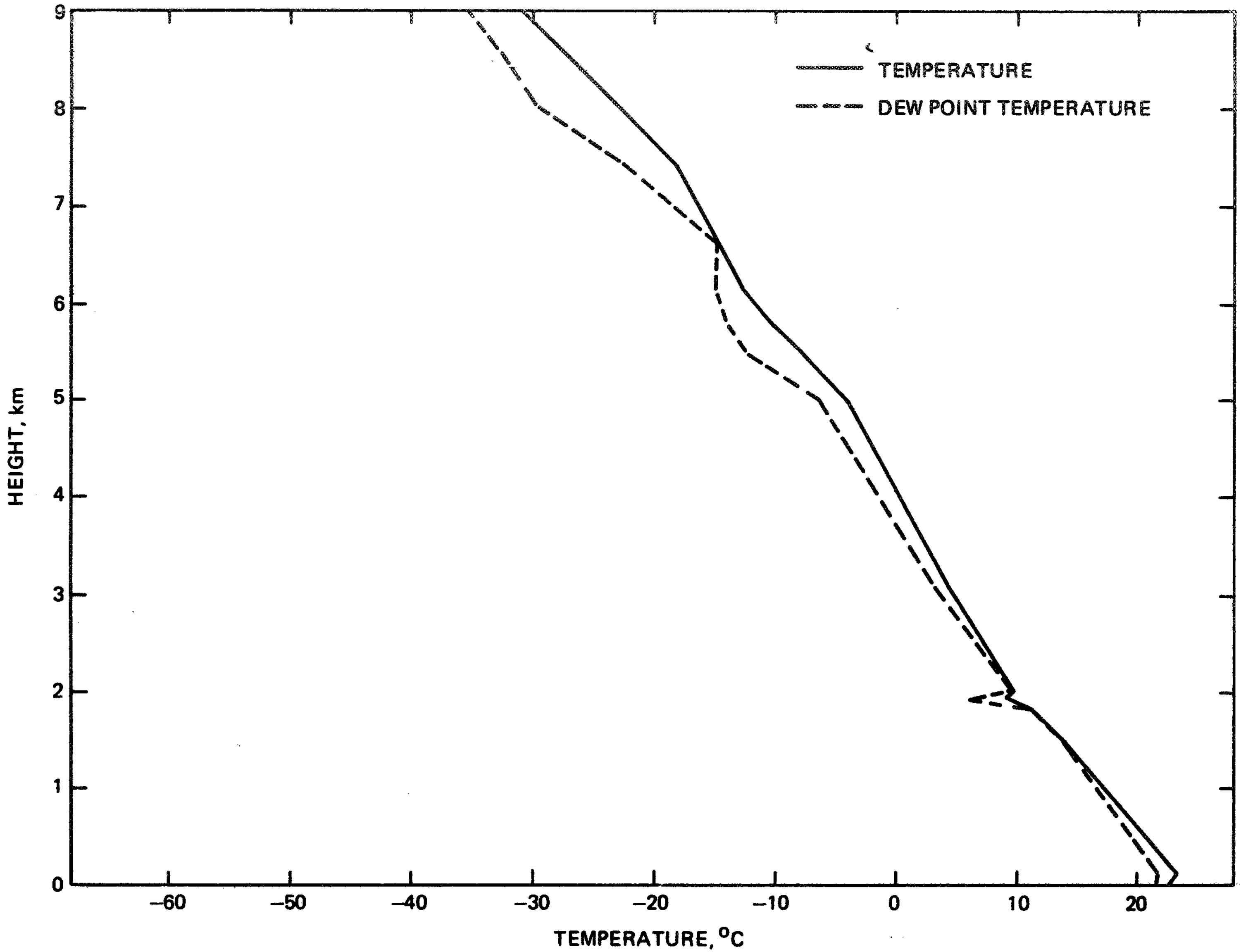
OBSERVATIONS FROM LOCAL WEATHER STATIONS
AUG. 21, 2100Z TO 0400Z, AUG. 22, 1973

TIME Z	SBY	NHK	PHF	LFI	NGU	ORF	WAL
2100	–	N	N		N	N	
2143						RAIN BEGAN	
2145		RAIN BEGAN					
2200	–	RW–	N		N	RW–	
2205						ENDED	
2214		ENDED					
2300	RW–	N	N		N	N	
2306			RAIN BEGAN				
2333			R*				
0000	RW–	N	R*		N	N	
0100	R––	N	R–		N	N	
0132			ENDED				
0200	R–**	N	N		N	N	
0300	R	N	N		N	N	
0335						RAIN BEGAN	
0400	R	–	N***		N	RW–	

*MODERATE RAIN OCCASIONALLY LIGHT RAIN

**LIGHT RAIN OCCASIONALLY MODERATE

***INTERMITTENT SPRINKLE



WALLOPS RADIOSONDE DATA FOR
AUGUST 21, 1973 RELEASED AT 2355Z

*U.S. GOVERNMENT PRINTING OFFICE: 1975 - 635-275/29