NBSIR 81-1656

NBS 30/60 MEGAHERTZ NOISE MEASUREMENT SYSTEM OPERATION AND SERVICE MANUAL

George J. Counas
Thomas H. Bremer

Electromagnetic Fields Division
National Engineering Laboratory
National Bureau of Standards
U.S. Department of Commerce
Boulder, Colorado 80303

December 1981

U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, Secretary

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

NBSIR 81-1656

NBS 30/60 MEGAHERTZ NOISE MEASUREMENT SYSTEM OPERATION AND SERVICE MANUAL

George J. Counas
Thomas H. Bremer

National Bureau of Standards
U.S. Department of Commerce
Boulder, Colorado 80303

December 1981

TABLE OF CONTENTS

Page

ABSTRACT..1

1. INTRODUCTION...3

2. GENERAL THEORY OF OPERATION..............................4

A. DESCRIPTION OF MEASUREMENT SYSTEM........................4

B. ANATOMY OF A MEASUREMENT.................................10

3. OPERATING INSTRUCTIONS...................................18

A. ADDITIONAL EQUIPMENT REQUIRED............................18

B. GETTING STARTED..18

C. PREPARING THE SYSTEM FOR MEASUREMENT.....................19

1. POWER-OFF INSPECTION AND SETUP...........................19

2. POWER-ON CHECKS AND SYSTEM WARMUP.........................23

3. LOADING AND EXECUTING THE MEASUREMENT PROGRAM.............24

D. SYSTEM TURN-OFF..29

4. SOFTWARE...30

A. GENERAL DESCRIPTION AND SUBPROGRAMS......................30

B. MATRICES...34

C. EQUATIONS..46

5. MAINTENANCE..50

A. EQUIPMENT DESCRIPTION....................................50

B. SYSTEM CHECKS..51

C. COMPONENT DESCRIPTION AND TECHNICAL INFORMATION..........54

1. Switch Driver Module.....................................54

a) Power Supplies and Switches..............................54

b) Card 110, Decoder Card...................................54

c) Switch Driver Cards......................................60

d) 117 Output Display Card Operation and Adjustment..63

TABLE OF CONTENTS continued

Page

2. 30 MHz and 60MHz PREAMPLIFIERS........................71

3. INTERCONNECTION AND WIRING DIAGRAMS...................73

4. PARTS LISTS...74

ACKNOWLEDGMENTS 99

REFERENCES...100

APPENDIX I...101

LIST OF FIGURES

page

Figure 1. 30/60 MHz Radiometer-Illustration....................2

Figure 2. Simplified Block Diagram of Noise Measurement System....5

Figure 3. 30/60 MHz Radiometer-Block Diagram....................6

Figure 4. Sample System Printout Part 1.........................11

Figure 5. Sample System Printout Part 2.........................12

Figure 6. Ambient and Cryogenic Noise Standards.................20

Figure 7. Functional Diagram of Software Segments...............32

Figure 8. 30/60 MHz Radiometer Block Diagram....................55

Figure 9. 110 Decoder Card Schematic Diagram....................56

Figure 10. Decoder Chip Truth Table.............................57

Figure 11. 110 Decoder Card Parts Placement.....................58

Figure 12. 111-114 Switch Driver Card Schematic Diagram.........61

Figure 13. Switch Driver Card Parts Placement...................62

Figure 14. 117 Output Display Card Schematic Diagram... 65

Figure 15. 117 Output Display Card Front Panel Connections.......66

Figure 16. 117 Output Display Card Parts Placemenmt.............67

Figure 17. 30 MHz and 60 MHz Preamplifier Schematic Diagram.....72

Figure 18. POWER METER WIRING DIAGRAM AND SCANNER CONNECTIONS······75

Figure 19. NOISE STANDARDS WIRING DIAGRAM AND SCANNER CONNECTIONS...76

Figure 20. System Cable Interconnection Diagram.................77

Figure 21. Pin Connections for J104, Switch Driver Module Input....78

Figure 22. Pin Connections for J102, Switch Driver Module Output...79

Figure 23. Complete Wiring Diagram for J 102....................80

Figure 24. J110, Decoder Card Input and Output Connector........81

LIST OF FIGURES continued

Page

Figure 25. J111, Switch Driver Card Input and Output Connector.....82

Figure 26. J112, Switch Driver Card Input and Output Connector.....83

Figure 27. J113, Switch Driver Card Input and Output Connector.....84

Figure 28. J114, Switch Driver Card Input and Output Connector.....85

FIGURE 29. J117, Output Display Card Input and Output Connector....86

LIST OF TABLES

Page

Table 1. LOSS CONSTANTS AND UNCERTAINTIES 21

Table 2. N Matrix Contents..36

Table 3. M Matrix Contents..41

Table 4. Z Matrix Contents..43

Table 5. SYSTEM CABLES--INSTRUMENTS TO SCANNER 73

Table 6. MANUFACTURER'S CODE TABLE 87

Table 7. Parts List for Switch Driver Module Components.........91

IMPORTANT NOTICE

The specific components selected for the system were chosen on the basis of suitability, availability, and cost. They do not necessarily represent the only possible choice or even the best choice. The National Bureau of Standards states only that they were used in the system described here. Substitution of nominally equivalent components meeting the same specification should cause no difficulty; however NBS has not tested all such possible choices

NBS 30/60 MEGAHERTZ NOISE MEASUREMENT SYSTEM

OPERATION AND SERVICE MANUAL

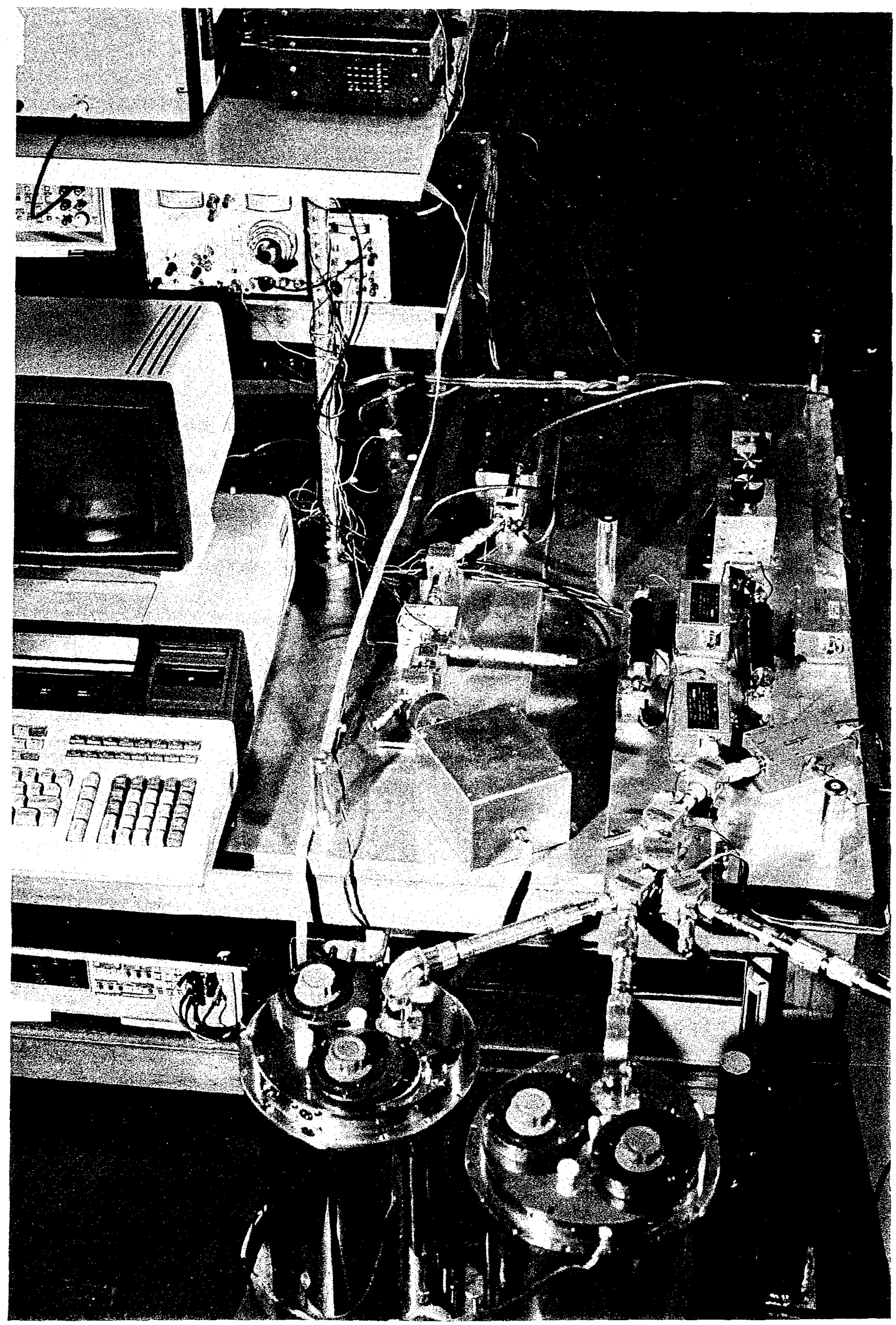
BY

George Counas and Tom Bremer
Electromagnetic Fields Division
National Bureau of Standards
Boulder, Colorado 80303

Calibration of coaxial noise sources at 30 and 60 MHz is now being accomplished using a total power radiometer designed to operate under computer control. Use of the IEEE 488 Instrument Bus and structured software techniques allows use and substitution of commercially available components with a minimum of hardware and software modification.

This manual addresses the general theory of operation, operating procedures, and maintenance procedures for the NBS 30/60 MHz automated noise measurement system using a commercially available desktop calculator as the controller.

Key words: Automated noise measurement system; coaxial noise sources; controller; IEEE 488 Bus; total power radiometer.



30/60 MHz RADIOMETER

FIGURE 1

1. INTRODUCTION

The use of the total power radiometer to measure noise sources requires a comparison of the unknown source with known or standard noise sources. To accomplish this with any degree of accuracy, mismatch considerations mandate either a correction for mismatch between the standards and the device under test or tuning to minimize it. Another factor which must be taken into account is noise contributed by the measurement system itself which limits system range and accuracy. This is especially true of the first amplifier noise contribution. Tuneable cryogenic and ambient noise standards plus amplifiers with high gain, low noise figure, and good input and output impedance characteristics were designed and constructed at NBS and make the measurement system described by this manual possible.

Figure 1 is a photograph of the 30/60 MHz radiometer which shows the physical layout of components, Figure 2 is a simplified block diagram showing basically how a measurement is made, and Figure 3 is a detailed block diagram of the measurement system. Figure 3, shows the general arrangement of system hardware with signal flow starting at the lower right. During a measurement sequence, the noise power from the unknown source is compared to that delivered by the system ambient and cryogenic standards. Results of this comparison are used to determine the noise temperature of the unknown source. An automated system such as this, can make large numbers of measurements in a relatively short time without operator involvement. This permits economical gathering of statistical results not previously possible.

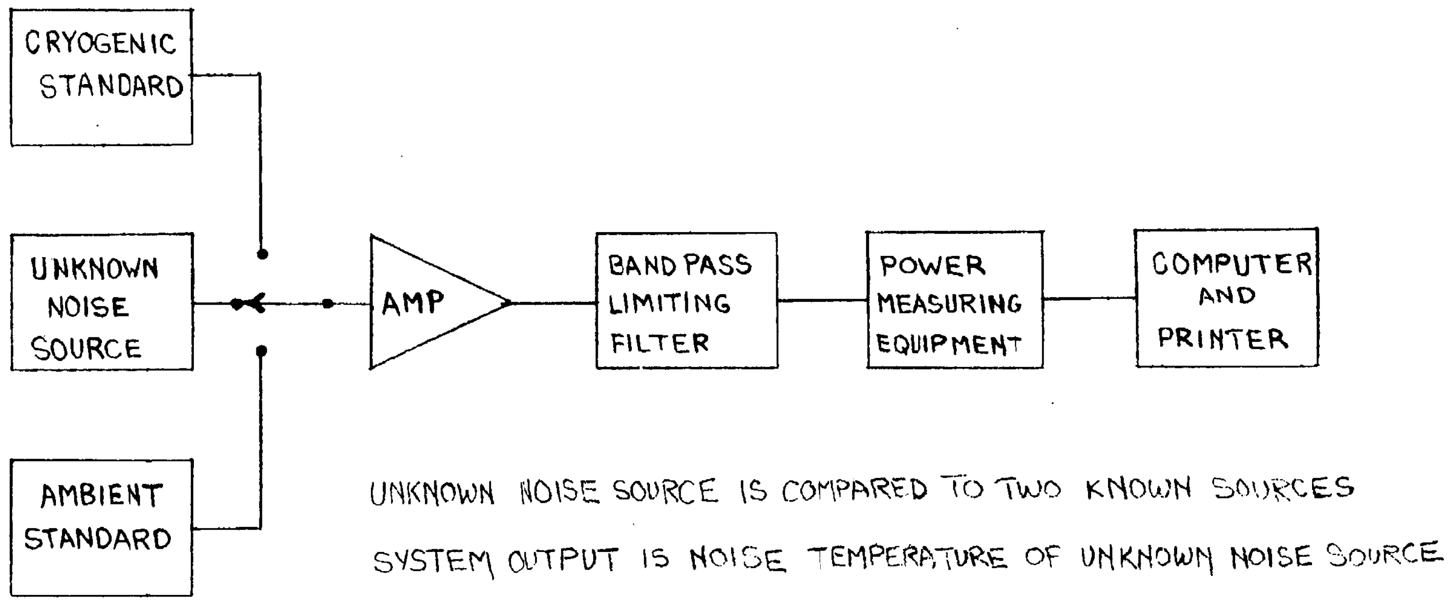
2. GENERAL THEORY OF OPERATION

A. DESCRIPTION OF THE MEASUREMENT SYSTEM

Refer to Figure 2. This is a functional block diagram of the noise measurement system. To calibrate or find the output noise temperature of the device under test, the output noise powers of this device, the ambient standard, and the cryogenic standard are amplified, filtered, and measured in sequence. The noise temperatures of the two standards are well known. Using the noise equations detailed on page 16 of this manual, the output noise powers and noise temperatures of the two standards are compared with the output noise power of the device under test resulting in the determination of the output noise power of this device. These noise power comparisons are made by using the 30/60 Mhz radiometer system described in the following paragraphs.

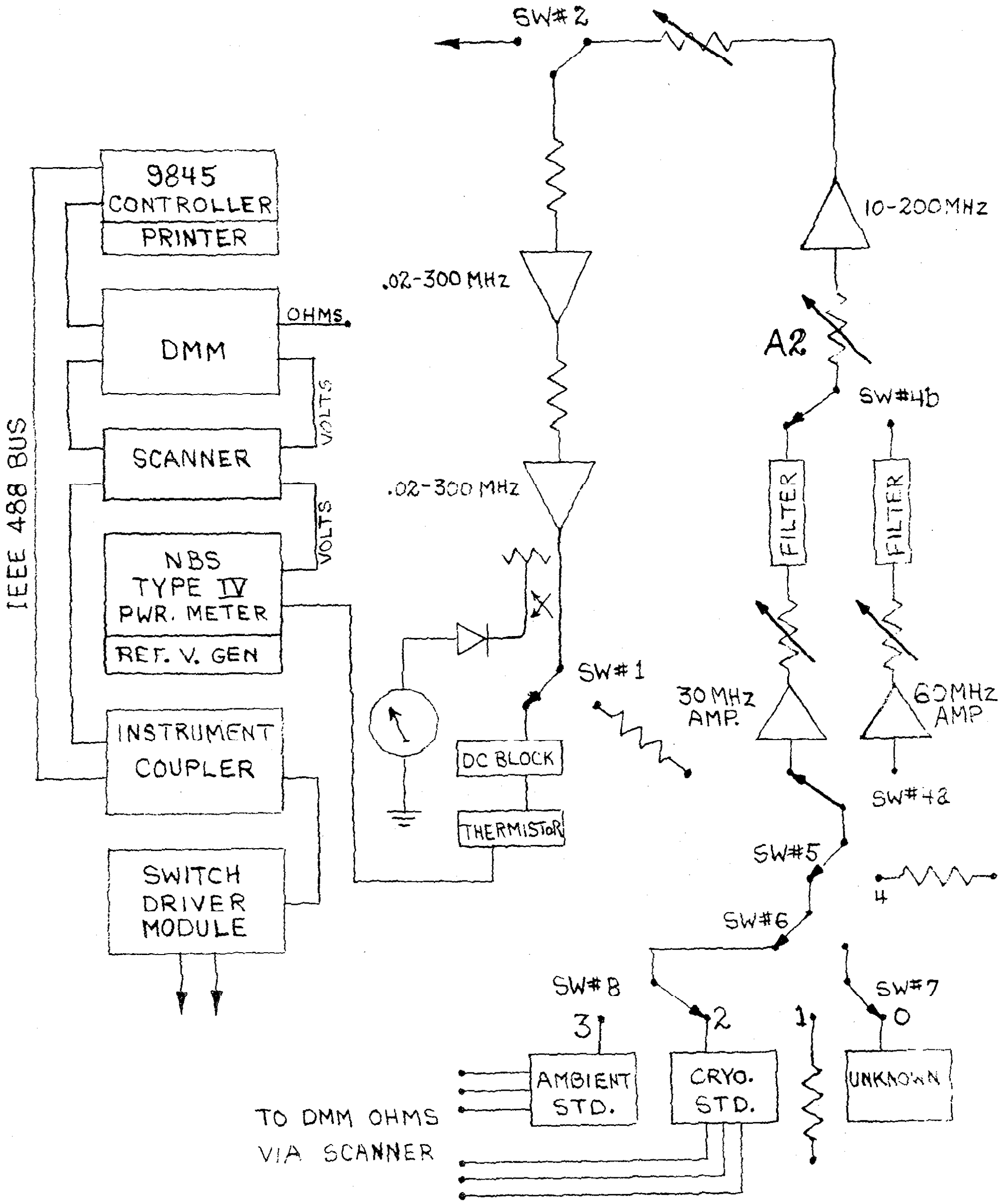
For purposes of explanation, the 30/60 MHz radiometer system as shown in Figure 3, can be divided into four general parts which are: (1) the switching and noise source section, (2) the 30 or 60 MHz preamplifier section, (3) the output amplifier and power measurement section, and (4) the instrument and controller section.

The switching section provides for selection of the unknown or standard noise sources for comparison by the system. The unknown coaxial noise source is usually a noise diode network at an effective temperature of approximately 11,000 K or a load which is either heated to a temperature of approximately 376 K or cooled with liquid nitrogen to a temperature of approximately



SIMPLIFIED BLOCK DIAGRAM OF NOISE MEASUREMENT SYSTEM

FIGURE 2



30/60 MHZ RADIOMETER BLOCK DIAGRAM

FIGURE 3

77 K. The normal system range covers this region. The two noise standards used to calibrate these unknown noise sources over this range are a coaxial ambient standard and a coaxial cryogenic standard.

The ambient noise standard is a load placed in an oil bath which is allowed to come to equilibrium with room temperature. The controlled room temperature of the standards laboratory, the mass of the standard housing, and the oil bath insure slow temperature change of the load element and thus a stable noise power output. Normally, this temperature change is less than 0.05 K over an 8 hour period. The temperature of the standard is measured often enough to pick up any small temperature changes which do occur.

The cryogenic standard is similar to the ambient standard except that the load is housed in a bath of liquid nitrogen. The temperature of these loads is measured by 3-wire-platinum thermometers which are remotely read by the instrument and controller section. Both standards have tunable output ports which provide for impedance matching and are currently connected to the system with 14mm coaxial fittings and air lines. Precision adaptors are used to connect the standards and unknown noise sources to the system ports where necessary. Coaxial connector types currently accepted for the item under test include but are not limited to: precision N, GR900, APC7, and SMA.

Noise power from the item under test is amplified by either the 30 MHz preamplifier or the 60 MHz preamplifier. These frequencies were selected to meet the needs of NBS calibration service customers. The frequency channel is remotely selected by the ganged switches at the input and output. The two channels are similar but the gain of the 30 MHz amplifier is 70 dB while that of the 60 MHz amplifier is 35 dB. The noise bandwidth of the two amplifier channels is determined by the amplifier and filter combination and is 0.77 MHz for the 30 MHz channel and 1.38 MHz for the 60 MHz channel. The system bandwidth at these frequencies is not critical as long as the input noise being amplified is constant over the bandwidth being used. The bandwidths above meet this specification. Since they have a noise figure less than 1.6 decibel, these amplifiers contribute little additional noise to that being amplified. They are not available commercially and were designed and built at NBS.

The output from the preamplifier section is amplified by three additional broadband amplifiers. The first has a bandpass of 10 to 200 MHz and the second and third have a bandpass of 0.02 to 300 MHz. All three have a gain of 30 decibels. The attenuators in this section are used to isolate components and to provide for linear operation. The output of this section is sampled through the side arm of a directional coupler to give the operator a visual indication of system power levels.

Power output is measured by using a thermistor mount connected to the output port through a DC (direct current) block. This thermistor mount in combination with an NBS Type IV Power Meter and a precision reference voltage generator is used to measure noise power.

The instrument and controller section encompasses all of the peripheral electronic equipment used to make the noise measurements including the controller, which in this case is the Hewlett Packard 9845 desktop calculator.

As shown at the left in Figure 3, the peripheral instruments are all interconnected on an IEEE 488 Bus. The instrument coupler shown connects the coaxial switch driver module to the controller. The switch driver assembly is the only instrument not compatable with the bus and so the instrument coupler, a sophisticated decoder, is used to interface the switch driver module to the controller--making it bus compatable. This switch driver module is used to control the various system switches and programmable and reference attenuator assemblies when they are used. An LED (light emitting diode) display on the front panel of the switch driver module gives a visual display of the digital code from the controller and the front panel meter indicates system output power levels. The scanner provides connection, at the proper time, of the ohmmeter section of the DMM (digital multimeter) to the platinum thermometers in the noise standard housings. Total resistance, lead resistance, and thermometer element resistance are determined. Conversion of these resistances to temperature is done by the software.

A check of system voltages is made by the DMM with proper connections made by the scanner before each measurement. Voltages checked include the 15V, 20V, 24V, and 28V switch driver and amplifier power supplies. In addition, the voltage output of the power meter is connected to the DMM through the scanner to collect output voltages which are then converted to power and noise temperature by the software.

B. ANATOMY OF A MEASUREMENT

A brief description of a measurement sequence is as follows:

1) The impedance of the device to be tested is measured and input to the computer along with the connector/adaptor description and associated loss constants. Instructions for making the impedance measurements are found on page 22; the loss constants are discussed on page 18.

2 The temperatures of the ambient and cryogenic standards are determined and stored.

3) The powers from the device under test, ambient standard, and cryogenic standard are measured and the temperature of the unknown noise source is calculated. This is normally done 100 times.

4) At the end of the first 50 measurements, the average noise temperature of the unknown is stored along with the standard deviation, calculated system temperature, and average power measured. If the printed results are obviously erroneous (values far from nominal or with very large standard deviations), the operator can abort the measurements at this time, correct the problem, and start over. Doing this at this point saves time. If the results printed are acceptable, the cycle is then repeated starting at 2) and the 2nd 50 measurements are made. The results are again stored.

5) A grand average of all measurements is obtained and a summary of results is output via the system printer.

TOTAL MISMATCH ERROR IS: 16.17 K

MEASUREMENT RECAP
AND
PRELIMINARY RESULTS

FREQUENCY= 30.00 MHZ
SOURCE IMPEDANCE 49.5+J00.0   LEVEL SETTING OF A2= 8.00

TA	R OHMS	TS	R OHMS	
295.94	218.23	76.21	36.36	(1ST 50 MEASUREMENTS)
295.94	218.23	76.21	36.36	(2ND 50 MEASUREMENTS)

TX	SX	TE	
5767.77	41.69	179.36	(1ST 50 MEASUREMENTS)
5772.87	46.87	180.45	(2ND 50 MEASUREMENTS)

AVE POWER IN MILLIWATTS P1,P2,P3
3.31 .26 .14
SD P1,P2,P3 IN WATTS (# OF MEAS= 100.00000000) .00000740 .00000105
.00000108

SAMPLE SYSTEM PRINTOUT PART 1
FIGURE 4

FREQUENCY = 30.MHZ

NOISE TEMPERATURE = 5770.32K +- 91.20K(BIAS) +- 13.26K (3
EXCESS NOISE RATIO= 12.76DB +- .06DB(BIAS+3*SEM)
RADIOMETER SYSTEM TEMPERATURE = 180K (2.1DB NF)
RADIOMETER GAIN = 76.4DB
RADIOMETER NOISE BANDWIDTH= 138.00 MHZ

ERROR SUMMARY

SOURCE OF ERROR	SOURCE UNCERTAINTY	% ERROR IN NOISE TEMPERATURE
CRYOGENIC STANDARD	0.28K	.12
AMBIENT STANDARD	0.10K	.04
POWER RATIO	0.01DB	.49
MISMATCH	0.5R;1.0J OHMS	.28
NONLINEARITY	6.90E-24	.00
SWITCH ASSYMMETRY	0.002DB	.08
ADAPTOR:GR900/N	0.0001DB	0.00
LINEAR SUM OF BIAS ERRORS		1.02
3*STANDARD ERROR OF MEAN (# MEAS= 100.)		.23
LINEAR SUM OF ERRORS		1.25

CUSTOMER: CHECK STANDARD
CUSTOMER'S STATION: NBS
CUSTOMER'S ADDRESS: BOULDER, COLORADO 80302

SOURCE MANUFACTURER: HEWLETT PACKARD COMPANY
SOURCE TYPE:
SOURCE MODEL: 346B
SOURCE SERIAL: 6000T

DATE OF CALIBRATION: JULY 10, 1981
CALIBRATION TEST #:
REQ OR REF #:

SAMPLE SYSTEM PRINTOUT PART 2
FIGURE 5

This summary is shown in Figure 4. The first item at the top of the page is the total mismatch error in K. This is followed by the date and time of calibration. The calibration frequency, impedance of the device under test, and system attenuator (A2) setting are printed next (documenting the A2 setting is an aid in reconstructing the measurement system power levels). Ambient standard temperature (Ta), cryogenic standard temperature (Ts), and the associated platinum thermometer resistances in ohms are then listed followed by the measured temperature of the calibrated item (Tx), the standard deviation of the measurement (Sx). and calculated system temperature (Te). All of these parameters are listed twice, furnishing a recap for each set of 50 measurements. Average powers measured are tabulated with their associated standard deviations. P1, P2, and P3 are the average powers measured for the device under test, the ambient standard, and the cryogenic standard respectively. Standard deviations for these powers are listed in the same order.

6) Figure 5 shows the final measurement results and error summary output at the end of the measurements. It simply details the results and gives a tabulation of system errors.

7) Finally, all information in the measurement summary, results, and error summary is stored, if desired, for future reference.

The ensuing discussion of the measurement process gives a more detailed description of how the above results were obtained. Since the coaxial noise standards are the basis for determining the noise temperature of the device under test, the error due to temperature uncertainty of these two standards must be known. The size and shape of these standards prevents a direct attachment to the measurement system, and as a result, the losses and temperature gradient in the adaptors and precision air lines used to make connection to the system were calculated and included in this temperature uncertainty.

The error attributed to these standards is listed in the error summary output by the system software and is 0.1 K for the ambient standard and 0.28 K for the cryogenic standard.

The mismatch error is due to the difference in port impedance between the device being tested and the measurement system. The error due to mismatch listed by the software is the root sum of squares of the errors determined for worst possible cases in phase and magnitude of this port impedance difference. It takes into account the impedances and the associated uncertainties of the measurement system ports, the coaxial noise standard ports, and the output port of the device under test. This error is dependent on the impedance of the device being tested and is normally between 0.1% and 0.4% of the noise temperature measured.

A vector impedance meter is used to determine the impedance of the source to be calibrated, and then the noise standards are tuned to match this impedance. The only mismatch error left to be considered, then, is the difference between the device under part and the system measurement ports. The system ports have been measured and found to have the same impedance. The real part of this impedance was measured to be 49.5 ohms at 30 MHz and [illegible] ohms at 60 MHz. The imaginary part was measured to be 0.0 ohm at 30 MHz and 0.5 ohm at 60 MHz. The estimated uncertainty is 0.5 ohm for the real part and 1.0 ohm for the imaginary part.

In this discussion, the noise temperature of the device under test will be designated Tx, and the temperatures of the ambient and cryogenic standards will be Ta and Ts. Numeric values for Ta and Ts expressed in K are determined from the resistance values of the platinum thermometers in the ambient and cryogenic standards. As mentioned previously, this resistance is measured and read under computer control and converted to temperature by the software routines.

During a measurement, the desired port is selected and the noise power from the device connected to that port is measured under computer control using the Type IV power meter, reference voltage generator, and digital multimeter. The reference voltage output is adjusted to equal the power meter voltage with no rf power applied to the thermistor mount before the measurements begin. This zeros the instrument. (Refer to figure 3. Rf power is removed from the thermistor mount by switching system switch number 1 to its terminated port.) Power is then determined with the scanner and system switches providing the proper conditions. A normal computer controlled sequence is:

1) The power meter voltage (A) is measured with the rf power off.

2 The power meter voltage minus the reference voltage (B) is measured with the power off.

3) The power meter voltage minus the reference voltage (C) is measured with the rf power on.

4) The power meter voltage (E) is measured with the power off to check drift.

5) The power meter voltage minus the reference voltage (D) is again checked with the power off.

6) Power (P) is then obtained by:

$P=[(A+E)-C+(B+D)/2][C-(B+D)/2]/R0$ where R0 is the resistance of the thermistor mount (200 ohms) [1].

The noise power measured from the device under test is designated P1, that from the ambient standard as P2, and that from the cryogenic standard as P3. The noise temperature of the unknown, Tx, is then determined by first finding the power ratios Y1 and Y3 and correlating them with the temperatures of the standards to find Tx:

$$Y1=P1/P2 \quad (1)$$

$$Y3=P3/P2 \quad (2)$$

$$Tx=Ta+(Ts-Ta)(Y1-1)/(Y3-1) \quad (3)$$

Note that because the standards are matched to the unknown, when Y1 and Y3 are calculated, only the mismatch terms between the unknown and the system are left to consider. The other terms cancel since they have been tuned to be equal. Tx is now determined and now must be corrected for any losses due to the adaptors or air lines used in connecting the unknown. Losses due to precision air lines and adaptors have been characterized and are entered as a constant (Alpha) when the measurement begins. The corrected temperature of Tx then, is given by:

$$\text{Corrected } Tx=(Tx-Ta)/\text{Alpha}+Ta \qquad (4)$$

where L=Loss in decibels of the adaptors and air lines used to connect the test device

$$\text{and Alpha}=10^{(-L/10)} \qquad (5)$$

In a normal calibration, the determination of Tx is made 100 times and the average of these 100 determinations is reported as is the standard deviation. Some of the other terms calculated are as follows [3] :

SYSTEM TEMPERATURE

$$Te=[Ts-(Y3)(Ta)]/(Y3-1) \qquad (6)$$

EXCESS NOISE RATIO dB

$$ENR=10\text{Log}(Tx-290)/(290) \qquad (7)$$

where 290 is a defined quantity

RADIOMETER SYSTEM TEMPERATURE

$$RST=10\text{Log}(1+Te)/290 \qquad (8)$$

RADIOMETER SYSTEM GAIN

$$RSG=10\text{Log}[(7.244)(10^{13})(P2)/Bw/(Ta+Ts)] \qquad (9)$$

where Bw is the system bandwidth in MHz.

and $(7.244)(10^{13})$ is a noise constant

The error summary in Figure 5 lists the source uncertainties on which the error calculation is based. These are the maximum errors calculated from the source listed. For example, 0.10 K is the maximum error contributed by the ambient standard. An in depth discussion of the error calculation is outside the scope of this manual other than to state that percent error is tabulated for each source and linearly summed. This sum is the error recorded on the test report.

3. OPERATING INSTRUCTIONS

A. ADDITIONAL EQUIPMENT REQUIRED

Besides the instruments contained in the measurement system, two additional pieces of equipment are needed to insure good measurements. These instruments are:

1. A frequency counter with at least 4 place accuracy: EIP 451D or equivalent.
2. Vector Impedance Meter: Hewlett Packard 4815A or equivalent.

B. GETTING STARTED

When an item is received for calibration, determine first that the device can be physically attached to the measurement system. If attachment is physically possible, the adaptor and/or air line combination needed to make connection should now be determined and the loss constants with the uncertainty for this combination is selected from Table 1 and recorded. Table 1 is a brief summary of common precision hardware used in making measurements. The frequency, loss constant (alpha), and uncertainty are listed. The alpha constant for a device is calculated as follows: First the loss of the device is either measured or looked up in the manufacturers specifications. Then alpha is calculated by raising 10 to the minus power of the loss of the device in question divided by 10. In equation form: Alpha=(10^(-dB/10)). Device input power multiplied by alpha is equal to device output power. If more than one item is used, the correct loss constant (alpha term) and its uncertainty can be computed by multiplying loss constants and adding uncertainties.

C. PREPARING THE SYSTEM FOR MEASUREMENT

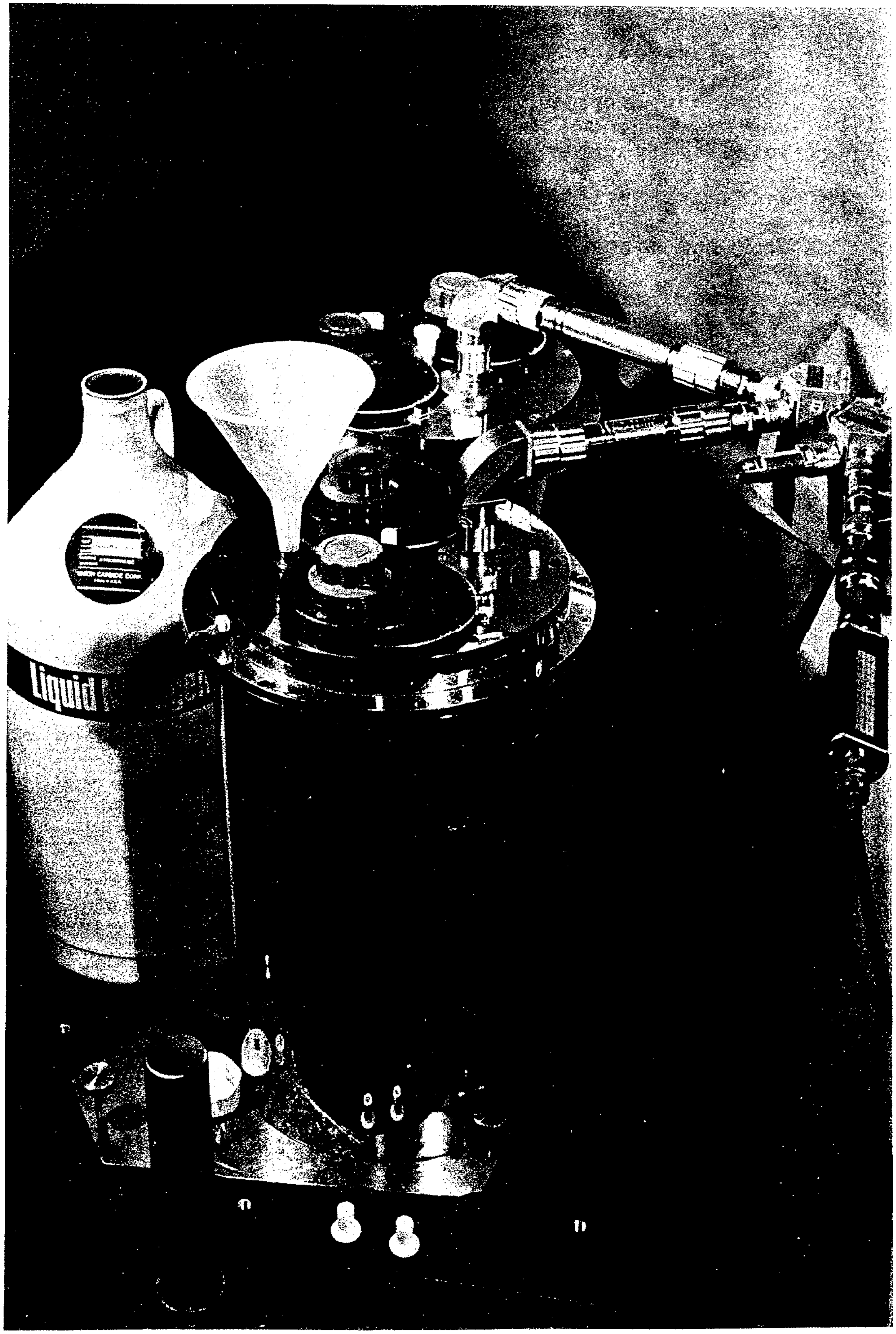
1. POWER-OFF INSPECTION AND SETUP

First check all cables and connections. The IEEE 488 bus cables should provide interconnection between the 9845 calculator, the scanner, the digital multimeter, and the instrument coupler. The switch driver module input jack (J110) should be connected to the instrument coupler output jack (J3).

The leads from the ambient and cryogenic standards should be securely plugged into the receptacles at the left front of the scanner. Check to make sure that the Type IV power meter and reference voltage generator are properly interconnected and that the output cable is plugged into the scanner. System wiring and interconnection diagrams are found in Section 5 of this manual.

Remove the standards and any other devices from the system measurement ports and check the system and standard connectors for damage. It is suggested that the connectors should all be cleaned with isopropyl alcohol.

Figure 6 shows the cryogenic and ambient standards as the cryogenic standard is being filled with nitrogen. Fill the small liquid nitrogen container shown in the figure with liquid nitrogen and locate the white filler cap near the tuning knobs on the top of the cryogenic standard. Remove this cap and the two



AMBIENT AND CRYOGENIC NOISE STANDARDS

FIGURE 6

FREQUENCY MHZ	CONNECTOR/ADAPTOR DESCRIPTION	LOSS CONSTANT ALPHA	ALPHA UNCERTAINTY
30	GR elbow, adaptor, 15cm air line	.99891	.00047
30	GR elbow, adaptor, 10cm air line	.99903	.00042
30	GR 15cm air line	.99952	.00021
30	GR 10cm air line	.99964	.00016
30	GR elbow	.99949	.00023
30	Adaptor-N to GR, APC7, SMA	.99985	.00010
60	GR elbow, adaptor, 15cm air line	.99843	.00067
60	GR elbow, adaptor, 10cm air line	.99986	.00060
60	GR 15cm air line	.99932	.00030
60	GR 10cm air line	.99949	.00023
60	GR elbow	.99928	.00032
60	Adaptor-N to GR, APC7, SMA	.99985	.00010

LOSS CONSTANTS AND UNCERTAINTIES
TABLE 1

white vent plugs from the standard. Using a funnel, SLOWLY pour a small amount of liquid nitrogen into the standard. After allowing several minutes for the inside of the standard to cool, add more nitrogen until the float on the top of the standard reaches the third red mark. Remove the funnel and replace the two vent caps and the filler cap.

The impedance of the item to be measured should now be determined by using the vector impedance meter. This instrument should be turned on at least one hour prior to making measurements. To save warmup time this instrument can be turned on the night before. Connect the RF OUTPUT jack on the front panel to a suitable frequency counter and set the desired calibration frequency by using the front panel RANGE SWITCH and TUNING KNOB. When the desired frequency is obtained, the instrument can be zeroed by using the PROBE CHECK on the front panel. Remove the probe from its adaptor by pulling it straight out and insert it into the PROBE CHECK receptacle. Use the MAGNITUDE ZERO and PHASE ZERO controls to get meter indications of 100 ohms and 0 degrees. Now the item can be checked by attaching the probe assembly to its output connector. If a noise diode assembly is measured, be sure to apply the voltage specified by the manufacturer (usually 28V) before making the impedance measurement. Record the impedance measured for the item. At this time, the adaptor/connector loss constant, the uncertainty of this loss constant, and the impedance of the device to be calibrated are tabulated for input to the computer during the measurement.

After the cryogenic standard reaches operating temperature, tune the standards to the impedance value obtained for the item to be calibrated. Simply attach the probe and adaptor from the vector impedance meter to the standard ports and carefully adjust the standard tuning knobs until the same impedance values are obtained for both the standards and the unknown. Connect the ambient standard to the leftmost calibration port (port 3), the cryogenic standard to the adjacent port (port 2), and the device to be calibrated to the rightmost port (port 0). The port adjacent to port 0 (port 1) is not used at this time. Leave this port terminated at all times. Figure 1 shows the measurement system with correct devices connected to all ports. If the device under test is a noise diode network, make sure that the correct voltage is applied to it.

2. POWER-ON CHECKS AND SYSTEM WARMUP

Before any power supplies are turned on, make certain that the 30/60 preamplifier voltage switch is in the off (center) position. This switch is located on the right side of the metal table as you face the system and opposite the the two preamplifiers. Moving the switch to the up position turns on the 28 volts to the 30 MHz preamplifier and moving it to the down position applies 28 volts to the 60 MHz preamplifier.

CAUTION

DUE TO THE HIGH GAIN OF THE PREAMPLIFIERS USED WITH THIS SYSTEM MAKE SURE THE 30/60 AMPLIFIER VOLTAGE SWITCH IS IN THE OFF (CENTER) POSITION BEFORE OPENING ANY MEASUREMENT PORT. DAMAGE WHICH IS EXPENSIVE AND TIME CONSUMING TO REPAIR WILL OCCUR IF THE AMPLIFIER INPUTS ARE SUDDENLY EXPOSED TO AN OPEN CIRCUIT

CONDITION. ONE OR MORE STAGES WILL BE DESTROYED AND THE AMPLIFIER WILL HAVE TO BE RETUNED AND THE NOISE FIGURE RESTORED.

After making sure the above switch is in the off position, power-up can be accomplished in the following order:

1. Turn on the controller
2. Turn on the digital multimeter and scanner.
3. Turn on the power meter and reference voltage generator.
4. Turn on the instrument coupler and press its reset button.
5 Turn on the switch driver module and press its reset button.
6. Now turn on the 28V, 25V, 24V, and 15V supplies.
7. After all measurement ports have devices attached to them it is safe to place the 30/60 preamplifier voltage switch in the 30 MHz (up) position or the 60 MHz (down) position as required.

It is good practice to let the system warm up or cool down, as the case may be, at least 2 hours before continuing.

3. LOADING AND EXECUTING THE MEASUREMENT PROGRAM

There are two measurement programs which are used; one for 30 MHz calibrations called "30M20" and one for 60 MHz called "60M20". The programs are stored on disc and cassette tape. If it is desired to load a program from cassette, insert the program cassette in the right hand tape drive (T15) and type MASS STORAGE IS ":T15"; press Execute. Type LOAD "30M20" for example ; press cassette. The program will now be loaded from cassette. The procedure for loading the program from disc is the same except that the MASS STORAGE IS statement is changed to MASS STORAGE IS "[illegible]". The disc is placed in the left hand drive and the "LOAD [illegible]" instruction when executed, loads the program from the disc.

After the program is loaded, press RUN. The system should make a series of 5 measurements as evidenced by numbers moving on the CRT display and clicking of the measurement switches. At the end of the five measurements, an average value of power at the measurement port #0 will be displayed. Adjust attenuator A2, (the precision manual step attenuator with the knobs above the plexiglass system cover) until the value of this measured power is 3 milliwatts. This is done by pressing RUN and adjusting the attenuator and then pressing RUN again to check the result. When the power level measured and displayed is 3 milliwatts consistantly, press the CONT (continue) button on the 9845. The system constants should now be displayed on the screen. A listing of these constants is available in the software portion of this manual but the important thing right now, is that they are present and displayed. If this is true, press CONT again.

At this point, the program section which requests operator input is reached. The software is designed to be as friendly as possible and whenever information is requested, a prompt describing the information required is displayed and the information requested by the prompt which is currently in memory is displayed. To leave the information as is, press only the space bar followed by CONT. If a change is desired, type the change in the same format as the sample displayed; then press Cont to go on. Information is requested by the measurement program in this order:

1. Enter the loss constant, alpha. This is the total alpha for all connectors, adaptors, and air lines used to connect the device under test.
2. Enter the uncertainty for the alpha in 1 above.
3. Enter the real and imaginary impedance of the device being tested in ohms. This is a literal representation of impedance in this form: 50.0 +J00.0. This input will be used in a printout.
4 Enter the real and imaginary impedance of the noise source being calibrated. This is a request for the real and imaginary parts of impedance in numeric form: 50.0,00.0. This input will be used in calculations.
5. Enter the item description.
    a) Enter the customer's name.
    b) Enter the customer's street address.
    c) Enter city, state, zip.
    d) Enter the manufacturer of the device under test.
    e) Enter type number of device under test.
    f) Enter model number of device under test.
    g) Enter serial number of device under test.
    h) Enter date of calibration.
    i) Enter NBS Test Number
    j) Enter reference Number

At this time the program returns to a) and the entire description can be checked by pressing the SPACE BAR and CONT unless a change is desired. To enter corrections, simply type that line over and press CONT.

6. Enter the setting of attenuator A2. Type in the setting in dB of the manual attenuator dials.

This concludes operator entry of data. The system will now run a check of the resistance and temperature of the standards and then check the system voltages. The date, time and standard temperatures measured in degrees Kelvin will be printed. A summary of system voltages and standard resistances measured will be displayed. If everything is satisfactory, press CONT.

The system will now do a complete measurement and error analysis under computer control and print the information shown in Figures 4 and 5. While the measurements are in progress, a print of all powers measured, device temperature calculated, and the standard deviation of the measurement is printed continously. Portions of the measurements such as power meter voltage readings are displayed on the screen in real time enabling a visual check of individual parts of the measurement. This is very helpful in finding trouble if erroneous measurements are made.

At the end of the 100 measurements and the printout of Figures 4 and 5, the program requests a data cassette to be inserted in the left hand deck and by following the instructions printed out, a complete recording of all results and device description is made. A complete catalog of the tape contents is maintained for easy access to data in the future if desired.

After the data are recorded, the software requests the operator to insert an additional 3 dB in attenuator A2 and press run. This is a routine system linearity check and is a complete repeat of the measurement just described at a different power level. The results of the second set of measurements should closely agree with the first set. Agreement within 0.2% should be expected. The outside limit is one half of the total error printed out for the first measurement. If the outside limit is exceeded, the system should be suspected of nonlinearity and all equipment should be checked to determine the cause.

In addition, check standards (devices which can be measured to evaluate system performance) are maintained which give a good indication of measurement integrity. These standards include a noise diode "tree" which incorporates three noise sources arranged with attenuators to give three different noise power outputs. The effective noise temperatures available from this standard are approximately 11000 K, 6000 K, and 3000 K. Measurement of this standard checks system performance over a broad temperature range. A physical temperature check standard with output noise temperatures of approximately 377 K and 77 K provides a check of system performance at these temperatures. It is intended to routinely cablibrate these standards and establish a control chart which will closely monitor system and standard performance. Not enough measurements have been made at the present time to establish a statistically signifigent chart. Measurements at this time show a total spread below 0.3%. The outside limit for measurement acceptance is estimated to be 0.5% of the measured value at this time. Measurements outside this specification indicate trouble with either the measurement system at the standard itself.

D. SYSTEM TURN-OFF

This procedure is essentially the reverse of turn-on and should be done in the order below.

1. Turn off the preamplifier voltage with the switch located on the side of the table.
2. Carefully turn the voltage down on the noise diode power supply (if used) and turn the supply off. Remove the calibrated item and replace it with a termination to protect the measurement port.
3. Turn off the system power supplies.
4. Turn off the instrument coupler, switch driver module, digital multimeter, scanner, power meter, and reference generator.
5. Turn off the 9845 and vector impedance meter.

If the measurements are to continue soon, uncouple the cryogenic standard from port 2, and refill it with liquid nitrogen. This will sustain its internal temperature allowing measurements to resume without waiting for the standard to stabilize.

4. SOFTWARE

A. GENERAL DESCRIPTION AND SUBPROGRAMS

The measurement programs "30M20" and "60M20" are written in a structured fashion. By this it is meant that each program consists of an executive section which contains the measurement sequence and provides for the orderly gathering of information by accessing the subprograms [4]. Variables exist in the executive program and the subprograms, but are not passed between the program segments unless they are made "global" by being listed in the common declaration or in the subprogram calling statement. All subprograms used in these programs are of the multi-line function type. These subprograms are nested in the program after the executive portion, and are identified by the prefix "DEF FN...(Q)" where Q is the variable being passed between program segments. Variables passed between segments in these programs are made "global" by being listed in the common declaration at the beginning of the program and at the beginning of each subprogram as well. These common declarations must match. The value returned from the subprograms by the calling statement is a dummy variable which is not used. In these programs values are passed between segments by use of the common declaration. The advantage of this programming technique is the ease with which subprograms can be called from any point in the program without regard to the variable transfer in the calling statement (since variable transfer is through common). The drawback is that each subprogram has to have a common declaration to match the one in the main program.

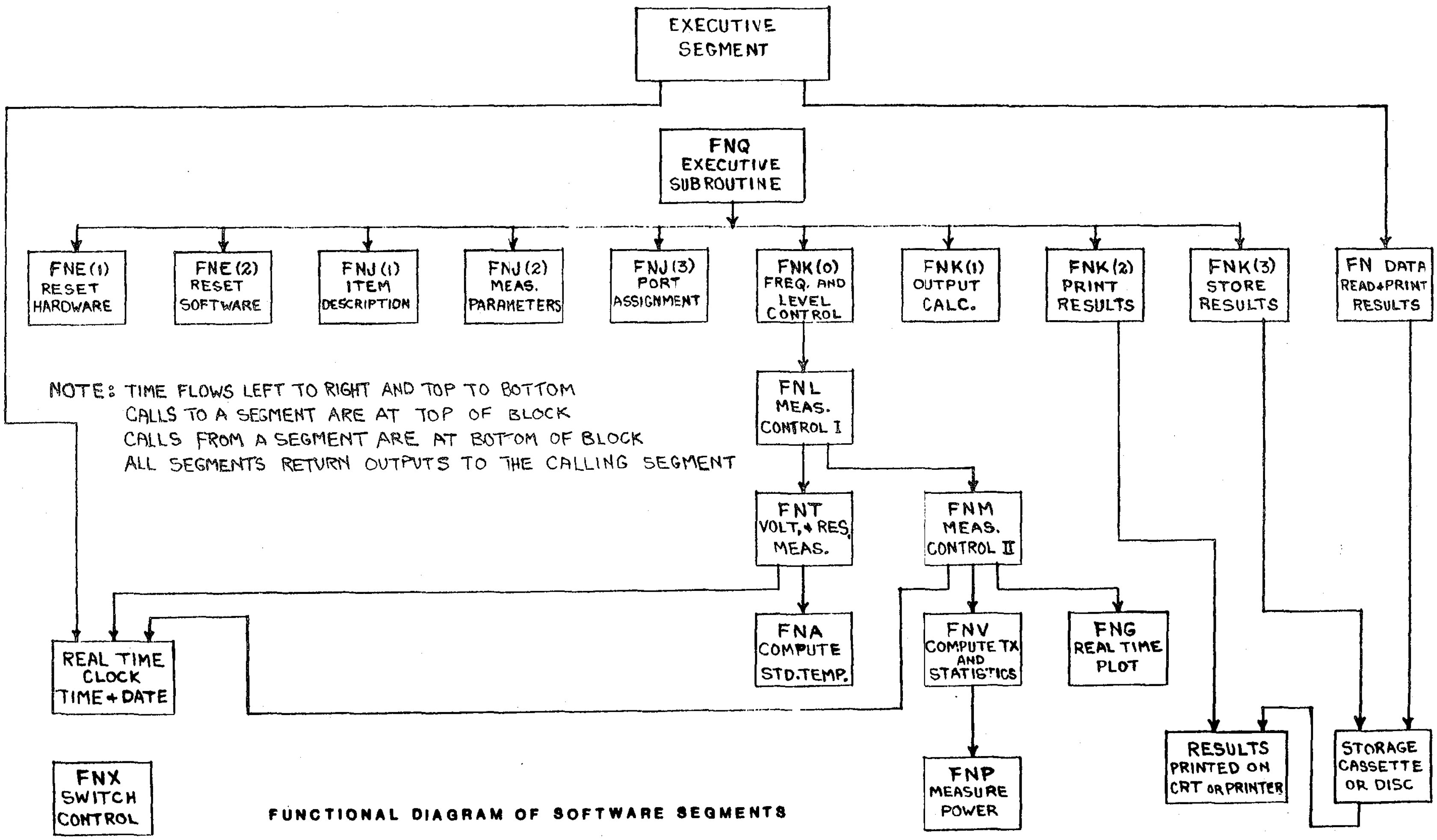
The instrument subprograms are flexible and easily changed to permit a change of instruments. Because subprogram input and output variables are transferred as described above, the only changes needed to permit a change of instruments are the instrument instruction codes output on the bus to each instrument from the controller. This is necessary because few different instruments respond to exactly the same coded set of instructions. A standard instruction format for control of instrument functions does not exist at this time.

Figure 7 shows the program structure and the relationship between the executive program and the primary subprograms which are called from it. The subprograms are essentially independent of one another and require only a proper calling sequence to provide the desired output. This output will be returned to the calling program segment.

As an explanation and clarification of Figure 7, a discussion of major program segments follows:

EXECUTIVE SEGMENT provides program constants and input of needed parameters; control is then passed to EXECUTIVE SUBPROGRAM FNQ.

EXECUTIVE SUBPROGRAM FNQ is called from the EXECUTIVE SEGMENT; it directs program sequence and provides for orderly execution of program instructions. FNQ provides calls to FNE to initialize software and hardware, to FNJ to get item description, measurement parameters and port assignments, and to FNK to start measurements, compute results, print results, and store results. Return is to the EXECUTIVE SEGMENT.



FUNCTIONAL DIAGRAM OF SOFTWARE SEGMENTS

FIGURE 7

SUBPROGRAM FNE is called from FNQ; FNE(0) performs necessary hardware reset while FNE(1) initializes the software. Return is to FNQ.

SUBPROGRAM FNJ is called from FNQ; FNJ(1) provides for input and confirmation of item under test description. FNJ(2) provides number of measurements, frequency, and system attenuator setting. FNJ(3) provides the measurement system port assignments. Return is t FNQ SUBPROGRAM FNK is called from FNQ; FNK(0) starts measurement sequence by calling subroutine FNL and also sets up and begins filling the L, Z, and M matrices. These matrices will be covered in detail later in this section. FNK(1) performs necessary calculations for error analysis and completes filling of the L, M, and Z matrices. FNK(2) provides a call to FNVswr to get mismatch error and outputs measurement results to the printer. FNK(3) provides for storage of measurement results, temperature, pressure, and item description on tape or disc. Return is to FNQ.

SUBPROGRAM FNData is called from the EXECUTIVE SEGMENT; it provides for reading of stored data and printing of results, item description, and other information in the proper format. Return is to EXECUTIVE SEGMENT.

SUBPROGRAM FNP is called from the EXECUTIVE SEGMENT before measurements are started to enable setting of system power. Return at this time is to EXECUTIVE SEGMENT. This subprogram is also called from FNV during the measurement sequence to provide the output power determination from the device under test and the standards. Return is to FNV.

TIME from real time clock is requested by EXECUTIVE and

SUBROUTINE FNM to provide date and time information. Return is to the calling segment.

SUBPROGRAM FNL is called from FNK; it provides calls to FNT for standard resistances and system voltage check, to FNA for conversion of standard resistances to temperature in K, and to FNM to initiate measurements. Return is to FNK.

SUBPROGRAM FNM is called from FNL; it provides calls to FNV and FNG to get measurements and a real time plot of results. It also prints results and computes standard deviation. Return is to FNL.

SUBPROGRAM FNV is called from FNM; it calls FNP for power measurements and computes the value of Tx (noise temperature of item being calibrated). It also computes the standard deviation of measured quantities and averages. Return is to FNM.

SUBPROGRAM FNA is called from FNL; it provides calculated temperatures of the standards. It requires constants relating to the resistance of the platinum thermometers in the standards. Return is to FNL.

SUBPROGRAM FNVswr is called from FNK; it provides calculated mismatch error for the item under test in K. It requires impedance parameters for the item under test and the system as well as Tx, Ta, and Ts values for the measurement. Return is to FNK.

SUBPROGRAM FNX has no direct call; it provides port and frequency code to the switch driver module when required. Return is to the calling segment.

B. MATRICES

Four matrices are used to store the program constants and measurement results. They are:

1) The N matrix-- a 26 X 11 matrix which contains all system constants used in computations. These include the platinum thermometer corrections, system errors and their sources, alphas and their uncertainties, and reserved space for additional constants to be added, if necessary, in the future. Table 2 is a listing of the contents of the N matrix with descriptions of the various parameters. This matrix is automatically read from the storage medium into computer memory when the program is run.

2) The L matrix-- a 1 by 12 matrix which is used for intermediate storage of measurement results and standard values.

3) The M matrix-- a 1 by 33 matrix contains the L matrix information and, in addition, contains the measurement results, statistics, error analysis results, and standard values. Table 3 shows the contents of the M matrix.

4) The Z matrix--a 1 by 60 matrix which is the output matrix for the measurement program. Table 4 is a listing of the Z matrix contents.

The above information concerning the various program storage registers is presented as an aid in program analysis if this is desired.

Appendix I of thi manual contains a complete program listing, printout of variables used, and their location in the program.

TABLE 2
N MATRIX

ELEMENT	FREQ MHZ	DESCRIPTION	VALUE
N(1,)		System #6 constants	
N(2,1)		"Hot" ambient std.	200.158
N(2,2)		"Hot" ambient std.	0.00391775
N(2,3)		"Hot" ambient std.	1.50289
N(2,4)		" Hot" ambient std.	0.12293
N(3,1)		Cryo. std. in amb. range	199.965
N(3,2)		Cryo. std. in amb. range	0.003922
N(3,3)		Cryo. std. in amb. range	1.51
N(3,4)		Cryo. std. in cryo range	0.11
N(4,*)			
N(5,*)			
N(6,1)		Cryo. std. in cryo. range	-0.00065732
N(6,2)		Cryo. std. in cryo. range	32.7792
N(6,3)		Cryo. std. in cryo. range	1.20769
N(7,1)		WCD std.	0.0
N(7,2)		WCD std.	-6.53922
N(7,3)		WCD std.	0.0210573
N(7,4)		WCD std.	65.1189
N(8,*)			
N(9,*)			

TABLE 2
N MATRIX continued

ELEMENT	FREQ MHZ	DESCRIPTION	VALUE
N(10,1)	30	"a" non-linearity	2.15 E-22
N(10,2)	30	System noise bandwidth	0.773
N(10,3)	60	"a" non-linearity	3.32 E-23
N(10,4)	60	System noise bandwidth	1.38
N(11,*)			
N(12,1)	30	Cryo. std. uncertainty K	0.22
N(12,2)	30	"Hot" amb. std uncertainty K	0.22
N(12,3)		Power ratio source (dB)	0.01
N(12,4)	30	"a" non-linearity"	2.15 E-22
N(12,7)	30,60	"switch assymmetry source	0.002
N(12,8)	30,60	N term	0.00047
N(12,9)		Power to gain constant	7.244 E+13
N(13,1)	30	Real Z fixed amb. ohms	50.5
N(13,2)	30	Imag. Z fixed amb. ohms	1.0
N(13,3)	30	Mismatch error, fixed amb.	0.368651
N(13,7)	60	Cryo. std. uncertainty	0.28
N(13,8)	60	"Hot" amb. std. uncertainty	0.25
N(13,9)	60	Cryo. std. correction	0.38
N(13,10)	60	"Hot" amb. std. correction	-0.15
N(14,1)	30	Cryo. std. correction	0.26

TABLE 2
N MATRIX continued

ELEMENT	FREQ MHZ	DESCRIPTION	VALUE
N(14,2)	30	"Hot" amb. std. correction	-0.1
N(14,8)	30,60	Amb. std. correction	0.0
N(14,9)	30,60	Amb. std. uncertainty	0.1
N(15,1)	30	Sys. refl. coef. magitude	0.005
N(15,2)	30	Sys. refl. coef. (real)	-0.005
N(15,3)	30	Sys. refl. coef. (imag)	0.010
N(15,4)	30	Uncertainty for N(15,2)	0.005
N(15,5)	30	Uncertainty for N(15,3)	0.010
N(15,6)	60	Sys. refl. coef. magnitude	0.007
N(15,7)	60	Sys. refl. coef. (real)	0.495
N(15,8)	60	Sys. refl. coef. (imag)	0.005
N(15,9)	60	Uncertainty for N(15,7)	0.005
N(15,10)	60	Uncertainty for N(15,8)	0.010
N(16,*)			
N(17,*)			
N(18,*)			
N(19,*)			
N(20,*)			
N(21,*)			
N(22,*)			

TABLE 2
N MATRIX continued

ELEMENT	FREQ MHZ	DESCRIPTION	VALUE
N(23,*)			
N(24,1)	30	Total alpha of GR adapt., ell, and 15cm air line	0.99891
N(24,2)	30	Uncertainty for N(24,1)	0.00047
N(24,3)	60	Total alpha of GR adapt., ell, and 15cm air line	0.99943
N(24,4)	60	Uncertainty for N(24,3)	0.00067
N(25,1)	30	Alpha for 15cm air line	0.99952
N(25,2)	30	Uncertainty for N(25,1)	0.00021
N(25,3)	60	Alpha for 15cm air line	0.99932
N(25,4)	60	Uncertainty for N(25,2)	0.00030
N(25,6)	30	Total alpha of GR adapt., ell, and 10cm air line	0.99903
N(25,7)	30	Uncertainty for N(25,6)	0.00042
N(25,8)	60	Total alpha of GR adapt., ell, and 10cm air line	0.99986
N(25,9)	60	Uncertainty for N(25,8)	0.00060
N(26,1)	30,60	Alpha for adaptor--N to GR, APC7, or SMA	0.99985

TABLE 2
N MATRIX continued

ELEMENT	FREQ MHZ	DESCRIPTION	VALUE
N(26,2)	30,60	Uncertainty for N(26,1)	0.00010
N(26,3)	30	Alpha for GR ell	0.99949
N(26,4)	30	Uncertainty for N(26,3)	0.00023
N(26,6)	30	Alpha for GR 10cm air line	0.99964
N(26,7)	30	Uncertainty for N(26,6)	0.00016
N(26,8)	60	Alpha for GR ell	0.99928
N(26,9)	60	Uncertainty for N(26,8)	0.00032
N(26,10)	60	Alpha for GR 10cm air line	0.99949
N(26,11)	60	Uncertainty for N(26,10)	0.00022

* Note: an * in the matrix element description denotes all columns of the indicated row of the matrix.

TABLE 3
M MATRIX

ELEMENT	DESCRIPTION	PROG LOCATION
M(1,1)	Frequency F	3050
M(1,2)	# of Freq and Levels	3060
M(1,3)	L(1,1)=T2 PO=1	3070
M(1,4)	L(1,2)=T3 PO=1	3080
M(1,5)	L(1,7)=T2 PO=2	3090
M(1,6)	L(1,8)=T3 PO=2	3100
M(1,7)	L(1,3)=T1 PO=1	3110
M(1,8)	L(1,4)=S1 PO=1	3120
M(1,9)	L(1,5)=T4 PO=1	3130
M(1,10)	L(1,9)=T1 PO=2 3140	
M(1,11)	L(1,10)=S1 PO=2	3150
M(1,12)	L(1,11)=T4 PO=2	3160
M(1,13)	T1 Average = Tx	3170
M(1,14)	Standard error of mean	3450
M(1,15)	T4 or Te average	3480
M(1,16)	T2 average = Ta	3500
M(1,17)	T3 average = Ts	3520
M(1,18)	Linear sum of bias errors	3790
M(1,19)	3 times std. error of mean	3800
M(1,20)	Linear sum of errors	3810

TABLE 3
M MATRIX continued

ELEMENT	DESCRIPTION	PROG LOCATION
M(1,21)	Excess noise ratio of Tx (dB)	3820
M(1,22)	Bias plus 3 times std. error	3850
M(1,23)	Ambient standard error	3550
M(1,24)	Cryogenic standard error	3560
M(1,25)	Power ratio error	3680
M(1,26)	Non-linearity error	3690
M(1,27)		
M(1,28)	Standard error of mean	3460
M(1,29)	Switch assymmetry error	3770
M(1,30)	L(1,6)=P2 PO=1	3170
M(1,31)	L(1,12)=P2 PO=2	3180
M(1,32)	Average power from ambient	3860
M(1,33)	Radiometer gain in dB	3620

TABLE 4
Z MATRIX

ELEMENT	DESCRIPTION	PROG LOCATION
Z(1,1)	T2 PO=1	6490
Z(1,2)	T3 PO=1	6500
Z(1,3)	T1 PO=1	6510
Z(1,4)	S1 PO=1	6520
Z(1,5)	T4 PO=1	6530
Z(1,6)	P2 PO=1	6540
Z(1,7)	T2 PO=2	6550
Z(1,8)	T3 PO=2	6560
Z(1,9)	T1 PO=2	6570
Z(1,10)	P2 PO=2	6580
Z(1,11)	T4 PO=2	6590
Z(1,12)	P2 PO=2	6600
Z(1,13)	3 times std. error (Tx)	4650
Z(1,14)	Excess noise ratio in dB (Tx)	4700
Z(1,15)	Bias plus 3 times std. error	4710
Z(1,16)	Te, radiometer sys. temp K	4740
Z(1,17)	System noise figure	4750
Z(1,18)	System gain in dB	4800
Z(1,19)	N(12,1)--s. error cryo. std.	4900
Z(1,20)	% error--cryo. std.	4910

TABLE 4
Z MATRIX continued

ELEMENT	DESCRIPTION	PROG LOCATION
Z(1,21)	N(14,9), ambient std. s. error	4940
Z(1,22)	% error- ambient std.	4950
Z(1,23)	N(12,3), power ratio s. error	4980
Z(1,24)	% error- power ratio	5020
Z(1,25)		
Z(1,26)	Total mismatch error K	5010
Z(1,27)	N(12,4) "a" non-linearity	5040
Z(1,28)	% error for non-linearity	5050
Z(1,29)	% error for switch assymmetry	5090
Z(1,30)	Linear sum of bias errors	5170
Z(1,31)	Total # of measurements, N	5230
Z(1,32)	% Error- 3 times SEM	5240
Z(1,33)	Linear sum of errors	5280
Z(1,34)	Frequency F	4510
Z(1,35)	Calibrated Tx (average)	4630
Z(1,36)	Bias error	4640
Z(1,37)		
Z(1,38)		
Z(1,39)		
Z(1,40)		

TABLE 4
Z MATRIX continued

ELEMENT	DESCRIPTION	PROG LOCATION
Z(1,41)	Sum of sqrs T1, 2nd 50, B6	9290
Z(1,42)	Sum of T1, 2nd 50, B8	9310
Z(1,43)	Sum of sqrs T1, 1st 50, B5	9350
Z(1,44)	Sum of T1, 1st 50, B7	9360
Z(1,45)	Sum of P1 (divide by N for ave)	9520,9600
Z(1,46)	Sum of P2 (divide by N for ave)	9530,9610
Z(1,47)	Sum of P3 (divide by N for ave)	9540,9620
Z(1,48)	Sum of sqrs P1	9550,9630
Z(1,49)	Sum of sqrs P2	9560,9640
Z(1,50)	Sum of sqrs P3	9570,9650
Z(1,51)	A2 atten. setting	2690
Z(1,52)	T1	3240
Z(1,53)	T2	3250
Z(1,54)	T3	3260
Z(1,55)	N term .00047	3860,5400
Z(1,56)		
Z(1,57)	N(12,8) switch assymmetry	3850
Z(1,58)		
Z(1,59)	R2 amb. std. thermometer res.	11290
Z(1,60)	R3 cryo. std. thermometer res.	11300

C. EQUATIONS

To provide a reference for the theoretical work underlying the algorhythms used in the software, a summary of equations used in the software (in addition to those in part 2) is presented at this point. This summary is not intended to be self-explanatory. In the following discussion, T1 is the temperature measured for the device under test, T2 is the temperature of the ambient standard, T3 is the temperature of the cryogenic standard, and T4 is the calculated system temperature, Te. The resulting errors in T1 are reported in K.

CALCULATION OF AMBIENT STANDARD TEMPERATURE

Definition of Terms:

C1=200.158 Note: C1-C4 are constants supplied for the ambient standard platinum thermometer.

C2=0.00391775

C3=1.50289

C4=0.12293

T2=Temperature of the ambient standard in K.

R=Measured resistance of the ambient standard platinum thermometer.

Computation: (iterate to invert the Callonder-Van Dusen equation.)

H3=(R/C1-1)/C2 (1)

If H3 is greater than 0 set H9=0; otherwise set H9=C4.

G9=H3/100 (2)

G8=G9-1 (3)

If H3 is greater than 0 set H3=H3+C3*G9*G8; otherwise set

H3=H3+C3*G8*G9+H9*G8*G9*G9 (4)

T2=H3+273.15 K (5)

CALCULATION OF CRYOGENIC STANDARD TEMPERATURE

Definition of Terms:

C1=-0.00065732

C2=32.7792

C3=1.20769

T3=Calculated cryogenic standard temperature in K.

R=Measured resistance of the cryogenic standard platinum thermometer.

Computation: (from a polynomial fit)

H3=C1*R^2 (6)

T3=C2+C3*R+H3 K (7)

AMBIENT STANDARD UNCERTAINTY (U) is 0.1 degree K.

at 30 and 60 MHZ.

R8=(T1-T2)/(T3-T2) (8)

where T1,T2, and T3 are the temperatures in K of the unknown device, ambient standard, and cryogenic standard respectively.

Let ES2=the error due to the ambient standard in measuring the unknown.

ES2=ABS(1-R8)*U (9)

CRYOGENIC STANDARD UNCERTAINTY (U) is 0.22 degree Kelvin at 30 MHz and is 0.28 degree K at 60 MHz.

Let ES3=Error due to the cryogenic standard uncertainty in measuring the unknown.

ES3=ABS(R8*U) (10)

UNCERTAINTY IN MEASURING POWER RATIOS is 0.01 dB.

Power factor (U) =0.0023

Let EPR=Error due to uncertainty in measuring power ratio.

A=1+T4/T1 (11)

B=1-T2/T1 (12)

C=(T3+T4)/(T3-T2) (13)

EPR=ABS[U*(A-B*C)] (14)

SYSTEM NON-LINEARITY CONSTANT (a) is 3.32 *10^-23 at 60 MHZ and 2.15 *10^-22 at 30 MHz.

Bandwidth (B)= 1.38MHz at 60 MHz and 0.773MHz at 30 MHz.

Radiometer Gain in dB=G

Let ENL=Error due to system non-linearity.

ENL=ABS[(a)*10^(G/10)(B)(10^6)(T1-T3)*(T1-T2)] (15)

UNCERTAINTY OF THE SWITCH SETTINGS IS 0.002 dB and the constant for switch assymmetry is 0.00047.

Let ESA=The error due to switch assymmetry.

A=ABS[(T1)(T3)+(T1)(T2)+(T2)(T3)/(T3-T2)] (16)

ESA=A*0.00047 (17)

SOURCE UNCERTAINTY (U) OF THE ADAPTOR/CONNECTOR LOSS is 0.0005 (0.0001dB).

Let EAL=Error due to adaptor/connector loss.

C1=Alpha for the connector adaptor combination

C2=Uncertainty for alpha.

C3=C1^2 (18)

A=1-1/C1 (19)

B=Bias Error(Linear Sum) (20)

C=A*B (21)

D=A*.1 (22)

E=ABS[(T1-T2)/C3*(C2)] (23)

EAL=B+D+E (24)

Calculate the OUTPUT NOISE TEMPERATURE of a Device when an adaptor has been used in its calibration use the following:

Tx=T1*A+Ta*(1-A) (25)

where Tx is the output noise temperature of the device. T1 is the noise temperature with the adaptor attached, Ta is the ambient temperature in K (the nominal value of Ta is 300 K), and A is the alpha for the attenuation present.

A is calculated by: A=10^(-Loss dB/10) (26)

STANDARD DEVIATION is calculated by:

S.D.=Square root of ((V-T*T/N)/(N-1)) (27)

where T is the sum of the individual measurements; V is the sum of the squares of the individual measurements, and N is the total number of measurements.

STANDARD ERROR OF THE MEAN is given by:

SEM=S.D./Square root of N (28)

5. MAINTENANCE

A. EQUIPMENT DESCRIPTION

Since the measurement system is largely made up of commercially available equipment, operating, periodic maintenance, and troubleshooting instructions can be found in the appropriate manual supplied with the instrument. A list of the equipment presently being used, the manufacturer, and the model number follows:

IMPORTANT NOTICE

The specific components selected for use with the system were chosen on the basis of suitability, availability, and cost. They do not necessarily represent the only possible choice or even the best choice. The National Bureau of Standards states only that they were used in the system described here. Substitution of nominally equivalent components meeting the same specifications should cause no difficulty; however NBS has not tested all such possible choices.

INSTRUMENT NAME	MANUFACTURER	MODEL
1. Controller	Hewlett Packard Co.	9845B
2. Digital Multimeter	John F. Fluke Co.	8502A
3. Scanner	Hewlett Packard Co.	3495A
4. Instrument Coupler	ICS Electronics Corp.	4883
5. Amplifier	Aertech	A1517
6. Amplifier	Avantek	AV-4

INSTRUMENT NAME	MANUFACTURER	MODEL
7. Power Supplies	Power Mate Corp	BP34D
8. Preamplifier	NBS	30MHz
9. Preamplifier	NBS	60MHz
10. Noise Standard	NBS	Ambient
11. Noise Standard	NBS	Cryogenic
12. Switch Driver Module	NBS	30-60
13. Power Meter	NBS	Type IV

Technical details, schematic diagrams, and parts lists for the switch driver module and the 30 and 60 MHz preamplifiers are included in this manual. Also included are wiring diagrams and system cable information. Technical information pertaining to the ambient and cryogenic noise standards can be obtained by contacting L.D. Driver, Division 723, National Bureau of Standards, Boulder, Colorado 80302.

B. SYSTEM CHECKS

A number of checks are performed automatically in the process of making a measurement with the system and its software. These include: 1) A check of system power measurements which is made by running the system power set portion of the program at the beginning of a measurement sequence. If the power meter, reference generator, and digital multimeter are not performing adequately, this fact will be made apparent by the values displayed during this program segment. Erratic and obviously wrong power values and large variations between consecutive measurements are the usual indication of malfunction of these instruments. System frequency and measurement port switches are also exercised during this test and defective switching can cause a substantial spread in measurement results, no change in power when a measurement port is changed, or a null to be read at one or more ports.

2) System voltage checks are made automatically before the measurement sequence begins. The values of these voltages are displayed along with the platinum thermometer resistances and noise standard temperatures. The operator must approve the displayed values before measurements continue. These checks reaffirm that the voltmeter and ohmmeter portions of the digital multimeter are working properly, that intercabling between instruments is intact, and that the system power supplies are adjusted and functioning properly.

3) Large scatter in successive readings of power and temperature taken during a calibration are an indication of erratic switch operation or poor peripheral instrument performance. Experience will dictate what this scatter should be for a given item. Three times the standard error is normally below 1 percent of the noise power measured.

In addition, system operation is verified in two other ways during a measurement sequence.

1) Measurement of the device under test at two different power levels is required and will pinpoint system non-linearity. 2) Applicable reference standards with effective noise temperatures of 11000, 6000, 3000, 377, and 77 degrees K are checked immediately before or after a device is calibrated to test system accuracy. These measurements provide an excellent check of

overall system performance. Results obtained by measurement of the reference standards are the single most important indicator of system precision and accuracy. These results will show whether or not a major failure has occurred in such a subtle manner that the failure was not detected by other checks.

If the system fails to perform properly during any of the tests, try to pinpoint the location of the trouble by logically analyzing in which test the trouble occurred, and working backwards to isolate the instrument or component responsible for the failure. For example, if a switch is intermittant, the tests outlined will give an indication of the measurement port involved (possibly a large scatter in power measured at one port). Switch operation then can be isolated to the faulty switch and/or driver card by parts substitution and in-circuit testing.

In the event that a major repair is made on the system preamplifiers or input port switches, a complete analysis of the impedance and noise figure of the radiometer "front-end" should be made and impedance parameters contained in the N-matrix changed if necessary. System linearity and bandwidth should also be re-evaluated and the constants relating to these parameters changed in the N-matrix if necessary.

Diagnostic tests of commercial units, to which faults have been isolated, can be performed by following the instructions provided in the applicable operation and service manual.

No specialized diagnostic software has been written to aid in troubleshooting the equipment because the above described tests will isolate most faults to at least the instrument level.

C. COMPONENT DESCRIPTION AND TECHNICAL INFORMATION

For commercial equipment used in the system,- this information is available in manuals supplied by the manufacturer.

1. SWITCH DRIVER MODULE

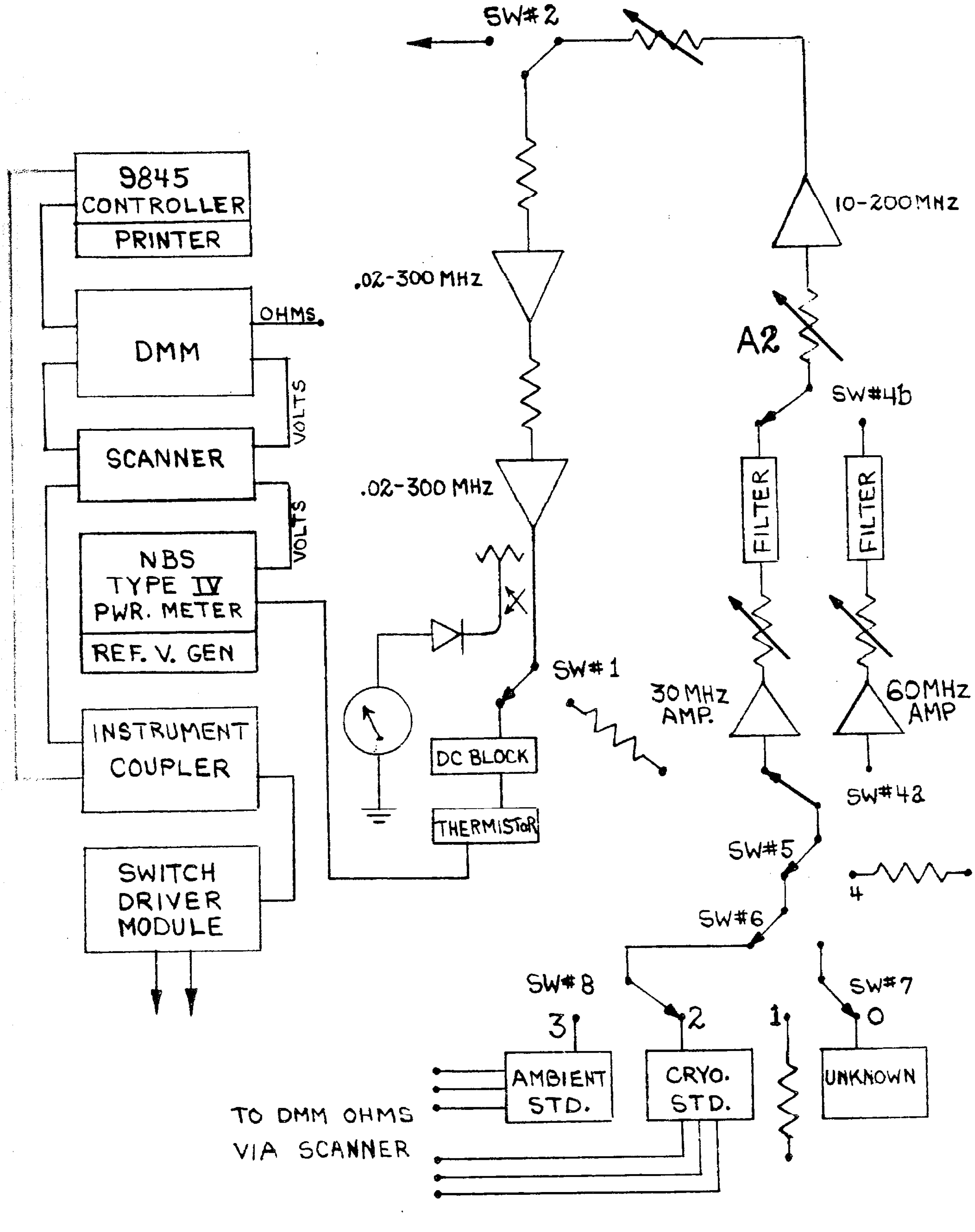
This instrument is comprised of power supplies, remote switches, a decoder card, LED display, switch driver output cards, and an output display card with its associated analog meter. The output display card is the only card requiring adjustments and these are covered with the description for this card.

a) Power Supplies and Switches

The switch driver module contains one 5V power supply which supplies operating voltage for the integrated circuits on the decoder, switch driver, and output display cards. 15V and 25V drive voltages for the switches controlled by the switch driver cards are also supplied to this unit from external power supplies after passing through two remotely controlled switches. This permits the drive voltage for the system switches to be turned on and off by the controller. Also present in the unit are the positive and negative 15V supplies for the operational amplifiers on the output display card.

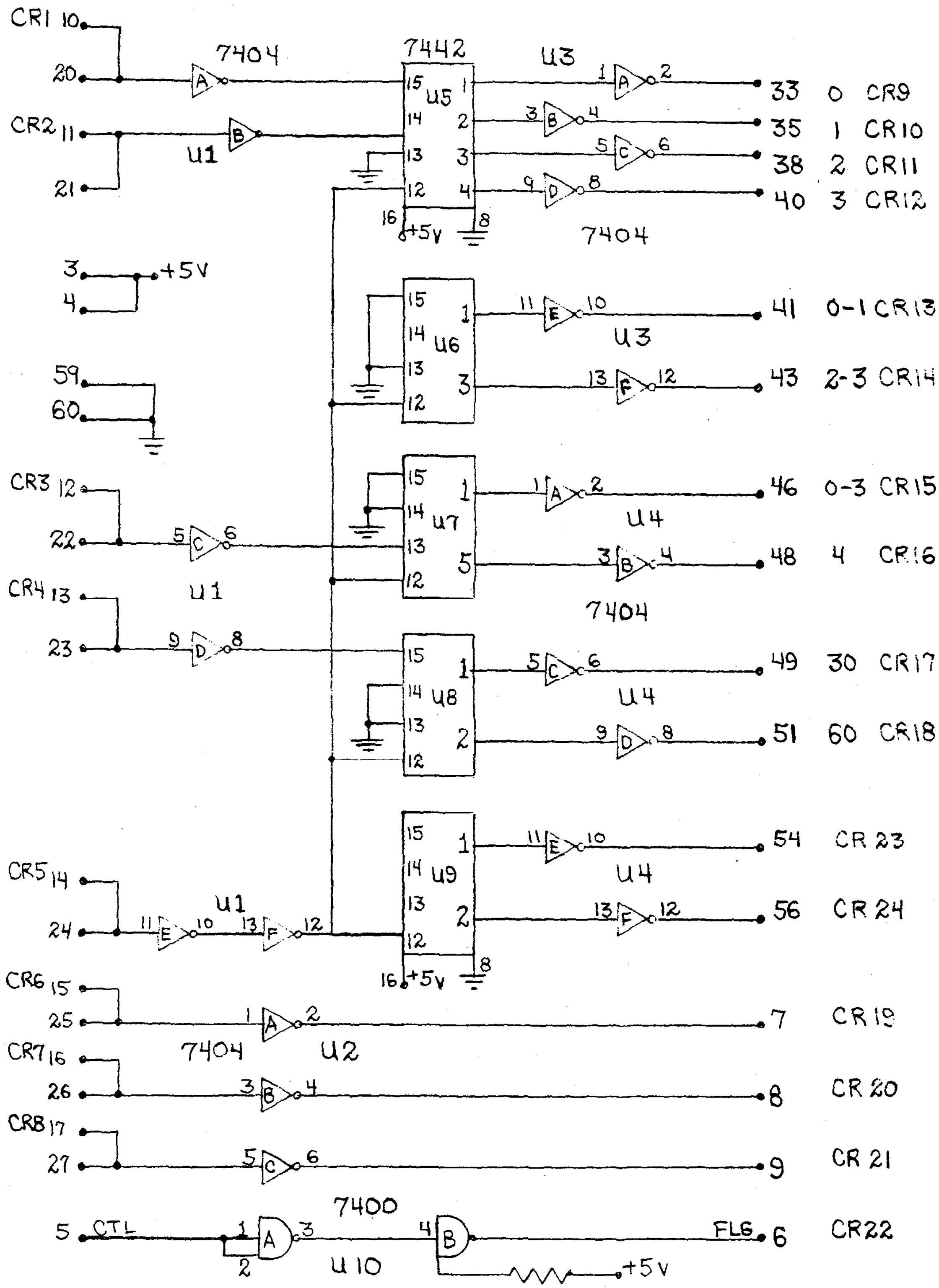
b) Card 110, Decoder Card.

This card uses a type 7442 decoder chip which is a BCD to decimal decoder (1 of 10). Four of these elements are used; one spare which is presently not used is supplied. Figure 10 shows the truth table for this type of decoder chip. In



30/60 MHZ RADIOMETER BLOCK DIAGRAM

FIGURE 8



110 DECODER CARD SCHEMATIC DIAGRAM

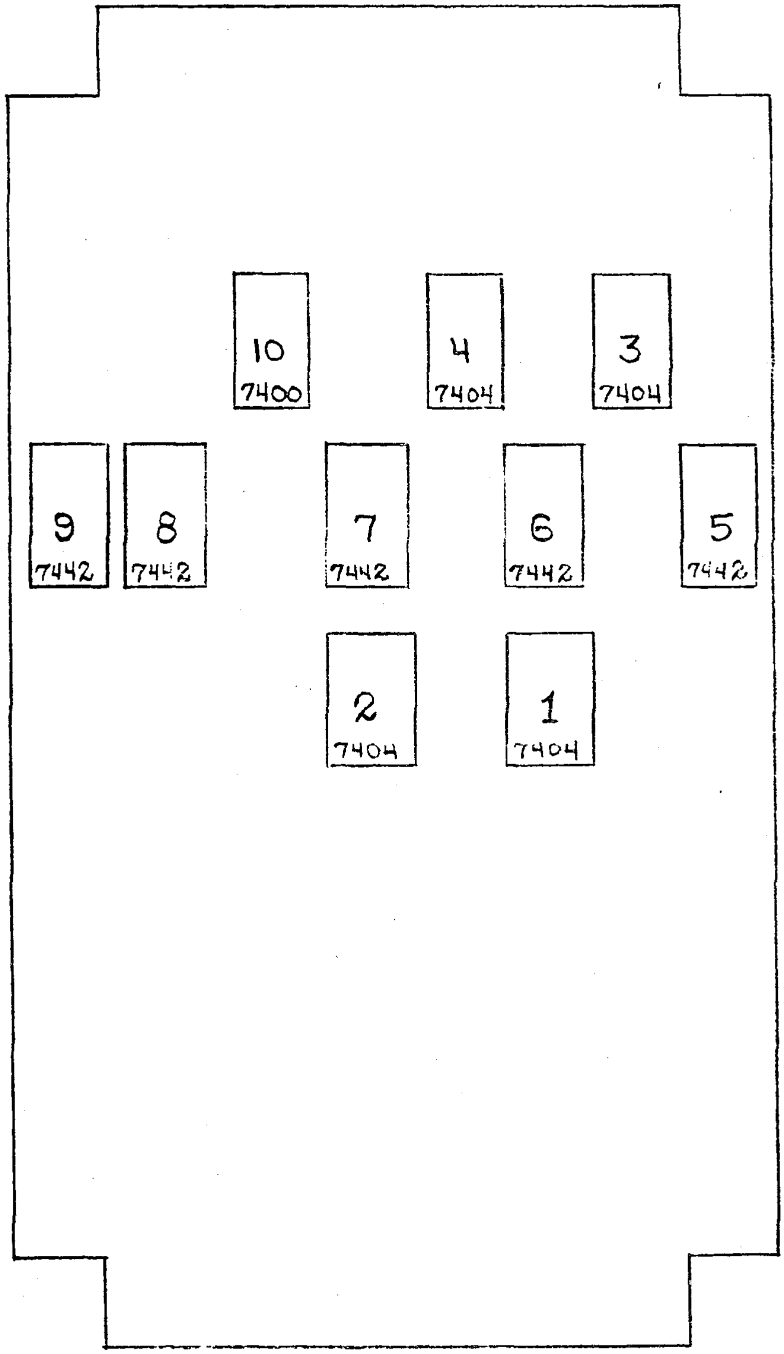
FIGURE 9

SN7442

BCD INPUT			DECIMAL OUTPUT									
C	B	A	0	1	2	3	4	5	6	7	8	9
0	0	0	0	1	1	1	1	1	1	1	1	1
0	0	1	1	0	1	1	1	1	1	1	1	1
0	1	0	1	1	0	1	1	1	1	1	1	1
0	1	1	1	1	1	0	1	1	1	1	1	1
1	0	0	1	1	1	1	0	1	1	1	1	1
1	0	1	1	1	1	1	1	0	1	1	1	1
1	1	0	1	1	1	1	1	1	0	1	1	1
1	1	1	1	1	1	1	1	1	1	0	1	1
0	0	0	1	1	1	1	1	1	1	1	0	1
0	0	1	1	1	1	1	1	1	1	1	1	0
0	1	0	1	1	1	1	1	1	1	1	1	1
0	1	1	1	1	1	1	1	1	1	1	1	1
1	0	0	1	1	1	1	1	1	1	1	1	1
1	0	1	1	1	1	1	1	1	1	1	1	1
1	1	0	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1

DECODER CHIP TRUTH TABLE

FIGURE 10



110 DECODER CARD PARTS PLACEMENT

FIGURE 11

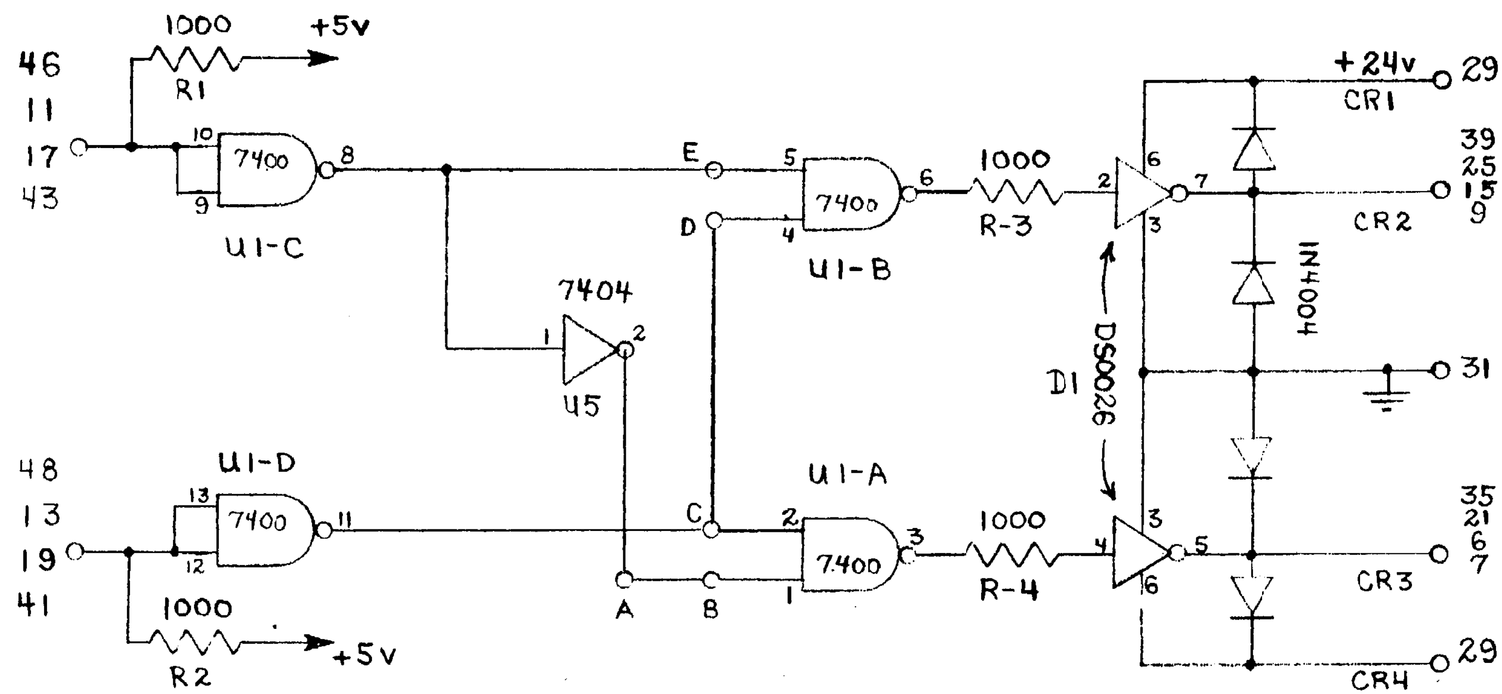
Figure 10, the BCD (binary coded decimal) inputs labled D, C, B, A correspond to device pin numbers 15, 14, 13, and 12 respectively. The decimal outputs listed correspond, in ascending order, to device pin numbers 1 through 11.

Inputs from the controller are sent to the decoder card via the instrument coupler. These inputs are decoded and sent to the proper switch driver card to achieve the desired switch action. Referring to Figures 8 and 9, outputs from pins 33, 35, 38, and 40 on this card control the switching of ports 0, 1, 2, and 3. Outputs from pins 41 and 43 select either the port 0-1 position or the port 2-3 position of switch #6. Outputs from pins 46 and 48 position switch #5 to connect ports 0-3 or port 4 to the remainder of the measurement system. Outputs from pins 49 and 51 select either the 30 Mhz or the 60 MHz position of switches 4a and 4b. As can be seen in Figure 9, input pin 24 on the decoder card is the "strobe" input for all of the decoder chips. This signal is used to enable the decoder output. Removing this signal provides for removing switch current without disturbing switch position. This signal is utilized in this manner to prevent heating of the switches. Outputs from pins 7 and 8 on this card are used to control the remote switches for the 15V and 25V power supplies for the switch drivers. The output from pin 9 on this card is used as a control bit for the thermistor mount switch and provides for removing current from this switch after it is properly positioned. The output from pin 6 on this card is the return flag signal to the controller from this card.

The LED display on the front panel of the switch driver module originates on the decoder card. The upper 8 bits of the display represent the digital input bits to the decoder since a LED is connected to pins 10, 21, 12, 13, 14, 15, 16, and 17. The lower portion of the LED display is formed by connecting a LED to each of the following output pins: 33, 34, 38, 40, 41, 43, 46, 48, 49, 51, 54, 56, 7, 8, and 9. By observing the lower portion of the display, the output of the decoder card can be determined at any time.

c) Switch Driver Cards

The switch driver module uses two different switch driver designs. One is intended to use the decoder outputs to control switching. This configuration is found on cards 111, 112, and 113. The other model uses a data bit and a control bit from the controller with no decoder in between. This configuration is found on card 114. Use of this card represents a hardware update to utilize a design incorporated in new equipment now being built for other systems. Cards 111, 112, and 113 control the system measurement port and frequency switches. Referring to Figure 12, the cards are configured for the decoder input model by installing jumper wires between points B and C, and points D and E with no connection between points D and C and points A and B. There are 4 complete switch driver circuits on a card; Figure 12 shows only one of these circuits for illustration purposes with inputs and outputs for all



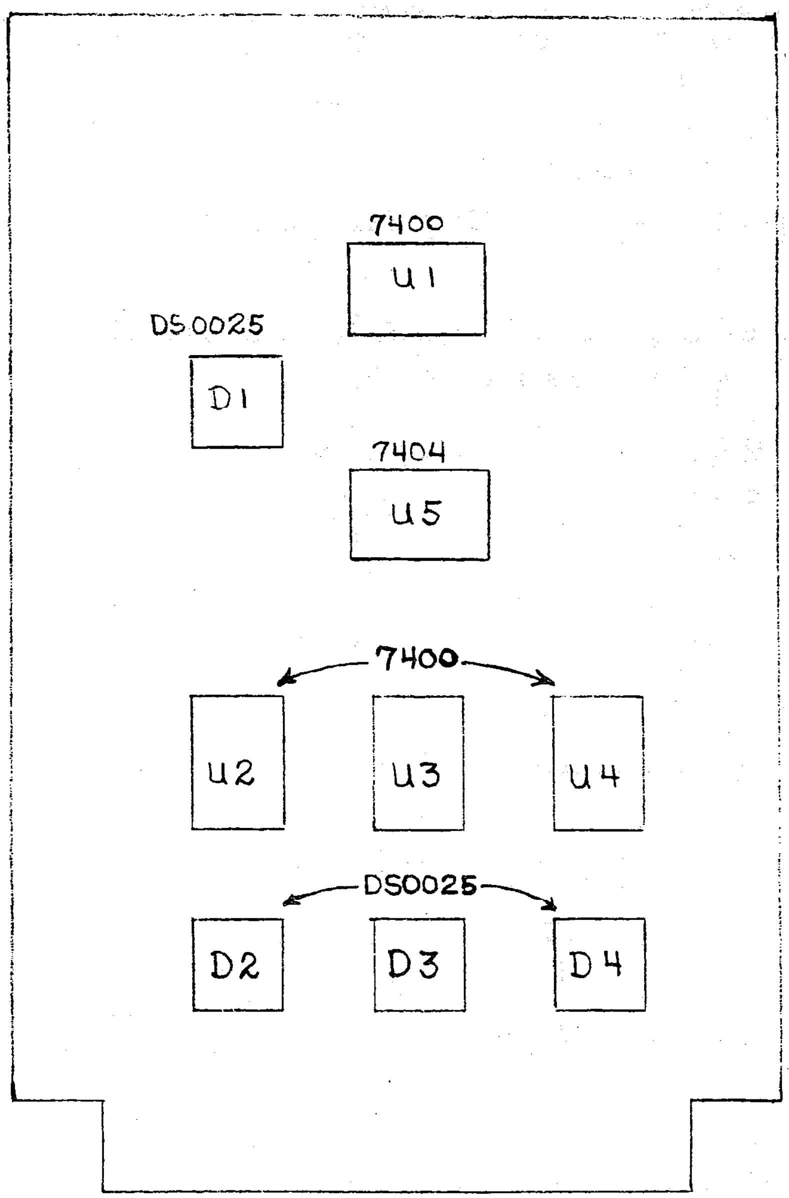
U2, U3, U4 SAME AS U1

D2, D3 D4 SAME AS D1

WHEN DS0025 IS USED
SHORT CIRCUIT R3 AND R4

111-114 SWITCH DRIVER CARD SCHEMATIC DIAGRAM

FIGURE 12



SWITCH DRIVER CARD PARTS PLACEMENT

FIGURE 13

four circuits indicated by multiple pin numbers. Inputs are in pairs and produce outputs in pairs (inputs of the proper polarity at pins 46 and 48 produce outputs of opposite polarity at pins 9 and 7). Connected to opposite sides of a switch, these outputs cause it to toggle with a change in polarity. Inputs which cause the paired outputs to have the same polarity produce a positive voltage which is applied to both sides of a switch. There is no current flow, and as a result, the switch does not toggle. The system port switches #7 and #8 are controlled by the outputs of driver card 111. The action of switches #5 and #6 is controlled by driver card 112. The frequency selection switches #4a and #4b are controlled by the output from driver card 113.

Card 114 is similar to the other switch driver cards but, as previously mentioned, is designed to operate without the decoder. To configure this card, remove the jumpers described previously and install jumpers between points A and B and points D and C.

Binary bit 7 or decimal 128 from the decoder card is used as the enabling input for the drivers on this card. It is applied to pin 19 on card 114. The source for this control bit is the controller.

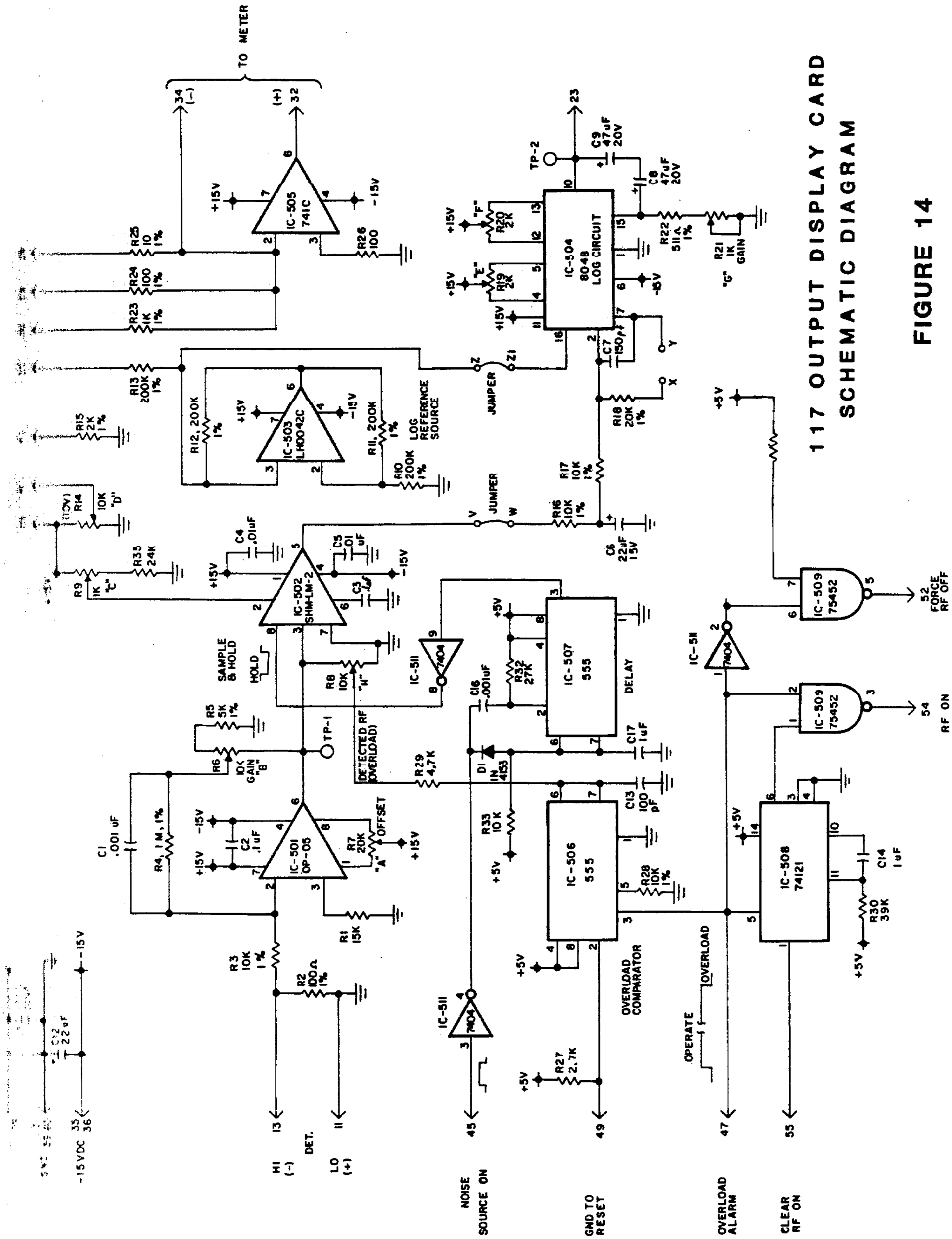
d) 117 Output Display Card Operation and Adjustment

Figures 14 and 15 are the schematic diagrams for this card. The output display printed circuit card monitors the output of the diode detector. The input on pin 13 is amplified by IC-501 and input to the overload level comparator, IC-506, through the overload-adjust potentiometer "H" (R5). If the rf power exceeds 5 milliwatts the overload comparator triggers and latches. This energizes the sonalert alarm and overvoltage LED via Pin 52. The comparator cannot be reset by pressing the reset button until the power level has been reduced to a safe level.

The incoming signal level is also processed through a series of amplifiers to the front panel RF level meter. The output of the log-amplifier, IC501, passes through a sample and hold circuit, IC-502. The output of the sample and hold circuit drives the log-amplifier, IC-504, to convert the meter reading to a dB scale. IC-503 forms a constant current source to set the zero reference of the log amplifier. The output of IC-504 is connected to the input of the meter driver amplifier, IC-505. The gain of this amplifier is switched for gains of 10, 1, and .1 to obtain meter scales of 1.0 decibel, 0.1 decibel, and 0.01 decibel. Potentiometer "D" (R14) adjusts the times 1 scale zero reference.

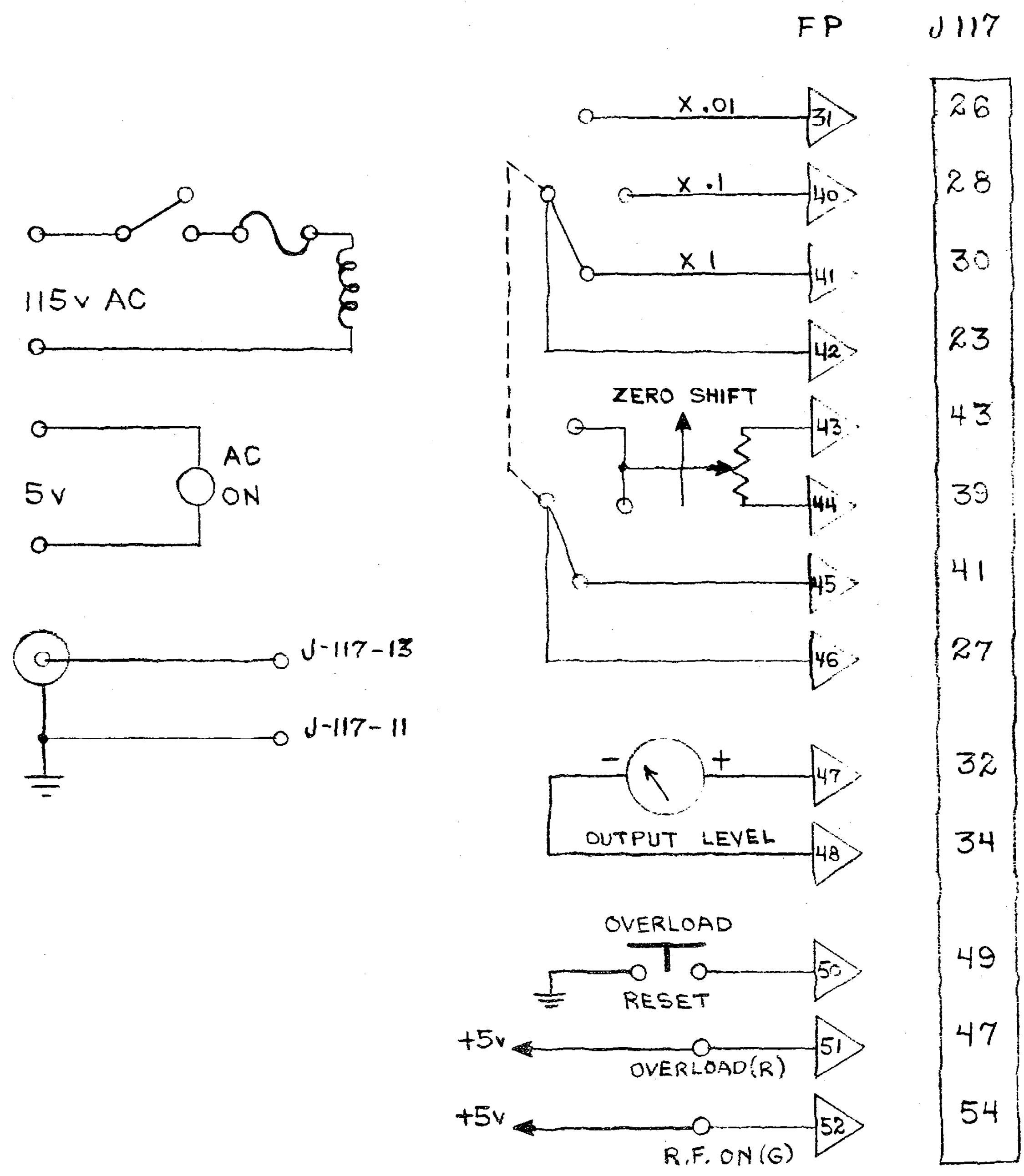
Adjustment of the Output Display Card

This is the only card in the switch driver module which requires adjustment. Adjustment is necessary only when the circuit has been repaired. The adjustments establish the logarithmic amplifier gain for the decibel scale on the front panel signal level meter and set the overload alarm threshold. Complete alignment requires two, 1 milliampere



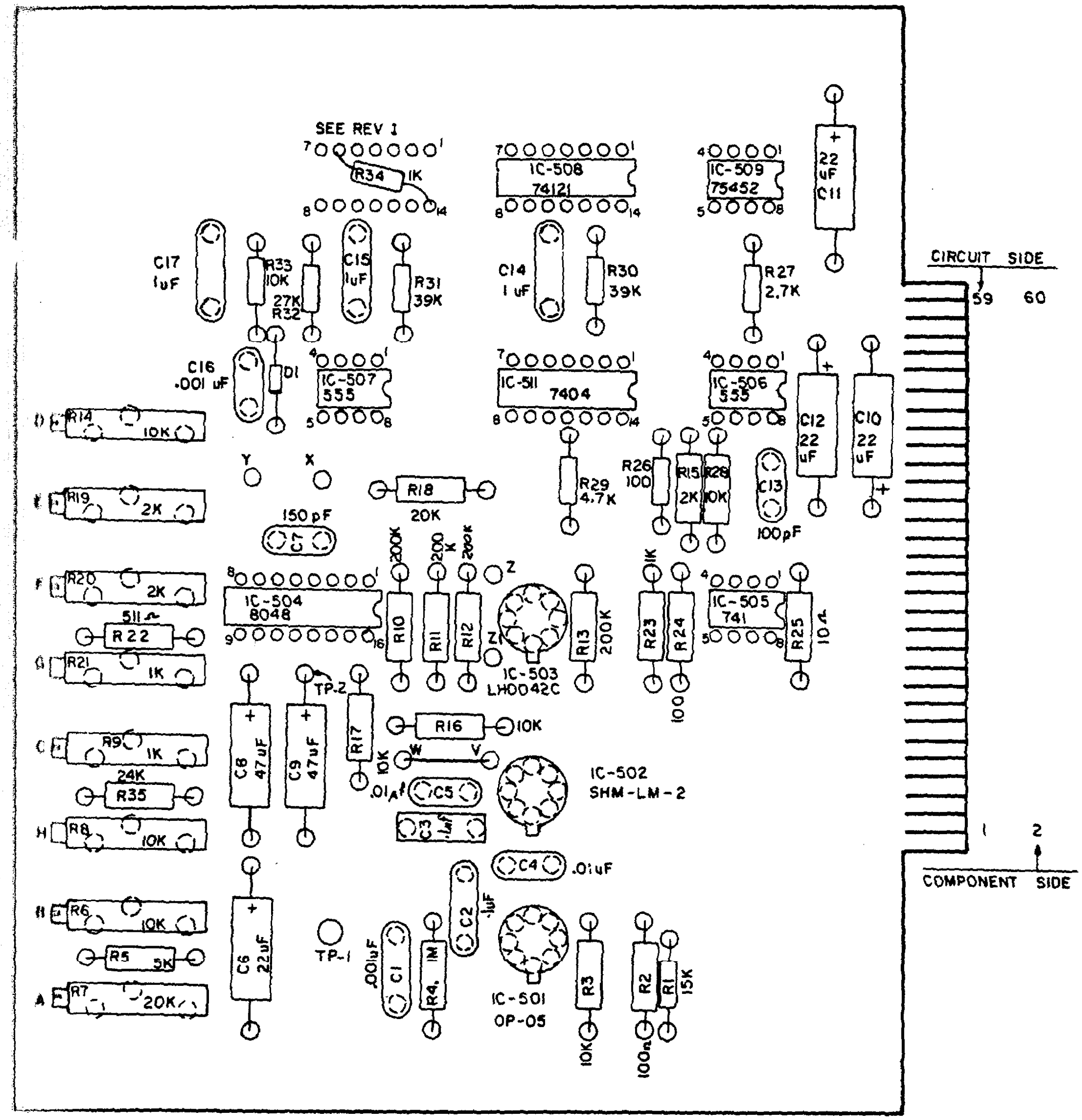
117 OUTPUT DISPLAY CARD
SCHEMATIC DIAGRAM

FIGURE 14



117 OUTPUT DISPLAY CARD FRONT PANEL CONNECTIONS

FIGURE 15



117 OUTPUT DISPLAY CARD PARTS PLACEMENT

FIGURE 16

constant current sources. Refer to Figure 14 when adjustment of the 1700 card is performed. Adjustments should be made in the following order:

1. Mount the 1700 printed circuit card on a PC extension card and remove the signal input cable from the diode detector to the front panel.
2. Connect an external voltmeter between TP 1 and ground. Adjust "A" (R7), DC offset of first amplifier, for zero on the voltmeter.
3. Connect the external voltmeter to TP V and adjust offset control, "C" (R9) for a zero reading on the voltmeter.
4. Remove the jumper from TP V to TP W. Connect a temporary jumper from TP X to TP Y. Adjust "E" (R19), DC offset of the first log-amplifier, for a zero voltmeter reading.
5. Remove the temporary jumper from TP X to TP Y. Remove the jumper from TP Z to TP Z1. Connect one +1 milliampere constant current source into TP Z1 from ground. Connect the other +1 milliampere constant current source into TP W from ground. Set both current sources to 1 milliampere. (Place two suitable current meters in series with the sources and adjust the output of the current sources to 1 milliampere on these meters). Connect the external voltmeter between TP 2 and ground. Adjust "F" (R20), the DC offset of the second stage of the log amplifier, for zero volts on the voltmeter.
6. Remove both constant current sources. Replace the jumper

from TP V to TP W. Replace the jumper between TP Z and TP Z1.

7. Connect a suitable cable between the DET IN jack on the front panel and the system diode detector output connector at on end of coaxial switch #1.

   (a) Place a diode noise standard on port 0 and apply voltage (normally 28 volts) to it.

   (b) After making sure all ports are properly terminated, turn the measurement system on.

   (c) Place the preamplifier voltage switch to the 30 MHz or up position.

   (d) Turn on all system power supplies.

   (e) Load the measurement program (30M20).

   (f) Type the following on the 9845 keyboard:
   OUTPUT 702;"0","0","7","0"
   PRESS EXECUTE

   (g) Remove the termination from the auxillary port on system switch #1. Place a suitable thermistor mount on this port and connect it to an external power meter.

   (e) Set attenuator A2 for 1 milliwatt of system output power at this port.

8. Connect an external voltmeter to TP 1. Adjust "B" (R6), the first amplifier gain, for 1 volt on the voltmeter.

9 Adjust system attenuator A2 to set the external power meter reading to 2 milliwatts. Switch the meter range

selector on the front panel to the X1 position. Adjust "D" (R14), log reference zero offset, for a zero reading on the front panel signal level meter.

10. Increase the setting of system attenuator A2 by 5 dB. Adjust "G" (R21), log-amplifier gain, for a front panel meter reading of -5 divisions. Decrease the attenuator A2 setting 10 dB and note the front panel meter reading. Touch up "G" if necessary to obtain approximately a +5 reading on the meter scale. Recheck the -5 reading.

11. Set the input attenuator for a power level of 1 milliwatt on the power meter. Readjust "D" for a +3 reading on the front panel meter.

12. Adjust the front panel attenuators for a 5 milliwatts (+7dBM) power indication on the power meter. Adjust "H" (R5), overload threshold adjust, clockwise until the alarm sounds. Now turn R5 1/2 turn counter-clockwise. Reduce the input power and push the reset button on the front panel. Slowly increase the power to test the alarm threshold. The alarm should be activated at the +5 milliwatt power level.

13. Adjust attenuator A2 until the external power meter reads 2 milliwatts. Adjust "D" (R14), log reference zero offset, for a zero reading on the front panel signal level meter.

This completes the alignment of the Output Display Card. These adjustments do not affect system operation or accuracy. They do however, provide for the accurate display of system power levels.

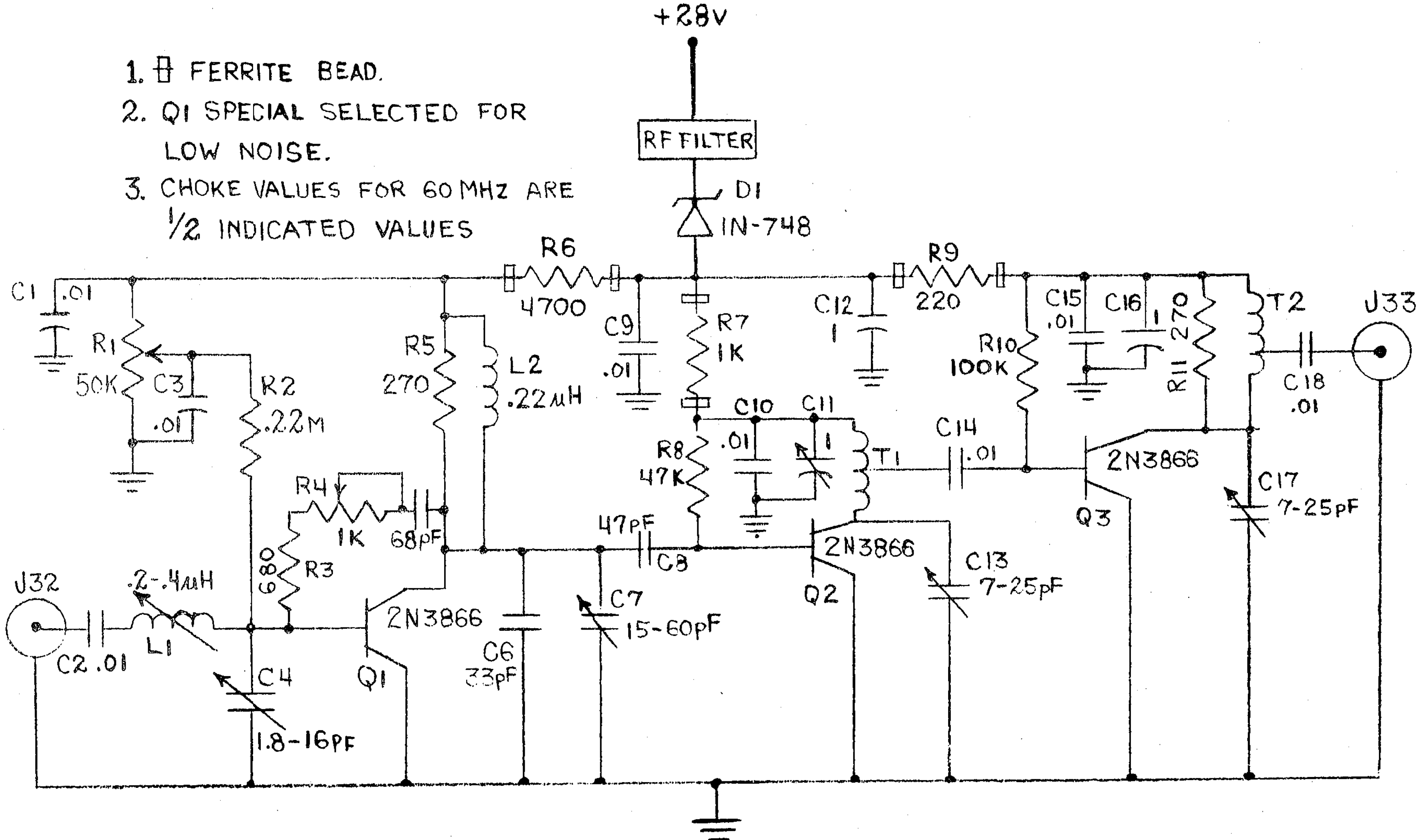
2. 30 MHZ AND 60 MHZ PREAMPLIFIERS

Referring to Figure 17, note that essentially the same schematic diagram is used for both the 30 MHz and the 60 MHz preamplifiers. The main difference is the value of the RF chokes, L1 and L2. The values of these components in the 30 MHz amplifier are double the value of those used in the 60 MHz amplifier.

These amplifiers were very carefully built with extreme care being taken with parts selection and placement. Ground strapping is extremely important as is proper shielding. Some stock components as well as some component locations produced an inferior amplifier. For this reason, amplifier performance was checked with impedance and noise figure meters as construction progressed.

Input impedance, output impedance, and noise figure are adjustable. However, because the adjustments are interdependent, a compromise is necessary to obtain optimum tuning for both noise figure and impedance. The lowest noise figure achieved with acceptable input impedance was between 1.5 and 1.6 decibels. This noise figure was obtained while maintaining the real and imaginary parts of the input impedance as specified previously. The impedances were measured using a vector impedance meter, and the noise figure was measured using a commercial noise figure meter with a calibrated noise diode reference.

Since failure of one of these amplifiers will undoubtedly cause a long "system down time" while repairs and adjustments are made, spare amplifiers are mounted beside the two being used. If



30MHZ AND 60MHZ PREAMPLIFIER SCHEMATIC DIAGRAM

FIGURE 17

failure occurs, simply remove the defective amplifier and replace it with the proper spare.

I. INTERCONNECTION AND WIRING DIAGRAMS

The system interconnection cables include the IEEE 488 bus cables which connect the controller to the scanner, digital multimeter, and instrument coupler. In addition to the instrument bus interconnection cables, the equipment is coupled together by the following:

TABLE 5
SYSTEM CABLES--INSTRUMENTS TO SCANNER

Cable #	Figure #	Source	Destination
1. Cable 1	18	DC Power Supplies	Scanner
2. Cable 1A	18	Scanner	DMM Rear Panel Input Connector
3. Cable 2	18	Type IV Power Meter	Scanner
4. Cable 2a	18	Scanner	Rear Panel Input Connector
5. Cable 3	19	Ambient Standard	External Terminal Board on Scanner
7. Cable 4	19	Cryogenic Standard	External Terminal Board on Scanner
8. Cable 5	19	External Terminal Board on Scanner	DMM Front Panel Input Terminals

The cables listed in Table 5 are those directly concerned with the transfer of measurement information from the various instruments to the digital multimeter which acts as a central processing point since it measures the cable outputs and sends the measured results back to the controller on the IEEE 488 bus.

Commands from the controller are sent to the switch control module via the instrument coupler. The switch control module then controls the system switches by accessing them through the cables connected to its output jacks. Figures 20 through 28 detail the pin connections of the switch driver module input and output jacks.

An overview of all connections made to the switch driver module from the controller and within the switch driver module to the various switch driver cards is shown in Figure 20.

Figure 21 is a diagram of J104 which is the input cable from the instrument coupler to the switch driver module.

Figure 22 is a diagram of J102 which is the output jack from the switch driver module to the system switches.

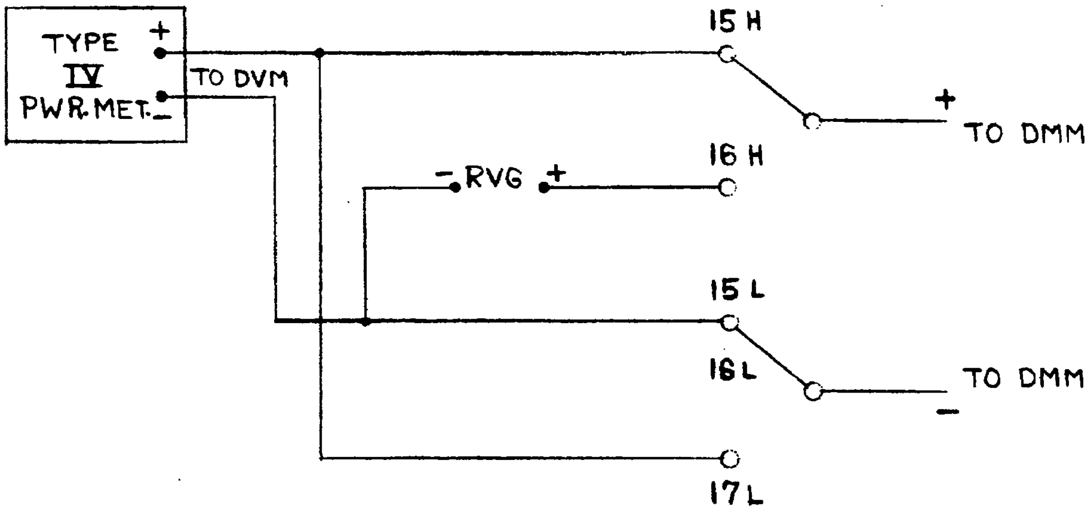
Figure 23 is a wiring list for J-102 and its associated cable.

Figure 24 is a diagram showing the inputs and outputs to J-110, the decoder edge connector.

Figures 25 through 28 are diagrams of the switch driver card edge connectors J-111, J-112, J113, and J114.

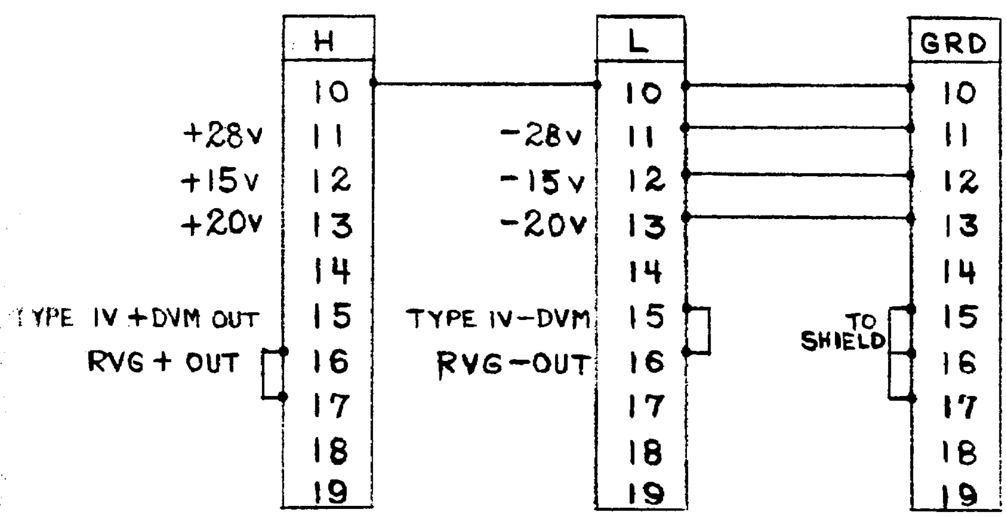
4. PARTS LISTS

Information relating to the parts lists for the digital voltmeter, scanner, instrument coupler, thermistor mount, power meter, and power supplies can be obtained from the instrument manual supplied by the manufacturer. The parts lists for NBS manufactured equipment will be found in TABLE 7. Manufacturers Codes used in these parts lists are tabulated in TABLE 6.



CABLE 2

SCANNER DECADE (LOW THERMAL) CHANNELS 10-19

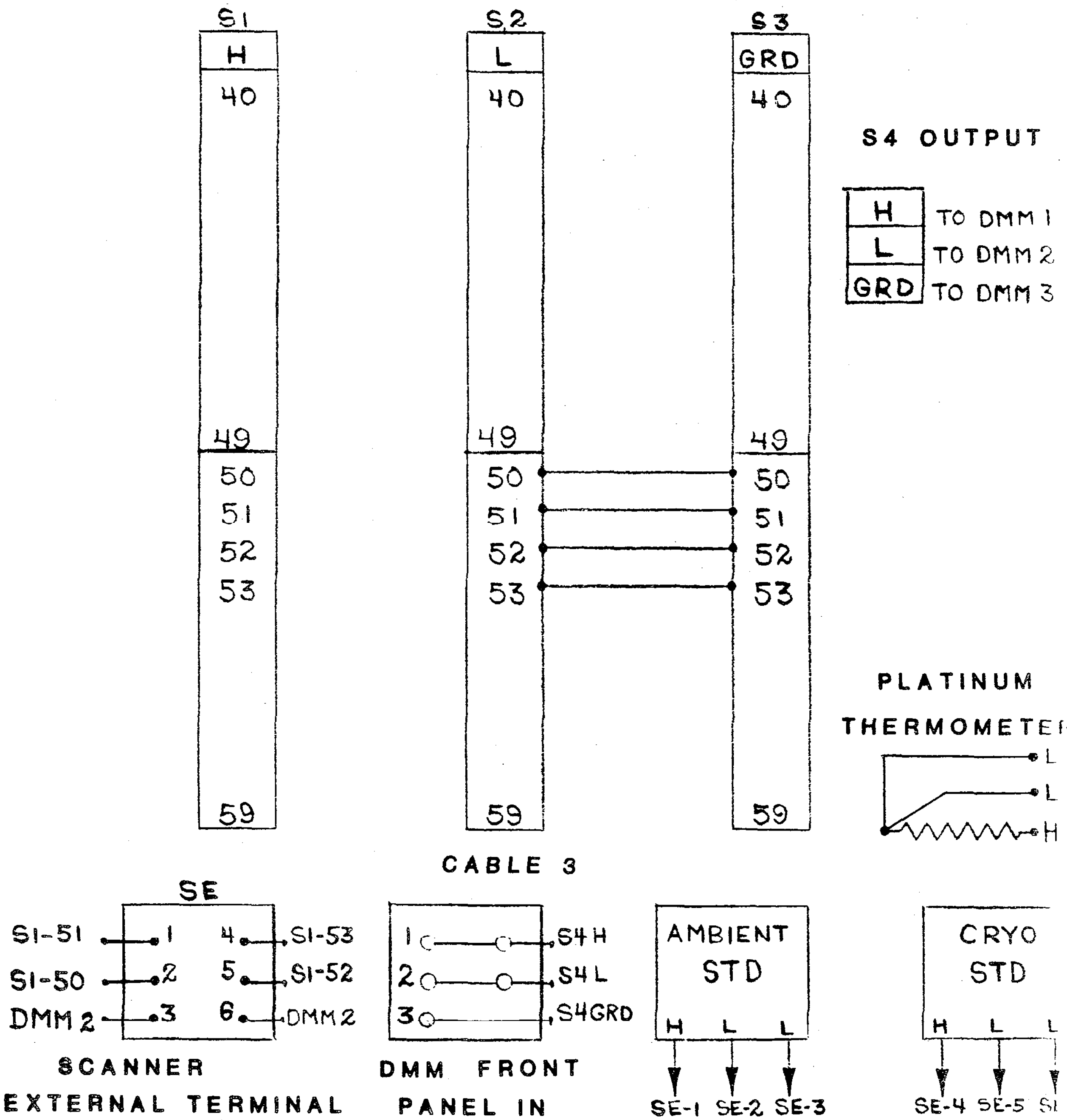


SCANNER CONNECTIONS CABLE 1 (10-13)

SCANNER CONNECTIONS CABLE 2 (15-17)

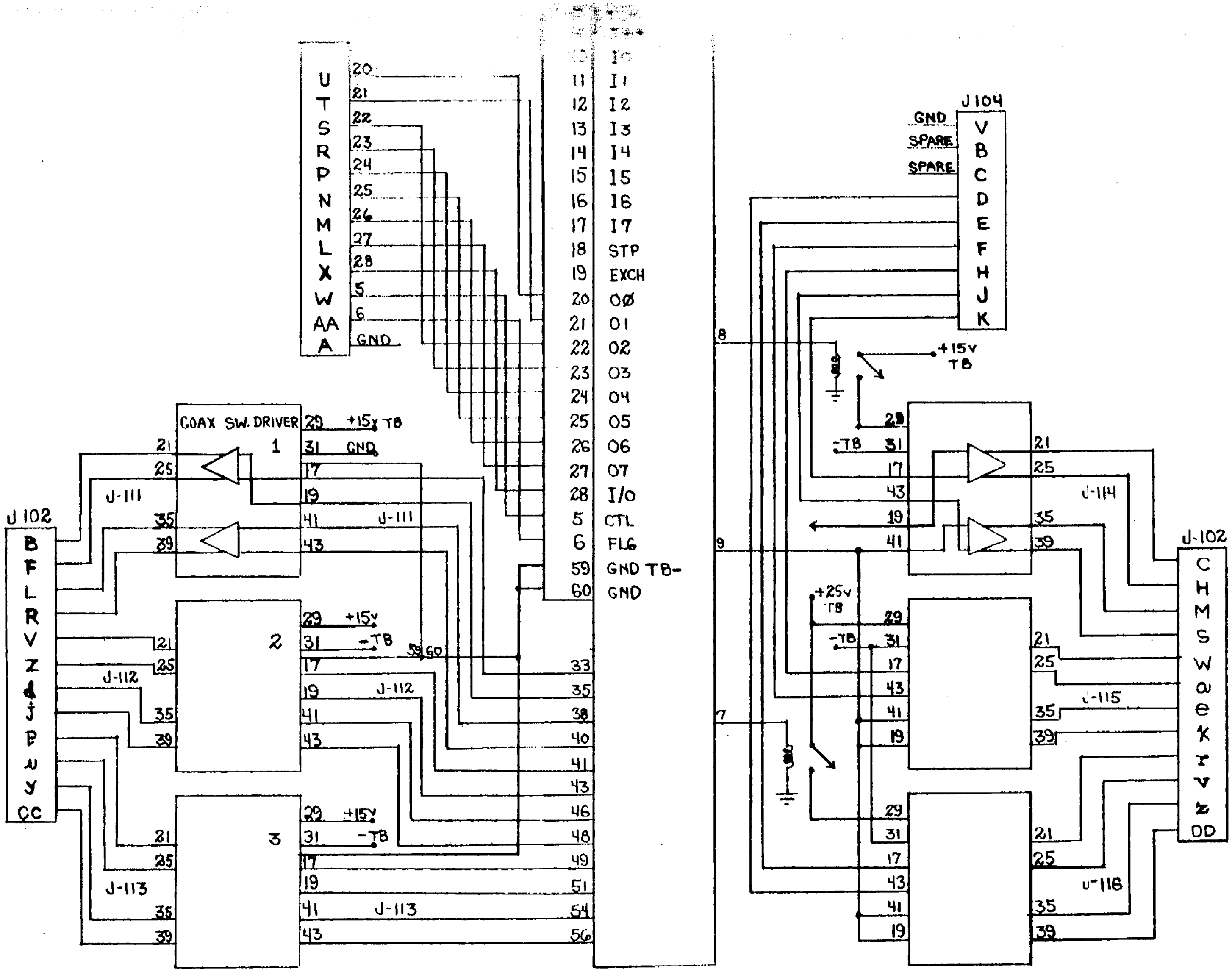
POWER METER WIRING DIAGRAM AND SCANNER CONNECTIONS

FIGURE 18



NOISE STANDARDS WIRING DIAGRAM AND SCANNER CONNECTIONS

FIGURE 19



SYSTEM CABLE INTERCONNECTION DIAGRAM

FIGURE 20

J-104

GND	V	
DO 15	B	SPARE
DO 14	C	SPARE
DO 13	D	J116-43
DO 12	E	J116-17
DO 11	F	J115-43
DO 10	H	J115-17
DO 9	J	J114-43
DO 8	K	J114-17
DO 7	L	J110-27
DO 6	M	J110-26
DO 5	N	J110-25
DO 4	P	J110-24
DO 3	R	J110-23
DO 2	S	J110-22
DO 1	T	J110-21
DO 0	U	J110-20
PCNTL	W	J110-5
I/O	X	J110-28
PFLG	AA	J110-6
GND	A	J110-60

PIN CONNECTIONS FOR J104, SWITCH DRIVER MODULE INPUT

FIGURE 21

J102

		A	d	SW5+	J112-35
J111-21	SW7+	B	e		J115-35
J114-21		C	f		
		D	h		
		E	j	SW5-	J112-39
J111-25	SW7-	F	k		J115-39
J114-25		H	m		
		J	n		
		K	p	SW +	J113-21
J111-35	SW8+	L	r		J116-21
J114-35		M	s		
		N	t		
		P	u	SW -	J113-25
J111-39	SW8-	R	v		J116-25
J114-39		S	w		
		T	x		
		U	y	SPARE	J113-35
J112-21	SW6+	V	z		J116-35
J115-21		W	AA		
		X	BB		
		Y	CC	SPARE	J113-39
J112-25	SW6-	Z	DD		J116-39
J115-25		a	EE		
		b	FF		
		c	HH		

PIN CONNECTIONS FOR J102, SWITCH DRIVER MODULE OUTPUT

FIGURE 22

	A			VIO	d	J-112-35	PORT-4 SW5
BRN	B	J-111-21	PORT-0 SW7	VIO	e	J-115-35	2dB +
BRN	C	J-114-21	RF ON +		f		
	D				h		
	E			GRY	j	J-112-39	PORT 0-3 SW5
RED	F	J-111-25	PORT-1 SW7	GRY	k	J-115-39	2dB −
RED	H	J-114-25	RF ON −		m		
	J				n		
	K			WHT	p	J-113-21	60 MHz
OR	L	J-111-35	PORT-3 SW8	WHT	r	J-116-21	4dB +
OR	M	J-114-35	REF +		s		
	N				t		
	P			BLK	u	J-113-25	30 MHz
YEL	R	J-111-39	PORT-2 SW8	BLK	v	J-116-25	4 dB −
YEL	S	J-114-39	REF −		w		
	T				x		
	U				y	J-113-35	
GRN	V	J-112-21	TR-0-1 SW6	BRN	z	J-116-35	8 dB +
GRN	W	J-115-21	1dB +		AA		
	X				BB		
	Y				CC	J-113-39	
BLU	Z	J-112-25	TR2-3 SW6	RED	DD	J-116-39	8dB −
BLU	a	J-115-25	1dB −		EE		
	b				FF		
	c				HH		

COMPLETE WIRING DIAGRAM FOR J102

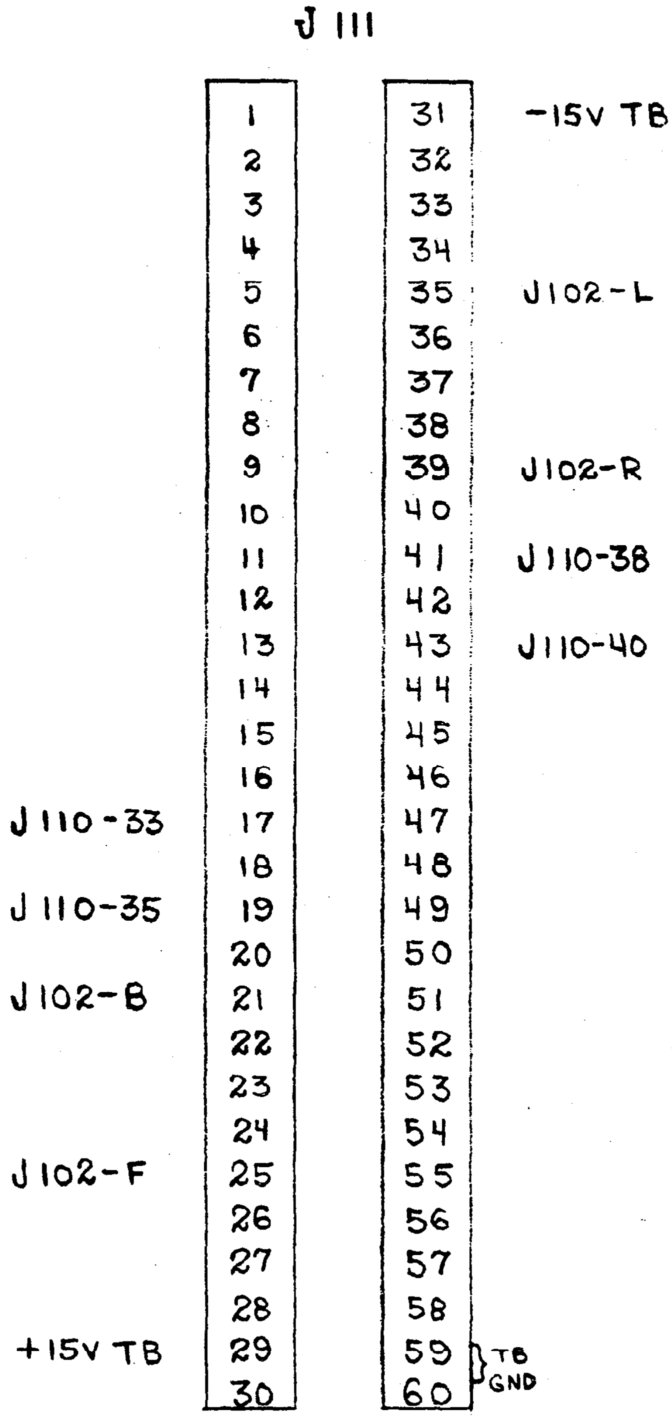
FIGURE 23

J 110

	1	31	
	2	32	
+5V	3	33	J 111-17
TB+	4	34	
J 104 - W	5	35	J 111-19
J 104 - AA	6	36	
+ 25V SWITCH	7	37	
+ 15V SWITCH	8	38	J 111-41
J·114, 15, 16 - 41+19	9	39	
	10	40	J 111-43
	11	41	J 112-17
	12	42	
	13	43	J 112-19
	14	44	
	15	45	
	16	46	J 112-41
	17	47	
	18	48	J 112-43
	19	49	J 113-17
J 104 - U	20	50	
J 104 - T	21	51	J 113-19
J 104 - S	22	52	
J 104 - R	23	53	
J 104 - P	24	54	J 113-41
J 104 - N	25	55	
J 104 - M	26	56	J 113-43
J 104 - L	27	57	
J 104 - X	28	58	
	29	59	-5V GND
	30	60	TB-

J110, DECODER CARD INPUT AND OUTPUT CONNECTOR

FIGURE 24



J111, SWITCH DRIVER CARD INPUT AND OUTPUT CONNECTOR

FIGURE 25

J 112

	1	31	-15 TB
	2	32	
	3	33	
	4	34	
	5	35	J 102-d
	6	36	
	7	37	
	8	38	
	9	39	J 102-j
	10	40	
	11	41	J 110-46
	12	42	
	13	43	J 110-48
	14	44	
	15	45	
	16	46	
J 110-41	17	47	
	18	48	
J 110-43	19	49	
	20	50	
J 102-V	21	51	
	22	52	
	23	53	
	24	54	
J 102-Z	25	55	
	26	56	
	27	57	
	28	58	
+15 TB	29	59	GND-TB
	30	60	GND-TB

J112, SWITCH DRIVER CARD INPUT AND OUTPUT CONNECTOR

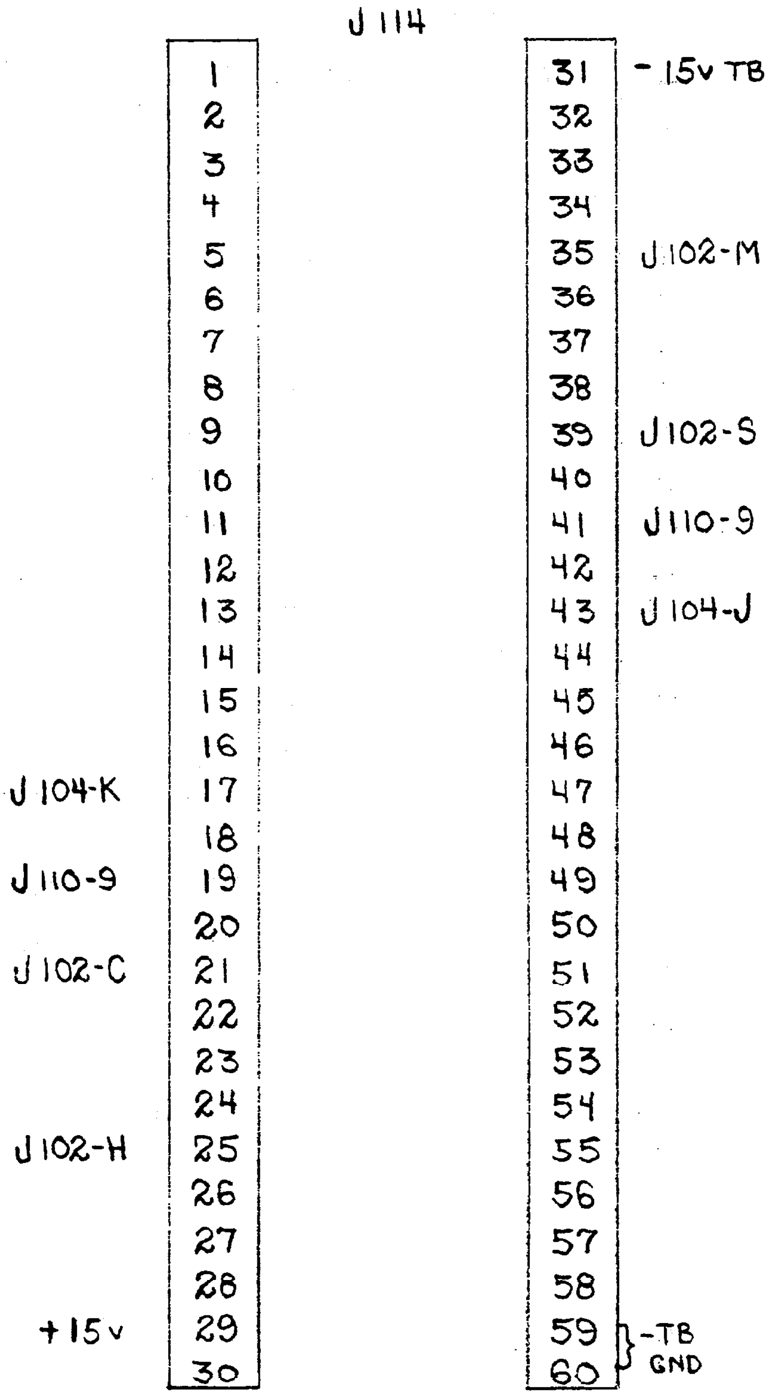
FIGURE 28

J113

	1	31	-15VTB
	2	32	
	3	33	
	4	34	
	5	35	J102-Y
	6	36	
	7	37	
	8	38	
	9	39	J102-CC
	10	40	
	11	41	J110-54
	12	42	
	13	43	J110-56
	14	44	
	15	45	
	16	46	
J110-49	17	47	
	18	48	
J110-51	19	49	
	20	50	
J102-P	21	51	
	22	52	
	23	53	
	24	54	
J102-u	25	55	
	26	56	
	27	57	
	28	58	
+15VTB	29	59	-TB GND
	30	60	

J113, SWITCH DRIVER CARD INPUT AND OUTPUT CONNECTOR

FIGURE 27



J114, SWITCH DRIVER CARD INPUT AND OUTPUT CONNECTOR

FIGURE 28

J117

Signal	Pin	Pin	Signal
ANALOG GND	1	31	
" "	2	32	FP-47
	3	33	
	4	34	FP-48
	5	35	
	6	36	-15v
	7	37	
	8	38	+15v
	9	39	FP-44
	10	40	
SHIELD XTAL DET.	11	41	FP-45
	12	42	
XTAL DET.	13	43	FP-43
	14	44	
	15	45	
	16	46	
	17	47	FP-51 LED R
	18	48	
	19	49	FP-50 RESET
	20	50	
	21	51	
	22	52	J-114-19
FP-42	23	53	
	24	54	LED-GRN FP-52
	25	55	
FP-31	26	56	
FP-46	27	57	+5v
FP-40	28	58	+5v
	29	59	GND
FP-41	30	60	"

J117, OUTPUT DISPLAY CARD INPUT AND OUTPUT CONNECTOR

FIGURE 29

TABLE 6

MANUFACTURER'S CODE TABLE

[illegible]

3M Company, Electronics Products Division
3M Center
St. Paul, Minnesota 55101

[illegible]

Allen-Bradley Company
1201 S. Second Street
Milwaukee, Wisconsin 53204

[illegible]

Alcoswitch Division of Alco Electronic Products, Inc.
P.O. Box 1348
Lawrence, Massachusetts 01842

[illegible]

Amphenol Connector Division
Bunker-Ramo Corporation
Broadview, Illinois 60153

[illegible]

Bourns, Incorporated, Trimpot Division
1200 Columbia Avenue
Riverside, California 92507

[illegible]

Bud Radio Incorporated
4605 East 355th Street
Willoughby, Ohio 44094

TABLE 6

MANUFACTURER'S CODE TABLE continued

CORG

Corning Glass Works

Electronic Products Division

Corning, New York 14830

DATL

Datel Systems, Incorporated

1020 Turnpike Street

Canton, Massachusetts 02021

DIAL

Dialignt Corporation

Division of North American Phillips Corporation

Brooklyn , New York 11237

DUNC

Duncan Electric Company, Inc.

2865 Fairview Road

Lafayette, Indiana 47902

GARY

Garry Manufacturing, Inc.

1010 Jersey Avenue

New Brunswick, New Jersey 08902

ITSL

Intersil, Incorporated

10900 North Tantau Avenue

Cupertino, California 95014

TABLE 6

MANUFACTURER'S CODE TABLE continued

MODT

Modutec, Incorporated
18 Marshall Street
Norwalk, Connecticut 06854

MONO

Precision Monolithics, Inc.
1500 Space Drive
Santa Clara, California 95050

MOT

Motorala Semiconductor Products, Incorporated
2002 West 10th Place
Tempe, Arizona 85281

NATL

National Semiconductor Corp.
2900 Semiconductor Drive
Santa Clara, California 95051

NBS

National Bureau of Standards
325 Broadway
Boulder, Colorado 80302

SAMT

Samtec, Incorporated
2652 Charlestown Road
New Albany, Indiana 47150

TABLE C

MANUFACTURER'S CODE TABLE continued

SCBE

Scanbe Canosa Industries

3445 Fletcher Avenue

El Monte, California 91731

SEAC

Seacor, Incorporated

598 Broadway

Norwood, New Jersey 07648

SPRG

Sprague Electric Company

418 Marshall Street

North Adams, Massachusetts 012147

THER

Thermalloy Inc.

2021 West Valley View

Dallas, Texas 75234

TABLE 7
PARTS LIST FOR SWITCH DRIVER MODULE COMPONENTS

DECODER CARD (110)

Category 1	Resistors			
R1	1ea	Resistor, Carbon, 0.25W 5%	AB	FSN 5905-681-6462
Category 4	Diodes			
CR1-CR24,	24ea	LED Indicator	DIAL	550-0506
Category 5	Integrated Circuits			
U1,	1ea	I. C. Hex Inverter	TI	SN7404N
U2,	1ea	I. C. Hex Inverter	TI	SN7404N
U3	1ea	I. C. Hex Inverter	TI	SN7404N
U4	1ea	I. C. Hex Inverter	TI	SN7404N
U5	1ea	I. C. Decoder	TI	SN7442N
U6	1ea	I. C. Decoder	TI	SN7442N
U7	1ea	I. C. Decoder	TI	SN7442N
U8	1ea	I. C. Decoder	TI	SN7442N
U9	1ea	I. C. Decoder	TI	SN7442N
U10	1ea	I. C. Quad Nand Gate	TI	SN7400N
Category 6	Connectors			
	10ea	DIP Socket 14 Pin	THER	8204-NF-414-1

TABLE 7

PARTS LIST FOR SWITCH DRIVER MODULE COMPONENTS continued

SWITCH DRIVER CARD (111, 112, 113, 114)

Catagory 1---Resistors---				
R1	4ea	Resistor, Carbon, 0.25W 5%,1K	AB	FSN 5905-681-6462
R2	4ea	Resistor, Carbon, 0.25W 5%,1K	AB	FSN 5905-681-6462
R3	4ea	Resistor, Carbon, 0.25W 5%,1K	AB	FSN 5905-681-6462
R4	4ea	Resistor, Carbon, 0.25W 5%,1K	AB	FSN 5905-681-6462
Catagory 4---Diodes---				
CR1	4ea	Diode Rectifier	MOTO	1N4004
CR2	4ea	Diode Rectifier	MOTO	1N4004
CR3	4ea	Diode Rectifier	MOTO	1N4004
CR4	4ea	Diode Rectifier	MOTO	1N4004
Catagory 5---Integrated Circuits---				
U1	4ea	I. C. Quad Nand Gate	TI	SN7400N
U2	1ea	I. C. Hex Inverter	TI	SN7404N
U3	2ea	I. C. Mos Memory Clock Driver	NATL	DS0025C
U4	2ea	I. C. Mos Memory Clock Driver	NATL	DS0025C
Catagory 6---Connectors---				
	5ea	14 Pin DIP Socket	THER	8204-NF-414-1
	4ea	8 Pin DIP Socket	THER	8204-NF-408-1

TABLE 7

PARTS LIST FOR SWITCH DRIVER MODULE COMPONENTS continued

OUTPUT DISPLAY CARD (117)

Category 1-------------------Resistors--------------------------------

R1	1ea	Resistor, Carbon, 0.25W, 5%, 15K	AB	CB
R2	2ea	Resistor, MF, 0.25W, 1%, .1K	CORG	NC5
R3	4ea	Resistor, MF, 0.25W, 1%, 10K	CORG	NC5
R4	1ea	Resistor, MF, 0.25W, 1%, 1000K	CORG	NC5
R5	1ea	Resistor, MF, 0.25W, 1%, 5.1K	CORG	NC5
R6	3ea	Resistor, Var, Trim, CERMET, 10K	BRNS	3006W-1-103
R7	1ea	Resistor, Var, Trim, CERMET, 20K	BRNS	3006W-1-203
R8		Same as R6		
R9	2ea	Resistor, Var, Trim, CERMET, 1K	BRNS	3006W-1-102
R10	4ea	Resistor, MF, 0.25W, 1%, 200K	CORG	NC5
R11	Same as R10			
R12		Same as R10		
R13		Same as R10		
R14		Same as R6		
R15	1ea	Resistor, MF, 0.25W, 1%, 2K	CORG	NC5
R16		Same as R3		
R17	Same as R3			
R18	1ea	Resistor, MF, 0.25W,1%, 20K	CORG	NC5
R19	2ea	Resistor, Var, Trim,CERMET,2K	BRNS	300-62-1-202
R20		Same as R19		
R21		Same as R9		

TABLE 7

PARTS LIST FOR SWITCH DRIVER MODULE COMPONENTS continued

OUTPUT DISPLAY CARD (117)

R22	1ea	Resistor, MF, 0.25W, 1%, 511K	CORG	NC5
R23	1ea	Resistor, MF, 0.25W, 1%, 1K	CORG	NC5
R24		Same as R2		
R25	1ea	Resistor, MF, 0.25W, 1%, .01K	CORG	NC5
R26	1ea	Resistor, Carbon, 0.25W, 5%, .1K	AB	CB
R27	1ea	Resistor, Carbon, 0.25W, 5%, 2.7K	AB	CB
R28		Same as R3		
R29	1ea	Resistor, Carbon, 0.25W, 5%, 4.7K	AB	CB
R30	2ea	Resistor, Carbon, 0.25W, 5%, 39K	AB	CB
R31		Same as R30		
R32	1ea	Resistor, Carbon, 0.25W, 5%, 27K	AB	CB
R33	1ea	Resistor, Carbon, 0.25W, 5%, 10K	AB	CB
R34	1ea	Resistor, Carbon, 0.25W, 5%, 1K	AB	CB
R35	1ea	Resistor, Carbon, 0.25W, 5%, 24.3K	AB	CB

Catagory No. 2---------------Capacitors----------------------------

C1	2ea	Capacitor, Disc, .001UF		
C2	1ea	Capacitor, Disc, Ceramic, .1UF		
C3	1ea	Capacitor, Polycarbonate, .1UIF	SEAC	CMK
C4	2ea	Capacitor, Disk, .01UF		
C5		Same as C4		
C6	4ea	Capacitor, Tant, 35V, 22UF		
C7	1ea	Capacitor, DIP, Mica, 150PF		

TABLE 7

PARTS LIST FOR SWITCH DRIVER MODULE COMPONENTS continued

OUTPUT DISPLAY CARD (117)

[illegible]ory 2		---Capacitors---		
[illegible]	2e	Capacitor, Tant, 20V, 47UF		
[illegible]		Same as C8		
[illegible]		Same as C6		
[illegible]		Same as C6		
[illegible]		Same as C6		
[illegible]	1ea	Capacitor, DIP, Mica, 100PF		
[illegible]	3ea	Capacitor,HI-K MONO,50V, 1UF	SPRG	5C023105X025053
[illegible]		Same as C14		
[illegible]		Same as C1		
[illegible]		Same as C14		
[illegible]ory 4		---Diodes---		
[illegible]	1ea	Diode, Silicon,100V	MOT	1N4153
[illegible]ory 5		---Integrated Circuits---		
[illegible]	1ea	I. C. Op Amp	MONO	OP-05C
[illegible]	1ea	I. C. Sample and Hold	DATL	SHM-LM-2 I
[illegible]	1ea	I. C. FET, Op Amp	NATL	LH0042C I
[illegible]	1ea	I. C. Log Amp	ITSL	ICL 8048ECBE
[illegible]	1ea	I. C. Op Amp	NATL	LM741C
[illegible]	2ea	I. C. Timer	NATL	LM 555
[illegible]		Same as IC6		
[illegible]	1ea	I. C. One Shot	TI	SN74121N

TABLE 7

PARTS LIST FOR SWITCH DRIVER MODULE COMPONENTS continued

OUTPUT DISPLAY CARD (117)

Catagory 5----------------Integrated Circuits----------------------				
IC9	1ea	I. C. Nand Drive	TI	SN7552N
IC11	1ea	I. C. Hex Inverter	TI	SN74LS04N
Catagory 7----------------Terminals---------------------------------				
K1	2ea	Socket, Round, DIP, 8Pin	SANT	
K2	1ea	Socket, Dual, In-line, DIP	SANT	IC-316-SGG
K3		Same as K1		
J1	2ea	Jack, Jumper, IC, 1Pin	GARY	AA-C
J2		Same as J1		
T1	1ea	Term, Test Point, 1Pin	GARY	AA-C
Catagory 10----------------Hardware----------------------------------				
B1		PC Brd, RF Process Ckt	NBS	PC-500

TABLE 7

PARTS LIST FOR SWITCH DRIVER MODULE COMPONENTS continued

Front Panel and Chassis

Catagory 1		------Resistors------		
R1	1ea	Resistor, Var, 10 Turn, 10K	DUNC	3253
Catagory 3		------Diodes------		
D1	1ea	LED, Green	DIAL	9173
D2	1ea	LED, Red	DIAL	550-0506
Catagory 6		------Connectors------		
J1	1ea	Connector, Panel, BNC	AMPH	U6 492/U
J102	1ea	Connector, Amp, 50 Pin	AMPH	AMP200277 2
J104	1ea	Same as J102		
J110	6ea	Edge Connector, PC, 50 Pin	AMPH	261-100302
J111		Same as J110		
J112		Same as J110		
J113		Same as J110		
J114		Same as J110		
J117		Same as J110		
Catagory 8		------Switches------		
S1	1ea	Switch, AC Power, Toggle	ALCO	MST 105D
S2	1ea	Switch, Push Button	ALCO	MSP 105F
S3	1ea	Switch, Rotary, 3Pole	ALCO	MRB-3-3

TABLE 7

PARTS LIST FOR SWITCH DRIVER MODULE COMPONENTS continued

Front Panel and Chassis

Catagory 9---------------------Meters-----------------------------				
M1	1ea	Meter, Panel, 0 Center, 1.5Ma	MODT	25DMA1
Catagory 10--------------------Hardware----------------------------				
		Plate, Front Panel 7"X9"	BUD	91[illegible]
		Card Cage	SCBE	6004[illegible]
Catagory 10-------------------Hardware------------------------------				
		Fuseholder	Littlefuse	342001
Catagory 11------------------Miscellaneous---------------------------				
		Power Supply 5V, 1A	Standard	SPS/[illegible]

ACKNOWLEDGMENTS

The existence of this measurement system is the result of a joint effort involving cooperation of many people over a long period of time. These include: Gerome Reeve for the original system design, Lanny D. Driver for development of the ambient and cryogenic coaxial standards, Lanny D. Driver and David F. Wait for the original software model, John P. Wakefield for the switch driver module design and software tie-in, and William Daywitt who was largely responsible for the theory, error modeling, and analysis.

REFERENCES:

[1] Larsen, N.T.; NBS Type IV Power Meter Operation and Maintenance Manual; NBSIR 77-866, Oct. 1977.

[2] Larsen, N.T.; A New Self-Balancing D.C. Substitution RF Power Meter IEEE Transactions on Instrumentation and Measurement; Vol. IM-25, No. 4, pp. 343-347, Dec. 1976.

[3] Miller, C.K.S., Daywitt W.C.,and Arthur M.G.; Noise Standards, Measurements, and Receiver Noise Definitions; Proceedings of the IEEE, Vol 55, No. 6, June 1967.

[4] Wait D.F.; Earth Terminal Measurement System Operations Manual; NBSIR 78-879, April 1978.

[5] Wakefield, J.P.; Earth Terminal Measurement System Maintenance Manual; NBSIR 78-895, April 1978.

APPENDIX I

PROGRAM LISTING AND VARIABLE CROSS REFERENCE TABLE

This is a listing of program "30M20" arranged to allow easy reference to the main program and associated subprogram segments. Each segment listing is followed by the cross reference table for the variables referenced. Except for frequency dependent program constants, this program listing is identical to that for "60M20". Line numbers referenced for variables apply to both programs.

```
1 SEPT 1981
30M20

1     ! THIS VERSION IS JULY101981 VS
10    ! 30RAD
20   ! 30RAD    30 MHZ CONSTANTS IN THIS VERSION
30 ! RE-STORE "30M20"     !MARCH26 1981 1100
31 !
32     !
33     !
34     !
35     !
40      OPTION BASE 1
50     COM File,Flag
60     COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
70     COM SHORT F(4),L(8,20),M(32,33),N(26,11)
80     COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
90     COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
100    COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
110    COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
120    COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
130    COM Real,Imag
140    DIM Z$[100]
150    Ptest=0
160    Ipause=0
170    FOR K=1 TO 5
171   ! Q=FNT(Q)
172  ! Q=FNK(3)
173    Q=FNData(Q)
174    GOTO 220
180   Q=FNP(Q)
190    PRINTER IS 16
200    PRINT P1*1000,P2*1000,P3*1000
210    Ptest=Ptest+P1
220    NEXT K
230    P1=Ptest/(K-1)
240    PRINT "AVERAGE POWER AT PORT 0 IS ";P1*1000;"MILLIWATTS"
250    PAUSE
251    MASS STORAGE IS ":F8,1"
260    C1=.99949      ! THIS IS ALPHA OF GR900/N ADAPTER
270    C2=.00010      ! THIS IS UNCERTAINTY OF THIS ADAPTER ALPHA
280    R5=16
290    H$[1,10]="GR900/N"
300    H$[11,20]="47.0+J00.0"
310    Real=47
320    Imag=.00001
330 Printer=0
340 File=0+.15
350    PRINTER IS 0
360    PRINTER IS 16
370 ! CREATE "NFILE:F8",40
380 ! ASSIGN #1 TO "NFILE"
390 ! PRINT #1;N(*),END
400 ! ASSIGN #1 TO *
410  ASSIGN #2 TO "NFILE"
420  READ #2;N(*)
430  ASSIGN #2 TO *
440 MAT PRINT N
450    PRINTER IS 16
460 DISP "STOP--CHECK N MAT PRESS CONT TO GO ON"
470 ! PAUSE
480  Z$="30/60 MHZ AUTOMATED NOISE MEASUREMENT SYSTEM  <D 1-M -4><T1-T1 >"
490  V$="EXECUTIVE PROGRAM     VERSION GJC 2-45 MAR 81      ETMS #6.11"
500  PRINT TAB(15),Z$
510 Q=FNS(1)
```

```
520  PRINT TAB(7),V$
530 Q=FNS(4)
540   PRINT "ENTER ALPHA FOR CONNECTOR/ADAPTOR COMBINATION USED ON UNKNOWN POR
550 C1=FNN(C1)
560   PRINT "ENTER UNCERTAINTY FOR ADAPTER COMBINATION USED"
570   C2=FNN(C2)
580   Q=FNS(1)
590   P$=H$[1,10]
600   I2=2
610   PRINT "ENTER ADAPTER USED TO CONNECT DEVICE UNDER TEST"
620    Q=FNO(1)
630    H$[1,10]=P$
640   Q=FNS(1)
650   P$=H$[11,20]
660   PRINT "ENTER REAL AND IMAGINARY SOURCE IMPEDANCE IN THIS FORM"
670   Q=FNO(1)
680   H$[11,20]=P$
690   PRINT "ENTER REAL PART OF THE SOURCE IMPEDANCE"
700   Real=FNN(Real)
710   PRINT "ENTER THE IMAGINARY PART OF THE SOURCE IMPEDANCE"
720   Imag=FNN(Imag)
730   PRINT C1;C2;H$[1,10];H$[11,20];Real;Imag
740   F=30
750   Z7=3
760   K9=0
770   Q5=10000
780   D9=1
790   Z8=0
800   PRINT TAB(7),V$
810   Q=FNS(4)
820 ! OUTPUT 9;"S11,04,09,35,50"  ! RESET TIME HERE
830   OUTPUT 9;"R"
840   ENTER 9;P$
850   PRINT TAB(15),P$;":1981"
860  Q=FNS(2)+FNE(0)+FNE(1)
870  IMAGE "IF HARDWARE HANGS UP",/,/,"(1)STOP+STOP",/,"(2)KEY0",/,"(3)0 RESTR
880 ! PRINT USING 440
890 Q=FNQ(1)
900   Q=FNQ(10)
```

<u>MAIN</u>

C1	*	260	550	550	730				
C2	*	270	570	570	730				
D9	780								
F	*	740							
File	*	340							
H$	*	290	300	590	630	650	680	730	730
I2	*	600							
Imag	*	320	720	720	730				
Ipause	160								
K	170	220	230						
K9	760								
N(	*	420	440						

```
*    590    630    650    680    840    850

*    200    210    230    240

*    200

*    200

330

150    210    210    230

173    173    180    180    510    530    580    620    640
810    860    890
     900

*    770

*    280

*    310    700    700    730

*    490    520    800

140    480    500

750

790
```

```
910 DEF FNQ(Q)
920   OPTION BASE 1
930   COM File,Flag
940   COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
950   COM SHORT F(4),L(*),M(32,33),N(26,11)
960   COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
970   COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
980   COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
990   COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
1000  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismat
1010  COM Real,Imag
1020  Branch=Q
1030  PRINT Q
1040  ON Branch GOTO 1280,1300,1300,2380,1310,1340,2400,1350,1370,1090
1050  IF (Branch>=1) AND (Branch<=10) THEN ON Branch GOTO 1280,1300,1300,2380,1
10,1340,2400,1350,1370
1060  RETURN Q
1070  FNEND
1080  GOTO 1110
1090 Z1=Z2=Z3=Z4=Z5=Z6=0
1100 Flag(5)=0
1110 REM  THIS IS THE MAIN TRAP
1120 Q=FNB(2)
1130 Q=FNS(1)
1140 K6=1
1150 REM  NOISE SOURCE CALIBRATION
1160 Z1=0
1170 Q=FNJ(1)+FNJ(2)+FNJ(3)
1180  GOTO 1230
1190 Z2=0
1200 Q=FNJ(2)
1210 GOTO 1120
1220 Z3=0
1230 Q=FNK(0)+FNK(1)+FNK(2)+FNK(3)+FNCheck(1)
1240  PRINT "END OF MEASUREMENT SEQUENCE -PRESS RUN TO REPEAT"
1250  PAUSE
1260 GOTO 310
1270 RETURN 0
1280 ! CONTINUE
1290  RETURN 0
1300 PRINT "CONNECT UNKNOWN  TO PORT";Q7
1310 PRINT "CONNECT AMBIENT  TO PORT";Q8
1320 PRINT "CONNECT STANDARD TO PORT";Q9
1330 RETURN 0
1340 ! CONTINUE
1350 ! CONTINUE
1360 RETURN 0
1370 ! CONTINUE
1380 RETURN 0
1390  FNEND
```

<u>FNQ(</u>

Branch	1020	1040	1050	1050	1050				
Flag(	1100								
K6	1140								
Q	910	1020	1030	1060	1120	1130	1170	1200	1230
Q7	*	1300							
Q8	*	1310							

09	*	1320	
21	*	1090	1160
22	*	1090	1190
23	*	1090	1220
24	*	1090	
25	*	1090	
26	*	1090	

```
1400 DEF FNE(Q)
1410 OPTION BASE 1
1420 COM File,Flag
1430 COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
1440 COM SHORT F(4),L(*),M(32,33),N(26,11)
1450 COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
1460 COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
1470 COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
1480  COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
1490  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
1500  COM Real,Imag
1510 IF Q THEN 1580
1520 REM  THIS INITIALIZES THE HARDWARE        (FNE0)
1530 Flag(1)=0
1540 Flag(5)=0
1550 Q=FNQ(8)
1560 PRINT "HARDWARE INITIALIZED"
1570 RETURN 0
1580 REM  THIS INITIALIZES THE SOFTWARE        (FNE1)
1590 Q=I=N=N3=N8=P=L0=F0=I0=I1=I2=K6=Z1=Z2=Z3=0
1600 Q7=0
1610 Q8=1
1620 Q9=2
1630 A7=A8=A9=6
1640 PRINT "SOFTWARE INITIALIZED"
1650 RETURN 0
1660  FNEND
```

<u>FNE(</u>

A7	*	1630			
A8	*	1630			
A9	*	1630			
F0	*	1590			
Flag(		1530	1540		
I	*	1590			
I0		1590			
I1		1590			
I2	*	1590			
K6		1590			
L0		1590			
N	*	1590			
N3	*	1590			
N8	*	1590			
P		1590			
Q		1400	1510	1550	1590
Q7	*	1600			

[illegible]	*	1610
[illegible]	*	1620
[illegible]	*	1590
[illegible]	*	1590
[illegible]	*	1590

```
1670 DEF FNJ(Q)                                    !!(FNJ)
1680  OPTION BASE 1
1690  COM File,Flag
1700  COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
1710 COM SHORT F(4),L(*),M(32,33),N(26,11)
1720  COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
1730  COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
1740  COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X912
1750  COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
1760  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
1770  COM Real,Imag
1780 Branch=Q
1790 ! CONTINUE
1800 IF (Branch<=1) AND (Branch<=4) THEN ON Branch GOTO 1810,2470,2680
1810  IF Z1=2 THEN 2470
1820 Q=FNS(2)
1830 PRINT "CUSTOMER?(0=BY,SP=NC)";
1840 P$=C$[1,29]
1850 IF I2=0 THEN 1920
1860 DISP "NOW: ";P$;
1870 LINPUT Q$
1880 IF Q$="0" THEN 2430
1890 IF Q$=" " THEN 1980
1900 C$[1,29]=Q$
1910 GOTO 1990
1920 DISP "NOW: ";P$
1930 I0=FNB(2)+FNS(1)+FNW(50)
1940 LINPUT Q$
1950 IF Q$="0" THEN 2430
1960 IF Q$=" " THEN 1980
1970 C$[1,29]=Q$
1980 Q=FNS(1)
1990 PRINT "CUST'S ADDRESS--STREET  ?";
2000 P$=C$[30,69]
2010 Q=FNO(1)
2020 C$[30,69]=P$
2030 Q=FNS(1)
2040 PRINT "CUST'S ADDRESS?--CITY,STATE,ZIP   ?";
2050 P$=C$[70,99]
2060 Q=FNO(2)
2070 C$[70,99]=P$
2080 Q=FNS(1)
2090 PRINT "SOURCE MANUFTR?";
2100 P$=G$[1,39]
2110 Q=FNO(3)
2120 G$[1,39]=P$
2130 Q=FNS(1)
2140 PRINT "SOURCE TYPE ?  ";
2150 P$=G$[40,79]
2160 Q=FNO(4)
2170 G$[40,79]=P$
2180 Q=FNS(1)
2190 PRINT "SOURCE M0DL # ?";
2200 P$=G$[80,89]
2210 Q=FNO(5)
2220 G$[80,89]=P$
2230 Q=FNS(1)
2240 PRINT "SOURCE SER. # ?";
2250 P$=G$[90,99]
2260 Q=FNO(6)
2270 G$[90,99]=P$
2280 Q=FNS(1)
2290 PRINT "DATE OF CALIBRATION"
2300 P$=R$[1,19]
```

```
2310 Q=FNO(7)
2320 R$[1,19]=P$
2330 Q=FNS(1)
2340 PRINT "CALIB. TEST # ?";
2350 P$=R$[20,39]
2360 Q=FNO(7)
2370 R$[20,39]=P$
2380 Q=FNS(1)
2390 PRINT "REQ OR REF # ? ";
2400 P$=R$[40,69]
2410 Q=FNO(9)
2420 R$[40,69]=P$
2430 I2=1
2440 Z1=Z1+1
2450 Q=FNS(2)+FNB(1)
2460 RETURN 0
2470 REM  GET PARAMETERS SUBROUTINE             (FNJ2)
2480 IF Z2 THEN 2680
2490 Q=FNS(2)
2500 !                            DISP "NUMBER OF FREQUENCIES DESIRED ?";
2510 F0=1
2520 !                            DISP "NUMBER OF LEVELS PER FREQUENCY ?";
2530 L0=1
2540 FOR I0=1 TO F0
2550 F(I0)=F
2560 NEXT I0
2570 Q=FNS(1)
2580 P$="ENTER VALUE OF ATTEN A2"
2590 PRINT P$
2600  R5=FNN(R5)
2610  P$="                                  LEVEL SETTING A2="
2620 N3=5
2630 N8=5
2640  Z(1,51)=R5
2650 Z2=1
2660 Q=FNS(2)+FNB(1)
2670 RETURN 0
2680 REM  PORT ASSIGNMENT SUBROUTINE            (FNJ3)
2690 IF Z3=1 THEN 2810
2700 Q=FNS(2)
2710 PRINT "****NORMAL PORT ASSIGNMENTS****"
2720 Q=FNS(2)
2730  Q7=0
2740 PRINT "UNKNOWN  CONNECTED TO PORT";Q7
2750  Q8=3
2760 PRINT "AMBIENT  CONNECTED TO PORT";Q8
2770  Q9=2
2780 PRINT "STANDARD CONNECTED TO PORT";Q9
2790 Q=FNS(2)
2800 Z3=1
2810 Q=FNS(2)+FNB(1)
2820 RETURN 0
2830  FNEND
```

<u>FNJ(</u>

Branch	1780	1800	1800	1800					
C$	*	1840	1900	1970	2000	2020	2050	2070	
F	*	2550							
F(	*	2550							

```
F0                    *   2510   2540

G$                    *   2100   2120   2150   2170   2200   2220   2250   2270

I0                   1930   2540   2550   2560

I2                    *   1850   2430

L0                   2530

N3                    *   2620

N8                    *   2630

P$                    *   1840   1860   1920   2000   2020   2050   2070   2100
120   2150   2170   2200
                          2220   2250   2270   2300   2320   2350   2370   2400
420   2580   2590   2610

Q                    1670   1780   1820   1980   2010   2030   2060   2080   2110
 2130   2160   2180   2210
                          2230   2260   2280   2310   2330   2360   2380   2410
450   2490   2570   2660
                          2700   2720   2790   2810

Q$                    *   1870   1880   1890   1900   1940   1950   1960   1970

Q7                    *   2730   2740

Q8                    *   2750   2760

Q9                    *   2770   2780

R$                    *   2300   2320   2350   2370   2400   2420

R5                    *   2600   2600   2640

Z(                    *   2640

Z1                    *   1810   2440   2440

Z2                    *   2480   2650

Z3                    *   2690   2800
```

```
2840 DEF FNK(Q)                                    !!!(FNK0)
2850   OPTION BASE 1
2860   COM File,Flag
2870  COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
2880 COM SHORT F(4),L(*),M(32,33),N(26,11)
2890  COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
2900  COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
2910  COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
2920  COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
2930  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
2940  COM Real,Imag
2950  Branch=Q+1
2960  ON Branch GOTO 2980,3310,3920,5520
2970 ! !!  FREQUENCY SUBROUTINE                      (FNK0)
2980 FOR F9=1 TO F0
2990 F=F(F9)
3000 Q=FNL(1)
3010  L0=1
3020 I0=0
3030 FOR I1=F9*L0-L0+1 TO F9*L0
3040 I0=I0+1
3050 M(I1,1)=F
3060 M(I1,2)=I1
3070 M(I1,3)=L(I0,1)
3080 M(I1,4)=L(I0,2)
3090 M(I1,5)=L(I0,7)
3100 M(I1,6)=L(I0,8)
3110 M(I1,7)=L(I0,3)
3120 M(I1,8)=L(I0,4)
3130 M(I1,9)=L(I0,5)
3140 M(I1,10)=L(I0,9)
3150 M(I1,11)=L(I0,10)
3160 M(I1,12)=L(I0,11)
3170 M(I1,30)=L(I0,6)
3180 M(I1,31)=L(I0,12)
3190 NEXT I1
3200 NEXT F9
3210  T2=(M(1,3)+M(1,5))/2
3220  T3=(M(1,4)+M(1,6))/2
3230  T1=(M(1,7)+M(1,10))/2
3240  Z(1,52)=T1
3250  Z(1,53)=T2
3260  Z(1,54)=T3
3270 Q=FNS(4)
3280 Z4=1
3290 Q=FNS(2)+FNB(1)
3300 RETURN 0
3310 ! !!  NUMBER CRUNCHER SUBROUTINE                (FNK1)
3320  L0=1
3330  F0=1
3340 R9=F0*L0
3350 FOR I9=1 TO R9
3360  T8=B8+B7
3370 T1=(M(I9,7)+M(I9,10))/2
3380 M(I9,13)=T1
3390  N=N8*N3*2
3400  N9=N
3410  T7=B5+B6
3420  T8=T8*T8/N
3430  S1=(T7-T8)/(N-1)
3440  S1=SQR(S1)
3450  M(I9,14)=S1/SQR(N)
3460  M(I9,28)=S1/SQR(N)
3470 T4=(M(I9,9)+M(I9,12))/2
```

```
3480 M(I9,15)=T4
3490 T2=(M(I9,3)+M(I9,5))/2
3500 M(I9,16)=T2
3510 T3=(M(I9,4)+M(I9,6))/2
3520 M(I9,17)=T3
3530 R8=(T1-T2)/(T3-T2+1E-6)
3540  ! !!!!!!!!!!!!!!!!!!!!!!!!!!!TEMP IS FOR 30 MHZ  N(14,9)
3550 M(I9,23)=ABS(1-R8)*N(14,9)
3560 M(I9,24)=ABS(R8)*N(12,1)
3570  M(I9,32)=M(I9,30)+M(I9,31)/2
3580  Q=M(I9,32)
3590 ! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! !  BANDWIDTH W IS FOR 30 MHZ
3600  W=.773
3610  Q=N(12,9)*Q/W/(T2+T4)
3620  M(I9,33)=10*LGT(Q)
3630  Q=.0023
3640  Q0=1+Z(1,16)/Z(1,52)     !1+ TE/TX
3650  Q1=1-Z(1,53)/Z(1,52)     !1-TA/TX
3660  Q2=(Z(1,54)+Z(1,16))/(Z(1,54)-Z(1,53))  !TS+TE/TS-TA)
3670  Q3=Z(1,52)*(Q0-Q1*Q2)
3680  M(I9,25)=Q*Q3
3690  M(I9,26)=N(10,1)*10^(M(1,33)/10)*N(10,2)*(T1-T3)*(T1-T2)
3700  Q=T2/T1+ABS((1-T2/T1)/(1-T3/T2)+1E-6)
3710  Q=ABS(1-T2/T1)+1.7*Q
3720  Z(1,57)=N(12,8)
3730  Z(1,55)=N(12,7)
3740  Q3=T1*T3+T1*T2+T3*T2
3750  Q3=Q3/(T3-T2)
3760  Q3=ABS(Q3*N(12,8))
3770  M(1,29)=Q3
3780  Q=M(I9,23)+M(I9,24)+M(I9,25)
3790  M(I9,18)=Q+M(I9,26)+M(I9,29)
3800  M(I9,19)=3*M(I9,28)
3810  M(I9,20)=M(I9,18)+M(I9,19)
3820  M(I9,21)=10*LGT(ABS((T1-290+1E-6)/290))
3830  Q2=(M(1,19)+M(1,18))/(T1-290)
3840  Q3=ABS(1+Q2)
3850  M(I9,22)=10*LGT(Q3)
3860  M(I9,32)=(M(I9,30)+M(I9,31))/2
3870  NEXT I9
3880  Z5=1
3890  Q=FNB(2)
3900  RETURN 0
3910  !                                                      FNK2
3920  Q=FNVswr(Q)
3930  PRINTER IS 0
3940  Z(1,26)=Mismatch
3950  E7=M(1,18)+Mismatch
3960  E6=1-1/C1
3970  E1=E6*(E7/M(1,13))
3980  E2=E6*.0005
3990  C9=C1*C1
4000  E0=(M(1,13)-M(1,3))/C9*(C2/T1)
4010  E3=ABS(E1)+ABS(E2)+ABS(E0)
4020  E3=ABS(E3)
4030 V$="*********************************************************************"
4040  L0=1
4050 ! PRINT V$
4060 I8=0
4070 FOR I9=1 TO F0
4080 FOR J9=1 TO L0
4090 I8=I8+1
4100 Q1=FNS(3)
4110 PRINT Z$
4120 A$="------------------------------------------------------------"
```

```
4130 Q1=FNS(1)
4140  N9=N3*N8*2
4150 ! PRINT PAGE
4160  PRINT TAB(6),A$
4170  Q=FNS(10)
4180  PRINT TAB(23);"MEASUREMENT RECAP"
4190  PRINT TAB(30);"AND"
4200  PRINT TAB(22);"PRELIMINARY RESULTS"
4210  Q=FNS(5)
4220  PRINT TAB(6);"FREQUENCY=";M(1,1);"MHZ"
4230  PRINT TAB(6);"SOURCE IMPEDANCE";H$[11,20],"     LEVEL SETTING OF A2=";R5
4240 PRINT TAB(6);A$
4250  PRINT TAB(10);"TA";TAB(20),"R OHMS";TAB(34);"TS";TAB(45);"R OHMS"
4260  PRINT TAB(6);" --------    --------    --------    --------"
4270  FIXED 2
4280  PRINT TAB(8);M(1,3);TAB(20);Z(1,59);TAB(32);M(1,4);TAB(45);Z(1,60);"      "
;"1ST 50 MEASUREMENTS"
4290  PRINT TAB(8);M(1,5);TAB(20);Z(1,59);TAB(32);M(1,6);TAB(45);Z(1,60);"      "
;"2ND 50 MEASUREMENTS)"
4300  PRINT TAB(6);A$
4310  PRINT TAB(11);"TX";TAB(21);"SX";TAB(34);"TE"
4320  PRINT TAB(6);"   --------   --------   --------"
4330  PRINT TAB(8);M(1,7);TAB(20);M(1,8);TAB(32);M(1,9);"      ";"(1ST 50 MEASURE
MENTS)"
4340  PRINT TAB(8);M(1,10);TAB(20);M(1,11);TAB(32);M(1,12);"      ";"(2ND 50 MEAS
UREMENTS)"
4350  PRINT
4360  PRINT TAB(6);A$
4370  PRINT
4380  STANDARD
4390  N9=N8*N3*2
4400  PRINT TAB(6);"AVE POWER IN MILLIWATTS P1,P2,P3"
4410  PRINT TAB(6);Z(1,45)/N9*1000;Z(1,46)/N9*1000;Z(1,47)/N9*1000
4420  S1=SQR((Z(1,48)-Z(1,45)*Z(1,45)/N9)/(N9-1))
4430  S2=SQR((Z(1,49)-Z(1,46)*Z(1,46)/N9)/(N9-1))
4440  S3=SQR((Z(1,50)-Z(1,47)*Z(1,47)/N9)/(N9-1))
4450  Z(1,31)=N9
4460  PRINT TAB(6);"SD P1,P2,P3 [# OF MEAS=";Z(1,31);"]";S1;S2;S3
4470  PRINT TAB(6);A$
4480  Q=FNS(20)
4490 ! PAGE
4500 PRINT USING 4520;M(I8,1)
4510  Z(1,34)=M(1,1)
4520 IMAGE 25X,"FREQUENCY =",M3D.D,"MHZ"
4530 PRINT
4540  PRINT Z$
4550 Q1=FNS(1)
4560  E4=100*E3/M(1,13)
4570  E5=E3+Mismatch
4580  M2=100*(M1/M(1,13))
4590  M5=E4+M2
4600  M(1,18)=M(1,18)+E5
4610 PRINT USING 4620;M(I8,13),M(I8,18),M(I8,19)
4620 IMAGE 10X,"NOISE TEMPERATURE =",M5D.2D,"K  +-",M3D.2D,"K(BIAS) +-",M3D.2D,"
K (3*SEM)"
4621  Q2=(M(1,18)+M(1,19))/(T1-290)
4622  Q3=ABS(1+Q2)
4623  M(1,22)=10*LGT(Q3)
4630  Z(1,35)=M(1,13)
4640  Z(1,36)=M(1,18)
4650  Z(1,13)=M(1,19)
4660  IF T1<220 THEN 4690
4670 PRINT USING 4680;M(I8,21),M(I8,22)
4680 IMAGE 10X,"EXCESS NOISE RATIO=",M3D.2D ,"DB   +-",MD.2D ,"DB(BIAS+3*SEM)"
4690 Q1=FNS(1)
```

```
4700  Z(1,14)=M(1,21)
4710  Z(1,15)=M(1,22)
4720 PRINT USING 4730;M(I8,15),10*LGT(1+M(I8,15)/290)
4730 IMAGE 10X,"RADIOMETER SYSTEM TEMPERATURE =",4D ,"K (",4D.D,"DB NF)"
4740  Z(1,16)=M(1,15)
4750  Z(1,17)=10*LGT(1+M(1,15)/290)
4760 PRINT USING 4770;M(I8,33)
4770 IMAGE 10X,"RADIOMETER GAIN =",M4D.1D ,"DB"
4780  Z(1,56)=.773
4790  PRINT "           RADIOMETER NOISE BANDWIDTH=";Z(1,56);"MHZ"
4800  Z(1,18)=M(1,33)
4810 Q1=FNS(3)
4820 PRINT TAB(28),"ERROR SUMMARY"
4830 Q1=FNS(1)
4840 PRINT TAB(5),"SOURCE OF ERROR";TAB(35)," SOURCE";TAB(58),"% ERROR IN"
4850 PRINT TAB(34),"UNCERTAINTY";TAB(55),"NOISE TEMPERATURE"
4860  !                          CONSTANTS FOR TEMP ARE 30 MHZ
4870 Q1=FNS(1)
4880 PRINT USING 4890;N(12,1);100*M(I8,24)/M(I8,13)
4890 IMAGE 6X,"CRYOGENIC STANDARD",10X,MZ.2D,"K",16X,M4D.2D
4900  Z(1,19)=N(12,1)
4910  Z(1,20)=100*M(1,24)/M(1,13)
4920 PRINT USING 4930;N(14,9),100*M(I8,23)/M(I8,13)
4930 IMAGE 6X,"AMBIENT STANDARD",12X,MZ.2D,"K",16X,M4D.2D
4940  Z(1,21)=N(14,9)
4950  Z(1,22)=100*M(1,23)/M(1,13)
4960 PRINT USING 4970;N(12,3),100*M(I8,25)/M(I8,13)
4970 IMAGE 6X,"POWER RATIO",17X,MZ.2D ,"DB",15X,M4D.2D
4980  Z(1,23)=N(12,3)
4990  PRINT USING 5000;100*Mismatch/M(I8,13)
5000  IMAGE 6X,"MISMATCH",21X,"0.5R;1.0J OHMS",7X,M4D.2D
5010  Z(1,26)=Mismatch
5020  Z(1,24)=100*M(1,25)/M(1,13)
5030 PRINT USING 5060;N(10,3),100*M(I8,26)/M(I8,13)
5040  Z(1,27)=N(12,4)
5050  Z(1,28)=100*M(1,26)/M(1,13)
5060 IMAGE 6X,"NONLINEARITY",16X,M1D.2DE,12X,M5D.2D
5070 PRINT USING 5080;Z(1,55),100*M(I8,29)/M(I8,13)
5080 IMAGE 6X,"SWITCH ASSYMETRY",12X,MZ.3D,"DB",12X,M6D.2D
5090  Z(1,29)=100*M(1,29)/M(I8,13)
5110  Adapter=100*E3/Z(1,35)
5120  PRINT USING 5130;H$[1,10],100*E3/Z(1,35)
5130  IMAGE 6X,"ADAPTER:",10A,11X,"0.0001DB",11X,M6D.2D
5140 PRINT TAB(6),A$
5150 PRINT USING 5160;100*M(I8,18)/M(I8,13)
5160 IMAGE 6X,"LINEAR SUM OF BIAS ERRORS",24X,M5D.2D
5170  Z(1,30)=100*M(1,18)/M(I8,13)
5180 PRINT USING 5190;N9,100*M(I8,19)/M(I8,13)
5190 IMAGE 5X,"3*STANDARD ERROR OF MEAN  ( # MEAS="M3D.,")",10X,M4D.2D
5200  Q=100*M(I8,18)/M(I8,13)
5210  Q1=100*M(I8,19)/M(I8,13)
5220  M(I8,20)=Q+Q1
5230  Z(1,31)=N
5240  Z(1,32)=100*M(I8,19)/M(I8,13)
5250 PRINT TAB(6),A$
5260 PRINT USING 5270;M(I8,20)
5270 IMAGE 6X,"LINEAR SUM OF ERRORS",31X,M3D.2D
5280  Z(1,33)=M(1,20)
5290 Q1=FNS(1)
5300 PRINT TAB(6),A$
5310 NEXT J9
5320 NEXT I9
5330 PRINT
5340  PRINT
5350  PRINT TAB(6),"CUSTOMER:";TAB(30),C$[1,29]
5360  PRINT TAB(6),"CUSTOMER'S STATION:";TAB(30),C$[30,69]
```

```
5370  PRINT TAB(6),"CUSTOMER'S ADDRESS:";TAB(30),C$[70,99]
5380  PRINT
5390  PRINT TAB(6),"SOURCE MANUFACTURER:";TAB(30),G$[1,39]
5400  PRINT TAB(6),"SOURCE TYPE:";TAB(30),G$[40,79]
5410  PRINT TAB(6),"SOURCE MODEL:";TAB(30),G$[80,89]
5420  PRINT TAB(6),"SOURCE SERIAL:";TAB(30),G$[90,99]
5430  PRINT
5440  PRINT TAB(6),"DATE OF CALIBRATION:";TAB(30),R$[1,19]
5450  PRINT TAB(6),"CALIBRATION TEST #:";TAB(30),R$[20,39]
5460  PRINT TAB(6),"REQ OR REF #:";TAB(30),R$[40,69]
5470  PRINT
5480 Q=FNS(10)
5490 Z6=1
5500 Q=FNB(1)
5510 RETURN 0
5520 ! !!  STORE DATA SUBROUTINE                    (FNK3)
5530  MASS STORAGE IS ":T14"
5531  PRINTER IS 16
5540 LINPUT "PLACE DATA CASSETTE IN T14 AND PRESS SPACE BAR AND CONT",A$
5550 PRINT "ENTER FILE NAME--30-1 FOR EXAMPLE"
5560  LINPUT F$
5570  CREATE F$,6,220
5580  LINPUT "TEMPERATURE?",H$[21,30]
5590  LINPUT "PRESSURE MM MERCURY",H$[31,40]
5600  ASSIGN #1 TO F$
5610   PRINT #1;H$[1,40],Z(*),C$[1,100],G$[1,100],R$[1,100]
5620   ASSIGN #2 TO F$
5630   READ #2;H$[1,40],Z(*)
5640   DISP H$[1,100],Z(*)
5650   MASS STORAGE IS ":F8"
5660 Q=FNS(1)
5670  Q=FNCheck(Q)
5680  PAUSE
5690 RETURN 0
5700 !                                     FNL0
5710  !
5720  !
```

<u>FNK(</u>

```
A$                 *   4120   4160   4240   4300   4360   4470   5140   5250   5
300   5540

Adapter           5110

B5                 *   3410

B6                 *   3410

B7                 *   3360

B8                 *   3360

Branch            2950   2960

C$                 *   5350   5360   5370   5610

C1                 *   3960   3990   3990

C2                 *   4000

C9                3990   4000

E0                4000   4010
```

```
E1                  3970   4010

E2                   *   3980   4010

E3                  4010   4020   4020   4560   4570   5110   5120

E4                  4560   4590

E5                  4570   4600

E6                  3960   3970   3980

E7                   *   3950   3970

F                    *   2990   3050

F$                  5560   5570   5600   5620

F(                   *   2990

F0                   *   2980   3330   3340   4070

F9                  2980   2990   3030   3030   3200

G$                   *   5390   5400   5410   5420   5610

H$                   *   4230   5120   5580   5590   5610   5630   5640

I0                  3020   3040   3040   3070   3080   3090   3100   3110   3120
 3130   3140   3150   3160
                         3170   3180

I1                  3030   3050   3060   3060   3070   3080   3090   3100   3110
 3120   3130   3140   3150
                         3160   3170   3180   3190

I8                  4060   4090   4090   4500   4610   4610   4610   4670   4670
 4720   4720   4760   4880
                         4880   4920   4920   4960   4960   4990   5030   5030   5
070   5070   5090   5150
                         5150   5170   5180   5180   5200   5200   5210   5210   5
220   5240   5240   5260

I9                  3350   3370   3370   3380   3450   3460   3470   3470   3480
 3490   3490   3500   3510
                         3510   3520   3550   3560   3570   3570   3570   3580   3
620   3680   3690   3780
                         3780   3780   3790   3790   3790   3800   3800   3810   3
810   3810   3820   3850
                         3860   3860   3860   3870   4070   5320

J9                  4080   5310

L(                   *   3070   3080   3090   3100   3110   3120   3130   3140   3
150   3160   3170   3180

L0                  3010   3030   3030   3030   3320   3340   4040   4080

M(                   *   3050   3060   3070   3080   3090   3100   3110   3120   3
130   3140   3150   3160
                         3170   3180   3210   3210   3220   3220   3230   3230   3
370   3370   3380   3450
                         3460   3470   3470   3480   3490   3490   3500   3510   3
510   3520   3550   3560
                         3570   3570   3570   3580   3620   3680   3690   3690   3
```

```
770   3780   3780   3780
                         3790   3790   3790   3800   3800   3810   3810   3810   3
820   3830   3830   3850
                         3860   3860   3860   3950   3970   4000   4000   4220   4
280   4280   4290   4290
                         4330   4330   4330   4340   4340   4340   4500   4510   4
560   4580   4600   4600
                         4610   4610   4610   4621   4621   4623   4630   4640   4
650   4670   4670   4700
                         4710   4720   4720   4740   4750   4760   4800   4880   4
880   4910   4910   4920
                         4920   4950   4950   4960   4960   4990   5020   5020   5
030   5030   5050   5050
                         5070   5070   5090   5090   5150   5150   5170   5170   5
180   5180   5200   5200
                         5210   5210   5220   5240   5240   5260   5280

M1                    4580

M2                    4580   4590

M5                    4590

Mismatch                *   3940   3950   4570   4990   5010

N                       *   3390   3400   3420   3430   3450   3460   5230

N                       *   3550   3560   3610   3690   3690   3720   3730   3760   4
880   4900   4920   4940
                         4960   4980   5030   5040

N3                      *   3390   4140   4390

N6                      *   3390   4140   4390

N9                    3400   4140   4390   4410   4410   4410   4420   4420   4430
 4430   4440   4440   4450
                         5180

O                     2840   2950   3000   3270   3290   3580   3610   3610   3620
 3630   3680   3700   3710
                         3710   3780   3790   3890   3920   3920   4170   4210   4
480   5200   5220   5480
                         5500   5660   5670   5670

O0                    3640   3670

O1                      *   3650   3670   4100   4130   4550   4690   4810   4830   4
870   5210   5220   5290

O2                      *   3660   3670   3830   3840   4621   4622

O3                      *   3670   3680   3740   3750   3750   3760   3760   3770   3
840   3850   4622   4623

R$                      *   5440   5450   5460   5610

R5                      *   4230

R8                    3530   3550   3560

R9                    3340   3350

S1                      *   3430   3440   3440   3450   3460   4420   4460
```

S2 4430 4460

S3 4440 4460

T1 * 3230 3240 3370 3380 3530 3690 3690 3700
700 3710 3740 3740
3820 3830 4000 4621 4660

T2 * 3210 3250 3490 3500 3530 3530 3610 3690
700 3700 3700 3710
3740 3740 3750

T3 * 3220 3260 3510 3520 3530 3690 3700 3740
740 3750

T4 * 3470 3480 3610

T7 * 3410 3430

T8 * 3360 3420 3420 3420 3430

V$ * 4030

W * 3600 3610

Z$ 4110 4540

Z(* 3240 3250 3260 3640 3640 3650 3650 3660
660 3660 3660 3670
3720 3730 3940 4280 4280 4290 4290 4410
410 4410 4420 4420
4420 4430 4430 4430 4440 4440 4440 4450
460 4510 4630 4640
4650 4700 4710 4740 4750 4780 4790 4800
900 4910 4940 4950
4980 5010 5020 5040 5050 5070 5090 5110
120 5170 5230 5240
5280 5610 5630 5640

Z4 * 3280

Z5 * 3880

Z6 * 5490

```
5730 DEF FNL(Q)
5740 REM  MULTI-LEVEL SUBROUTINE                    (FNL0)
5750   OPTION BASE 1
5760   COM File,Flag
5770  COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
5780  COM SHORT F(4),L(*),M(32,33),N(26,11)
5790  COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
5800  COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
5810  COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
5820  COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
5830  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
5840  COM Real,Imag
5850  PRINTER IS 0
5860 Q=FNS(4)
5870 FOR P0=1 TO 2
5880  Q=FNT(Q)
5890 ON P0 GOTO 5900,5920
5900 PRINT "PRESS CONTINUE IF OK ,  PRESS RUN TO REDO EVERTHING"
5910  PAUSE
5920 X6=2
5930 T2=FNA(Q)
5940  PRINTER IS 0
5950  A$="Ta"
5960  X6=3
5970  ! IF HOT AMB IS USED INSTEAD OF CRYO MAKE CHNGE HERE (X6=2)
5980 ! R=R3
5990  PRINTER IS 0
6000  T3=FNA(Q)
6010  PRINTER IS 16
6020  PRINT "X6,T3,R3,T2,R2",X6;T3;R3;T2;R2
6030  PRINTER IS 0
6040  IF X6>2 THEN 6080
6050  T3=T3+N(14,2)
6060  PRINTER IS 0
6070  GOTO 6090
6080  T3=T3+N(14,1)
6090 PRINT "TS=";T3
6100  PRINT A$;T2
6110 REM  LEVEL LOOP
6120  N=N3*N8*2
6130  L0=1
6140 FOR L=1 TO L0
6150 ! Q=FNQ(7)
6160 Q=FNM(Q)
6170 L(L,6*P0-5)=T2
6180 L(L,6*P0-4)=T3
6190 L(L,6*P0-3)=T1
6200 L(L,6*P0-2)=S1
6210 L(L,6*P0-1)=T4
6220 L(L,6*P0)=P2
6230 NEXT L
6240 Q=FNS(3)
6250 NEXT P0
6260 Q=FNS(4)
6270 REM  PRELIMINARY RESULTS
6280  A$="------------------------------------------------------------"
6290  ! !!!PAGE
6300  GOTO 6480
6310  PRINTER IS 0
6320 Q=FNS(11)
6330  PRINT TAB(23),"MEASUREMENT RECAP"
6340  PRINT TAB(30),"AND"
6350 PRINT TAB(22),"PRELIMINARY RESULTS"
6360 Q=FNS(7)
```

```
6370 PRINT TAB(6),"FREQUENCY=";F;"MHZ"
6380  PRINT TAB(6),"SOURCE IMPEDANCE";TAB(23),H$[11,20];TAB(38),"LEVEL SETTING O
F A2=";R5
6390  PRINT TAB(6),A$
6400 Q=FNS(2)
6410 PRINT TAB(10),"TA";TAB(20),"R OHMS";TAB(34),"TS";TAB(44),"R OHMS"
6420 PRINT TAB(6)," --------    --------    --------    -------- "
6430  FIXED 2
6440  PRINT TAB(8),Z(1,1);TAB(20),Z(1,59);TAB(32),Z(1,2);TAB(44),Z(1,60)
6450  PRINT TAB(8),Z(1,7);TAB(20),Z(1,59);TAB(32),Z(1,8);TAB(44),Z(1,60)
6460  PRINT TAB(6),A$
6470  GOTO 6630
6480 FOR L=1 TO L0
6490  Z(L,1)=L(1,1)
6500  Z(L,2)=L(1,2)
6510  Z(L,3)=L(L,3)
6520  Z(L,4)=L(L,4)
6530  Z(L,5)=L(L,5)
6540  Z(L,6)=L(L,6)
6550  Z(L,7)=L(L,7)
6560  Z(L,8)=L(L,8)
6570  Z(L,9)=L(L,9)
6580  Z(L,10)=L(L,10)
6590  Z(L,11)=L(L,11)
6600  Z(L,12)=L(L,12)
6610 NEXT L
6620 GOTO 6310
6630  PRINT TAB(11),"TX";TAB(21),"SX";TAB(34),"TE"
6640  PRINT TAB(6),"   --------   --------    --------"
6650  PRINT TAB(8),Z(1,3);TAB(20),Z(1,4);TAB(32),Z(1,5)
6660  PRINT TAB(8),Z(1,9);TAB(20),Z(1,10);TAB(32),Z(1,11)
6670  PRINT
6680  PRINT TAB(6),A$
6690  PRINT
6700  STANDARD
6710  N9=Z(1,31)
6720  PRINT TAB(6),"AVE POWER IN MILLIWATTS P1,P2,P3"
6730  PRINT TAB(6),Z(1,45)/N*1000,Z(1,46)/N*1000,Z(1,47)/N*1000
6740  S1=SQR((Z(1,48)-Z(1,45)*Z(1,45)/N)/(N-1))
6750  S2=SQR((Z(1,49)-Z(1,46)*Z(1,46)/N)/(N-1))
6760  S3=SQR((Z(1,50)-Z(1,47)*Z(1,47)/N)/(N-1))
6770  PRINT TAB(6),"SD P1,P2,P3 (# OF MEAS=";N;")";S1;S2;S3
6780  PRINT TAB(6),A$
6790  Q=FNS(20)
6800  PRINT TAB(6),A$
6810  PRINT
6820  PRINT " END OF MEASUREMENT  PRESS CONTINUE FOR FULL REPORT"
6830  PAUSE
6840 RETURN 0
6850  FNEND
6860  !                       EDITED FOR 9845
6870  ! !!!!!!SUBROUTINES OUTSIDE OF MAIN PROGRAM STRUCTURE START HERE!!!!!!!!
6880  !
```

<u>FNL(</u>

```
A$                  *   5950   6100   6280   6390   6460   6680   6780   6800

F                   *   6370

H$                  *   6380

L                   *   6140   6170   6180   6190   6200   6210   6220   6230
480    6490    6500    6510
                        6510   6520   6520   6530   6530   6540   6540   6550
```

```
[illegible]   6560   6560   6570
                        6570   6580   6580   6590   6590   6600   6600   6610

[illegible]           *   6170   6180   6190   6200   6210   6220   6490   6500   6
[illegible]   6520   6530   6540
                        6550   6560   6570   6580   6590   6600

[illegible]           6130   6140   6480

[illegible]           *   6120   6730   6730   6730   6740   6740   6750   6750   6
[illegible]   6760   6770

[illegible]           *   6050   6080

[illegible]           *   6120

[illegible]           *   6120

[illegible]           6710

[illegible]           *   5870   5890   6170   6180   6190   6200   6210   6220   6
[illegible]

[illegible]           *   6220

[illegible]           5730   5960   5880   5880   5930   6000   6160   6160   6240
 6260   6320   6360   6400
                        6790

[illegible]           *   6020

[illegible]           *   6020

[illegible]           *   6380

[illegible]           *   6200   6740   6770

[illegible]           6750   6770

[illegible]           6760   6770

[illegible]           *   6190

[illegible]           *   5930   6020   6100   6170

[illegible]           *   6000   6020   6050   6050   6080   6080   6090   6180

[illegible]           *   6210

[illegible]           *   5920   5960   6020   6040

[illegible]           *   6440   6440   6440   6440   6450   6450   6450   6450   6
 490   6500   6510   6520
                        6530   6540   6550   6560   6570   6580   6590   6600   6
 650   6650   6650   6660
                        6660   6660   6710   6730   6730   6730   6740   6740   6
 740   6750   6750   6750
                        6760   6760   6760
```

```
6890 DEF FND(Q)
6900 IF Q THEN 6920
6910 RETURN FNX(68)+FNX(67)+FNX(63)+FNX(81)+FNX(33)
6920 Q=FNX(68)+FNX(28)+FNX(102)+FNW(460)+FNR(2)+FNR(2)
6930 V=FNX(68)+FNX(29)+FNX(103)+FNW(550)+FNR(2)+FNX(111)+FNX(27)+FNW(100)
6940 RETURN 0
6950  FNEND
```

<u>FND(</u>

Q	6890	6900	6920
V	6930		

```
6960 DEF FNP(Q)                          !!(FNP)    MOD VS JAN 16 1981   GJC
6970  ! TEST OF NEW MANIFOLD STARTED NOV 21
6980  ! ! THIS VERSION HAS CODE TO ACCOMODATE BAD PROG ATTEN!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
6990   OPTION BASE 1
7000   COM File,Flag
7010  COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
7020  COM SHORT F(4),L(*),M(32,33),N(26,11)
7030  COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
7040  COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
7050  COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
7060  COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
7070  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
7080  COM Real,Imag
7090 ! OUTPUT 701;"*"  !RESET FLUKE
7100  DIM Po(6)
7110  PRINTER IS 16
7120  Q=0
7130 Pout$="0"                        !Q=FNX(Q7)
7140  OUTPUT 702;"0","0","7",Pout$ ! 0000 0000 0111 XXXX SETFREQ+PORT
7150  WAIT 50
7160  OUTPUT 702;"0","0",">","Pout$"!CCONTROL
7170 ! PRINT "PORT #",Pout$
7180  WAIT 150
7190  OUTPUT 709;"C"  !CLEAR SCANNER
7200  OUTPUT 709;15  !CHANNEL 15
7210  OUTPUT 701;"VR1F2T2S5?" !VOLTS FILTER #SA
7220 ! WAIT 600
7230  ENTER 701;V0  !VALUE OF BRIDGE POWER OFF
7240 ! PRINT "BRIDGE PWR OFF=";V0
7250 ! OUTPUT 709;16   !CHANNEL 16
7260 ! WAIT 300
7270 ! OUTPUT 701;"VRF2S5?"    !OUTPUT FLUKE
7280 ! ENTER 701;V1       !VALUE OF REF
7290 ! PRINT "VALUE OF REF=";V1
7300 ! PAUSE
7310  OUTPUT 709;17
7320  WAIT 300
7330  OUTPUT 701;"VR0F2T2S5?"
7340 ! WAIT 600
7350  ENTER 701;V3  !BRIDGE -REF WITH NO POWER
7360 PRINT "BRIDGE -REF N0 PWR=";V3
7370  FOR Loop=1 TO 3
7380  ON Loop GOTO 7390,7430,7490
7390 Pout$="0"                                 ! Q=FNX(Q8)
7400 ! PRINT "PAUSE 1",Pout$
7410 ! PAUSE
7420  GOTO 7500
7430  Pout$="3"                                 ! Q=FNX(Q8)
7440 ! PRINT "PAUSE2",Pout$
7450 ! PAUSE
7460  GOTO 7500
7470 ! PRINT "PAUSE 3",Pout$
7480 ! PAUSE
7490 Pout$="2"                                  ! Q=FNX(Q9)
7500  OUTPUT 702;"0","1","7",Pout$  !0000 0001 0111 XXXX
7510  WAIT 50
7520  OUTPUT 702;"0","1",">",Pout$  !0000 0001 1000 XXXX
7530  WAIT 150
7540  OUTPUT 701;"VR0F2T2S5?" !OUTPUT FLUKE
7550 ! WAIT 600
7560  ENTER 701;V4 !ENTER BRIDGE -REF WITH POWER
7570 PRINT "BRIDGE -REF PWR=";V4
7580  Po(Loop)=V4
```

```
7590  NEXT Loop
7600  OUTPUT 702;"0","0","7",Pout$  !0000 0000 0111 XXXX
7610  WAIT 50
7620  OUTPUT 702;"0","0",">",Pout$  !0000 0000 1000 XXXX
7630  WAIT 150
7640  OUTPUT 701;"VR0F2T2S5?"  !OUTPUT FLUKE
7650  ! WAIT 600
7660  ENTER 701;V5!INPUT RECHECK BRIDGE -REF PWR OFF
7670 PRINT "BRIDGE -REF PWR OFF";V5
7680  OUTPUT 709;15
7690  WAIT 300
7700  OUTPUT 701;"VR1F2T2S5?" !OUTPUT FLUKE
7710  ! WAIT 600
7720  ENTER 701;V6!RECHECK BRIDGE WITH POWER OFF
7730  DISP "BRIDGE NO PWR";V6
7740  E6=V0+V6
7750  DISP "E6=";E6
7760  E7=(V3+V5)/2
7770  DISP "E7=";E7
7780  FOR I=4 TO 6
7790  E8=E6-Po(I-3)+E7
7800  DISP "E8=";E8
7810  E9=Po(I-3)-E7
7820  DISP "E9=";E9
7830  Po(I)=E8*E9/200
7840  NEXT I
7850  P1=Po(4)
7860  P2=Po(5)
7870  P3=Po(6)
7880 ! PRINT "P1,P2,P3";Po(4),Po(5),Po(6)
7890 ! PAUSE
7900  PRINTER IS 0
7910  RETURN Q
7920  FNEND
```

<u>FNP(</u>

```
E6              7740   7750   7790

E7               *   7760   7770   7790   7810

E8              7790   7800   7830

E9              7810   7820   7830

I                *   7780   7790   7810   7830   7840

Loop            7370   7380   7580   7590

P1               *   7850

P2               *   7860

P3               *   7870

Po(             7100   7580   7790   7810   7830   7850   7860   7870

Pout$            *   7130   7140   7390   7430   7490   7500   7520   7600   7
620

Q               6960   7120   7910

V0              7230   7740
```

V3	7350	7360	7760
V4	7560	7570	7580
V5	7660	7670	7760
V6	7720	7730	7740

```
7930 DEF FNB(Q)                         !!(FNB)
7940   OPTION BASE 1
7950   COM File,Flag
7960  COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
7970  COM SHORT F(4),L(*),M(32,33),N(26,11)
7980  COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
7990  COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
8000  COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
8010  COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
8020  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
8030  COM Real,Imag
8040 FOR I=1 TO Q
8050 BEEP
8060 WAIT ABS(100*(I-4))
8070 NEXT I
8080 RETURN 0
8090  FNEND
```

FNB(

```
I                     *    8040    8060    8070

Q                  7930    8040
```

```
8100 DEF FNN(Q)                    !!(FNN)
8110   OPTION BASE 1
8120  COM File,Flag
8130  COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
8140  COM SHORT F(4),L(*),M(32,33),N(26,11)
8150  COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
8160  COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
8170  COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
8180  COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
8190  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
8200  COM Real,Imag
8210 DISP "( =NC):";Q;
8220 LINPUT B$
8230 IF B$[1,1]=" " THEN 8250
8240 RETURN VAL(B$)
8250 RETURN Q
8260  FNEND
```

FNN(

```
**                  *    8220    8230    8240

                  8100    8210    8250
```

```
8270 DEF FNI(Q)                    !!(FNI)
8280 A$="- - ------====####@@@@"
8290 A$=A$[4*Q-3,4*Q]
8300 A$[5]=A$
8310 A$[9]=A$
8320 IMAGE M2D.1D
8330 PRINT USING 8320;A$,A$,A$,A$,A$
8340 RETURN 0
8350  FNEND
```

<u>FNI(</u>

```
A$                 *   8280    8290    8290    8300    8300    8310    8310     330    8
330    8330    8330    8330

Q                    8270    8290    8290
```

```
8360 DEF FNW(Q)                    !!(FNW)
8370 WAIT Q
8380 RETURN 0
8390  FNEND
```

<u>FNW(</u>

```
Q                  8360   8370
```

```
8400 DEF FNS(Q)                          !!(FNS)
8410   OPTION BASE 1
8420  COM File,Flag
8430  COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
8440  COM SHORT F(4),L(*),M(32,33),N(26,11)
8450  COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
8460  COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
8470  COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
8480  COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
8490  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
8500  COM Real,Imag
8510 FOR I=1 TO Q
8520 PRINT
8530 NEXT I
8540 RETURN 0
8550  FNEND
```

FNS(

I	*	8510	8530
Q	8400	8510	

```
8560 DEF FNO(Q)                       !!(FNO)
8570   OPTION BASE 1
8580  COM File,Flag
8590  COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
8600  COM SHORT F(4),L(*),M(32,33),N(26,11)
8610  COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
8620  COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
8630  COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
8640  COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
8650  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
8660  COM Real,Imag
8670 IF I2=0 THEN 8730
8680 DISP "( =NC)NOW: ";P$;
8690 LINPUT Q$
8700 IF Q$=" " THEN 8780
8710 P$=Q$
8720 GOTO 8780
8730 DISP "( =NC)NOW: ";P$
8740 I0=FNS(1)+FNW(50)
8750 LINPUT Q$
8760 IF Q$=" " THEN 8780
8770 P$=Q$
8780 RETURN Q
8790  FNEND
```

<u>FNO(</u>

```
I0                8740

I2                 *   8670

P$                 *   8680   8710   8730   8770

Q                 8560   8780

Q$                 *   8690   8700   8710   8750   8760   8770
```

```
8800 DEF FNM(Q)
8810   OPTION BASE 1
8820   COM File,Flag
8830  COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
8840  COM SHORT F(4),L(*),M(32,33),N(26,11)
8850  COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
8860  COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
8870  COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
8880  COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
8890  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
8900  COM Real,Imag
8910  PRINT
8920  OUTPUT 9;"R"
8930  ENTER 9;P$
8940  PRINT TAB(20),"DATE:";P$[1,2];"-";P$[4,5];"-1981";"     TIME:";P$[7,14]
8950  PRINT
8960  X5=1
8970  E8=500
8980 Z9=T7=T8=T9=P7=P8=P9=0
8990  W4=W5=W6=0
9000 FOR J8=1 TO N8+1
9010  Q=J8
9020 T1=FNV(Q)+FNG(Q)
9030  IF J8>1 THEN 9050
9040  GOTO 9150
9050  T1=T1*N3
9060 T8=T8+T1
9070 T9=T9+T4
9080 T7=T7+V2
9090  P7=P7+P4
9100  P8=P8+P5
9110 P9=P9+P6
9120  W4=W4+W1
9130  W5=W5+W2
9140  W6=W6+W3
9150 NEXT J8
9160 T1=T8/(N8*N3)
9170 T4=T9/N8
9180 S1=SQR((T7-T8*T8/(N8*N3))/(N8*N3-1))
9190  IF P0=1 THEN 9250
9200  B6=T7
9210  Z(1,41)=B6
9220  B8=T8
9230  Z(1,42)=B8
9240  GOTO 9310
9250  B5=T7
9260  B7=T8
9270  Z(1,43)=B5
9280  Z(1,42)=B7
9290  ! REM B5 AND B6=SUM OF SQRS-B7 AND B8=SUM OF T1
9300  PRINTER IS 0
9310  PRINT "          TX AVE        STD DEV      TE"
9320  PRINT
9330  PRINT USING 9340;T1,S1,T4
9340  IMAGE 5X,10D.D,5X,7D.2D,5X,7D.2D
9350  PRINT
9360  PRINT
9370  PRINT "P1 AVE MW=";P7/(N3*N8);"P2 AVE MW=";P8/(N3*N8);"P3 AVE MW=";P9/(N3*
N8)
9380  PRINT
9390  PRINT "STANDARD ERROR OF MEAN=";S1/SQR(N8*N3)
9400  PRINT
9410  PRINT
9420  PRINTER IS 16
```

```
9430  IF P0=2 THEN 9500
9440  Z(1,45)=P7
9450  Z(1,46)=P8
9460  Z(1,47)=P9
9470  Z(1;48)=W4
9480  Z(1,49)=W5
9490  Z(1,50)=W6
9500  IF P0=1 THEN 9590
9510  ! B5 AND B6 = SUM OF SQRS T1; B7 AND B8=SUM OF T1
9520  Z(1,45)=Z(1,45)+P7
9530  Z(1,46)=Z(1,46)+P8
9540  Z(1,47)=Z(1,47)+P9
9550  Z(1,48)=Z(1,48)+W4
9560  Z(1,49)=Z(1,49)+W5
9570  Z(1,50)=Z(1,50)+W6
9580  Q=FNB(1)
9590  Z8=1
9600 ! !DISP"ANOTHER ROUND"
9610  IF Z8=0 THEN 8980
9620  GOTO 9630
9630  RETURN 0
9640  FNEND
9650  ! !!!!!!!!!!!!!!CUT 7 NOV 24 1980 0830 !!!!!!!!!!!!!!!!!!!!!!!!!!
```

FNM(

```
B5                 *   9250   9270

B6                 *   9200   9210

B7                 *   9260   9280

B8                 *   9220   9230

E8                8970

J8                 *   9000   9010   9030   9150

N3                 *   9050   9160   9180   9180   9370   9370   9370   9390

N8                 *   9000   9160   9170   9180   9180   9370   9370   9370   9
390

P$                 *   8930   8940   8940   8940

P0                 *   9190   9430   9500

P4                 *   9090

P5                 *   9100

P6                 *   9110

P7                 *   8980   9090   9090   9370   9440   9520

P8                 *   8980   9100   9100   9370   9450   9530

P9                 *   8980   9110   9110   9370   9460   9540

Q                 8800   9010   9020   9020   9580

S1                 *   9180   9330   9390

T1                 *   9020   9050   9050   9060   9160   9330
```

T4	*	9070	9170	9330					
T7	*	8980	9080	9080	9180	9200	9250		
T8	*	8980	9060	9060	9160	9180	9180	9220	92[illegible]
T9	*	8980	9070	9070	9170				
V2	*	9080							
W1	*	9120							
W2	*	9130							
W3	*	9140							
W4	*	8990	9120	9120	9470	9550			
W5	*	8990	9130	9130	9480	9560			
W6	*	8990	9140	9140	9490	9570			
X5	8960								
Z(	*	9210	9230	9270	9280	9440	9450	9460	9470

480 9490 9520 9520

9530 9530 9540 9540 9550 9550 9560 9560

570 9570

Z8	9590	9610
Z9	8980	

```
9660 DEF FNV(Q)
9670   OPTION BASE 1
9680   COM File,Flag
9690  COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
9700  COM SHORT F(4),L(*),M(32,33),N(26,11)
9710  COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
9720  COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
9730  COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
9740  COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
9750  COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
9760  COM Real,Imag
9770 T1=T4=V2=P4=P5=P6=W1=W2=W3=0
9780  X5=1
9790  E8=1000
9800  PRINTER IS 0
9810 FOR Z2=1 TO N3
9820 J5=1
9830 ! Qo=FNX(Q7)
9840 ! Q=1
9850 ! P1=FNP(Q)
9860 ! J5=2
9870 ! Qone=FNX(Q8)
9880 ! Q=2
9890 ! P2=FNP(Q)
9900 ! J5=3
9910 ! Qtwo=FNX(Q9)
9920 ! Q=3
9930 ! P3=FNP(Q)
9940 ! Po=FNP(Q)
9950  Q=FNP(0)
9960 ! PRINT "PAUSE AFTER RETURN FROM FNP:4462"
9970 ! PRINT "THIS IS P1,P2,P3";P1,P2,P3
9980 ! PAUSE
9990  X5=1
10000 Y1=P1/P2
10010 Y3=P3/P2
10020 X8=T2+(T3-T2)*(Y1-1)/(Y3-1)
10030 T6=X8-T2
10040 T5=T6/C1
10050 T5=T2+T5
10060 X8=T5
10070 IF X5=0 THEN 10110
10080 PRINTER IS 0
10090 PRINT X8;P1*1000;P2*1000;P3*1000
10100 GOTO 10130
10110 PRINTER IS 0
10120 PRINT X8
10130 IF J8=1 THEN 10200
10140 GOTO 10200
10150 E8=10000
10160 E6=X8-E7
10170 IF ABS(E6)<=E8 THEN 10200
10180 DISP "DEV EXCEEDS MAX--REDO LAST TEMP"
10190 GOTO 9820
10200 T1=T1+X8
10210 T4=T4+(T3-Y3*T2)/(Y3-1)
10220 V2=V2+X8*X8
10230 P4=P4+P1
10240 P5=P5+P2
10250 P6=P6+P3
10260 W1=W1+P1*P1
10270 W2=W2+P2*P2
10280 W3=W3+P3*P3
10290 NEXT Z2
```

```
10300 T4=T4/N3
10310 S=SQR((V2-T1*T1/N3)/(N3-1))
10320 T1=T1/N3
10330 E7=T1
10340 RETURN T1
10350 FNEND
```

<u>FNV(</u>

```
C1                    *  10040

E6                  10160  10170

E7                    *  10160  10330

E8                   9790  10150  10170

J5                   9820

J8                    *  10130

N3                    *   9810  10300  10310  10310  10320

P1                    *  10000  10090  10230  10260  10260

P2                    *  10000  10010  10090  10240  10270  10270

P3                    *  10010  10090  10250  10280  10280

P4                    *   9770  10230  10230

P5                    *   9770  10240  10240

P6                    *   9770  10250  10250

Q                    9660   9950

S                     *  10310

T1                    *   9770  10200  10200  10310  10310  10320  10320  10330  10
340

T2                    *  10020  10020  10030  10050  10210

T3                    *  10020  10210

T4                    *   9770  10210  10210  10300  10300

T5                    *  10040  10050  10050  10060

T6                    *  10030  10040

V2                    *   9770  10220  10220  10310

W1                    *   9770  10260  10260

W2                    *   9770  10270  10270

W3                    *   9770  10280  10280

X5                   9780   9990  10070

X8                    *  10020  10030  10060  10090  10120  10160  10200  10220  1(
220
```

Y1	10000	10020		
Y3	10010	10020	10210	10210
[illegible]	*	9810	10290	

```
10360 DEF FNG(Q)
10370  OPTION BASE 1
10380  COM File,Flag
10390 COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
10400 COM SHORT F(4),L(*),M(32,33),N(26,11)
10410 COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
10420 COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
10430 COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
10440 COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
10450 COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
10460 COM Real,Imag
10470 PRINTER IS 0
10480 IF J8>1 THEN 10830
10490 I6=T1
10500 ! PRINT "ENTER SCALE DESIRED"
10510 ! INPUT Q5
10520 ! GO TO 8485
10530 Q5=100
10540 I5=Q5/25
10550 IMAGE 5X,"TX(K) =",M7D. ,"SIG(K) =",M5D.
10560 IMAGE /,/,/,/
10570 D9=1
10580 Q=FNS(2)
10590 PRINT "A2 SETTING=";R5;"DB"
10600 PRINT F;"MHZ"
10610 PRINT USING 10560
10620 IMAGE 17X,"# OF PTS IN AVE =",M3D
10630 IMAGE 7X,"UNIT =",M9D.D," KELVINS",/
10640 PRINT USING 10620;N3
10650 PRINT USING 10630;I5
10660 PRINT
10670 IF Q5>=10 THEN 10720
10680 PRINT USING 10710;-Q5,-3*Q5/5,-Q5/5,Q5/5,3*Q5/5,Q5
10690 GOTO 10730
10700 IMAGE 4X,M5D ,4X,M5D ,4X,M5D ,4X,M5D ,4X,M5D ,4X,M5D ," KELVINS"
10710 IMAGE 5X,M1DE,4X,M1DE,4X,M1DE,4X,M1DE,4X,M1DE,4X,M1DE," KELVINS"
10720 PRINT USING 10700;-Q5,-3*Q5/5,-Q5/5,Q5/5,3*Q5/5,Q5
10730 A$="!....!....!....!....!....!....!....!....!....!....!"
10740 PRINT TAB(8),A$
10750 IMAGE "#/TIME",21X,"ZERO=",M5D ," KELVINS",16X,"TX(K)  ",3X,"SIG(K)"
10760 IF (T1>=100) AND (T1<=1E5) THEN 10800
10770 PRINT USING 10780;I6
10780 IMAGE "#/TIME",21X,"ZERO=",M1D.2DE," KELVINS",15X,"TX(K)  ",3X,"SIG(K)"
10790 GOTO 10820
10800 PRINTER IS 0
10810 PRINT USING 10750;I6
10820 RETURN 0
10830 I6=T1
10840 IMAGE M3D ,4X
10850 PRINTER IS 0
10860 PRINT USING 10840;J8-
10870 X3=INT((T1-I6)/I5)+25
10880 X4=INT(S/I5)
10890 IF X3>0 THEN 10920
10900 PRINT "<---";TAB(51),
10910 GOTO 11080
10920 IF X3<50 THEN 10950
10930 PRINT TAB(47),"--->";
10940 GOTO 11080
10950 X3=X3
10960 IF (X3-X4>0) AND (X3+X4<50) THEN 10980
10970 GOTO 11000
10980 PRINT TAB(X3-X4),"!";TAB(X3),"+";TAB(X3+X4),"!";TAB(51),
10990 GOTO 11080
```

```
11000 IF (X3-X4>0) AND (X3<50) THEN 11020
11010 GOTO 11040
11020 PRINT TAB(X3-X4),"!";TAB(X3),"+";TAB(51),
11030 GOTO 11080
11040 IF (X3>0) AND (X3+X4<50) THEN 11070
11050 PRINT TAB(X3),"X";TAB(51),
11060 GOTO 11080
11070 PRINT TAB(X3),"+";TAB(X3+X4),"!";TAB(51),
11080 IF (T1>=100) AND (T1<=1E5) THEN 11120
11090 IMAGE 2X,M1D.2DE,2X,M1D.2DE
11100 PRINT USING 11090;T1,S
11110 GOTO 11160
11120 PRINT USING 11130;T1,S
11130 IMAGE 2X,M5D ,2X,M5D
11140 IF (J8-1)/20-INT((J8-1)/20)>0 THEN 11160
11150 PRINT TAB(8),A$
11160 RETURN 0
11170 FNEND
```

ENG(

```
A$                  *  10730  10740  11150

D9                10570

I                   *  10600

I5                  *  10540  10650  10870  10880

I6                  *  10490  10770  10810  10830  10870

J8                  *  10480  10860  11140  11140

N3                  *  10640

O                 10360  10580

Q5                  *  10530  10540  10670  10680  10680  10680  10680  10680  10
680  10720  10720  10720
                       10720  10720  10720

R5                  *  10590

S                   *  10880  11100  11120

T1                  *  10490  10760  10760  10830  10870  11080  11080  11100  11
120

X3                  *  10870  10890  10920  10950  10950  10960  10960  10980  10
980  10990  11000  11000
                       11020  11020  11040  11040  11050  11070  11070

X4                10880  10960  10960  10980  10980  11000  11020  11040  11070
```

```
11180 DEF FNA(Q)
11190  OPTION BASE 1
11200  COM File,Flag
11210 COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
11220 COM SHORT F(4),L(*),M(32,33),N(26,11)
11230 COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
11240 COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
11250 COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
11260 COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
11270 COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
11280 COM Real,Imag
11290 Z(1,59)=R2
11300 Z(1,60)=R3
11310 PRINTER IS 16
11320 PRINT "FNA",X6,Z9
11330 IF X6>1 THEN 11370
11340 DISP "BULB PRESS(MM)=";
11350 INPUT H6
11360 GOTO 11590
11370 IF N(X6,1)>0 THEN 11460
11380 DISP "R0=";
11390 INPUT N(X6,1)
11400 DISP "ALPHA=";
11410 INPUT N(X6,2)
11420 DISP "DELTA=";
11430 INPUT N(X6,3)
11440 DISP "BETA=";
11450 INPUT N(X6,4)
11460 IF X6>2 THEN 11850
11470 H4=R2
11480 PRINT "9526 X6,H4,R2",X6,H4,R2
11490 IF H4<50 THEN 11630
11500 H6=N(X6,1)
11510 H7=N(X6,2)
11520 H3=(H4/H6-1)/H7
11530 H8=N(X6,3)
11540 IF H3>0 THEN 11570
11550 H9=N(X6,4)
11560 GOTO 11690
11570 H9=0
11580 GOTO 11690
11590 H5=N(7,2)*H6*H6
11600 H5=N(7,3)*H6+H5+N(7,4)
11610  H5=H5-273.15
11620 GOTO 9815
11630 H5=N(6,1)*H4*H4
11640 H5=N(6,2)+N(6,3)*H4+H5
11650 H5=H5
11660 T3=H5
11670 PRINTER IS 0
11680 RETURN T3
11690 H5=H3
11700 PRINT
11710 FOR J9=1 TO 5
11720 G9=H5/100
11730 G8=G9-1
11740 IF H5>0 THEN 11770
11750 H5=H3+H8*G8*G9+H9*G8*G9*G9*G9
11760 GOTO 11790
11770 H5=H5+H8*G9*G8
11780 H5=H3+H8*G9*G8
11790 NEXT J9
11800 PRINTER IS 0
11810 T2=H5+273.15
```

```
11820 PRINT "AMBIENT STD",T2
11830 PRINTER IS 0
11840 RETURN T2
11850   H4=R3
11860 IF H4<50 THEN 11630
11870 H6=N(X6,1)
11880 H7=N(X6,2)
11890 H3=(H4/H6-1)/H7
11900 IF H3>0 THEN 11930
11910 H9=N(X6,4)
11920 GOTO 11940
11930 H9=0
11940  H5=H3
11950  FOR J9=1 TO 5
11960  G9=H5/100
11970  G8=G9-1
11980  IF H5>0 THEN 12010
11990  H5=H3+H8*G8*G9+H9*G8*G9*G9
12000  GOTO 12020
12010  H5=H3+H8*G9*G8
12020  NEXT J9
12030  T3=H5
12040  PRINT "AMBIENT CRYO",T3
12050  PRINTER IS 0
12060  RETURN T3+273.15
12070 FNEND
```

FNA(

```
G8                11730  11750  11750  11770  11780  11970  11990  11990  12010

G9                11720  11730  11750  11750  11750  11750  11770  11780  11960
11970  11990  11990  11990
                      12010

H3                11520  11540  11690  11750  11780  11890  11900  11940  11990
12010

H4                11470  11480  11490  11520  11630  11630  11640  11850  11860
11890

H5                11590  11600  11600  11610  11610  11630  11640  11640  11650
11650  11660  11690  11720
                      11740  11750  11770  11770  11780  11810  11940  11960  11
980  11990  12010  12030

H6                11350  11500  11520  11590  11590  11600  11870  11890

H7                11510  11520  11880  11890

H8                11530  11750  11770  11780  11990  12010

H9                11550  11570  11750  11910  11930  11990

J9                11710  11790  11950  12020

N(                  *  11370  11390  11410  11430  11450  11500  11510  11530  11
550  11590  11600  11600
                      11630  11640  11640  11870  11880  11910

Q                 11180

R2                  *  11290  11470  11480
```

```
R3                  *  11300  11850

T2                  *  11810  11820  11840

T3                  *  11660  11680  12030  12040  12060

X6                  *  11320  11330  11370  11390  11410  11430  11450  11460  11
480  11500  11510  11530
                       11550  11870  11880  11910

Z(                  *  11290  11300

Z9                 11320
```

```
12080 DEF FNT(Q)
12090 OUTPUT 9;"R"
12100 ENTER 9;P$
12110 OUTPUT 709;50
12120 WAIT 250
12130 OUTPUT 701;"*"
12140  OPTION BASE 1
12150  COM File,Flag
12160 COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,    N3,N8,N,F,F0,W
12170 COM SHORT F(4),L(*),M(32,33),N(26,11)
12180 COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
12190 COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],.   90]
12200 COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,.    V7,V8,V9
12210 COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout
12220 COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
12230 COM Real,Imag
12240 ! 801030 GJC SUBROUTINE TO READ RESISTANCE OF PLATINUM THERMOMETERS AND VO
LTAGES
12250 PRINTER IS 16
12260 OUTPUT 9;"R"
12270 ENTER 9;Y$
12280 PRINT Y$
12290 ! OUTPUT 9;"S10,30,11,37,50"
12300 ! STOP
12310 OUTPUT 709;50
12320 WAIT 250
12330 OUTPUT 701;"*"
12340 OUTPUT 701;"ZH2?"
12350 ENTER 701;R0
12360 PRINTER IS 0
12370 OUTPUT 709;51
12380 WAIT 250
12390 OUTPUT 701;"Z ?"
12400 ENTER 701;R1
12410 OUTPUT 709;50
12420 WAIT 250
12430 OUTPUT 701;"K",","
12440 OUTPUT 701;"Z","?"
12450 ENTER 701;Rthree
12460 OUTPUT 709;51
12470 WAIT 250
12480 OUTPUT 701;"K"
12490 OUTPUT 701;"ZP?"
12500 ENTER 701;R2
12510 !
12520 R2=R2-.022
12530 !
12540 OUTPUT 709;52
12550 WAIT 250
12560 OUTPUT 701;"*"
12570 OUTPUT 701;"Z?"
12580 ENTER 701;R7
12590 OUTPUT 701;"K,"
12600 OUTPUT 709;53
12610 OUTPUT 701;"Z?"
12620 ENTER 701;Rfive
12630 OUTPUT 701;"ZP?"
12640 ENTER 701;R3
12650 !
12660 R3=R3-.026-.045+.035
12670 !
12680 OUTPUT 709;C
12690 OUTPUT 701;"*"
12691 PRINTER IS 0
```

```
12692 PRINT R2,R3
12694 PRINTER IS 16
12695   RETURN Q
12700 OUTPUT 709;10
12710 OUTPUT 701;"VKFH0?"
12720 ENTER 701;V0
12730 OUTPUT 701;"VPFH4?"
12740 ENTER 701;V0
12750 OUTPUT 709;11
12760 OUTPUT 701;"VP0FH0?"
12770 ENTER 701;V1
12780 OUTPUT 701;"VPFH0?"
12790 ENTER 701;V1
12800 OUTPUT 709;12
12810 OUTPUT 701;"VPFH0?"
12820 ENTER 701;V2
12830 OUTPUT 709;13
12840 OUTPUT 701;"VPFH0?"
12850 ENTER 701;V3
12860 OUTPUT 709;C
12870 OUTPUT 709;13
12880 OUTPUT 701;"VPHF0?"
12890 ENTER 701;V4
12900 PRINTER IS 0
12910 PRINT
12920 OUTPUT 9;"R"
12930 ENTER 9;Y$
12940 PRINT
12950 PRINT
12960 PRINT "DATE AND TIME:";Y$,"     YEAR  1981       FREQ=";F;"MHZ"
12970 PRINT
12980 PRINT
12990 IMAGE 1X,"AMBIENT LEAD RESISTANCE",25X,DDD.DDD,5X,"CHANNEL 50"
13000 IMAGE 1X,"AMBIENT LEAD RESISTANCE+PLATINUM THERMOMETER",4X,DDD.DDD,5X,"CHA
NNEL 51"
13010 IMAGE 1X,"AMBIENT THERMOMETER RESISTANCE",18X,DDD.DDD,5X,"CHANNEL 51-50"
13020 IMAGE 1X,"CRYO LEAD RESISTANCE",28X,DDD.DDD,5X,"CHANNEL 52"
13030 IMAGE 1X,"CRYO LEAD RESISTANCE +PLATINUM THERMOMETER",6X,DDD.DDD,5X,"CHANN
EL53"
13040 IMAGE 1X,"CRYO THERMOMETER RESISTANCE",21X,DDD.DDD,5X,"CHANNEL 53-52"
13050 PRINTER IS 16
13060 PRINT USING 12990;R0
13070 PRINT USING 13000;R1
13080 PRINTER IS 0
13090 PRINT USING 13010;R2
13100 PRINTER IS 16
13110 PRINT USING 13020;R7
13120 PRINT USING 13030;Rfive
13130 PRINTER IS 0
13140 PRINT USING 13040;R3
13150 ! IMAGE 1X,"VOLTMETER ZERO CHECK ",28X,DD.DDD,5X,"CHANNEL 10"
13160 IMAGE 1X,"28 VOLT SUPPLY",35X,DD.DDD,5X,"CHANNEL 11"
13170 IMAGE 1X,"15 VOLT SUPPLY",35X,DD.DDD,5X,"CHANNEL 12"
13180 IMAGE 1X,"20 VOLT SUPPLY",35X,DD.DDD,5X,"CHANNEL 13"
13190 PRINTER IS 16
13200 ! PRINT USING 780;V0
13210 PRINT USING 13160;V1
13220 PRINT USING 13170;V2
13230 PRINT USING 13180;V3
13240 RETURN 0
13250 FNEND
```

FNT(

C	12680 12860
F	* 12960
P$	* 12100
Q	12080 12695
R0	12350 13060
R1	12400 13070
R2	* 12500 12520 12520 12692 13090
R3	* 12640 12660 12660 12692 13140
R7	12580 13110
Rfive	12620 13120
Rthree	12450
V0	12720 12740
V1	12770 12790 13210
V2	* 12820 13220
V3	12850 13230
V4	12890
Y$	12270 12280 12930 12960

```
13260 DEF FNX(Q)
13270  OPTION BASE 1
13280  COM File,Flag
13290 COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
13300 COM SHORT F(4),L(*),M(32,33),N(26,11)
13310 COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
13320 COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
13330 COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
13340 COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
13350 COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
13360 COM Real,Imag
13370 PRINTER IS 16
13380 PRINT "CALIBRATION FREQ";F
13390 F1=(F-30)/30
13400 K9=0
13410 K7=Q
13420 PRINT "Q";Q
13430 Q=Q+1
13440 PRINT "Q+1";Q
13450 ON F1+1 GOTO 13460,13470
13460 GOTO 13600
13470 ON Q GOTO 13480,13500,13520,13540
13480 Pout$="8"
13490 GOTO 13550
13500 Pout$="9"
13510 GOTO 13550
13520 Pout$=":"
13530 GOTO 13550
13540 Pout$=";"
13550 Strobe$="1"
13560 Svolts$="7"
13570 Sclear$=">"
13580 Zout$="0"
13590 GOTO 13690
13600 ON Q GOTO 13610,13630,13650,13670
13610 Pout$="0"
13620 GOTO 13690
13630 Pout$="1"
13640 GOTO 13690
13650 Pout$="2"
13660 GOTO 13690
13670 Pout$="3"
13680 PRINTER IS 16
13690   PRINT "PAUSE 11365";Pout$,Svolts$,Sclear$
13700 OUTPUT 702;Zout$,Zout$,Svolts$,Pout$
13710 ! !!!!!!!!!!!!!!!!!!!!!PAUSE
13720 WAIT 250
13730 ! OUTPUT 702;Zout$,Zout$,Sclear$,Pout$
13740 ! PRINT "PAUSE 11386";Sclear$
13750 WAIT 250
13760 Q=Q-1
13770 PRINTER IS 0
13780 RETURN 0
13790 FNEND
13800 END
13810 ! ALL SUBS RUN    CHECK OK          FINAL VS: 1-14-81
13820 ! Q=FNVswr(0)
13830 ! PRINT "T1,T2,T3";T1;T2;T3;"FREQUENCY=30MHZ"
13840 ! ALL SUBS RUN    CHECK OK          FINAL VS: 1-14-81
13850 ! 30 MHZ CONSTANTS
13860 ! OPTION BASE 1
13870 ! COM File,Flag
13880 ! COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
13890 ! COM SHORT F(4),L(8,20),M(32,33),N(26,11)
```

```
13900 ! COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
13910 ! COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
13920 ! COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
13930 ! COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
13940 ! COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I
13950 ! COM Real,Imag
13960 ! Real=R=52
13970 ! Imag=1
13980 ! T1=11000
13990 ! T2=296.00
14000 ! T3=76.00
14010 ! PRINT "T1,T2,T3";T1;T2;T3;"FREQUENCY=30MHZ"
```

<u>FNX(</u>

```
F                  *  13380  13390

F1                13390  13450

K7                13410

K9                13400

Pout$              *  13480  13500  13520  13540  13610  13630  13650  13670  13
690  13700

Q                 13260  13410  13420  13430  13430  13440  13470  13600  13760
13760

Sclear$           13570  13690

Strobe$           13550

Svolts$           13560  13690  13700

Zout$             13580  13700  13700
```

```
14020 DEF FNVswr(Q)  ! 30 MHZ VS 3-2-81 GJC
14030  OPTION BASE 1
14040 COM File,Flag
14050 COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
14060 COM SHORT F(4),L(8,20),M(32,33),N(26,11)
14070 COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
14080 COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
14090 COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
14100 COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
14110 COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
14120 COM Real,Imag
14130 DIM Di(60),I(60),Mi(60),Ni(60),Ei(60),Ci(60),Zi(60),Gi$[100]
14140 ! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!FNG
14150 PRINT T1,T2,T3;"FREQ=30MHZ"
14160 X=Real
14170 Y=Imag
14180 Qzero=(X+50)^2+Y^2
14190 Qone=Qzero*Qzero
14200 G1=(X^2-2500+Y^2)/Qzero
14210 G2=100*Y/Qzero
14220 Qthr=100*ABS((X+50)^2-Y^2)*.5
14230 G3=(Qthr+ABS(200*Y*(X+50)*1))/Qone
14240 Qfour=200*ABS(Y*(X+50))*.5
14250 Qeight=(X+50)^2
14260 Qseven=Y^2
14270 Qfive=100*ABS(Qeight-Qseven)*1
14280 G4=(Qfour+Qfive)/Qone
14290 ! GOTO 7309
14300 PRINT "Y";Y,"R";X
14310 PRINT
14320 PRINT
14330 PRINT "   G'";"                          G''";"                          DG'";"
    DG''"
14340 PRINT G1,G2,G3,G4
14350 PRINT
14360 PRINT
14370 G5=((X-50)^2+Y^2)/Qzero
14380 Qfive=200*(X^2-2500-Y^2)*.5
14390 Qfive=ABS(Qfive)
14400 G6=(Qfive+400*ABS(X*Y)*1)/Qone
14410 PRINT " GAMMA SQ"," D GAMMA SQ"
14420 PRINT G5,G6
14430 PRINT
14440 Zone=X/50
14450 Ztwo=Y/50
14460 Zzero=SQR((X^2+Y^2)/2500)
14470 G7=(Zzero^2-1)/(Zzero^2+1+2*Zone)
14480 G8=2*Ztwo/(Zzero^2+1+2*Z1)
14490 G9=SQR(G7*G7+G8*G8)
14500 Znine=(G8/G9)^2
14510 A1=ATN(G8/G9/SQR(1-Znine+.00000001))
14520 PRINT "GAMMA R";"                    GAMMA I";"                    GAMMA MAG";"
    ANGLE"
14530 PRINT G7,G8,G9,A1
14540 DISP T1,T2,T3
14550 Tfive=T1*T3
14560 Tsix=T1*T2
14570 Tseven=T3*T2
14580 Teight=T3-T2
14590 Tzero=T2-T3
14600 Tnine=T1-T2
14610 Cone=88.1
14620 ! CHECK CONSTANTS USED IN THIS  ROUTINE
14630 Ctwo=80.2
```

```
14640 Cthree=9.8
14650 Cfour=5.8
14660 H=-.005
14670 H1=0
14680 H2=.005
14690 Ri=.162
14700 Rone=.186
14710 Pone=G1
14720 Ptwo=G2
14730 Pthree=G3
14740 Pfour=G4
14750 Y=1
14760 F9=0
14770 GOTO 16210
14780 ! !!!!!!!!!!!!!!!!!!!!!!!FND
14790 Index=2
14800  T=1
14810 FOR L=0 TO 3
14820 GOTO 14860
14830 I2=I1=I7=I8=Ptwo
14840 D3=D4=D5=D6=Pone
14850 GOTO 14900
14860 I1=I2=Ptwo+Pfour
14870 I7=I8=Ptwo-Pfour
14880 D3=D4=Pone+Pthree
14890 D5=D6=Pone-Pthree
14900 D1=D7=Pone+L*Pthree/3
14910 D2=D8=Pone-L*Pthree/3
14920 I3=I5=Ptwo+L*Pfour/3
14930 I4=I6=Ptwo-L*Pfour/3
14940                           !   PRINT L,I5;I6;I7
14950 Di(L+1)=D1
14960 IF L=0 THEN 14980
14970 Di(L+4)=D2
14980 Di(L+8)=D3
14990 IF L=0 THEN 15010
15000 Di(L+11)=D4
15010 Di(L+15)=D5
15020 IF L=0 THEN 15040
15030 Di(L+18)=D6
15040 Di(L+22)=D7
15050 IF L=0 THEN 15070
15060 Di(L+25)=D8
15070 I(L+1)=I1
15080 IF L=0 THEN 15100
15090 I(L+4)=I2
15100 I(L+8)=I3
15110 IF L=0 THEN 15130
15120 I(L+11)=I4
15130 I(L+15)=I5
15140 IF L=0 THEN 15160
15150 I(L+18)=I6
15160 I(L+22)=I7
15170 IF L=0 THEN 15190
15180 I(L+25)=I8
15190 NEXT L
15200 IF Y=51 THEN 16570          !!!!!!!!!!!!!!RETURN FNC1
15210 IF Y=52 THEN 16820         !!!!!!!!!!!!!!RETURN TO FNC2
15220 IF Y=3 THEN 16050          !!!!!!!!!!!!!!RETURN TO FNH Y=3
15230 IF Y=8 THEN 17050
15240 ! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!FNM
15250 FOR Q=1 TO 28
15260 Wzero=SQR(Di(Q)*Di(Q)+I(Q)*I(Q))
15270 Wzero=1-Wzero*Wzero
15280 Wone=1-H2*H2
```

```
15290 Wtwo=(1-H*Di(Q)+H1*I(Q))^2
15300 Wthree=(H*I(Q)+H1*Di(Q))^2
15310 Wfour=Wzero*Wone/(Wtwo+Wthree)
15320 Mi(Q)=Wfour
15330 NEXT Q
15340 PRINT
15350 ! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!FNN
15360 FOR Q=1 TO 28
15370 V1=(Ri+Di(Q))^2+(Rone+I(Q))^2
15380 V2=(1-H*Di(Q)+H1*I(Q))^2+(H*I(Q)+H1*Di(Q))^2
15390 Ni(Q)=Cone+Ctwo*(V1/V2)
15400 NEXT Q
15410 GOTO 16280
15420 ! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!FNO
15430 IF F9=0 THEN 15460
15440 M1=M2=M3=Mi(1)
15450 Ni1=Ni2=Ni3
15460 K=1
15470 FOR Q=1 TO 28
15480 IF F9=1 THEN 15570
15490 IF K=1 THEN 15520
15500 IF K=2 THEN 15600
15510 IF K=3 THEN 15650
15520 Ni1=Ni(Q)
15530 Ni2=Ni3=Ni(1)
15540 M1=Mi(Q)
15550 M2=M3=Mi(1)
15560 GOTO 15690
15570 M1=M2=M3=Mi(1)
15580 Ni1=Ni2=Ni3=Ni(Q)
15590 GOTO 15690
15600 Ni2=Ni(Q)
15610 Ni1=Ni3=Ni(1)
15620 M2=Mi(Q)
15630 M1=M3=Mi(1)
15640 GOTO 15690
15650 M3=Mi(Q)
15660 M1=M2=Mi(1)
15670 Ni3=Ni(Q)
15680 Ni1=Ni2=Ni(1)
15690 E0=Tfive*(M3-M1)+Tsix*(M1-M2)+Tseven*(M2-M3)
15700 Z9=Tnine*(Ni3-Ni2)+Tzero*(Ni1-Ni2)
15710 Ei(Q)=(E0+Z9)/Teight
15720 NEXT Q
15730 E9=0
15740 E=Ei(1)
15750 FOR Q=1 TO 28
15760 E1=Ei(Q)
15770 IF ABS(E-E1)<E9 THEN 15790
15780 E9=ABS(E-E1)
15790 NEXT Q
15800 IF K=1 THEN 15830
15810 IF K=2 THEN 15870
15820 IF K=3 THEN 15910
15830 S1=E9
15840 E1=Ei(1)
15850 K=K+1
15860 GOTO 15470
15870 S2=E9
15880 E1=E(1)
15890 K=K+1
15900 GOTO 15470
15910 S3=E9
15920 E1=E(1)
15930 K=K+1
```

```
15940 IF Y=5 THEN 16440
15950 IF Y=51 THEN 16710
15960 IF Y=52 THEN 16960
15970 IF Y=8 THEN 17110
15980 GOTO 16300
15990 ! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!FNH
16000 Pone=H
16010 Ptwo=H1
16020 Pthree=.005
16030 Pfour=.01
16040 IF Y=3 THEN GOTO 14780     !!!!!!!!!!!!!!Q=FND(Q)
16050 FOR Q=1 TO 28
16060 Wzero=SQR(G1*G1+G2*G2)
16070 Wzero=1-Wzero*Wzero
16080 Temp=SQR(Di(Q)*Di(Q)+I(Q)*I(Q))
16090 Wone=1-Temp*Temp
16100 Wtwo=(1-Di(Q)*G1+I(Q)*G2)^2
16110 Wthree=(Di(Q)*G2+I(Q)*G1)^2
16120 Wfour=Wzero*Wone/(Wtwo+Wthree)
16130 Mi(Q)=Wfour
16140 V1=(Ri+G1)^2+(Rone+G2)^2
16150 V2=(1-H*G1+H1*G2)^2+(H*G2+H1*G1)^2
16160 Ni(Q)=Cone+Ctwo*(V1/V2)
16170 NEXT Q
16180 IF Y=3 THEN 16410                        !!RETURN FROM FNH Y=3
16190 Y=0
16200 GOTO 14160
16210 ! !!RETURN #1 FROM FNC
16220 Pone=G1
16230 Ptwo=G2
16240 Pthree=G3
16250 Pfour=G4
16260 Y=1
16270 GOTO 14780                    !Q=FND(1)+FNM(1)+FNN(1)
16280 Y=2
16290 GOTO 15420                    ! Q=FNO(Q)
16300 Y=3                           !RETURN FROM FNO
16310 Qone=S1
16320 Qtwo=S2
16330 Qthree=S3
16340 ! SET FOR FNH HERE
16350 Pone=H
16360 Ptwo=H1
16370 Pthree=.005
16380 Pfour=.01
16390 GOTO 15990                    !Q=FNH(1)
16400 ! Y=4                           !RETURN FROM FNH
16410 Y=4                           !RETURN FROM FNH
16420  Y=5
16430  GOTO 15420                    !Q=FNO(1)
16440 Qfour=S1
16450 Qfive=S2
16460 Qsix=S3
16470 Index=4
16480 F9=1
16490 IF Index>4 THEN 16750         !ON INDEX GO TO FNC(INDEX)
16500 ! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!Q=FNC1
16510 Pone=Ctwo
16520 Ptwo=0
16530 Pthree=7.28
16540 Pfour=0
16550 Y=51
16560 GOTO 14780                 !FND(1)
16570 FOR Q=1 TO 28
16580 Wzero=SQR(G1*G1+G2*G2)
```

```
16590 Wzero=1-Wzero^2
16600 Wone=1-H2*H2
16610 Wtwo=(1-H*G1+H*G2)^2
16620 Wthree=(H*G2+H1*G1)^2
16630 Wfour=Wzero*Wone/(Wtwo+Wthree)
16640 Mi(Q)=Wfour
16650 V1=(Ri+G1)^2+(Rone+G2)^2
16660 V2=(1-H*G1+H*G2)^2+(H*G2+H1*G1)^2
16670 V3=V1/V2
16680 Ni(Q)=Cone+Di(Q)*V3
16690 NEXT Q
16700 GOTO 15420                    ! Q=   FNO(Q)
16710 Y=6                           ! RETURN FNO
16720 Qseven=S1
16730 Qeight=S2
16740 Qnine=S3
16750 ! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!! FNC2
16760 Y=52
16770 Pone=.3282
16780 Ptwo=.0262
16790 Pthree=.031
16800 Pfour=.065
16810 GOTO 14780                    ! Q=FND1
16820 FOR Q=1 TO 28                 ! RETURN FND
16830 V1=(Di(Q)+G1)^2+(I(Q)+G2)^2
16840 V2=(1-H*G1+H1*G2)^2+(H*G2+H1*G1)^2
16850 Ni(Q)=Cone+Ctwo*(V1/V2)
16860 Wzero=1-Wzero^2
16870 Wone=1-H2*H2
16880 Wtwo=(1-H*G1+H1*G2)^2
16890 Wthree=(H*G2+H1*G1)^2
16900 Wfour=Wzero*Wone/(Wtwo+Wthree)
16910 Mi(Q)=Wfour
16920 NEXT Q
16930 F9=1
16940 Y=52
16950 GOTO 15420                            ! Q=FNO
16960 U1=S1                                  ! RETURN FNO
16970 U2=S2
16980 U3=S3
16990 Y=8
17000 Pone=H
17010 Ptwo=H1
17020 Pthree=.005
17030 Pfour=.01
17040 GOTO 14780                            !Q=FND
17050 V1=(Ri+G1)^2+(Rone+G2)^2               !RETURN FND
17060 FOR Q=1 TO 28
17070 V2=(1-Di(Q)*G1+I(Q)*G2)^2+Di(Q)*G2+(I(Q)*G1)^2
17080 Ni(Q)=Cone+Ctwo*(V1/V2)
17090 F9=1
17100 GOTO 15420                               !Q=FNO
17110 U4=S1                                    ! RETURN FN0
17120 U5=S2
17130 U6=S3
17140 PRINTER IS 0
17150 PRINT "DGX,DGA,DGS:",Qone,Qtwo,Qthree
17160 PRINT "DGHX,DGHA,DGHS:",Qfour,Qfive,Qsix
17170 PRINT "DT2NI,DT2N2,DT2N3:",Qseven,Qeight,Qnine
17180 PRINT "DSN1,DSN2,DSN3:",U1,U2,U3
17190 PRINT "DS11N1,DS11N2,DS11N3:",U4,U5,U6
17200 PRINT
17210 PRINT PAGE
17220 Mismatch=SQR(Qone^2+Qtwo^2+Qthree^2+Qfour^2+Qfive^2+Qsix^2+Qseven+U1+U4)
17221 FIXED 2
```

```
17230 PRINT "SUMMATION OF MISMATCH ERRORS=(RSS)";Mismatch
17240 RETURN Q
17250 FNEND
```

FNVswr(

```
A1                 14510  14530

Cfour              14650

Ci(                14130

Cone               14610  15390  16160  16680  16850  17080

Cthree             14640

Ctwo               14630  15390  16160  16510  16850  17080

D1                 14900  14950

D2                 14910  14970

D3                 14840  14880  14980

D4                 14840  14880  15000

D5                 14840  14890  15010

D6                 14840  14890  15030

D7                 14900  15040

D8                 14910  15060

Di(                14130  14950  14970  14980  15000  15010  15030  15040  15060
15260  15260  15290  15300
                       15370  15380  15380  16080  16080  16100  16110  16680  16
830  17070  17070

E                  15740  15770  15780

E(                 15880  15920

E0                 15690  15710

E1                 15760  15770  15780  15840  15880  15920

E9                 15730  15770  15780  15830  15870  15910

Ei(                14130  15710  15740  15760  15840

F9                 14760  15430  15480  16480  16930  17090

G1                 14200  14340  14710  16060  16060  16100  16110  16140  16150
16150  16220  16580  16580
                       16610  16620  16650  16660  16660  16830  16840  16840  16
880  16890  17050  17070
                       17070

G2                 14210  14340  14720  16060  16060  16100  16110  16140  16150
16150  16230  16580  16580
                       16610  16620  16650  16660  16660  16830  16840  16840  16
880  16890  17050  17070
                       17070
```

G3 14230 14340 14730 16240

G4 14280 14340 14740 16250

G5 14370 14420

G6 14400 14420

G7 14470 14490 14490 14530

G8 14480 14490 14490 14500 14510 14530

G9 14490 14500 14510 14530

Gi$ 14130

H 14660 15290 15300 15380 15380 16000 16150 16150 16350
16610 16610 16620 16660
16660 16660 16840 16840 16880 16890 17000

H1 14670 15290 15300 15380 15380 16010 16150 16150 16360
16620 16660 16840 16840
16880 16890 17010

H2 14680 15280 15280 16600 16600 16870 16870

I(14130 15070 15090 15100 15120 15130 15150 15160 15180
15260 15260 15290 15300
15370 15380 15380 16080 16080 16100 16110 16830 17
070 17070

I1 14830 14860 15070

I2 * 14830 14860 15090

I3 14920 15100

I4 14930 15120

I5 * 14920 15130

I6 * 14930 15150

I7 14830 14870 15160

I8 14830 14870 15180

Imag * 14170

Index 14790 16470 16490

K 15460 15490 15500 15510 15800 15810 15820 15850 15850
15890 15890 15930 15930

L * 14810 14900 14910 14920 14930 14950 14960 14970 14
980 14990 15000 15010
15020 15030 15040 15050 15060 15070 15080 15090 15
100 15110 15120 15130
15140 15150 15160 15170 15180 15190

M1 15440 15540 15570 15630 15660 15690 15690

M2 15440 15550 15570 15620 15660 15690 15690

M3 15440 15550 15570 15630 15650 15690 15690

Mi(14130 15320 15440 15540 15550 15570 15620 15630 15650
15660 16130 16640 16910

Mismatch * 17220 17230

Ni(14130 15390 15520 15530 15580 15600 15610 15670 15680
16160 16600 16050 17000

Ni1 15450 15520 15580 15610 15680 15700

Ni2 15450 15530 15580 15600 15680 15700 15700

Ni3 15450 15530 15580 15610 15670 15700

Pfour 14740 14860 14870 14920 14930 16030 16250 16380 16540
16800 17030

Pone 14710 14840 14880 14890 14900 14910 16000 16220 16350
16510 16770 17000

Pthree 14730 14880 14890 14900 14910 16020 16240 16370 16530
16790 17020

Ptwo 14720 14830 14860 14870 14920 14930 16010 16230 16360
16520 16780 17010

Q 14020 15250 15260 15260 15260 15260 15290 15290 15300
15300 15320 15330 15360
15370 15370 15380 15380 15380 15380 15390 15400 15
470 15520 15540 15580
15600 15620 15650 15670 15710 15720 15750 15760 15
790 16050 16080 16080
16080 16080 16100 16100 16110 16110 16130 16160 16
170 16570 16640 16680
16680 16690 16820 16830 16830 16850 16910 16920 17
060 17070 17070 17070
17070 17080 17240

Qeight 14250 14270 16730 17170

Qfive 14270 14280 14380 14390 14390 14400 16450 17160 17220

Qfour 14240 14280 16440 17160 17220

Qnine 16740 17170

Qone 14190 14230 14280 14400 16310 17150 17220

Qseven 14260 14270 16720 17170 17220

Qsix 16460 17160 17220

Qthr 14220 14230

Qthree 16330 17150 17220

Qtwo 16320 17150 17220

Qzero 14180 14190 14190 14200 14210 14370

Real * 14160

Ri 14690 15370 16140 16650 17050

Rone 14700 15370 16140 16650 17050

S1 * 15830 16310 16440 16720 16960 17110

S2 15870 16320 16450 16730 16970 17120

S3 15910 16330 16460 16740 16980 17130

T 14800

T1 * 14150 14540 14550 14560 14600

T2 * 14150 14540 14560 14570 14580 14590 14600

T3 * 14150 14540 14550 14570 14580 14590

Teight 14580 15710

Temp 16080 16090 16090

Tfive 14550 15690

Tnine 14600 15700

Tseven 14570 15690

Tsix 14560 15690

Tzero 14590 15700

U1 16960 17180 17220

U2 16970 17180

U3 16980 17180

U4 17110 17190 17220

U5 17120 17190

U6 17130 17190

V1 15370 15390 16140 16160 16650 16670 16830 16850 17050
17080

V2 * 15380 15390 16150 16160 16660 16670 16840 16850 17
070 17080

V3 16670 16680

Wfour 15310 15320 16120 16130 16630 16640 16900 16910

Wone 15280 15310 16090 16120 16600 16630 16870 16900

Wthree 15300 15310 16110 16120 16620 16630 16890 16900

Wtwo 15290 15310 16100 16120 16610 16630 16880 16900

Wzero 15260 15270 15270 15270 15310 16060 16070 16070 16070
16120 16580 16590 16590
16630 16860 16860 16900

14460 14750 15200 15210 15220 15230 15940 15950 15
960 15970 16040 16180
16190 16260 16280 16300 16410 16420 16550 16710 16
760 16940 16990

Z1 * 14480

Z9 15700 15710

Zi(14130

Znine 14500 14510

Zone 14440 14470

Ztwo 14450 14480

Zzero 14460 14470 14470 14480

```
17260 DEF FNData(Q)
17270  OPTION BASE 1
17280 COM File,Flag
17290 COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
17300 COM SHORT F(4),L(8,20),M(32,33),N(26,11)
17310 COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
17320 COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
17330 COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
17340 COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
17350 COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,Mismatch
17360 COM Real,Imag
17370 MASS STORAGE IS ":T14"
17380 INPUT "TAPE #,FILE NAME ",T,Q$
17390 ASSIGN #1 TO Q$
17400 READ #1;H$[1,100],Z(*),C$[1,100],G$[1,100]!,R$[1,100]
17410 ASSIGN #1 TO *
17420 REM PRELIMINARY RESULTS
17430 A$="-----------------------------------------------------------------"
17440 PRINTER IS 0
17442 ! PRINT PAGE
17443   FIXED 2
17444 PRINT "TOTAL MISMATCH ERROR IS:";Z(1,26);"DEGREES KELVIN"
17446 PRINT
17460 OUTPUT 9;"R"
17470 ENTER 9;P$
17480 PRINT TAB(20),"DATE:";P$[1,2];"-";P$[4,5];"-1981";"      TIME:";P$[7,14]
17490 PRINT
17500 PRINT TAB(6),A$
17510 PRINT TAB(6),"TAPE #:";T,"FILE:";Q$;TAB(50);R$[1,19]
17520 FOR I=1 TO 11
17530 PRINT
17540 NEXT I
17550 PRINT TAB(23),"MEASUREMENT RECAP"
17560 PRINT TAB(30),"AND"
17570 PRINT TAB(22),"PRELIMINARY RESULTS"
17580 FOR I=1 TO 7
17590 PRINT
17600 NEXT I
17610 Z(1,34)=30
17620 PRINT TAB(6),"FREQUENCY=";TAB(16);Z(1,34);"MHZ"
17630 PRINT TAB(6),"SOURCE IMPEDANCE";TAB(23),H$[11,20];TAB(38),"LEVEL SETTING O
F A2=";Z(1,51)
17640 PRINT TAB(6),A$
17650 PRINT
17660 PRINT
17670 PRINT TAB(10),"TA";TAB(20),"R OHMS";TAB(34),"TS";TAB(44),"R OHMS"
17680 PRINT TAB(6)," --------    --------    --------    -------- "
17690 FIXED 2
17700 PRINT TAB(8),Z(1,1);TAB(20),Z(1,59);TAB(32),Z(1,2);TAB(44),Z(1,60);"   (1S
T 50 MEASUREMENTS)"
17710 PRINT TAB(8),Z(1,7);TAB(20),Z(1,59);TAB(32),Z(1,8);TAB(44),Z(1,60);"   (2N
D 50 MEASUREMENTS)"
17720 PRINT TAB(6),A$
17730 PRINT TAB(11),"TX";TAB(21),"SX";TAB(34),"TE"
17740 PRINT TAB(6),"   --------   --------    --------"
17750 PRINT TAB(8),Z(1,3);TAB(20),Z(1,4);TAB(32),Z(1,5);"    (1ST 50 MEASUREMENT
S)"
17760 PRINT TAB(8),Z(1,9);TAB(20),Z(1,10);TAB(32),Z(1,11);"    (2ND 50 MEASUREME
NTS)"
17770 PRINT
17780 PRINT TAB(6),A$
      PRINT
```

```
17820 N=N9
17821 FIXED 2
17830 PRINT TAB(6),"AVE POWER IN MILLIWATTS P1,P2,P3"
17840 PRINT TAB(6),Z(1,45)/N*1000,Z(1,46)/N*1000,Z(1,47)/N*1000
17850 S1=SQR((Z(1,48)-Z(1,45)*Z(1,45)/N)/(N-1))
17860 S2=SQR((Z(1,49)-Z(1,46)*Z(1,46)/N)/(N-1))
17870 S3=SQR((Z(1,50)-Z(1,47)*Z(1,47)/N)/(N-1))
17871 FIXED 8
17880 PRINT TAB(6),"SD P1,P2,P3 IN WATTS  (# OF MEAS=";Z(1,31);")";S1;S2;S3
17890 PRINT TAB(6),A$
17910   PRINT PAGE
17920 F=30
17921 FIXED 2
17930 PRINT USING 17940;F
17940 IMAGE 25X,"FREQUENCY =",M3D.,"MHZ"
17950 PRINT
17960 PRINT Z$
17970 PRINT
17980 E4=100*E3/Z(1,35)
17990 E5=E3+Z(1,26)
18000 M1=Z(1,26)
18010 M2=100*(M1/Z(1,35))
18020 M5=E4+M2
18030 Z(1,36)=Z(1,36)+E5
18040 PRINT USING 18050;Z(1,35),Z(1,36),Z(1,13)
18050 IMAGE 10X,"NOISE TEMPERATURE =",M5D.2D,"K  +-",M3D.2D,"K(BIAS) +-",M3D.2D,
"K (3*SEM)"
18060 IF Z(1,52)<220 THEN 18090
18070 PRINT USING 18080;Z(1,14),Z(1,15)
18080 IMAGE 10X,"EXCESS NOISE RATIO=",M3D.2D ,"DB   +-",MD.2D ,"DB(BIAS+3*SEM)"
18090 PRINT USING 18100;Z(1,16),Z(1,17)
18100 IMAGE 10X,"RADIOMETER SYSTEM TEMPERATURE =",4D ,"K (",4D.D,"DB NF)"
18110 PRINT USING 18120;Z(1,18)
18120 IMAGE 10X,"RADIOMETER GAIN =",M2D.1D ,"DB"
18121 FIXED 2
18130 PRINT "            RADIOMETER NOISE BANDWIDTH=";Z(1,56);"MHZ"
18140 PRINT
18150 PRINT
18160 PRINT
18170 PRINT TAB(28),"ERROR SUMMARY"
18180 PRINT
18190 PRINT TAB(5),"SOURCE OF ERROR";TAB(35)," SOURCE";TAB(58),"% ERROR IN"
18200 PRINT TAB(34),"UNCERTAINTY";TAB(55),"NOISE TEMPERATURE"
18210 PRINT
18220 PRINT USING 18230;Z(1,19),Z(1,20)
18230 IMAGE 6X,"CRYOGENIC STANDARD",10X,MZ.2D,"K",16X,M4D.2D
18240 PRINT USING 18250;Z(1,21),Z(1,22)
18250 IMAGE 6X,"AMBIENT STANDARD",12X,MZ.2D,"K",16X,M4D.2D
18260 Q=.0023
18270 Q0=1+Z(1,16)/Z(1,52)
18280 Q1=1-Z(1,53)/Z(1,52)
18290 Q2=(Z(1,54)+Z(1,16))/(Z(1,54)-Z(1,53))
18300 Q3=Z(1,52)*(Q0-Q1*Q2)
18310 Z(1,24)=Q3/Z(1,35)*100*Q
18320 PRINT USING 18330;Z(1,23),Z(1,24)
18330 IMAGE 6X,"POWER RATIO",17X,MZ.2D ,"DB",15X,M4D.2D
18340 PRINT USING 18350;100*(Z(1,26)/Z(1,35))
18350 IMAGE 6X,"MISMATCH",21X,"0.5R;1.0J OHMS",7X,M4D.2D
18360 PRINT USING 18370;Z(1,27),Z(1,28)
18370 IMAGE 6X,"NONLINEARITY",16X,M1D.2DE,12X,M5D.2D
18380 PRINT USING 18390;Z(1,55),Z(1,29)
18390 IMAGE 6X,"SWITCH ASSYMETRY",12X,MZ.3D,"DB",12X,M6D.2D
18400 Adapter=100*E3/Z(1,35)
18410 PRINT USING 18420;H$[1,10],100*E3/Z(1,35)
18420 IMAGE 6X,"ADAPTER:",10A,11X,"0.0001DB",11X,M6D.2D
```

```
18430 PRINT TAB(6),A$
18440 Su=100*Z(1,26)/Z(1,35)
18450 Suu=100*E3/Z(1,35)
18460 Summ=Z(1,20)+Z(1,22)+Z(1,24)+Su+Z(1,28)+Z(1,29)+Suu
18470 Z(1;30)=Summ
18480 PRINT USING 18490;Z(1,30)
18490 IMAGE 6X,"LINEAR SUM OF BIAS ERRORS",24X,M5D.2D
18500 PRINT USING 18510;Z(1,31),Z(1,32)
18510 IMAGE 6X,"3*STANDARD ERROR OF MEAN  ( # MEAS="M3D.,")", 9X,M4D.2D
18520 Z(1,33)=Z(1,30)+Z(1,32)
18530 PRINT TAB(6),A$
18540 PRINT USING 18550;Z(1,33)
18550 IMAGE 6X,"LINEAR SUM OF ERRORS",31X,M3D.2D
18560 PRINT
18570 PRINT TAB(6),A$
18580 PRINT
18590 PRINT
18600 PRINT TAB(6),"CUSTOMER:";TAB(30),C$[1,29]
18610 PRINT TAB(6),"CUSTOMER'S STATION:";TAB(30),C$[30,69]
18620 PRINT TAB(6),"CUSTOMER'S ADDRESS:";TAB(30),C$[70,99]
18630 PRINT
18640 PRINT TAB(6),"SOURCE MANUFACTURER:";TAB(30),G$[1,39]
18650 PRINT TAB(6),"SOURCE TYPE:";TAB(30),G$[40,79]
18660 PRINT TAB(6),"SOURCE MODEL:";TAB(30),G$[80,89]
18670 PRINT TAB(6),"SOURCE SERIAL:";TAB(30),G$[90,99]
18680 PRINT
18690 PRINT TAB(6),"DATE OF CALIBRATION:";TAB(30),R$[1,19]
18700 PRINT TAB(6),"CALIBRATION TEST #:";TAB(30),R$[20,39]
18710 PRINT TAB(6),"REQ OR REF #:";TAB(30),R$[40,69]
18720 PRINT
18730 Z6=1
18740 MASS STORAGE IS ":F8"
18750 PRINT PAGE
18760 RETURN 0
18770 FNEND
```

<u>FNData(</u>

```
A$                * 17430  17500  17640  17720  17780  17890  18430  18530  18
570

Adapter          18400

C$                * 17400  18600  18610  18620

E3               17980  17990  18400  18410  18450

E4               17980  180

E5               17990  18030

F                 * 17920  17930

G$                * 17400  18640  18650  18660  18670

H$                * 17400  17630  18410

I                 * 17520  17540  17580  17600

M1               18000  18010
```

```
N                    *  17820  17840  17840  17840  17850  17850  17860  17860  17
870  17870

N9                   17810  17820

P$                   *  17470  17480  17480  17480

Q                    17260  18260  18310

Q$                   *  17380  17390  17510

Q0                   18270  18300

Q1                   *  18280  18300

Q2                   *  18290  18300

Q3                   *  18300  18310

R$                   *  17510  18690  18700  18710

S1                   *  17850  17880

S2                   17860  17880

S3                   17870  17880

Su                   18440  18460

Summ                 18460  18470

Suu                  18450  18460

T                    17380  17510

Z$                   17960

Z(                   *  17400  17444  17610  17620  17630  17700  17700  17700  17
700  17710  17710  17710
                        17710  17750  17750  17750  17760  17760  17760  17810  17
840  17840  17840  17850
                        17850  17850  17860  17860  17860  17870  17870  17870  17
880  17980  17990  18000
                        18010  18030  18030  18040  18040  18040  18060  18070  18
070  18090  18090  18110
                        18130  18220  18220  18240  18240  18270  18270  18280  18
280  18290  18290  18290
                        18290  18300  18310  18310  18320  18320  18340  18340  18
360  18360  18380  18380
                        18400  18410  18440  18440  18450  18460  18460  18460  18
460  18460  18470  18480
                        18500  18500  18520  18520  18520  18540

Z6                   *  18730
```

```
18780 DEF FNCheck(Q)
18790  OPTION BASE 1
18800 COM File,Flag
18810 COM Q6,Q7,Q8,Q9,R2,R3,L,R,A6,A7,A8,A9,Z1,I2,N3,N8,N,F,F0,W
18820 COM SHORT F(4),L(8,20),M(32,33),N(26,11)
18830 COM D$[80],P$[100],INTEGER D(6,75),N0,X$[80]
18840 COM C$[100],G$[100],R$[100],B$[10],H$[100],Q$[50],V$[100]
18850 COM A$[100],Z2,Z3,Z4,Z5,T1,S1,T4,T2,T3,Z6,F7,T7,T8,T9,P9,X6,X7,X8,X9
18860 COM Q1,Q2,Q3,Q5,E2,Z(1,100),B5,B6,B7,B8,C1,R5,P1,P2,P3,P4,V2,Pout$
18870 COM P5,P6,P7,P8,W1,W2,W3,W4,W5,W6,T5,T6,E7,J8,I6,S,I5,X3,P0,I,C2,Mismatch
18880 COM Real,Imag
18890 DIM L$[200]
18900 PRINTER IS 16
18910 L$="TO CHECK LINEARITY ADD 3 DB IN MANUAL WEINSCHEL ATTEN AND PRESS RUN "
18920 PRINT L$
18930 RETURN 0
18940 FNEND
```

FNCheck(

L$	18890	18910	18920
Q	18780		

GLOBAL NAMES

```
* A$                 100    980    1470   1740   2910   5810   7050   8000   8170
 8470   8630   8870   9730
                      10430  11250  12200  13330  14090  17330  18850

* A6                  60    940    1430   1700   2870   5770   7010   7960   8130
 8430   8590   8830   9690
                      10390  11210  12160  13290  14050  17290  18810

* A7                  60    940    1430   1700   2870   5770   7010   7960   8130
 8430   8590   8830   9690
                      10390  11210  12160  13290  14050  17290  18810

* A8                  60    940    1430   1700   2870   5770   7010   7960   8130
 8430   8590   8830   9690
                      10390  11210  12160  13290  14050  17290  18810

* A9                  60    940    1430   1700   2870   5770   7010   7960   8130
 8430   8590   8830   9690
                      10390  11210  12160  13290  14050  17290  18810

* B$                  90    970    1460   1730   2900   5800   7040   7990   8160
 8460   8620   8860   9720
                      10420  11240  12190  13320  14080  17320  18840

* B5                 110    990    1480   1750   2920   5820   7060   8010   8180
 8480   8640   8880   9740
                      10440  11260  12210  13340  14100  17340  18860

* B6                 110    990    1480   1750   2920   5820   7060   8010   8180
 8480   8640   8880   9740
                      10440  11260  12210  13340  14100  17340  18860

* B7                 110    990    1480   1750   2920   5820   7060   8010   8180
 8480   8640   8880   9740
                      10440  11260  12210  13340  14100  17340  18860

* B8                 110    990    1480   1750   2920   5820   7060   8010   8180
 8480   8640   8880   9740
                      10440  11260  12210  13340  14100  17340  18860

* C$                  90    970    1460   1730   2900   5800   7040   7990   8160
 8460   8620   8860   9720
                      10420  11240  12190  13320  14080  17320  18840

* C1                 110    990    1480   1750   2920   5820   7060   8010   8180
 8480   8640   8880   9740
                      10440  11260  12210  13340  14100  17340  18860

* C2                 120   1000    1490   1760   2930   5830   7070   8020   8190
 8490   8650   8890   9750
                      10450  11270  12220  13350  14110  18870

* D$                  80    960    1450   1720   2890   5790   7030   7980   8150
 8450   8610   8850   9710
                      10410  11230  12180  13310  14070  17310  18830

* D(                  80    960    1450   1720   2890   5790   7030   7980   8150
 8450   8610   8850   9710
                      10410  11230  12180  13310  14070  17310  18830
```

```
* E2                 110    990   1480   1750   2920   5820   7060   8010   8180
 8480   8640   8880   9740
                    10440  11260  12210  13340  14100  17340  18860

* E7                 120   1000   1490   1760   2930   5830   7070   8020   8190
 8490   8650   8890   9750
                    10450  11270  12220  13350  14110  17350  18870

* F                   60    940   1430   1700   2870   5770   7010   7960   8130
 8430   8590   8830   9690
                    10390  11210  12160  13290  14050  17290  18810

* F(                  70    950   1440   1710   2880   5780   7020   7970   8140
 8440   8600   8840   9700
                    10400  11220  12170  13300  14060  17300  18820

* F0                  60    940   1430   1700   2870   5770   7010   7960   8130
 8430   8590   8830   9690
                    10390  11210  12160  13290  14050  17290  18810

* F7                 100    980   1470   1740   2910   5810   7050   8000   8170
 8470   8630   8870   9730
                    10430  11250  12200  13330  14090  17330  18850

* File                50    930   1420   1690   2860   5760   7000   7950   8120
 8420   8580   8820   9680
                    10380  11200  12150  13280  14040  17280  18800

* Flag                50    930   1420   1690   2860   5760   7000   7950   8120
 8420   8580   8820   9680
                    10380  11200  12150  13280  14040  17280  18800

* C$                  90    970   1460   1730   2900   5800   7040   7990   8160
 8460   8620   8860   9720
                    10420  11240  12190  13320  14080  17320  18840

* H$                  90    970   1460   1730   2900   5800   7040   7990   8160
 8460   8620   8860   9720
                    10420  11240  12190  13320  14080  17320  18840

* I                  120   1000   1490   1760   2930   5830   7070   8020   8190
 8490   8650   8890   9750
                    10450  11270  12220  13350  14110  17350  18870

* I2                  60    940   1430   1700   2870   5770   7010   7960   8130
 8430   8590   8830   9690
                    10390  11210  12160  13290  14050  17290  18810

* I5                 120   1000   1490   1760   2930   5830   7070   8020   8190
 8490   8650   8890   9750
                    10450  11270  12220  13350  14110  17350  18870

* I6                 120   1000   1490   1760   2930   5830   7070   8020   8190
 8490   8650   8890   9750
                    10450  11270  12220  13350  14110  17350  18870

* Imag               130   1010   1500   1770   2940   5840   7080   8030   8200
 8500   8660   8900   9760
                    10460  11280  12230  13360  14120  17360  18880

* J8                 120   1000   1490   1760   2930   5830   7070   8020   8190
 8490   8650   8890   9750
                    10450  11270  12220  13350  14110  17350  18870

* [illegible]         60    940   1430   1700
```

8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* L(70 950 1440 1710 2880 5780 7020 7970 8140
8440 8600 8840 9700
10400 11220 12170 13300 14060 17300 18820

* M(70 950 1440 1710 2880 5780 7020 7970 8140
8440 8600 8840 9700
10400 11220 12170 13300 14060 17300 18820

* Mismatch 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* N 60 940 1430 1700 2870 5770 7010 7960 8130
8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* N(70 950 1440 1710 2880 5780 7020 7970 8140
8440 8600 8840 9700
10400 11220 12170 13300 14060 17300 18820

* N0 80 960 1450 1720 2890 5790 7030 7980 8150
8450 8610 8850 9710
10410 11230 12180 13310 14070 17310 18830

* N3 60 940 1430 1700 2870 5770 7010 7960 8130
8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* N8 60 940 1430 1700 2870 5770 7010 7960 8130
8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* P$ 80 960 1450 1720 2890 5790 7030 7980 8150
8450 8610 8850 9710
10410 11230 12180 13310 14070 17310 18830

* P0 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* P1 110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* P2 110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* P3 110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* P4 110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* P5 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* P6 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750

10450 11270 12220 13350 14110 17350 18870

* P7 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* P8 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* P9 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* Pout$ 110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* Q$ 90 970 1460 1730 2900 5800 7040 7990 8160
8460 8620 8860 9720
10420 11240 12190 13320 14080 17320 18840

* Q1 110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* Q2 110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* Q3 110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* Q5 110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* Q6 60 940 1430 1700 2870 5770 7010 7960 8130
8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* Q7 60 940 1430 1700 2870 5770 7010 7960 8130
8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* Q8 60 940 1430 1700 2870 5770 7010 7960 8130
8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* Q9 60 940 1430 1700 2870 5770 7010 7960 8130
8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* R 60 940 1430 1700 2870 5770 7010 7960 8130
8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* R$ 90 970 1460 1730 2900 5800 7040 7990 8160
8460 8620 8860 9720
10420 11240 12190 13320 14080 17320 18840

* R2 60 940 1430 1700 2870 5770 7010 7960 8130
8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* R3 60 940 1430 1700 2870 5770 7010 7960 8130
8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* R5 110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* Real 130 1010 1500 1770 2940 5840 7080 8030 8200
8500 8660 8900 9760
10460 11280 12230 13360 14120 17360 18880

* S 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* S1 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* T1 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* T2 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* T3 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* T4 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* T5 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* T6 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* T7 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* T8 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* T9 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* V$ 90 970 1460 1730 2900 5800 7040 7990 8160
8460 8620 8860 9720
10420 11240 12190 13320 14080 17320 18840

* V2 110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* W 60 940 1430 1700 2870 5770 7010 7960 8130

8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* W1 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* W2 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* W3 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* W4 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* W5 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* W6 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* X$ 80 960 1450 1720 2890 5790 7030 7980 8150
8450 8610 8850 9710
10410 11230 12180 13310 14070 17310 18830

* X3 120 1000 1490 1760 2930 5830 7070 8020 8190
8490 8650 8890 9750
10450 11270 12220 13350 14110 17350 18870

* X6 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* X7 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* X8 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

* X9 100 980 1470 2910 5810 7050 8000 8170 8470
8630 8870 9730 10430
11250 12200 13330 14090 17330 18850

* X912 1740

* Z(110 990 1480 1750 2920 5820 7060 8010 8180
8480 8640 8880 9740
10440 11260 12210 13340 14100 17340 18860

* Z1 60 940 1430 1700 2870 5770 7010 7960 8130
8430 8590 8830 9690
10390 11210 12160 13290 14050 17290 18810

* Z2 100 980 1470 1740 2910 5810 7050 8000 8170
8470 8630 8870 9730
10430 11250 12200 13330 14090 17330 18850

```
* Z3                100    980   1470   1740   2910   5810   7050   8000   8170
 8470   8630   8870   9730
                      10430  11250  12200  13330  14090  17330  18850

* Z4                100    980   1470   1740   2910   5810   7050   8000   8170
 8470   8630   8870   9730
                      10430  11250  12200  13330  14090  17330  18850

* Z5                100    980   1470   1740   2910   5810   7050   8000   8170
 8470   8630   8870   9730
                      10430  11250  12200  13330  14090  17330  18850

* Z6                100    980   1470   1740   2910   5810   7050   8000   8170
 8470   8630   8870   9730
                      10430  11250  12200  13330  14090  17330  18850

FNA(              11180   5930   6000

FNB(               7930   1120   1930   2450   2660   2810   3290   3890   5500
 9580

FNCheck(          18780   1230   5670

FND(               6890

FNData(           17260    173

FNE(               1400    860    860

FNG(              10360   9020

FNI(               8270

FNJ(               1670   1170   1170   1170   1200

FNK(               2840   1230   1230   1230   1230

FNL(               5730   3000

FNM(               8800   6160

FNN(               8100    550    570    700    720   2600

FNO(               8560    620    670   2010   2060   2110   2160   2210   2260
 2310   2360   2410

FNP(               6960    180   9950

FNQ(                910    890    900   1550

FNR(                  0   6920   6920   6930

FNS(               8400    510    530    580    640    810    860   1130   1820
 1930   1980   2030   2080
                       2130   2180   2230   2280   2330   2380   2450   2490   2
570   2660   2700   2720
                       2790   2810   3270   3290   4100   4130   4170   4210   4
480   4550   4690   4810
                       4830   4870   5290   5480   5660   5860   6240   6260   6
320   6360   6400   6790
                       8740  10580

FNT(              12080   5880

FNV(               9660   9020
```

```
FNVswr(            14020   3920

FNW(                8360   1930   6920   6930   6930   8740

FNX(               13260   6910   6910   6910   6910   6910   6920   6920   6920
 6930   6930   6930   6930
                         6930
```