1084-7-0M = RL-2027

TECHNICAL REPORT ECOM-0547

AZIMUTH AND ELEVATION DIRECTION FINDER

INSTRUCTION MANUAL

January, 1969

ECOM

UNITED STATES ARMY ELECTRONICS COMMAND FORT MONMOUTH, N.J.

CONTRACT DA AB07-67-C0547
THE UNIVERSITY OF MICHIGAN
DEPARTMENT OF ELECTRICAL ENGINEERING
RADIATION LABORATORY
ANN ARBOR, MICHIGAN

AZIMUTH AND ELEVATION DIRECTION FINDER

INSTRUCTION MANUAL

CHAPTER 1

INTRODUCTION

1.1.0 Scope

This manual covers installation and operation instructions for the Azimuth - Elevation Direction Finder.

Technical manuals covering detailed operation and maintenance instructions of several of the components of the Azimuth - Elevation Direction Finder are listed below. Those components not covered by separate manuals will be discussed in this manual.

Manual No.	Manual Title	Manufacturer
1	Antenna Scanning System	S. Sterling Company
2	450-A Amplifier	Hewlett-Packard
3	Memory Voltmeter Model 5201B	Micro Instrument Co.
4	Model 848 A/D Converter	Texas Instruments Inc.
5	Data 620/I System Reference Manual	Varian Data Machines
6	Data 620/I Maintenance Manual	Varian Data Machines
7	Interface Reference Manual	Varian Data Machines
8	Subroutine Descriptions	Varian Data Machines
9	Programming Reference Manual	Varian Data Machines
10	Fortrand Reference Manual	Varian Data Machines
11	Priority Interrupt Module	Varian Data Machines
12	Power Supply Model HW10-8	Mid-Eastern Electronics
13	Operating Instructions Listings	S. Sterling Company

1.1.1 Purpose and Use

The Azimuth - Elevation Direction Finder consists of an assembly of equipments for use in the detection, frequency measurements and determination of bearing (azimuth and elevation) of radio frequency (RF) transmissions from fixed, mobile, or portable airborne sets operating in the frequency range of 0.6 - 3.0 GHz.

The Azimuth - Elevation Direction Finder will give bearings and signals from continuous wave (CW), amplitude modulated (AM), frequency modulated (FM), and pulse type RF transmissions. The Azimuth - Elevation Direction Finder is designed as a semi-fixed installation with an easily erected and disassembled antenna system which will permit a change of site with a minimum of delay. Accessory items furnished with the Direction Finder set aid in the proper orientation of the antenna system. Bearing information is obtained either from the visual digital readout provided with the electronic equipment, or from the teletype printout provided with the computer.

1.1.2 Components of the Azimuth - Elevation Direction Finder

The following components make up the Azimuth - Elevation Direction Finder system:

a) Hemispherical Antenna System which consists of 17 circularly polarized spiral antennas designed to operate in the 0.6 - 3.0 GHz range.

b) Electromechanical Switch which interrogates each of the 17 antennas and properly provides the necessary interrupts to aid the computer in analyzing the data collected by the Azimuth - Elevation Direction Finder system.

c) Receiver that operates in the 0.6 - 3.0 GHz frequency range. This piece of equipment is to be furnished by the user and is not included in the equipment supplied by the contractor (The University of Michigan, Radiation Laboratory).

d) Video Amplifier (a component part of the Azimuth - Elevation analysis system). The purpose of this equipment is to amplify the video signals from the receiver to a level acceptable by the memory voltmeter.

e) Memory Voltmeter - this instrument measures and records the peak signal that is present at each of the 17 antennas which in turn is fed to the multiplexer.

f) Multiplexer which takes the 17 outputs from the peak reading detector and sequentially transfers them into the computer for later analysis.

g) Computer - makes the necessary analysis from the data collected from the 17 antennas and then determines the azimuth and elevation direction of the incoming signal.

h) Display System consists of the Nixie tubes which show the azimuth and elevation data in a numerical form easily readable by an operator.

i) Teletype - provides the operator with a means for communicating with the computer and can be programmed to readout additional information on the azimuth and elevation location and on other desired items of information stored in the computer.

1.2.0 Component Description

Below is a short description of each of the major components of the Azimuth - Elevation Direction Finder.

1.2.1 Description of Antenna System (Fig. 1)

The antenna system consists of 17 cavity backed Archemedian spirals mounted on a 6 foot diameter hemispherical surface. Employing the coordinate system of Fig. 2 each antenna is mounted on the hemispherical surface as follows: one antenna is located at $\theta = \phi = 0^{o}$. Eight antennas are located at $\theta = 40^{o}$ and equally spaced (at 45^{o} increments) in ϕ. The remaining eight antennas are located at $\theta = 80^{o}$ and are equally spaced (at 45^{o} increments) in ϕ. A longitudinal line has been inscribed on the surface of the hemisphere and passes through the center of elements 1 and 9 of the antenna system. This longitudinal line is usually aligned to a cardinal point of the compass, north, east, south or west. Each of the 17 antennas are connected to the electromechanical switch through RG58/U (50 Ω) coaxial cable. The electromechanical switch associated with the antenna system may be mounted in the room with the data

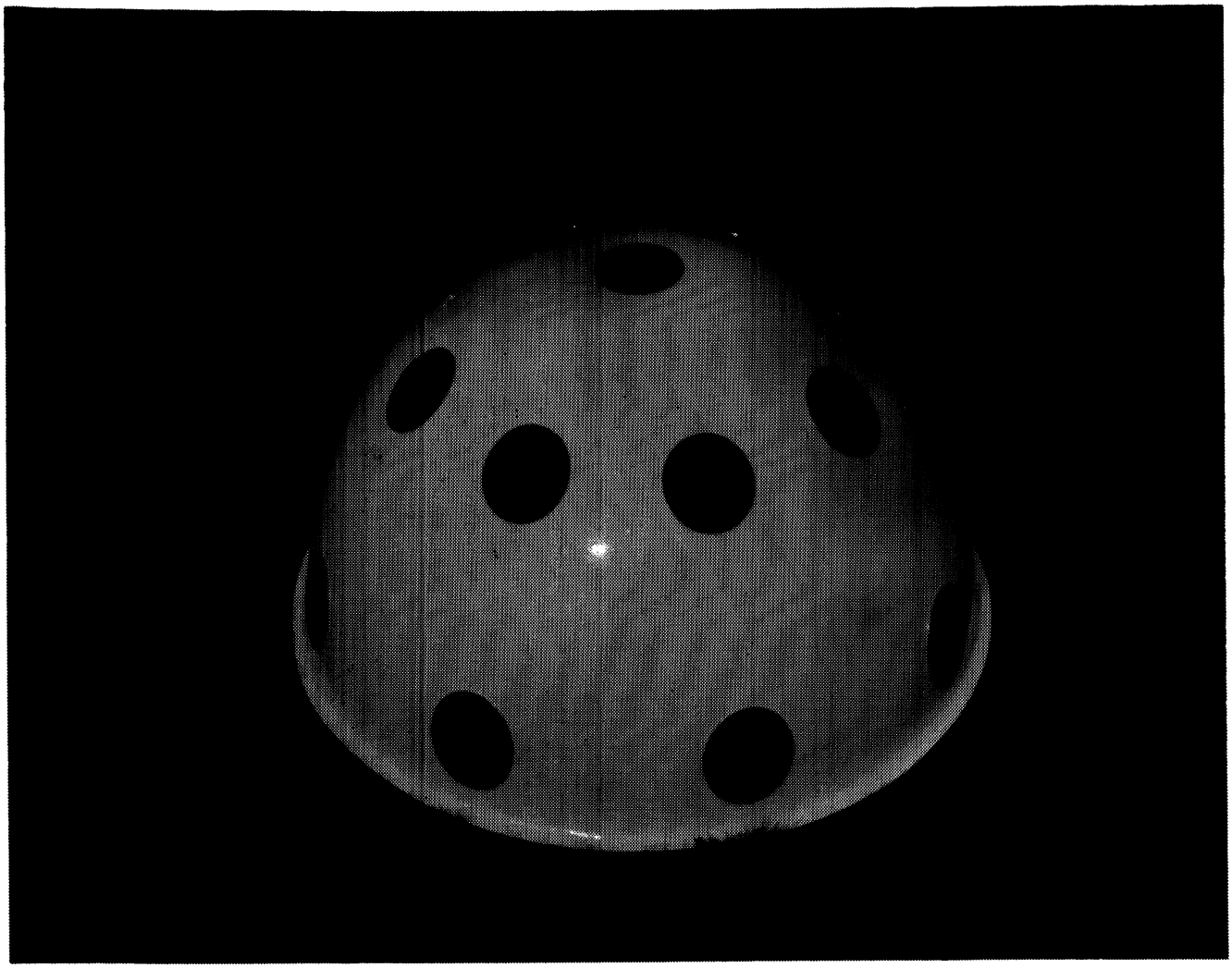

FIG. 1: Antenna System.

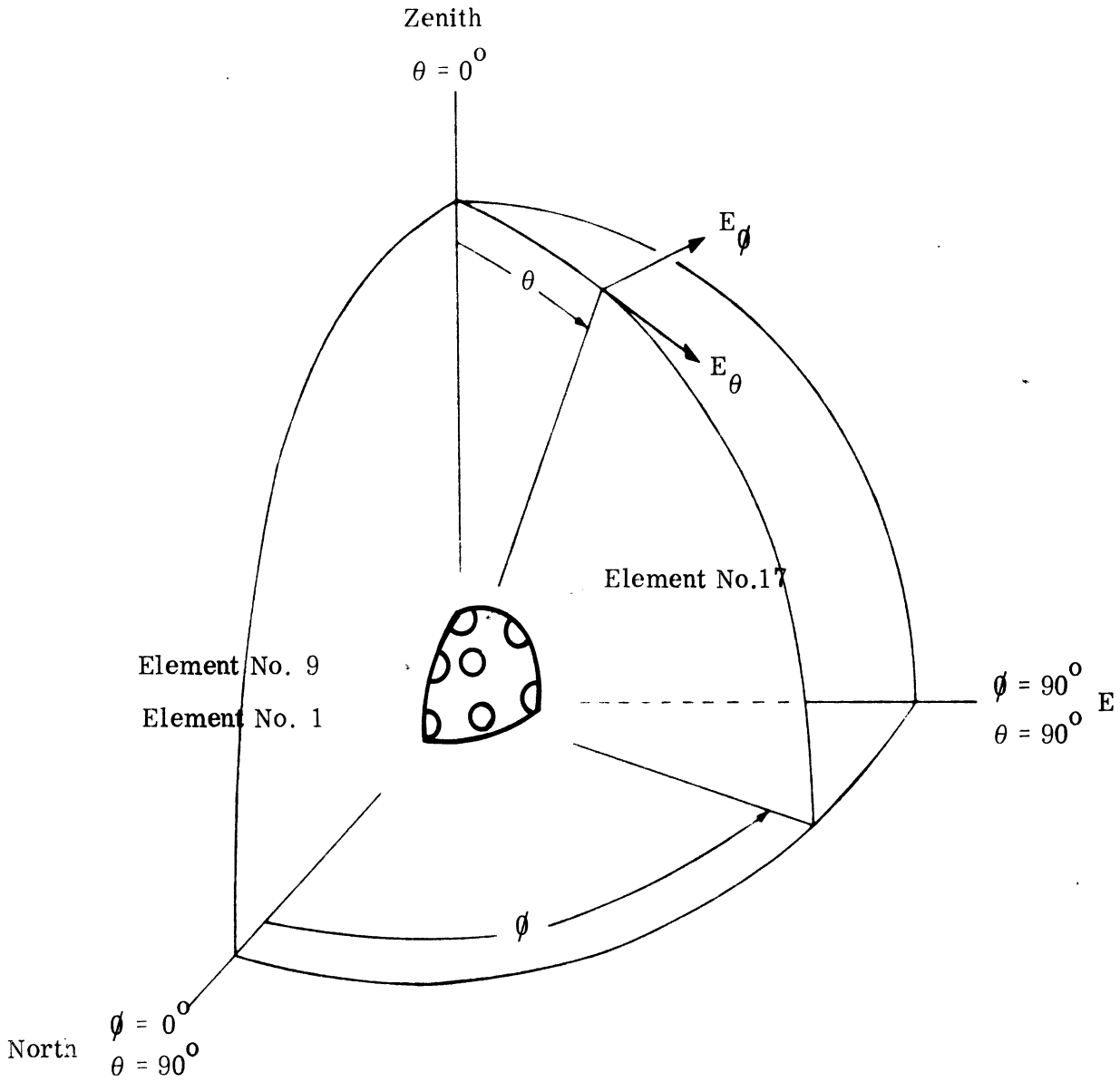

FIG. 2: Azimuth - Elevation Coordinate System.

analysis equipment. In the event the user wishes to reduce the losses in the system, the RG58 cable may be replaced with a low loss coaxial cable, such as the Andrew Corporation Heliax FH 1-50.

The 17 circularly polarized antennas are 15 turn Archemedian cavity backed spiral elements. The cavity backed spiral is fed through a broadband (Duncan - Minerva) modified balun configuration. The antenna base has four leveling screws, level bubbles, and a compass to aid in the positioning of the antenna system.

1.2.2 Description of the Electromechanical Switch

The electromechanical switch is shown in Fig. 3. The electromechanical switch assembly consists of the RF switch and the motor drive unit. The rotor of the switch is driven by a 1/8 horsepower synchronous speed motor through a multispeed gear transmission system. The multi-speed gear transmission provides the operator with a choice of ten rotor speeds ranging from 1 rpm to 1000 rpm. The motor is connected through a pulley and belt arrangement to the main drive system of the switch rotor. The RF switch is a frequency sensitive device designed to operate in the 0.6 - 3.0 GHz frequency range.

Three outputs are obtained from the electromechanical switch. One is the RF signal output which is fed to a receiver. The other two outputs are the data interrupt lines. One of the data interrupt lines provides a pulse output for each revolution of the rotor of the electromechanical switch. The second interrupt line provides a pulse output as each antenna is interrogated by the receiver. The two data interrupt lines are required to aid the computer in analyzing the data in the proper sequential manner.

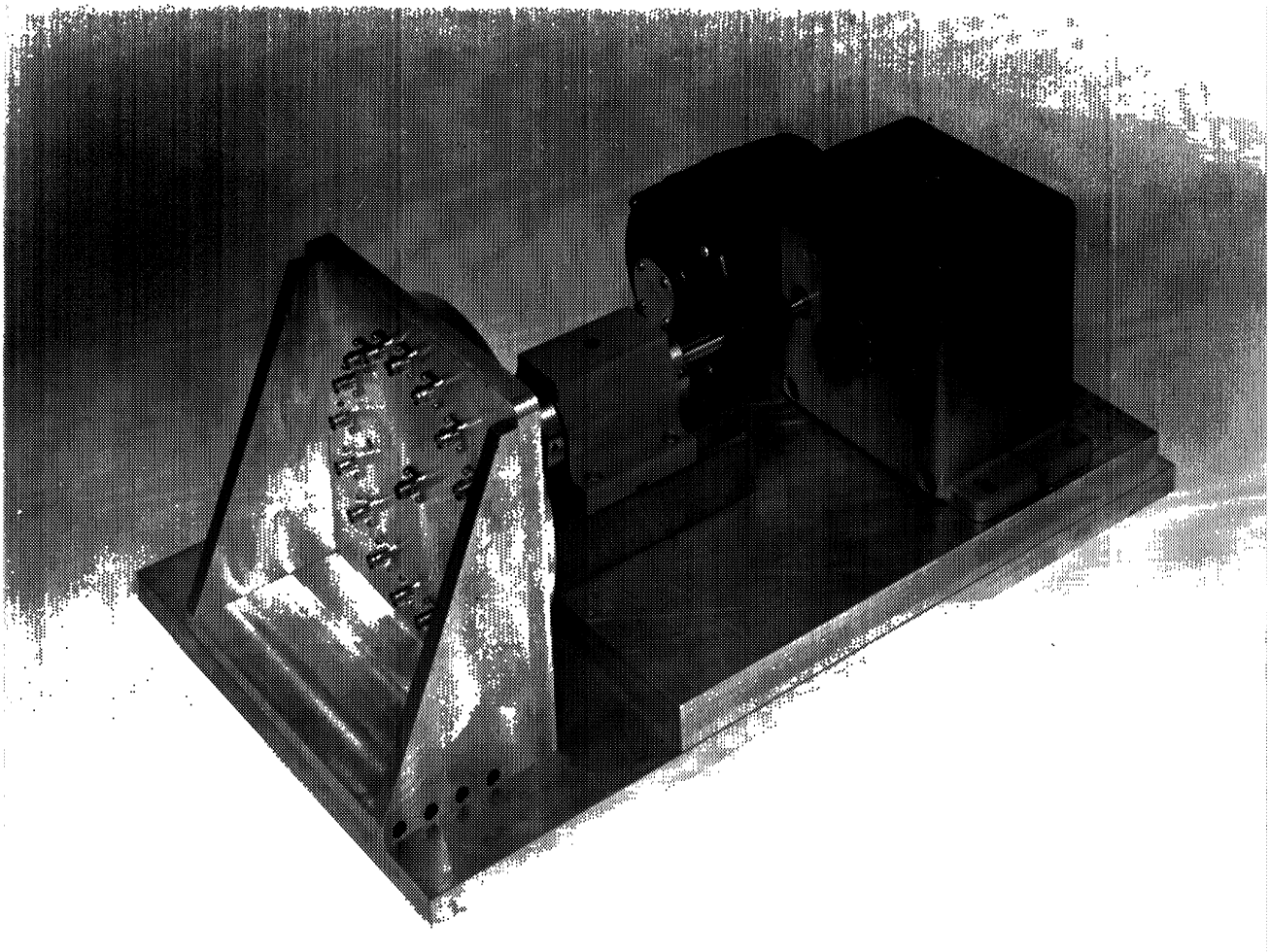

FIG. 3: Electromechanical Switch and Drive Assembly.

1.2.3 The Antenna Data Analysis System (Fig. 4)

The antenna data analysis system consists of the necessary electronic components to make the required calculations of the predicted azimuth and elevation direction of RF emissions in the 0.6 - 3.0 GHz frequency range. The data analysis system is not frequency sensitive, however, it is sensitive to the pattern characteristics of the antenna system used. It is a prerequisite that the electric field of the antenna system satisfy a cosine function.

The data analysis system receives its input from a receiver equivalent to a Micro Tel MR-200 Wide Band Receiver. The signal output from the receiver is a voltage whose amplitude varies proportionately with the signal input to the receiver.

1.2.3.1 Hewlett-Packard 450 Video Amplifier

The video amplifier is a broadband high gain amplifier manufactured by the Hewlett-Packard Company (Model 450A). The amplifier is required to amplify the video signals above the threshold level of the memory voltmeter. The broadband amplifier is employed to ensure that pulse signals will be faithfully amplified. A switch on the front panel allows the selection of either 20dB or 40dB gain. A DC restoring network has been added to the amplifier so that its output is always positive.

1.2.3.2 Micro Instruments 5201-B-1 Memory Voltmeter

The memory voltmeter (Peak Detector) is used to detect the highest signal level available at each of the antenna elements as the antenna switch interrogates the corresponding switch position. It is capable of registering all signals from DC to pulses as short as 50 nanoseconds. The voltmeter is activated by the computer at the same time the antenna switch is coupling one of the antennas to the receiver. At the end of this period, the voltmeter output continues to record the magnitude of the largest signal present during the interval.

FIG. 4: Data Conversion Equipment.

1.2.3.3 Texas Instruments 848 Analog to Digital Converter

The analog to digital converter (A/D) transforms the voltage output of the memory voltmeter into a digital form acceptable to the computer. On command from the computer, the converter samples the voltmeter output and forms the digital representation of it. This process takes about 29 μsec after which the computer may read the result into its memory.

1.2.3.4 Varian 620 I Computer

The computer function is to control and coordinate the whole system. It can turn the memory voltmeter on and off, trigger the A/D converter, read data from the A/D converter and display results (angles) on the NIXIE tube registers. Also, it has interrupt lines from the antenna switch and A/D converter which allow these devices to interrupt the normal operation of the computer to inform it that some external event has occurred. Available for use by the computer is a clock which can be turned on and off, and which interrupts at 100 μsec intervals after being activated. Also [illegible] to the computer is a model 33ASR teletype through which the operator can communicate with the computer either by the use of the keyboard or punched paper tape. Likewise the computer can punch or print information for the operator. The core memory of the 620 I has 4096 words, each 16 bits long and a full cycle time of 1.8 μsec.

1.2.3.5 Other Equipment

In addition to the components described above, the main equipment rack houses logic circuitry which interfaces the computer with the various external devices and it also contains the 100 μsec clock. The NIXIE tube displays along with their high voltage power supply and some logic cards are mounted on the front panel. In back is a separate power supply used to run the logic circuits.

1.2.4 Additional Equipment Required

The following equipment although not supplied as a part of the Azimuth - Elevation Direction Finder set is needed for use with it.

Power Source - The equipment requires a power source capable of supplying 115 volts - 60 cycle power at approximately 1000 watts. Standard commercial power is adequate and is not felt that additional filtering or regulation is required.

Receiver - A second item required is a receiver. The receiver should be capable of covering the frequency band of 0.6 - 3.0 GHz. The sensitivity of this receiver should be at a minimum -70dBm. The receiver should provide a voltage output that has a linear 40dB dynamic range as a function of the input. The Micro-Tel model WR 200 receiver was used with this system. The Scientific Atlanta model 1630 wide range receiver should perform equally well.

The entire system should be enclosed in a shelter to give adequate space for equipment and operator. A suggested shelter is a S-44/G. This shelter is a knock-down type field mobile unit that may be used to house the operating personnel and equipment. For complete information on shelter S-44/G, see TL11-2599.

1.3.0 System Application

A single Azimuth - Elevation Direction Finder system is capable of determining the azimuth and elevation bearing of a distant transmitter. At present it appears that azimuth and elevation data are accurate to within $\pm 5^{o}$. Elevation data is reliable only when the source is located 30^{o} or more above the horizon. However, azimuth data is accurate to within $\pm 5^{o}$ through the entire range (azimuth angles from $\phi = 0^{o} - 360^{o}$ and elevation angles from $\theta = 10^{o} - 90^{o}$). For the purposes of this system a standard spherical coordinate system (Fig. 2) is employed.

1.4.0 Data Interrupt Pulse Generator

Associated with the Azimuth - Elevation Direction Finding system is a 17 element antenna array and mechanical switch to scan the array. It is necessary to alert the system when one particular antenna is switched into the circuit. This is accomplished by a series of holes in the switch rotor. A light source is placed on one side of the rotor and a light sensitive diode on the other. The holes are arranged so that when an antenna is switched into the receiver, the light passes through the hole and illuminates the photo-diode. The diode is connected to a Schmitt trigger, which generates the necessary pulse to alert the computer that data is available.

Figure 5 is a schematic diagram of the pulse generator circuit. The circuits for the 1 pulse per revolution and the 17 pulses per revolution channels are identical.

Q_1 is a current preamplifier and its function is to insure that a high impedance is maintained across the diode while providing a moderate impedance intput to the trigger circuit. Q_2 and Q_3 comprise the trigger circuit. The trigger has an input threshold of about 3 volts and a hysteresis of slightly over one volt. This provides a high degree of noise immunity and precludes any potentially unstable illumination levels. The switch output controls Q_4 which is an emitter follower current amplifier. Q_4 is used to drive the cable connecting the switch location to the computer location. Cable lengths exceeding 100 feet of RG-58 have been successfully used. The pulse is differentiated and received by Q_5 which switches the computer interrupt line.

The unit described has been in use for the past several months and has experienced the extreme variations of temperature and humidity associated with a Michigan autumn without any sign of performance degradation.

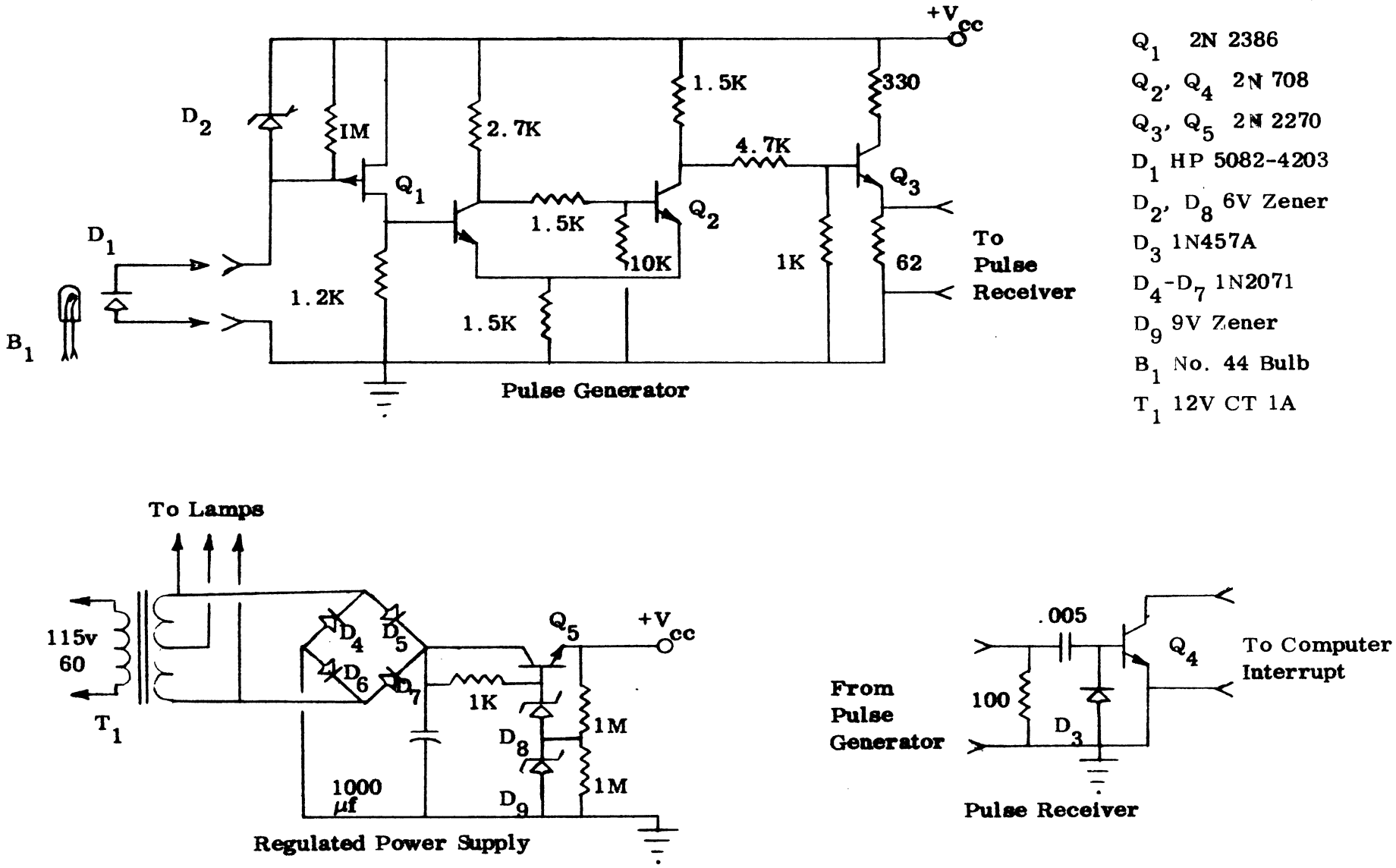

FIG. 5: Data Interrupt Pulse Generator

CHAPTER 2

INSTALLATION

The accuracy of the Direction Finder (DF) depends to a great extent on its location. Factors that must be considered in selecting the site are the ground contour, obstructions that may be in the vicinity of the antenna system, the nearness of the antenna system to large bodies of water and its height above the ground. Therefore, it is important for the user to inspect the proposed site with the following instructions in mind.

2.1.0 Selection of Site

The site area should be gently rolling within the first 150 to 200 yards from the center of the antenna array. Whether installed in rolling or mountainous country the antenna system should be located at the highest elevation.

Efforts should be made to avoid large bodies of water when possible. Therefore, it is desirable to locate the Azimuth - Elevation DF system inland if possible. If it is necessary to locate the antenna system near the coast, it is suggested that the user select a flat site and install the antenna as high as possible above the surface of the water. Regardless of where the antenna system is located, it is important that it not be installed near tall trees, buildings, wire fences, power or telephone lines, radio antennas, chimney stacks, or other tall obstructions.

2.1.1 Preparation of Site

It is suggested that the antenna system be placed on a tower 40 feet or more above the surface of the ground. It is recommended that the remainder of the DF equipment be located in a room directly beneath the antenna system so as to minimize the length of cables that interconnect the antenna system

with the electromechanical switch assumed to be located inside the shelter. In the event commercial power is not available, a portable unit capable of supplying 115 volts and 1000 watts of 60 Hz power will be necessary. It is suggested that the power unit be located at the base of the tower for simplicity of operation.

2.1.2 General Instructions

The developer of the Azimuth - Elevation DF system has not had extensive experience with the system and there is still much to be learned in regards to the accuracy of the system. During the initial tests of azimuth - elevation DF system, the user should concentrate his efforts at 1.6 GHz, since this is a frequency at which the individual elements of the antenna system operate reasonably well. As the user gains experience with the DF system and increases his knowledge of the flexibility of the computer in the processing of data, it is felt that the accuracy of the system can be improved at other frequencies in the 0.6 - 3.0 GHz frequency range. It is our belief that the accuracy of the system is strongly dependent upon the site, therefore much care must be taken in its selection.

2.1.3 Antenna Installation

The array of 17 antenna elements was delivered with the antennas installed in the hemispherical surface and cabled to the 17 output jacks located in the lower portion of the hemisphere. The hemisphere is bolted to the wooden platform through four mounting holes during shipment. Four leveling screws, four 8" x 8" Benelex base plates and 17 six-foot RG58/U cables are included with the antenna system.

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2.1.3.9 In the event the user wishes to position the antenna to 'true' north, he must refer to a map of the local area to determine the declination east or west of north and set this accordingly on the vernier scale (the long lines on the vernier scale are 1^{o} increments; the short lines are 1/10th degree increments).

2.2.0 Cabling of the Azimuth - Elevation Direction Finder

2.2.1 Installation of Power Cables

The data link cable and the power cables for both the computer and the teletype are packaged inside the back of the teletype console. The back of the console is removed by removing the two phillips screws at the top of the console and sliding the panel out.

2.2.1.1 The data link between the teletype and computer is installed by tilting the computer forward and installing the plug into the receptacle (36) in the lower right-hand portion of the computer cabinet.

2.2.1.2 The AC cable of the teletype is installed in the AC plug mold at the back of the computer. The AC line to the computer can be plugged into any 115 volt single phase outlet. The power requirement for the computer teletype combination is 600 watts. The line voltage should be 115 volts $\pm$ 10 volts with a line frequency of 60 Hz $\pm$ 2 Hz. Operating temperatures for the Azimuth - Elevation Direction Finder are 0^{o} to 45^{o} centigrade inside the cabinet.

2.2.2 Antenna to Switch Cabling

The antenna should be installed as in Section 2.1.3.

2.2.2.1 Connect one of the 17 six foot RG58/U cables from jack No. 1 on the hemisphere to jack No. 1 of the electromechanical switch.

2.2.2.2 Continue with the remaining 16 six foot lengths of cable connecting the antennas in numerical order from 2 through 17 to the respective switch jacks that are numbered from 2 through 17.

2.2.2.3 Plug the switch power cord to a single phase 115 volt, 10 amp, 60 Hz circuit. Operating temperature of the switch is 10^{o} to 40^{o} centigrade. The switch is not weather-proof and should be kept in the equipment shelter as noted in 2.1.1 to prevent damage to the precision machined surfaces. The speed of the switch is controlled by the knurled aluminum knob on the (green) Geartronics gear box. (NOTE: Change speed only with the motor off). Speed position No. 1 results in a 1000 rpm operation of the switch. Position No. 2 of the switch is equivalent to a 2:1 gear reduction resulting in 500 rpm operation of the switch; other positions of the switch are similar indications of the gear reduction.

2.2.2.4 Turn on the AC switch and note that the output shaft of the Geartronics gear box is turning. In the event the output shaft does not turn, it will be necessary to turn the motor off and jiggle the speed switch while the motor shaft is hand rotated until gear meshing is felt, then turn the AC switch on.

2.2.3 Computer to Switch Cabling

Connect the two lengths of RG/58 cable labeled Nos. S-1 and S-17 to the two BNC terminations (S-1 and S-17) on the switch pulse generator located on the electromechanical switch to the two BNC terminations (S-1 and S-17) on the data interrupt module inside the back of the computer.

2.2.4 Cabling the Receiver

It is recommended that a Micro-Tel receiver or its equivalent be used with the Azimuth - Elevation DF system since the system is designed to operate

employing a linear voltage detector similar to that available from the Micro-Tel receiver.

2.2.4.1 Cable the electromechanical switch using the center RF connector of the stator of the switch to the receiver input employing the cable labeled "RF" (RG9/U cable, approximately 8' long).

2.2.4.2 The video output of the receiver is connected to the input of the video amplifier located in the computer rack using the cable labeled "Video" (RG58/U cable, approximately 3' long).

It is to be noted that an APR-4 receiver may be used with the system. However, when using this receiver, it is important the AGC circuit be turned off or disabled. In this case the video output is again connected to the input of the broadband amplifier located in the computer cabinet as noted above.

2.2.5 Cabling the Broadband Amplifier to the Memory Voltmeter

The signal from the amplifier may be monitored by the tee installed between the amplifier and the memory voltmeter by connecting a cable from the tee to one input of a dual trace scope. The dual trace presentation may be stabilized by connecting a cable to a second tee installed on the input side of the data interrupt module (connection S-1 located in the back of the computer) and connecting this cable to the second input of the dual trace scope. By synchronizing the display to the single pulse per revolution the individual voltage from the switch can be stabilized, and become more meaningful, since it is possible to observe the data being collected from each antenna sequentially from 1 through 17. The output of the receiver should be adjusted until the display from the broadband amplifier has a maximum of 10 volts as

noted on the oscilloscope. This is important since the memory voltmeter cannot detect voltages greater than 10 volts and excessive voltages will introduce errors into the DF system.

With the computer turned on print out "A" table (see paragraph 3.1.3) and observe if all values are less than 2047. In the event one or more has a value of 2047 reduce the receiver gain until all values are less than 2047. The scope may or may not be used at the discretion of the user.

No further cabling is required as the memory voltmeter is connected internally to the A/D converter which in turn is internally connected to the computer.

2.3.0 Turn-on Procedure for Azimuth - Elevation Direction Finder System

IMPORTANT

IT IS IMPERATIVE THAT THE TURN-ON PROCEDURE DESCRIBED BELOW BE FOLLOWED EXACTLY SO AS TO PREVENT DAMAGE TO THE COMPUTER PROGRAM. IF THESE INSTRUCTIONS ARE NOT FOLLOWED; THE COMPUTER PROGRAM MAY BE DAMAGED AND THE PROGRAM WILL HAVE TO BE RE-INSERTED INTO THE COMPUTER.

IMPORTANT

2.3.1 Computer Turn-On

The computer turn-on must be followed in the following step-by-step sequence.

2.3.1.1 Turn on computer and rack power by pushing the 'on' button located on the right side of the computer.

2.3.1.2 Turn on the teletype with the switch located in the right hand corner of the teletype; rotate switch CCW to 'line'.

2.3.1.3 Place the toggle switch labeled 'memory' (in the upper right hand corder of the computer) to 'enable'.

2.3.1.4 The register 'U' should be placed in an 'up' position with all other register switches 'down'.

2.3.1.5 Depress the 'reset' switch of the upper row of 20 switches.

2.3.1.6 Place register 'P' up with all other registers down.

2.3.1.7 Again depress the 'reset' switch.

2.3.1.8 Depress the 'system reset' switch. At this time all lights on the face of the computer should have been turned off except for the light titled 'step' which should now be on.

2.3.1.9 On the front of the computer you will observe five groups of three switches in a group. Depress the red switch of group 3 and a light will occur.

2.3.1.10 Now depress the 'run' switch. If the computer is operating properly, the 'step' light will turn off and the 'run' light will turn on.

IMPORTANT

IF THE RUN LIGHT DOES NOT OCCUR AND THE COMPUTER STILL INDICATES 'STEP' DO NOT PUSH THE 'RUN' SWITCH AGAIN, AS THIS WILL MODIFY THE COMPUTER PROGRAM. IF THE COMPUTER DOES NOT DISPLAY A RUN LIGHT, PLACE THE 'MEMORY' SWITCH TO 'DISABLE' AND REPEAT STEPS 2.3.1.3 THROUGH 2.3.1.10. IF YOU DO NOT OBTAIN A RUN ON TWO CONSECUTIVE TRIES, CONSULT A COMPUTER PROGRAMMER.

IMPORTANT

2.3.1.11 If a run light is lit the sense switch S-1 should be in the 'up' position. S-2 and S-3 should be placed in the 'down' position. The computer is now ready to operate the Direction Finder system.

2.3.1.12 Turn on electromechanical switch.

To prevent erroneous readings, the Azimuth and Elevation display is not turned on (display tubes do not turn on) until a signal of a pre-set magnitude is read into the computer. This is accomplished automatically and does not require any command from the operator. This prevents the computer from displaying erroneous answers which are due only to the noise level in the receiver and amplified by the broadband amplifier. This level can be adjusted by the teletype console and is to be made only by a computer programmer, and is discussed in paragraphs 3.1.3 and 4.2.0.

2.3.2 Turn-Off Procedure for the Azimuth - Elevation DF System

To turn the computer off there are several simple steps that must be observed to prevent damage to the computer program and are as follows.

2.3.2.1 Depress key 'H' on the teletype keyboard.

IMPORTANT

IF KEY 'H' IS NOT DEPRESSED BEFORE TURNING THE COMPUTER OFF, THE CURRENT INSTRUCTION MAY BE LOST FROM MEMORY AND THE PROGRAM MODIFIED SO THAT THE COMPUTER WILL NOT OPERATE UNTIL RE-PROGRAMMED.

IMPORTANT

2.3.2.2 Switch the 'memory' toggle switch on the front of the computer to 'disable'.

2.3.2.3 Turn the teletypewritter off.

2.3.2.4 Turn the computer and the entire rack off by depressing the 'on-off' switch on the front of the computer.

2.3.2.5 Turn off the electromechanical switch.

2.4.0 Computer Program Modification

High voltage pulses from electronic equipment such as a radar can modify the computer program. For this reason, the Azimuth - Elevation Direction Finder should not be operated in the proximity of such equipment. If the computer program is modified by voltage pulses or operator error, a computer programmer must be consluted. The computer programmer can read the program tape (see Chapter IV for a discussion of tapes) into the computer according to the instructions in the Program Reference Manual (page 3-4) under the heading "Binary Load/Dump". NOTE: This is not to be done by an operator.

The instruction counter on the computer face is in octal with 3 bits per octal number. In each group of three on the instruction counter the value of the right tab is one, the center tab is two and the left tab has a value of four.

If complete alteration of the computer memory has occurred, the computer programmer will have to use the boot strap loader tape (see Chapter IV) shipped with the computer. Instructions for the boot strap loader program are found in Section 3 of the Programming Reference Manual (Manual IX).

CHAPTER 3

COMPUTER INSTRUCTIONS AND TABLES

3.1.0 Teletype Keyboard and Command

Through the use of the teletype keyboard, operating personnel are able to communicate with the computer within the limitations of the program that has been inserted into the computer. The program employed with the Azimuth - Elevation Direction Finder has been written to provide a maximum degree of flexibility. To increase the degree of flexibility, the program is written with six fixed instructions (that cannot be changed by the operator and are a part of the computer program) and nine variable instructions (that may be implemented through the use of the keyboard by the operator) in addition to ten auxiliary instructions (which are required when personnel wish to converse with the eight tables that are used in the Azimuth - Elevation Direction Finder program).

3.1.1 Fixed Instructions

The six fixed instructions associated with the Azimuth - Elevation Direction Finder are listed in Table I. All data for these instructions are in numerical form employing a base 10 system.

TABLE I

FIXED INSTRUCTIONS

	Key	Instructions
1.	Depress Key C	Calculate antenna coefficients from P and T tables and S value.
2.	Depress Key D	Disables interrupts.
3.	Depress Key E	Enables interrupts.
4.	Depress Key G	T-type will print out Hi, Lo, and Avg of ten scans of computer.
5.	Depress Key H	A stop command is given to the computer.
6.	Depress Key V	T-type will print out current azimuth and elevation position.

Key 'C' - Whenever the θ and ϕ angular positions associated with each of the 17 antennas are reassigned, a change in the 'T' (θ) and 'P' (ϕ) tables is required. However, before the correct data can be displayed by the NIXIE tubes, the operator must depress key 'C' of the teletype to ensure that the proper antenna coefficients have been calculated for the new θ and ϕ pointing vectors, and inserted in the x, y, and z tables.

Keys 'D' and 'E' - Keys 'D' and 'E' are self explanatory in that they either disable or enable the interrupts from the electromechanical switch.

Key 'G' - Activation of key 'G' is essentially asking the computer to read out the average of ten computer scans of Azimuth and Elevation data, and also to print the high and low value that was noted during those ten scans.

Key 'H' - Key 'H' is employed to stop the operation of the computer as is noted in the turning-off procedure in paragraph 2.3.2. In the event 'H' is inadvertently depressed during normal operation, the operator must restart the computer by following the procedures of 2.3.1.4-2.3.1.10.

Key 'V' - 'V' is used when the operator is interested in having the current Azimuth and Elevation data printed out on the teletype.

3.1.2 Variable Instructions

The second form of instructions are variable instructions. There are nine variable instructions available to operating personnel and are listed in Table II.

TABLE II

VARIABLE INSTRUCTIONS

	Key	Instructions
1	F	Weighting factor associated with the B table.
2	I	Automatic cycle length.
3	J	Low signal level cut off.
4	K	Low antenna level cutoff.
5	L	Memory voltmeter on time.
6	M	Display change interval.
7	N	Number of antenna elements.
8	Q	Display hold time.
9	S	ϕ and θ scale factor.

To make a change in the variable instruction, the operator must first depress the numerical change he wishes to make and then depress the key of the particular variable instruction he wishes changed. For example, in the event the average weighting factor 'F' is to be changed from its present value of 10 to 20, the operator would type '20F'. In the event the operator is interested in learning what variable instruction is presently inserted in the computer, he merely needs to depress the key of the instruction he is interested in and the teletype will print out the present instruction that is in the computer.

Key 'F' - The 'F' key as noted in the table is the averaging factor that is associated with the B table as noted in the following expression.

$$B_n = \frac{(F-1)\, B_{n-1} + A_n}{F}$$

where n = scans in time

A_n = new value from A/D converter

B_{n-1} = previous value in the B table.

Key 'I' - Key 'I' is discussed in paragraph 4.2.6 and not used by the operator. It should be set to 'zero' for normal operation.

Keys 'J' and 'Q' - Keys 'J' and 'Q' sets the minimum acceptable level at which a minimum usable signal is considered to be present. If all antenna element levels are less than the 'J' value no calculations are made for this scan and the NIXIE tube display is not changed. Furthermore, if this condition exists for more than 'Q' successive scans, the NIXIE tube display is turned off. The 'J' value should be limited to a range of 0 - 2047 which corresponds to a voltage range of 0 - 10 v at the input of the memory voltmeter. A suggested value for Q is 4000.

Key 'K' - It is possible to limit the data employed by the Azimuth and Elevation prediction such that only data from the stronger portions of the antenna radiation patterns are used. This is accomplished by computing a cutoff level which is a fraction of the maximum signal present for a particular scan. If a level on any particular antenna is less than the cutoff value that antenna is set to zero. The fraction used to set the cutoff level is K/1000. In the event data for all antennas are to be used K should be set to zero.

Key 'L' - Key 'L' is associated with the on-time of the memory voltmeter in units of 100 μsec. Thus typing '10L' forces the voltmeter on time to be 1000 μsec. It is important to note that when 'L' is set to zero the on-time is determined automatically by the computer which is considered to the "normal" mode of operation.

Key 'M' - Key 'M' determines the display change interval. This interval may arbitrarily be set by the operator. A typical interval is 20 which tells the computer to change the NIXIE tube display to current value after each 20 computer scans of the data.

Key 'N' - 'N' represents the number of antenna elements used in the system. Presently there are 17 elements in the system.

Key 'S' - The purpose of 'S' is to provide the operator with the capability of entering fractional parts of a degree. The 'T' and 'P' entries are divided by 'S' when they are used by the computer.

3.1.3 Computer Tables

The eight tables associated with the Azimuth - Elevation system are listed in Table III.

TABLE III

Computer Data Tables

1	A	Input data from electromechanical switch.
2	B	Input data from electromechanical switch as modified by 'J', 'K' and 'F' instructions.
3	P	ϕ position assigned to each of the antennas.
4	T	θ position assigned to each of the antennas.
5	W	Weighting factors for elevation data, to be changed only by a computer programmer, (see paragraph 4.3.1).
6	X	X coefficients.
7	Y	Y coefficients.
8	Z	Z coefficients.

Keys 'A' and 'B' - The 'A' and 'B' tables are essentially data that is generated as a result of the input data directly from the electromechanical switch. The 'B' table differs from the 'A' table in that it is modified by the 'J', 'K' and 'F' instructions. The numbers in these tables range from 0 - 2047 which correspond to a voltage range of 0 - 10 V at the input of the memory voltmeter.

Keys 'X', 'Y', and 'Z' - These tables are the x, y, and z coefficients which are calculated from the 'P' and 'T' tables when key 'C' is depressed.

Keys 'P' and 'T' - The 'P' and 'T' tables contain respectively the ϕ and θ positions assigned to each of the 17 antennas. Values to be entered in the 'P' and 'T' tables are obtained by multiplying the ϕ and θ antenna positions in degrees by S (see Table II for a description of S). As was noted previously, the mere insertion of data in the 'P' and 'T' tables will not cause the computer to display the proper azimuth and elevation coordinates of the incoming signal on the NIXIE tubes unless the instruction key 'C' of Table I has been depressed.

3.1.4 Auxiliary Instructions

Table IV is a list of the auxiliary instructions that are used when communicating with the computer.

TABLE IV

Auxiliary Instructions

	Key	Instructions
1	1 - 0	Accumulate current input number
2	-	Change sign of current input number
3	=	Print current input number
4	←	Delete current input number
5	ESC	Stop printing and clear input buffer
6	CTRL-A	Simulate switch interrupt
7	CTRL-Z	Simulate zeroing switch interrupt
8	RETURN	Carriage Return, line feed, delete current number
9	?	Print Current Table
10	,	Set/Print Current Element number
11	/	Set/Print Current table entry

Numbered Keys - The digits in the current input number are entered by employing the number keys in the normal typewriter manner. The maximum magnitude of the current input number is 32767.

Minus '-' Sign Key - A '-' sign indicates a change in the sign of the current number being inserted.

Equal '=' Key - The '=' signature causes the computer to print out the current input number.

'←' Key - The '←' key deletes the current input number.

Escape 'ESC' Key - In the event it is desired to stop the output from the computer, the 'ESC' key may be depressed. This will stop the printer and clear the input buffer.

Control 'CTRL' Key - It may be necessary for a programmer at times to simulate switch interrupts. This may be done by depression of the 'CTRL' 'A' keys or if he wishes to simulate zeroing switch interrupt this can be done by depression of 'CTRL' 'Z'.

RETURN Key - Returns print head to left side of page spaces the paper and deletes the current input number.

To communicate with the tables of the computer there are three commands in addition to the table letters of Table IV that must be used. These commands are the question mark '?', comma ',', and the slash '/'.

Whenever a table letter is typed that table is established as the 'current table' and remains as such until another table letter is typed.

'?' Key - To print the entire content of the 'current table' one must enter the appropriate table letter followed by a question mark, e.g., 'A?' will cause the A table to be printed out.

Two additional terms associated with the computer tables to be defined here are the 'table entries' and the 'table indexes'.

Each of the computer tables contain 'table entries' which are the numbered values in that table. The 'table index' is a number between 1 and N which specifies a particular 'table entry'.

',' Key - The 'table index' is set by typing the desired table letter and index number followed by a comma ',', e.g., '1' will set the table index to 1. To read out the present index value type a comma, e.g., ',' will print out the current table index number.

'/' Key - The 'table entry' in the 'current table' which is specified by the 'table index' is printed or changed by use of the slash '/'. A value may be entered in this entry by typing the desired table letter, index number, comma, and entry value followed by a slash '/', e.g., 'A2, 21/' requests that the value 21 be inserted in the second entry of table A. This operation also increments

the table index after the value is stored. To print out the present 'table entry' enter the table letter, index number, a comma followed by a slash '/', e.g., 'B4,/' requests that the value of the fourth index of table B be printed out. This number is then established as the current input number.

3.1.5 Preliminary Checkout of System

With the system turned on in accordance with paragraph 2.3.1, the following procedure may be followed to check out system operation.

3.1.5.1 Disable computer interrupts by depressing Key 'D' on the teletype.

3.1.5.2 Print out 'P' table by depressing Keys 'P' and '?' of the teletype.

3.1.5.3 Print out 'T' table by depressing Keys 'T' and '?' of the teletype.

NOTE: The 'P' and 'T' values printed out are respectively the azimuth and elevation coordinates associated with each of the 17 antennas and are printed sequentially as follows: P_1, P_2, P_3, ... P_{17}, and T_1, T_2, T_3, ... T_{17}.

3.1.5.4 Enter the following 17 numbers in the A table as follows:

A1, 1000/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/

3.1.5.5 Observe the Nixie Tube display to see that the elevation data agree with T_1 and that the azimuth data agree with P_1.

3.1.5.6 In the event an error is noted in 3.1.5.5 there is trouble in the computer program and a computer programmer must be consulted.

3.1.5.7 If there is no error in the data of 3.1.5.5 the computer is operating properly.

3.1.5.8 Enable computer interrupts by depressing Key 'E' of the teletype.

3.1.5.9 Disconnect the cable from the input to the memory voltmeter.

3.1.5.10 Disconnect the electromechanical switch output cable from the receiver input.

3.1.5.11 Connect the output of the electromechanical switch to the input of the memory voltmeter. (The switch may be running during this step). Note: a connector adapter may be required to make this connection.

3.1.5.12 Disconnect the 17 cables (from the antenna system) from the 17 inputs of the electromechanical switch.

3.1.5.13 Connect a 5 volt DC or video source to input port 1 of the electromechanical switch. Note: The meter and front panel control knobs of the memory voltmeter perform no useful function in the azimuth and elevation direction finder system. However, it is recommended the range selector switch be placed in the 10 volt position.

3.1.5.14 Observe the azimuth and elevation Nixie tube displays. Print out the current azimuth and elevation values by depressing key 'V' on the teletype. One should observe that these two sets of data agree and they both should be equal to P_1 and T_1 of 3.1.5.3.

3.1.5.15 In the event 3.1.5.14 is in error print out the A table by depressing (A?) on the teletype keyboard. One should observe a number in the range of 1000 ± 100 in the first position of the A table and very large negative numbers in the remaining 16 positions.

3.1.5.16 In the event 3.1.5.15 is in error trouble exists in either the memory voltmeter or A/D converter and a competent electronic repairman or computer programmer should be consulted.

3.1.5.17 If 3.1.5.15 is satisfactory disconnect the output of the electromechanical switch from the memory voltmeter and reconnect the output from video amplifier to the memory voltmeter input.

3.1.5.18 Turn off the DC or video source.

3.1.5.19 Disconnect the output of the RF receiver from the input of the video amplifier.

3.1.5.20 Place the gain switch of the video amplifier in the 20dB position.

3.1.5.21 Connect the output of the electromechanical switch to the input of the video amplifier.

3.1.5.22 Turn on the DC or video source and adjust the output for a 0.5 volt signal.

3.1.5.23 Repeat 3.1.5.14 and 3.1.5.15.

3.1.5.24 In the event 3.1.5.15 is in error trouble exists in the video amplifier and a competent electronic repairman should be consulted.

3.1.5.25 If 3.1.5.15 is satisfactory disconnect the output of the electromechanical switch from the video amplifier and reconnect the receiver output to the video amplifier input.

3.1.5.26 Disconnect the DC or video source from input No. 1 of the electromechanical switch and connect a RF signal generator having a frequency in the range of 600 MHz to 3.0 GHz and a calibrated output to input No. 1 of the electromechanical switch.

3.1.5.27 Connect the output of the electromechanical switch to the input of the receiver. Check to be sure the receiver is turned on and tuned to the frequency of the RF source.

3.1.5.28 Adjust the RF source to produce a CW output and adjust the level to -45dBm. Set the receiver gain to mid-scale.

3.1.5.29 Print out the A table of the computer by depressing (A?).

3.1.5.30 To comply with the remainder of this step it will be necessary to repeatably print out the A table as noted above. A number should occur between 0 and 2047 only in the first position and large negative numbers in the remaining 16 positions. In the event 2047 occurs in the first position reduce either the signal generator level or the receiver gain until a number between 1000 and 2047 can be obtained. In the event 0 or a negative number occurs increase either the output level of the signal generator or the receiver gain until a number between 1000 and 2047 can be obtained.

3.1.5.31 In the event numbers greater than 0 occur in more than one position of the A table in the above step or the conditions of 3.1.5.30 cannot be complied with trouble exists with the receiver and a competent electronic repairman should be consulted.

3.1.5.32 If 3.1.5.30 is satisfactory print out the current azimuth and elevation data by depressing Key 'V' of the teletype and observe the Nixie tube display. This data should agree and also should agree with the data for P_1 and T_1 of step 3.1.5.3. In the event it does not a competent computer programmer should be contacted.

3.1.5.33 Disconnect the signal generator from input No. 1 of the electromechanical switch and reconnect the 17 antennas to their respective switch positions.

3.1.5.34 To check out the antenna system it is recommended that the antenna system be placed on an antenna range and a RF CW signal at a frequency of 1.6 GHz be radiated from a known azimuth and elevation and the signal processed by the A-EDF system. If the NIXIE tube display designates the azimuth and elevation of the signal accurately to within $\pm 5^{o}$, the antenna system is operating properly.

3.1.5.35 In the event an error exists in 3.1.5.34 one or more of the antennas may be faulty and an antenna specialist should be consulted.

3.1.5.36 Turn off the equipment in accordance with paragraph 2.3.2.

NOTE: During the operation of the system, the operator will observe that the light on the front of the A/D converter flickers. He should not be alarmed as this is normal for the A/D converter.

CHAPTER 4

COMPUTER PROGRAM

4.1.0 Introduction

The following is a detailed description of the computer program for the Varian 620/i used by the Azimuth - Elevation Direction Finder system. It is assumed that the reader of this section is familiar with general programming notation and terminology and with the specific traits of the 620/i. The material in this section along with information given in the various 620/i computer manuals should allow the programmer to modify or extend the direction finder program as desired.

4.2.0 General Program Operation

This program makes use of the interrupt system available on the 620/i to communicate with the external devices connected to the computer. These devices include the following:

1) the antenna switch which interrupts on interrupt line 2 once for each antenna and on line 3 once for each revolution of the switch.
2) the 100μsec clock which interrupts on line 1,
3) the A/D converter which interrupts on line 4 when it is through converting.
4) the teletype which uses line 5 when it finishes typing a character and line 6 when a key is struck or the tape reader reads a character.

Associated with each of these interrupt lines is an interrupt location and an interrupt processing routine where action appropriate to each interrupt is taken.

The main loop of the program looks at the data from the antennas which has been read in by the interrupt time processors and from this determines

the azimuth and elevation of the incoming signal. This is accomplished by reducing the signal from each antenna element into X, Y, and Z components. The corresponding X, Y, and Z components from the 17 antennas are added and the result is expressed in terms of a spherical coordinate system. Because the antenna elements are located only on a hemisphere instead of on a full sphere, a correction must be applied to the elevation result as obtained above. The correction is made by using a piecewise linear approximation, the breakpoints and slopes for which are stored in the W table (WTAB) which may be changed from the teletype.

The program inspects the antenna data to see that at least one element has a signal level greater than a minimum specified by control code 'J', and if not, then the entire set of data is skipped. If the level on any one element is less than some fraction of the maximum element level, as specified by control code 'K', then the level on that one element is set to zero. The value entered with control code 'M' determines how often the azimuth and elevation displays are changed while the code 'Q' determines the length of time the displays remain lighted after the signal goes below the level given with the 'J' control code.

A large segment of the program is concerned with the processing of characters typed in from the teletype. This picks up characters from a buffer where they have been put by the interrupt processor, determines the meaning of each, and takes appropriate action No more than one character is examined between scans of the antenna data and the time spent waiting for the teletype to finish typing out a character is spent scanning the data. Note

that the teletype finished interrupt is not used, but rather a SEN instruction in the teletype output routine decides whether the teletype is still busy.

The floating point numbers used in parts of the program are not the standard Varian form because of the limited use for them does not warrent the size and generality of the Varian supplied routines. Each floating point number used in this program consists of three computer words. The first word is the magnitude of the fraction part which is normalized with the radix point at the left hand end. The second word is the exponent part which is the negative of the integer power of two to be applied to the fraction. That is, if the second word contains a -4, then the magnitude of the floating point number is the fraction part times two to the power four. The third word is the sign and only the sign bit of the word is used.

4.2.1 Program Description

The detailed description of the program is given with each part in order as it appears in the assembly listings. It may be of value to refer to the listing of each part as it is described.

There are actually two separate assemblies involved in the entire program. This was necessary due to the restriction on the size of the symbol table available in the assembler. The first assembly is designated 'DF 1.6', and contains code for the interrupt processors and for the antenna data scan, while the second assembly is designated 'DF 2.6', and contains code for the processing of control information from the teletype. The two assemblies are linked after they are loaded, each time the program is started by a routine at the beginning of DF 2.6 using a table in DF 1.6.

ALLOCATION OF CORE SPACE

Core Location (octal)	Contents
0000-0017	Interrupt locations
0020-0037	DF 1.6 pointers
0040-0107	DF 1 6 literals
0110-0117	DF 2.6 pointers
0120-0177	DF 2.6 literals
0200-0227	Start location and linkage tables
0230-0645	Data and temporary storage
0646-1067	Interrupt processing routines
1070-2017	Subroutines used mainly by DF 1.6
2020-2416	Initialization and antenna data processing
2417-2777	Unused
3000-3030	Link routine
3031-3506	General teletype processors and table
3507-4213	Processors for specific characters
4214-5777	Unused
6000-7777	Varian debug routine, loader, etc.

4.2.2 Interrupt Locations
DF 1.6

There are two core locations associated with each interrupt line; locations 0 and 1 for line 1, 2 and 3 for line 2, 4 and 5 for line 3, and so on. When an interrupt condition exists, the instruction at the first of the

two locations is executed and if this is a double word instruction, the second is used also. In the particular case where the instruction is a 'JMPM', further interrupts are inhibited, but not forgotten, until the interrupt module is re-enabled by the program. Thus each interrupt processor must execute an 'EXC 0240' to turn the module back on. There is also an interrupt mask in the interrupt module which allows interrupts on any line or set of lines to be selectively ignored. Note that there are eight interrupt lines available but only six are used. The other two may be implemented for other uses if desired. If more than one interrupt is pending at a time, the one with the lower line number is taken first.

4.2.3 Teletype Interrupt Processor

If the teletype key is hit, the interrupt is processed by the routine, TTYH. If the teletype key was a CTRL-A, CTRL-Z, or ESC, then immediate action is taken. A CTRL-A simulates an antenna switch interrupt while CTRL-Z simulates a zeroing switch interrupt (which normally occurs once each revolution). In either case, the corresponding interrupt processor is entered. ESC clears the teletype input buffer and stops any printing that may be going on.

If sense switch 3 is on, all other teletype characters are ignored. Otherwise, the character is stored in a buffer for later processing. The buffer is circular and holds 20 characters so that if more than this number is entered, before they can be processed, then later ones will replace earlier ones.

4.2.4 Clock Interrupt Processor

During the time when the clock is on, it interrupts once at the end of each 100 μsec. interval measured from the time it was turned on. During the period when the peak detector (memory voltmeter) is on, i.e., signals from the switch are being looked at, clock interrupts are directed to the processor "CLOK". At each interrupt, a counter (CCTR) is incremented and compared with a fixed number (NCS). If the counter is less than the limit, nothing more is done and the interrupted program is resumed. When the counter reaches the limit, the peak detector is turned off by executing 'EXC PDF', the A/D converter is turned on by executing 'EXC ADN', and location 1 is changed so that future clock interrupts go to the 'AUTT' auto-cycle processor.

4.2.5 Antenna Switch Interrupt Processor

Each time the switch moves into position so that the peak detector should be turned on to look at one of the elements, the switch interrupts to this processor. The peak detector is turned on with a 'EXC PDN'. The processor then determines how long the peak detector is to be left on in the following manner. If there is a non-zero value in the location NCS+1 (as stored there by the use of the 'L' control code) then that value is placed in NCS. If NCS+1 is zero, then the number in CCTR, which represents the total time since the last switch interrupt occurred, is divided by three and stored in NCS. In this automatic mode, the peak detector will always be on for one third of the time between switch interrupts. The clock is then turned on, and future clock interrupts are directed to the processor 'CLOK' by changing the address in location 1.

4.2.6 Clock Interrupt Processor - Automatic Cycle

During the time when the clock is running but the peak detector is off, clock interrupts are handled by the routine 'AUTT'. Each time an interrupt occurs, CCTR is incremented and compared with the value in AUTC which may be set by the use of the 'I' control code. If AUTC is greater than zero and if CCTR is greater than or equal to AUTC, then a fake switch interrupt is generated. This automatic cycling is sometimes useful in debugging the program when no real interrupts from the switch are available. If AUTC is zero, no automatic cycling takes place and if also NCS+1 is non-zero, indicating a fixed peak detector on-time, then the clock is turned off since it is not needed.

4.2.7 Analog/Digital Converter Interrupt Processor

The A/D Converter interrupts each time it has finished converting a number, or about 29 μsec after it is signaled to begin conversion. When the interrupt occurs, the processor reads the digital result and stores it in the A table (ATAB). The location APTR contains the address in ATAB into which the current antenna value is to be stored. The processor increments APTR and if it then points above the top of the table, resets it to the start of ATAB.

4.2.8 Zeroing Switch Interrupt Processor

Once each revolution of the antenna switch this interrupt is given for the purpose of positively synchronizing the position of the switch with the pointer, APTR, in ATAB. When the interrupt occurs, APTR is set to the beginning of the input table, ATAB.

4.2.9 BNBC: Binary to BCD Conversion

This routine is called with a binary number in the A register and returns the BCD equivalent in the A and B registers. The low order four

decimal digits of four bits each are in the B register while the high order digit is in the A register. The number is assumed to be positive.

4.2.10 Teletype Output Routines

The routines TCW and TCAW are used only during initialization to set up the teletype, and at no other time. If the teletype is busy, they enter a loop and wait for it to finish.

4.2.11 FATN: Floating Point Arctangent

This subroutine computes the arctangent in degrees between 0^{o} and 360^{o} of X/Y where X and Y are the two floating point arguments whose addresses are given in the calling sequence. The program computes either X/Y or Y/X whichever results in a magnitude between zero and one and uses the Varian routine, XATN, to actually compute the inverse tangent. The correct quadrant for the result is determined from the signs of X and Y and the integer answer is returned in the A register.

4.2.12 FSQT: Floating Point Square Root

FSQT computes the floating point square root of the floating point number whose address is given in the calling sequence. The result is stored back in the location of the argument. The sign word is ignored and unchanged. The Varian routine, XSQT, is used to take the square root.

4.2.13 FNMZ: Floating Point Normalization

This routine is entered with a double precision fraction in the A and B registers and exponent in the X register. It returns with the fraction normalized in the A and B registers and the exponent adjusted accordingly. Note that if the fraction is all zeros, then the X register is made to be the largest possible positive number which corresponds to the smallest possible exponent.

4.2.14 FMPY: Floating Point Multiply

FMPY computes the product of two floating point numbers whose addresses are given in the call. The result is returned with the exponent in the A register and the fraction in the B register and no sign given since the signs of the operands are ignored.

4.2.15 XDCO: Double Precision Complement

This is a Varian supplied routine which takes the 2's complement of the double precision number in the A and B registers and leaves it in the A and B registers.

4.2.16 FADD: Floating Point Addition

The magnitude of the two floating point arguments whose addresses are contained in the calling sequence are added together and the result returned with the fraction in the A register and the exponent in the B register.

4.2.17 XSQT: Fixed Point Square Root

This Varian routine takes the square root of the number in the A register and returns it in the A register. If the number is negative, the error exit in the call is used.

4.2.18 XATN: Fixed Point Arctangent

This Varian supplied routine takes the arctangent of the number in the A register, which must be between zero and one in magnitude and returns the result in radians in the A register.

4.2.19 POLY: Polynomial Evaluator

This routine is used by several of the Varian functions to evaluate the polynomials used to compute the sine, cosine, arctan, etc. See the Varian manuals for details.

4.2.20 XDAB, XFLT: Integer to Floating Point Conversion

These two subroutines are used to convert a double precision integer into a floating point equivalent. XDAB takes the absolute value of the integer whose address is given in the call and stores it back in that address and also puts the sign in the third word. XFLT takes the number in this form and converts it to the program's floating point form.

4.2.21 XSIN, XCOS: Fixed Point Sine and Cosine

These are Varian supplied routines which compute the sine and cosine of the angle in the A register and return the result in the A register. See the Varian manuals for details on scaling.

4.2.22 AVG: Fixed Point Averaging

This routine is used to smooth out the values used for the antenna calculations. The arguments are a new value in the A register, the old value in the B register and a weighting factor (n) in the X register. The result, returned in the B register, is the value of the expression (B (X-1)+A)/X, where A, B, and X represent the numbers in those registers. Thus, this is a weighted average found by taking n - 1 parts of the old value and one part of the new value and dividing the sum by n. Note that if n is 1, the answer is equal to the new value or if n is 2, the answer is the normal arithmetic average of the old and new values given.

4.3.0 Initialization

This section of code simply sets up pointers and prepares the computer and teletype for the regular program run. It is entered whenever the program is started (at location 0200), whenever the control code 'R' is used and whenever the program is re-started after control code 'H' is used.

4.3.1 MLOOP: Main Program Loop (Fig. 6)

This is the main processing loop of the direction finder system. It calls on DF 2.6 (TTIN) to handle teletype input and uses the subroutines already covered in part DF 1.6 to process antenna data. Each call on TTIN processes not more than one input character and if output is produced, TTIN returns rather than waiting for the teletype to finish printing a previous character. The output is completed on subsequent calls to TTIN whenever the teletype is free.

If sense switch 1 is on, then antenna data processing immediately follows each call on TTIN. If sense switch 1 is off, then the data is processed only once each time sense switch 2 is turned on and then off.

The first instruction during the scan of the antenna data is to move the values corresponding to each antenna from the A table (ATAB) into the B table (BTAB) and at the same time set any negative values to zero. Once the values are in BTAB they will not be changed by the interrupt routines, and therefore a complete scan can be made of the one set of numbers. A search is made to find the largest signal present. If this signal is lower than the value specified by the 'J' control code (stored in T1+4) then transfer is made to LOSG and the entire set of values is ignored. If the signal is large enough, then the data will be processed. The counter at T1+9 is reset to the value entered with the control code 'Q' (in T1+8) so that the next time a low signal is found, the full delay will be used before the displays are blanked.

The highest signal is multiplied by the value entered with the 'K' control function and divided by 1000 and then compared with each of the antenna levels. If any level is less than this, then that level is set to zero.

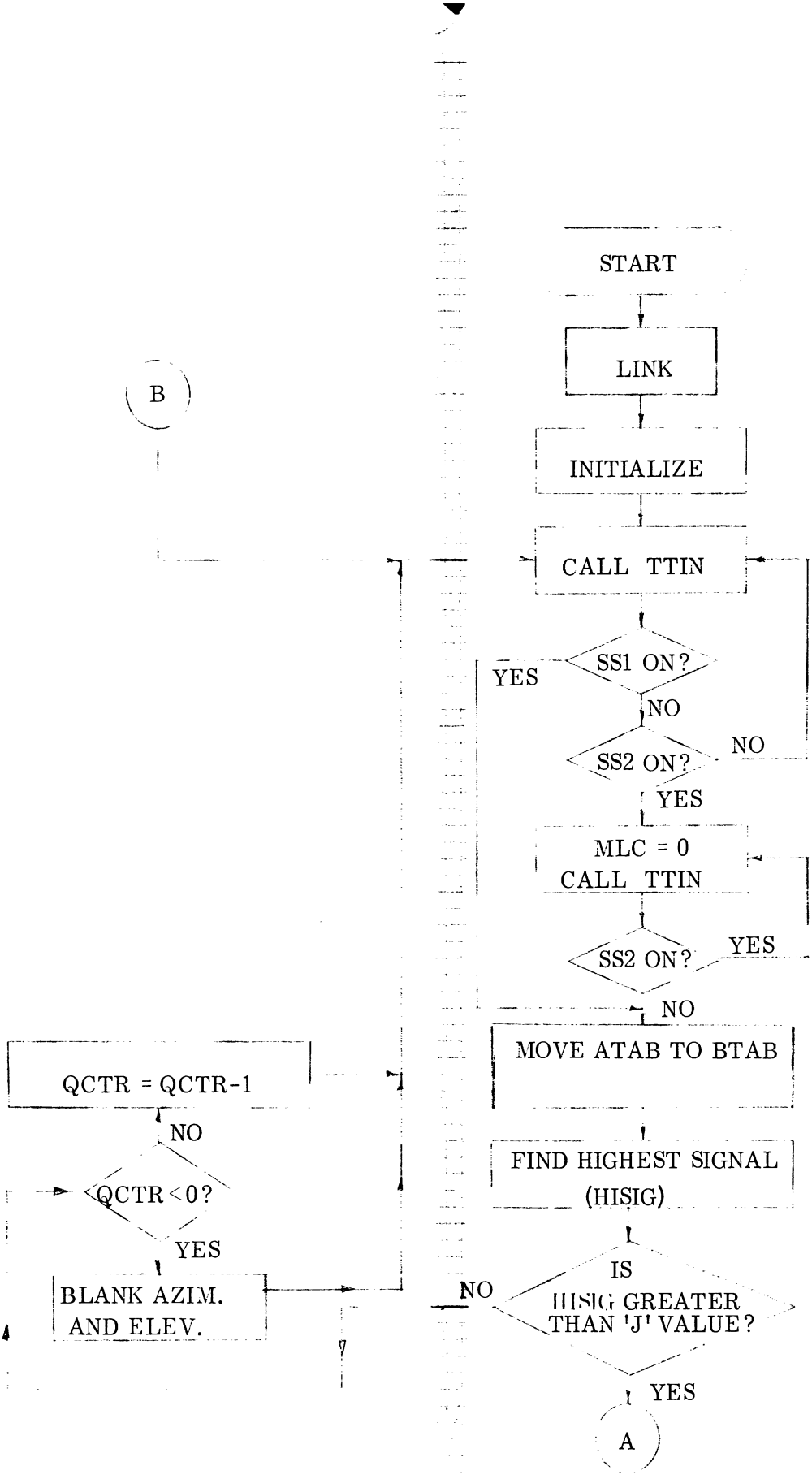

FIG. 6a: FLOW CHART FOR MAIN LOOP.

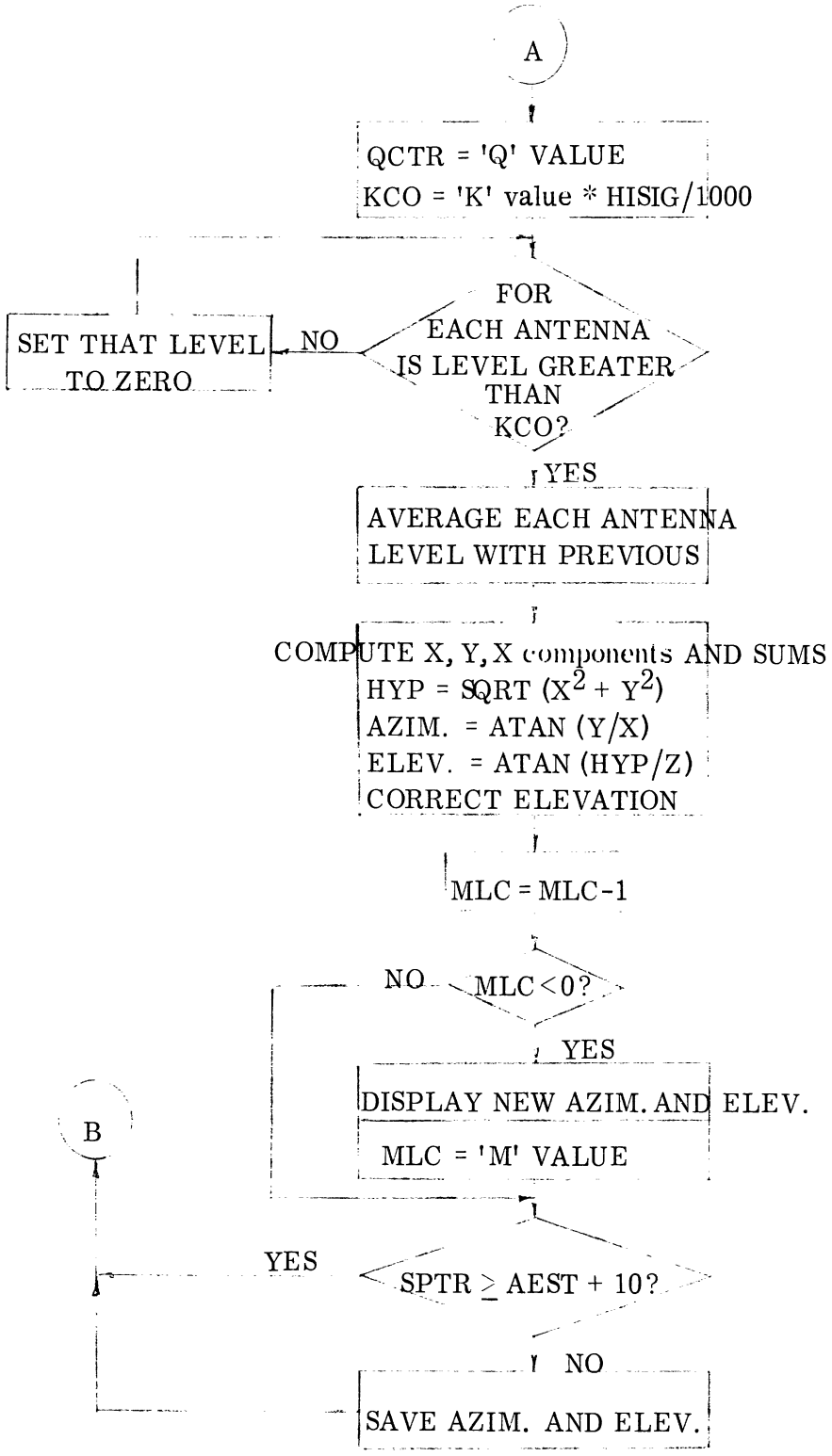

FIG. 6b: FLOW CHART FOR ANTENNA SCAN OF MAIN LOOP.

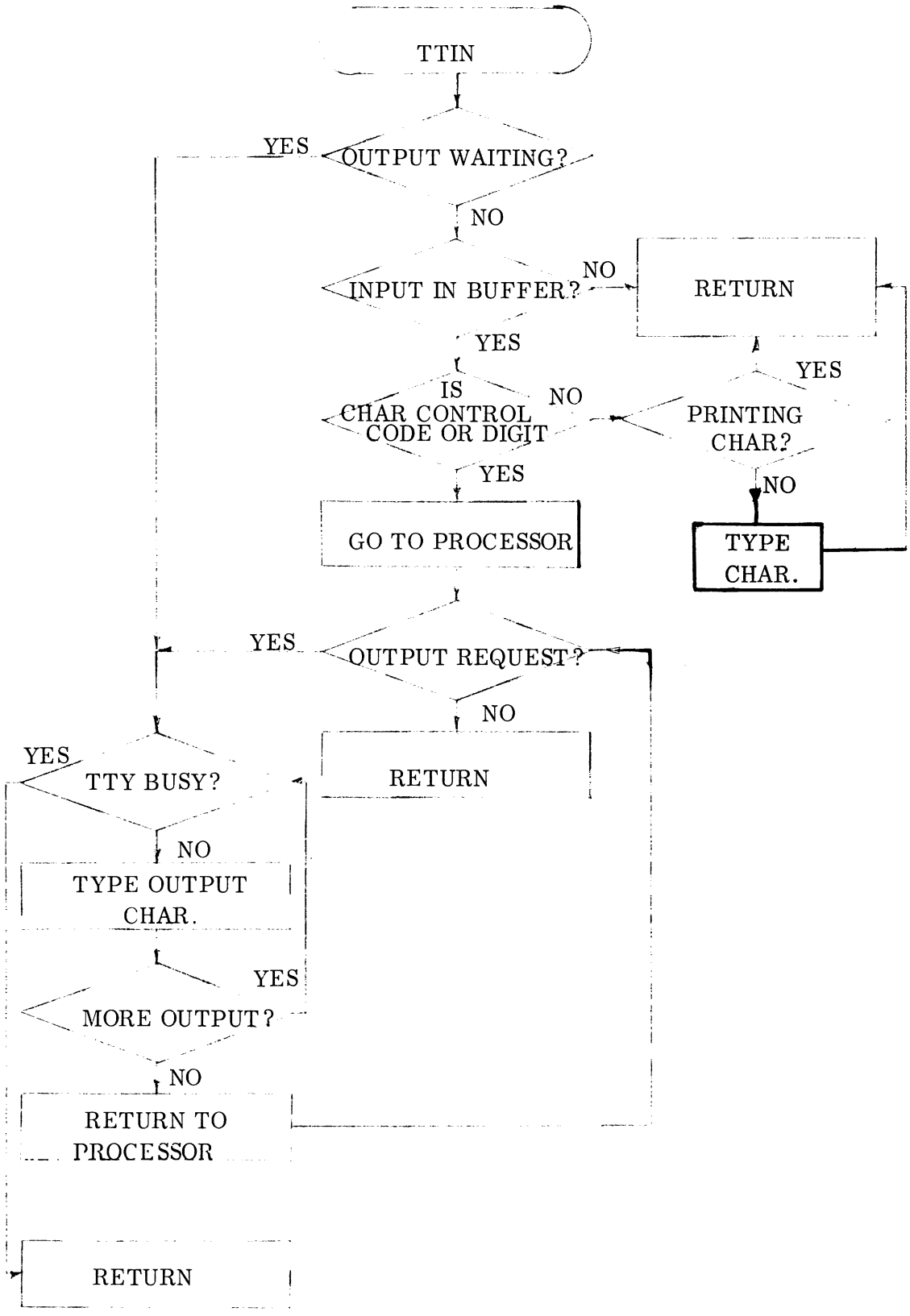

FIG. 6c: FLOW CHART FOR TELETYPE PROCESSOR.

Next, the signal on each antenna is averaged with previous levels on the same element. The subroutine, AVG, is used with the weighting factor given with the control code 'F' (stored in T1+7). Each entry in BTAB (multiplied by sixteen) is averaged with the corresponding entry in the U table (UTAB) and the result stored back in UTAB and in BTAB (divided by 16).

Now the signal from each element is broken up into its X, Y, and Z components by multiplying each antenna value by the corresponding values in the X, Y, and Z coefficients tables. These components are each added to the corresponding sums using double precision addition to form the composite components. Each of these is converted to floating point. The square root of the sum of the X and Y components is computed and stored in HYP. The azimuth angle is then the arctan of the Y component divided by the X component, while the elevation angle is the arctan of HYP over the Z component. The elevation result must then be corrected for the lack of antennas on the lower hemisphere by using the piecewise linear approximation whose break points and slopes are stored in the W table (WTAB). The first four entries are the differences in the breakpoints in terms of the computed elevation, the second four are the numerators of the slope up to the break point, the third four are the denominators of the slope and the last four the values of the break points at the lower end of the linear section in terms of the corrected angle. The differences are subtracted successively from the computed elevation angle until the result goes negative. Then the last difference is added back and the sum multiplied by the corresponding numerator, divided by the denominator and added to the lower break point to form the corrected elevation angle.

At this point the counter in MLC is decremented. If it goes negative, then the currently computed values for the azimuth and elevation are displayed on the NIXIE tubes and MLC is reset to the value entered with the 'M' control code which is stored in MLC+1. If the counter is positive, the displays are not changed.

The pointer SPTR points to a location in the table, AEST. It is set to the beginning of the table each time the control code 'G' is used and incremented once each time the antenna data is fully processed until it reaches the end of the tables. Since the current azimuth and elevation are stored in AEST each time the pointer is incremented, the ten successive values are available for use by the 'G' control code processor as soon as the pointer reaches the top of the table.

4.3.2 LOSG: Low Signal Condition

Each time that it is found that the highest level signal is less than the 'J' value, the counter in T1+9 is decremented. If the counter becomes negative then the azimuth and elevation displays are blanked. If the counter is not negative then the displays continue to register the angles for the last signal observed. Since the counter is initialized to the 'Q' value each time a good signal is found, this count down determines how long the display remains lighted after the signal is gone.

4.4.0 LINK
DF 2.6

This section of code serves to link the two separate assemblies together after they have been loaded. It stores the address of TTIN, which is in DF 2.6, in those places where it is needed in DF 1.6. The addresses needed from DF 1.6 are stored in a table following the call on LINK (loc 3000) while the addresses needed from DF 2.6 are assembled into the code.

4.4.1 TTIN: Teletype Input Processor

Each time a character comes in from the teletype, it is stored in a buffer by the interrupt time routine, TTYH, Each time TTIN is called and there is no output waiting for the teletype, the next character, if any, is taken from the buffer and examined. If a character is found, and is either a decimal digit or one of the control codes found in the table, TTAB, then the appropriate processor is entered. Otherwise, the character is typed out if it is non-printing or ignored if it is a printing character.

4.4.2 TCAR, TCBR: Teletype Output Control

Each time one of the processors in DF 2.6 wants to print something out on the teletype, it calls TCAR with the output in the A register or TCBR with the output in the B register. Two characteris can be typed from the register; the low order eight bits first then the high order eight bits. If the high order bits are all zero, only the low order bits are printed. If the teletype is busy printing when an attempt to print something else occurs, all three high speed registers are saved and control returned to the program that called TTIN. The next time TTIN is called, a check is made to see whether there is something waiting to be printed out, as evidenced by the fact that loatction TOCH is non-zero. If something is waiting, but the teletype is still busy, TTIN returns immediately. Otherwise, the new character is printed. When the output from a call on TCAR or TCBR is finally completed in this manner, the subroutine returns to the processor which originally called for output. Note that the ESC control function inhibits further print out simply by storing a zero in location TOCH and thus may not have the desired effect if it occurs during the control code processing before the output routines are called. This, however, seldom occurs and does not cause any trouble.

4.4.3 PRAD: Decimal Printout

The number in the A register is printed out as a decimal integer. If it is negative a minus sign is printed but if it is positive, no plus sign is given. PRAD uses BNBC to convert the number to BCD and then converts each digit to teletype code by adding 0260 octalto the BCD code.

4.4.4 SNCS: Special Sine and Cosine

This subroutine computes the sine and cosine of the angle in the A register divided by the scale factor at location TPSF, the latter being the value stored by the use of the 'S' control code. The angle in the A register is in degrees and the sine is returned in the A register with the cosine in the B register.

4.4.5 GADR: Get Table Address

GADR computes the actual address of the location of the table entry given by the element number in EL (stored there by the use of the ',' control code) and the displacement of the table from the A table in EL+1 (stored as the result of the use of one of the table specification codes, 'A', 'B', 'X', etc.). This address is returned in the X register. A check is made to see that the element number is greater than zero and less than or equal to the number of elements as specified by the value in NANT which is set by the 'N' control code. If EL is outside this range, a normal return is not made, but rather control is given to the address specified in the calling sequence. Note that the number in EL is incremented after it is used by each all on GADR.

4.4.6 GTNM: Get Input Number

A call on GTNM returns in the A register the value of the current input number which has been accumulated as digits were entered. It also resets things so that when more digits are typed in, they will begin forming a new number.

4.4.7 SACN: Store as Current Number and Print

The number in the A register is stored as the current input number and also printed on the teletype. If anything has already been typed in as the current number, it is lost.

4.4.8 VSOP: Store or Print Variable

This section of code is used by many of the control codes which set or print the value of a simple variable parameter. At the time the JMP to VSOP is made, the A register should contain the address of the variable to be referenced. If there have been digits entered as the current input number, then that value is stored at the address given and the control letter is printed out. If no current input number exists then the number currently stored at the address given is printed followed by the control letter.

4.4.9 TTAB: Teletype Character Table

This table contains entries for all the legal control codes recognized by the direction finder system. Each table entry consists of two words, the first of which is the 620/i internal code for the teletype character and the second of which is the address of the routine which processes that character. The end of the table is designated by an entry whose first word is zero. Extra space has been left at the end of the table to allow for the addition of new control codes.

4.5.0 Teletype Character Processors

Many of the processors which simply use VSOP to store or print the value of a variable and some others which are straight-forward and self-explnaatory will not be described in detail here since their operation can be easily seen from the assembly listings. Note that at the time any of the processors are entered, the A register is zero, the B register has the 620/i internal code for the teletype character and the X register has the number of digits contained in the current input number.

4.5.1 STV: Store or Print Table Entry

Each time the control code '/' is used and a current input number exists, that number is stored in the current entry of the current table as determined from EL and EL+1 by GADR. Since GADR increments the table entry pointer, the next time '/' is used to store or print a table value, the new value will be stored in or come from the next higher table entry. Operation when the table value is printed out is slightly different, however. When the entry is printed it is also established as the current input number and the table pointer which was incremented by GADR is decremented by STV so that it still points at the same entry. Thus, if a table entry has been printed out and it is desired to change it, the current number must be deleted, the new value entered and a '/' typed to store the new value.

4.5.2 DIG: Digit Entry Processor

DIG is entered from a different place than the other processors and in a manner such that the A register contains the numerical value of the digit typed in. Since the multiply instruction on the 620/i adds the A register to the product when it is executed, it provides a very easy way to accumulate a decimal number. The accumulated number is in INUM, the sign is in INUM+1 and the count of the number of digits in the number is in INUM+2.

4.5.3 EQLS: Complete Table Listing

When a question mark is typed, all the entries of the current table are printed out. This routine prints the letter associated with the table, then '1' to indicate that the first entry follows and then loops printout each of the entries. After nine entries have been printed, a carriage return and line feed are given to insure that there is room for all the digits to be printed on the teletype paper.

4.5.6 A: Select Table

Whenever any of the control codes which specify a table to be used is typed in, this routine computes the displacement of the table from the A table and stores it in EL+1 so that GADR can use it. The character associated with the table is stored in EL+2 so that EQLS can use it. The codes involved are 'A', 'B', 'P', 'T', 'U', 'W', 'X', 'Y', 'Z'.

4.5.7 C: Calculation of the X, Y, and Z coefficients

When the θ and ϕ tables are changed, there is no immediate effect on the antenna calculation because these tables are not used directly. In order that the information in these tables be used, the control code 'C' must be given. This causes the angles in the θ and ϕ tables to be used to compute coefficients stored in the X, Y, and Z tables which are used by the antenna data processing loop. The program uses SNCS to compute the sine and cosine of each of the angles and from these computes the desired coefficients.

4.5.8 DBUG: Debug Routine Entry

During debugging of the program it is useful to be able to easily transfer to the debug routine. The control code 'CTRL-D' provides this ability. Normally, the program will ignore this code but if the address in the JMP instruction is changed to that of the beginning of the debugging routine then the interrupts will automatically be turned off and the routine called.

4.5.9 G: Print Hi, Lo, and Average of 10 Scans

Every time the control code 'G' is recognized, the pointer, SPTR, is reset to the beginning of the table, AEST, where the azimuth and elevation angles are to be saved The 'G' processor then waits for the ten values of each to be stored by typing out RUBOUT's until SPTR has been incremented enough by the antenna data processing loop. Then the subroutine PHLA is called to type out the high, low, and average of the ten entries each of azimuths and of elevations.

4.6.0 Note on the Tapes Supplied with the System

Both source and object tapes for the direction finder system are supplied along with various source and object tapes from Varian which come with the computer.

There are two forms of object tapes for the direction finder program. One is marked 'direction finder - with corrections - complete'. This contains all the code needed by the program and includes correct values in all the tables and parameters. It may be simply loaded using the regular 620/i loader and run (start at 0200). The other form consists of three separate tapes. Two are the object tapes produced by the assembler and are labeled 'DF 1.6 (DAS)' and 'DF 2.6 (DAS)'. The third tape contains corrections to these first two and is labeled 'corrections to DF 1.6 and DF 2.6'. Note that there are four corrections involved and that they have been made in the source tapes and listing. To use the second form, load the tapes into the computer in the order names above and start at location 0200. Once this has been done and the program is running, the tables and parameters may be initialized from the tape marked 'SETUP', by placing the tape in the reader and turning it on.

The source tapes consist of 17 tapes for DF 1.6 and 11 tapes for DF 2.6, each tape identified by 'DF n.6 (m)', where n is either 1 or 2 and m is the sequential tape number. Each tape ends with a 'MORE' pseudo-op so the assembler will stop there. The last tape in each asembly has the 'MORE' followed by an 'END' statement to complete the assembly. Each tape makes a one page listing when printed on the teletype and all the tapes may be combined together to make one long tape.

ASSEMBLY LISTINGS

```
*
* DF 1.6 (EC118) (1)
*
* EQU'S
*
        000001    RX    ,EQU  ,01
        000002    RB    ,EQU  ,02
        000040    PIM   ,EQU  ,040      PGM INT MSK
        000140    PIC   ,EQU  ,0140     CLR INT MODULE
        000240    PIN   ,EQU  ,0240     PGM INT ON
        000340    PICN  ,EQU  ,0340     PGM INT CLR/ON
        000440    PIF   ,EQU  ,0440     PGM INT OFF
        000540    PII   ,EQU  ,0540     INIT PGM INT MOD
        000057    ADC   ,EQU  ,057      A/D (INPT)
        000056    ADN   ,EQU  ,056      A/D ON
        000044    ADCB  ,EQU  ,044      A/D BUSY (SEN)
        000054    PDN   ,EQU  ,054      PEAK DET. ON
        000055    PDF   ,EQU  ,055      P/D OFF
        000046    CLKN  ,EQU  ,046      CLOCK ON
        000047    CLKF  ,EQU  ,047      CLOCK OFF
        000051    DISE  ,EQU  ,051      ELEV DISPLAY
        000050    DISA  ,EQU  ,050      AZIM DISPLAY
*
* INTERRUPT LOCS
*
000000                  ,ORG  ,0
000000  002000    ILOC  ,JMPM ,CLOK     LINE 01 - CLOCK
000001  000736 R
000002  002000        ,JMPM ,SWP        02 - ANTENNA SW
000003  000757 R
000004  002000        ,JMPM ,SWPZ       03 - ZERO SW
000005  001037 R
000006  002000        ,JMPM ,ECON       04 - A/D DONE
000007  001050 R
000010  005000        ,NOP  ,           05 - TTY DONE (IGNORED)
000011  005000        ,NOP  ,
000012  002000        ,JMPM ,TTYH       06 - TTY HIT
000013  000660 R
*
        000020    IAOR  ,BEGI ,020      POINTERS
        000040    LTOR  ,BEGI ,040      LITERALS
*
000200                  ,ORG  ,0200
000200  002000        ,CALL ,03000      (LINK WITH PART 2)
000201  003000
000202  001000        ,JMP  ,INIT       BEGIN SCAN
000203  002020 R
000204  002062 R        ,DATA ,MLOOP+1,MLOOP+11,0 (REF TO TTIN)
000205  002074 R
000206  000000
000207  001070 R        ,DATA ,BNBC,XCOS,XSIN,0 (ADR NEEDED BY PART 2)
000210  001762 R
000211  001723 R
000212  000000
```

```
000230                  ,ORG  ,0230
*
* DF 1.6 (EC118) (2)
*
* STORAGE
*
000230  000000    MLC   ,DATA ,0,0      MLOOP COUNTER
000231  000000
000232  000001    TPSF  ,DATA ,1        THETA/PHI SCALE FACTOR
000233  000144    NCS   ,DATA ,100,0    NBR CLOCK CYCLES FOR PDN
000234  000000
000235  000000    EL    ,DATA ,0,0,0    ELEMENT NR,TABLE,LETTER
000236  000000
000237  000000
000240  000001    NANT  ,DATA ,1        NBR ANTENNAS
000241  000000    AUTC  ,DATA ,0        NBR CLK CYCLES FOR AUTO CYCLE
000242  000372 R  SPTR  ,DATA ,AEST     AZIM, ELEV SAVE TABLE PTR
000243                  ,BSS  ,10
000255            IMSK  ,BSS  ,1        INTERRUPT MASK
000256            CCTR  ,BSS  ,1        CLK CNTR
000257            SVD   ,BSS  ,2        SAVED AZIM. & ELEV.
000261            SAVR  ,BSS  ,3        SAVE REG
000264            ISVR  ,BSS  ,3        SAVE REG
000267            TSVR  ,BSS  ,3        SAVE REG
000272            ESVR  ,BSS  ,3        SAVE REG
000275            APTR  ,BSS  ,1        ATAB PTR
000276            SZCT  ,BSS  ,1        ZERO SW CTR
000277            TOSI  ,BSS  ,1        TOS PTR OUT
000300            TOSP  ,BSS  ,1        TOS PTR IN
000301            TOS   ,BSS  ,20       TYPE IN STACK
000326            TOSL  ,BES  ,2
000327            T1    ,BSS  ,10       TEMP
000341            T2    ,BSS  ,5        TEMP
000346            INUM  ,BSS  ,3        INPUT NR, SIGN & COUNT
000351            TOCH  ,BSS  ,3        TTY OUT CHAR & REG SAVE
000354            XSUM  ,BSS  ,3
000357            YSUM  ,BSS  ,3
000362            ZSUM  ,BSS  ,3
000365            HYP   ,BSS  ,3
000370            FATT  ,BSS  ,2        FATN TEMP
000372            AEST  ,BSS  ,20       AZIM, ELEV SAVE TABLE
000416            ATAB  ,BSS  ,17       INPUT TABLE
000437            BTAB  ,BSS  ,17       WORK TABLE (ATAB+17)
000460                  ,BSS  ,17       X COEF TABLE (+34)
000501                  ,BSS  ,17       Y COEF TABLE (+51)
000522                  ,BSS  ,17       Z COEF TABLE (+68)
000543                  ,BSS  ,17       PHI TABLE    (+85)
000564                  ,BSS  ,17       THETA TABLE (+102)
000605                  ,BSS  ,17       U TABLE     (+119) ANTENNA AVGS
*     ,BSS  ,17       W TABLE     (+136) ELEV CORR TABLE
000626  000012    WTAB  ,DATA ,10,30,20,077777 BREAK POINT (INCREMENTS)
000627  000036
000630  000024
000631  077777
```

```
000632  000001          ,DATA ,1,3,7,0 MULTIPLY (NUMERATOR)
000633  000003
000634  000007
000635  000000
000636  000001          ,DATA ,1,2,4,1 DIVIDE (DENOMINATOR)
000637  000002
000640  000004
000641  000001
000642  000000          ,DATA ,0,10,55,90 ADD
000643  000012
000644  000067
000645  000132
*
* DF 1.6 (EC118) (3)
*
* ERHLT
*
000646  000000    ERHLT ,ENTR ,         ERROR HALT
000647  050272          ,STA  ,ESVR
000650  060273          ,STB  ,ESVR+1
000651  070274          ,STX  ,ESVR+2
000652  000111          ,HLT  ,0111     PUSH 'RUN' TO RESTART
000653  010272          ,LDA  ,ESVR
000654  020273          ,LDB  ,ESVR+1
000655  030274          ,LDX  ,ESVR+2
000656  001000          ,RETU* ,ERHLT
000657  100646 R
*
* TTY INTERPT PROC
*
000660  000000    TTYH ,ENTR ,          HERE IF TTY KEY HIT
000661  050267          ,STA  ,TSVR
000662  102501          ,CIA  ,01       (TTY)
000663  140040          ,SUB  ,=0201    (201=CTL-A)
000664  001010          ,JAZ  ,TTY1
000665  000715 R
000666  140041          ,SUB  ,=031     (232=CTL-Z)
000667  001010          ,JAZ  ,TTY1+5
000670  000722 R
000671  005311          ,DAR  ,         (233=ESC)
000672  001010          ,JAZ  ,TTY1+10
000673  000727 R
000674  100240          ,EXC  ,PIN
000675  001400          ,JSS3 ,TTY1-3   (IGNORE CHAR IF SS3 IS ON)
000676  000712 R
000677  070271          ,STX  ,TSVR+2
000700  030300          ,LDX  ,TOSP
000701  120042          ,ADD  ,=0233
000702  055000          ,STA  ,0,RX     SAVE CHARACTER
000703  005145          ,INCR ,045      (X+1 TO X & A)
000704  140043          ,SUB  ,=TOSL
000705  001004          ,JAN  ,*+3
000706  000710 R
000707  030044          ,LDX  ,=TOS
```

```
000710  070300          ,STX   ,TOSP
000711  030271          ,LDX   ,TSVR+2
000712  010267          ,LDA   ,TSVR
000713  001000          ,JMP*  ,TTYH
000714  100660 R
*
000715  010267     TTY1 ,LDA   ,TSVR     FAKE A SWITCH INTERRUPT
000716  002000          ,CALL  ,SWP
000717  000757 R
000720  001000          ,JMP*  ,TTYH
000721  100660 R
*
000722  010267          ,LDA   ,TSVR     FAKE A ZERO SW INT (CTL-Z)
000723  002000          ,CALL  ,SWPZ
000724  001037 R
000725  001000          ,JMP*  ,TTYH
000726  100660 R
*
000727  010300          ,LDA   ,TOSP     CLEAR TTY BUFFERS (ESC)
000730  050277          ,STA   ,TOSI
000731  005001          ,TZA   ,
000732  050351          ,STA   ,TOCH
000733  100240          ,EXC   ,PIN
000734  001000          ,JMP   ,TTY1-3
000735  000712 R
*
* DF 1.6 (EC118) (4)
*
* CLOCK IN PROC
*
000736  000000     CLOK ,ENTR  ,
000737  050264          ,STA   ,ISVR
000740  040256          ,INR   ,CCTR
000741  010256          ,LDA   ,CCTR
000742  140233          ,SUB   ,NCS
000743  001002          ,JAP   ,*+6
000744  000751 R
000745  010264     CLK1 ,LDA   ,ISVR
000746  100240          ,EXC   ,PIN
000747  001000          ,JMP*  ,CLOK
000750  100736 R
000751  100055          ,EXC   ,PDF
000752  010045          ,LDA   ,=AUTT
000753  050001          ,STA   ,1
000754  100056          ,EXC   ,ADN
000755  001000          ,JMP   ,CLK1
000756  000745 R
*
* ANTENNA SWITCH INTERRUPT PROCESSOR
*
000757  000000     SWP  ,ENTR  ,
000760  100054          ,EXC   ,PDN
000761  100047          ,EXC   ,CLKF
000762  050264          ,STA   ,ISVR
```

```
000763  060265          ,STB   ,ISVR+1
000764  020234          ,LDB   ,NCS+1
000765  005001          ,TZA   ,
000766  001020          ,JBZ   ,*+5
000767  000773 R
000770  050256          ,STA   ,CCTR
000771  001000          ,JMP   ,*+5
000772  000776 R
000773  020256          ,LDB   ,CCTR
000774  050256          ,STA   ,CCTR
000775  170046          ,DIV   ,=3
000776  100046          ,EXC   ,CLKN
000777  060233          ,STB   ,NCS
001000  020047          ,LDB   ,=CLOK
001001  060001          ,STB   ,1
001002  010264          ,LDA   ,ISVR
001003  020265          ,LDB   ,ISVR+1
001004  100240          ,EXC   ,PIN
001005  001000          ,JMP*  ,SWP
001006  100757 R
*
* AUTT: AUTO CYCLE
*
001007  000000    AUTT  ,ENTR  ,
001010  050264          ,STA   ,ISVR
001011  040256          ,INR   ,CCTR
001012  010241          ,LDA   ,AUTC
001013  001010          ,JAZ   ,AUT1
001014  001031 R
001015  140256          ,SUB   ,CCTR
001016  001004          ,JAN   ,*+6
001017  001024 R
001020  010264    AUT2  ,LDA   ,ISVR
001021  100240          ,EXC   ,PIN
001022  001000          ,JMP*  ,AUTT
001023  101007 R
*
* DF 1.6 (EC118) (4A)
*
* AUTT (CONCL.)
*
001024  010264          ,LDA   ,ISVR
001025  002000          ,CALL  ,SWP
001026  000757 R
001027  001000          ,JMP*  ,AUTT
001030  101007 R
001031  010234    AUT1  ,LDA   ,NCS+1
001032  001010          ,JAZ   ,AUT2
001033  001020 R
001034  100047          ,EXC   ,CLKF
001035  001000          ,JMP   ,AUT2
001036  001020 R
*
* SWPZ: ZERO SWITCH INT PROC
```

```
*
001037  000000     SWPZ ,ENTR ,
001040  050264          ,STA  ,ISVR
001041  040276          ,INR  ,SZCT
001042  010050          ,LDA  ,=ATAB
001043  050275          ,STA  ,APTR
001044  010264          ,LDA  ,ISVR
001045  100240          ,EXC  ,PIN
001046  001000          ,RETU* ,SWPZ
001047  101037 R
*
* DF 1.6 (EC118) (5)
*
* A/D CONV INT PROC
*
001050  000000     ECON ,ENTR ,          HERE WHEN A/D CONV DONE
001051  050264          ,STA  ,ISVR
001052  102557          ,CIA  ,ADC
001053  057275          ,STA* ,APTR
001054  040275          ,INR  ,APTR
001055  010275          ,LDA  ,APTR
001056  140050          ,SUB  ,=ATAB
001057  140240          ,SUB  ,NANT
001060  001004          ,JAN  ,*+4
001061  001064 R
001062  010050          ,LDA  ,=ATAB
001063  050275          ,STA  ,APTR
001064  010264          ,LDA  ,ISVR
001065  100240          ,EXC  ,PIN
001066  001000          ,RETU* ,ECON
001067  101050 R
*
* BNBC - BIN TO BCD CONV
*
001070  000000     BNBC ,ENTR ,          'A' REG HAS BIN NBR WHICH
001071  050261          ,STA  ,SAVR      IS TO BE CONVERTED
001072  070263          ,STX  ,SAVR+2    TO BCD
001073  030051          ,LDX  ,=4
001074  005002          ,TZB  ,
001075  005001     BNB5 ,TZA  ,
001076  060262          ,STB  ,SAVR+1
001077  020261          ,LDB  ,SAVR
001100  170052          ,DIV  ,=10
001101  060261          ,STB  ,SAVR
001102  020262          ,LDB  ,SAVR+1
001103  004544          ,LLSR ,4
001104  005344          ,DXR  ,
001105  001040          ,JXZ  ,*+4
001106  001111 R
001107  001000          ,JMP  ,BNB5
001110  001075 R
001111  010261          ,LDA  ,SAVR      RETURN BCD RESULT IN A
001112  030263          ,LDX  ,SAVR+2    AND B REGS
001113  001000          ,RETU* ,BNBC     X REG UNCHANGED
```

```
001114  101070 R
*
* TCW: WAIT & TYPE CHAR
*
001115  000000    TCW  ,ENTR ,          CHAR IN LOC AFTER CALL
001116  017020 I       ,LDA* ,TCW       IS TYPED
001117  002000         ,CALL ,TCAW
001120  001124 R
001121  041115         ,INR  ,TCW
001122  001000         ,RETU* ,TCW
001123  101115 R
*
* TCAW: WAIT & TYPE CHAR FROM 'A' REG
*
001124  000000    TCAW ,ENTR ,
001125  101101         ,SEN  ,0101,*+5 WAIT FOR TTY TO FINISH
001126  001132 R
001127  005000         ,NOP  ,          (ALLOW INTERRUPTS)
001130  001000         ,JMP  ,*-3        ,
001131  001125 R
001132  103101         ,OAR  ,01        TYPE CHAR
001133  001000         ,JMP* ,TCAW
001134  101124 R
*
* DF 1.6 (EC118) (6)
*
* FATN: FLOAT ATAN
*
001135  000000    FATN ,ENTR ,
001136  027021 I       ,LDB* ,FATN
001137  041135         ,INR  ,FATN
001140  037021 I       ,LDX* ,FATN
001141  041135         ,INR  ,FATN
001142  016001         ,LDA  ,1,RB
001143  145001         ,SUB  ,1,RX
001144  001010         ,JAZ  ,FAT1
001145  001260 R
001146  050370         ,STA  ,FATT
001147  001002         ,JAP  ,*+5
001150  001154 R
001151  005021    FAT2 ,TBA  ,
001152  005042         ,TXB  ,
001153  005014         ,TAX  ,
001154  016000         ,LDA  ,0,RB
001155  060371         ,STB  ,FATT+1
001156  005002         ,TZB  ,
001157  004501         ,LASR ,1
001160  175000         ,DIV  ,0,RX
001161  060327         ,STB  ,T1
001162  020371         ,LDB  ,FATT+1
001163  016001         ,LDA  ,1,RB
001164  020327         ,LDB  ,T1
001165  005311         ,DAR  ,
001166  145001         ,SUB  ,1,RX
```

```
001167  001002          ,JAP   ,*+6
001170  001175 R
001171  004001          ,ASLB  ,1
001172  005111          ,IAR   ,
001173  001000          ,JMP   ,*-4
001174  001167 R
001175  140053          ,SUB   ,=15
001176  001004          ,JAN   ,*+3
001177  001201 R
001200  005001          ,TZA   ,
001201  120054          ,ADD   ,=04117  (ASRB 15)
001202  051203          ,STA   ,*+1
001203  004100          ,ASRB  ,**0
001204  005021          ,TBA   ,
001205  002000          ,CALL  ,XATN
001206  001571 R
001207  005012          ,TAB   ,
001210  005001          ,TZA   ,
001211  160055          ,MUL   ,=229
001212  004502          ,LASR  ,2
001213  004116          ,ASRB  ,14
001214  001020          ,JBZ   ,*+3
001215  001217 R
001216  005111          ,IAR   ,
001217  020371          ,LDB   ,FATT+1
001220  050327     FAT3 ,STA   ,T1
001221  010370          ,LDA   ,FATT
001222  001002          ,JAP   ,*+8
001223  001232 R
001224  005021          ,TBA   ,
001225  005042          ,TXB   ,
001226  005014          ,TAX   ,
001227  010056          ,LDA   ,=90
001230  140327          ,SUB   ,T1
001231  050327          ,STA   ,T1
*
* DF 1.6 (EC118) (7)
*
* FATN (CONCL)
*
001232  016002          ,LDA   ,2,RB
001233  001004          ,JAN   ,*+12
001234  001247 R
001235  015002          ,LDA   ,2,RX
001236  001004          ,JAN   ,*+5
001237  001243 R
001240  010327          ,LDA   ,T1
001241  001000          ,JMP*  ,FATN
001242  101135 R
001243  010057          ,LDA   ,=180
001244  140327          ,SUB   ,T1
001245  001000          ,JMP*  ,FATN
001246  101135 R
001247  010060          ,LDA   ,=360
```

```
001250  140327          ,SUB  ,T1
001251  050327          ,STA  ,T1
001252  015002          ,LDA  ,2,RX
001253  001002          ,JAP  ,*-11
001254  001240 R
001255  010061          ,LDA  ,=540
001256  001000          ,JMP  ,*-10
001257  001244 R
001260  015000     FAT1 ,LDA  ,0,RX
001261  146000          ,SUB  ,0,RB
001262  050370          ,STA  ,FATT
001263  001010          ,JAZ  ,*+6
001264  001271 R
001265  001002          ,JAP  ,FAT2+3
001266  001154 R
001267  001000          ,JMP  ,FAT2
001270  001151 R
001271  010062          ,LDA  ,=45
001272  001000          ,JMP  ,FAT3
001273  001220 R
*
* FSQT: FLTNG SQRT
*
001274  000000     FSQT ,ENTR ,
001275  037022 I        ,LDX* ,FSQT
001276  041274          ,INR  ,FSQT
001277  015000          ,LDA  ,0,RX
001300  001010          ,JAZ* ,FSQT
001301  101274 R
001302  015001          ,LDA  ,1,RX
001303  005002          ,TZB  ,
001304  004501          ,LASR ,1
001305  055001          ,STA  ,1,RX
001306  001020          ,JBZ  ,FSQ1
001307  001313 R
001310  015000          ,LDA  ,0,RX
001311  004301          ,ASRA ,1
001312  055000          ,STA  ,0,RX
001313  015000     FSQ1 ,LDA  ,0,RX
001314  002000          ,CALL ,XSQT
001315  001554 R
001316  002000          ,CALL ,ERHLT
001317  000646 R
001320  055000          ,STA  ,0,RX
001321  001000          ,RETU* ,FSQT
001322  101274 R
*
* DF 1.6 (EC118) (8)
*
* FNMZ: FLTNG NORMALIZE
*
001323  000000     FNMZ ,ENTR ,
001324  001030          ,JIF  ,030,FNM1 (A=B=0)
001325  001340 R
```

```
001326  004041          ,LRLB ,1
001327  004441          ,LLRL ,1
001330  005144          ,IXR  ,
001331  001002          ,JAP  ,*-2
001332  001327 R
001333  005344          ,DXR  ,
001334  004477          ,LLRL ,31
001335  004141          ,LSRB ,1
001336  001000          ,RETU* ,FNMZ
001337  101323 R
001340  030063    FNM1  ,LDX  ,=077777
001341  001000          ,RETU* ,FNMZ
001342  101323 R
*
* FMPY: FLTNG MUL
*
001343  000000    FMPY  ,ENTR ,
001344  037023 I        ,LDX* ,FMPY
001345  041343          ,INR  ,FMPY
001346  027023 I        ,LDB* ,FMPY
001347  026000          ,LDB  ,0,RB
001350  005001          ,TZA  ,
001351  165000          ,MUL  ,0,RX
001352  035001          ,LDX  ,1,RX
001353  002000          ,CALL ,FNMZ
001354  001323 R
001355  005012          ,TAB  ,
001356  005041          ,TXA  ,
001357  001020          ,JBZ  ,*+4
001360  001363 R
001361  037023 I        ,LDX* ,FMPY
001362  125001          ,ADD  ,1,RX
001363  041343          ,INR  ,FMPY
001364  001000          ,RETU* ,FMPY
001365  101343 R
*
* XDCO: DBL PREC COMP
*
001366  000000    XDCO  ,ENTR ,
001367  005211          ,CPA  ,
001370  001020          ,JBZ  ,*+8
001371  001400 R
001372  005222          ,CPB  ,
001373  005122          ,IBR  ,
001374  004041          ,LRLB ,1
001375  004141          ,LSRB ,1
001376  001000          ,JMP* ,XDCO
001377  101366 R
001400  005111          ,IAR  ,
001401  001000          ,JMP* ,XDCO
001402  101366 R
*
* DF 1.6 (EC118) (9)
*
```

```
   * FADD: FLTNG ADD
   *
   001403  000000     FADD ,ENTR ,
   001404  027024 I        ,LDB* ,FADD
   001405  041403          ,INR  ,FADD
   001406  037024 I        ,LDX* ,FADD
   001407  016001     FAD2 ,LDA  ,1,RB
   001410  145001          ,SUB  ,1,RX
   001411  001002          ,JAP  ,FAD1
   001412  001420 R
   001413  005021          ,TBA  ,
   001414  005042          ,TXB  ,
   001415  005014          ,TAX  ,
   001416  001000          ,JMP  ,FAD2
   001417  001407 R
   001420  140053     FAD1 ,SUB  ,=15
   001421  001004          ,JAN  ,*+3
   001422  001424 R
   001423  005001          ,TZA  ,
   001424  120064          ,ADD  ,=04317  (ASRA 15)
   001425  051427          ,STA  ,*+2
   001426  016000          ,LDA  ,0,RB
   001427  004300          ,ASRA ,**0
   001430  125000          ,ADD  ,0,RX
   001431  025001          ,LDB  ,1,RX
   001432  041403          ,INR  ,FADD
   001433  001002          ,JAP* ,FADD
   001434  101403 R
   001435  004341          ,LSRA ,1
   001436  005322          ,DBR  ,
   001437  001000          ,RETU* ,FADD
   001440  101403 R
   *
   * XDAD: DBL PREC ADD
   *
   001441  071466          ,STX  ,XDAD+3
   001442  007400          ,ROF  ,
   001443  031463          ,LDX  ,XDAD
   001444  035000          ,LDX  ,0,1
   001445  051467          ,STA  ,XDAD+4
   001446  005021          ,TBA  ,
   001447  125001          ,ADD  ,1,1
   001450  006150          ,ANAI ,077777
   001451  077777
   001452  005012          ,TAB  ,
   001453  005001          ,TZA  ,
   001454  005511          ,AOFA ,
   001455  007400          ,ROF  ,
   001456  121467          ,ADD  ,XDAD+4
   001457  125000          ,ADD  ,0,1
   001460  041463          ,INR  ,XDAD
   001461  031466          ,LDX  ,XDAD+3
   001462  001000          ,JMP  ,0
   001463  000000
```

```
          001463 R  XDAD ,EQU  ,*-1
  001464  001000          ,JMP  ,*-19
  001465  001441 R
  001466  000000          ,DATA ,0,0
  001467  000000
  *
  * DF 1.6 (EC118) (10)
  *
  * XSQT: DBL PREC SQRT
  *
  001470  041554     BSQT ,INR  ,XSQT
  001471  041554          ,INR  ,XSQT
  001472  007400          ,ROF  ,
  001473  001010          ,JAZ* ,XSQT
  001474  101554 R
  001475  061567          ,STB  ,XSQT+11
  001476  131570          ,ERA  ,XSQT+12
  001477  001010          ,JAZ  ,*+4
  001500  001503 R
  001501  001000          ,JMP  ,*+5
  001502  001506 R
  001503  131570          ,ERA  ,XSQT+12
  001504  001000          ,JMP* ,XSQT
  001505  101554 R
  001506  131570          ,ERA  ,XSQT+12
  001507  071563          ,STX  ,XSQT+7
  001510  005006          ,ZERO ,06
  001511  005144          ,IXR  ,
  001512  004442          ,LLRL ,2
  001513  001022          ,JIF  ,022,*-2
  001514  001511 R
  001515  005344          ,DXR  ,
  001516  004456          ,LLRL ,14
  001517  061562          ,STB  ,XSQT+6
  001520  071566          ,STX  ,XSQT+10
  001521  011570          ,LDA  ,XSQT+12
  001522  051564          ,STA  ,XSQT+8
  001523  011562     SQT1 ,LDA  ,XSQT+6
  001524  171564          ,DIV  ,XSQT+8
  001525  005021          ,TBA  ,
  001526  141564          ,SUB  ,XSQT+8
  001527  051565          ,STA  ,XSQT+9
  001530  004301          ,ASRA ,1
  001531  121564          ,ADD  ,XSQT+8
  001532  051564          ,STA  ,XSQT+8
  001533  011565          ,LDA  ,XSQT+9
  001534  006120          ,ADDI ,0377
  001535  000377
  001536  001004          ,JAN  ,SQT1
  001537  001523 R
  001540  031563          ,LDX  ,XSQT+7
  001541  021566          ,LDB  ,XSQT+10
  001542  011564          ,LDA  ,XSQT+8
  001543  001020          ,JBZ  ,XSQT-3
```

```
001544  001551 R
001545  004301          ,ASRA ,1
001546  005322          ,DBR  ,
001547  001000          ,JMP  ,*-4
001550  001543 R
001551  031563          ,LDX  ,XSQT+7
001552  021567          ,LDB  ,XSQT+11
001553  001000          ,JMP  ,XSQT
001554  001554 R
        001554 R  XSQT  ,EQU  ,*-1
001555  051562          ,STA  ,*+5
001556  001004          ,JAN* ,XSQT
001557  101554 R
001560  001000          ,JMP  ,BSQT
001561  001470 R
001562                  ,BSS  ,6
001570  077777          ,DATA ,077777
*
* DF 1.6 (EC118) (11)
*
* XATN: FIXED POINT ATAN
*
001571  000000     XATN ,ENTR ,
001572  002000          ,CALL ,POLY
001573  001665 R
001574  000001          ,DATA ,1,0272,-01725,04633,-010226,014500
001575  000272
001576  176053
001577  004633
001600  167552
001601  014500
001602  152536          ,DATA ,-025242,0,077777,0
001603  000000
001604  077777
001605  000000
001606  001000          ,JMP* ,XATN
001607  101571 R
*
* POLY: POLYNOMIAL EVALUATOR
*
001610  071661     POL1 ,STX  ,POLY-4
001611  051662          ,STA  ,POLY-3
001612  051663          ,STA  ,POLY-2
001613  031665          ,LDX  ,POLY
001614  015000          ,LDA  ,0,1
001615  001010          ,JAZ  ,POLL
001616  001625 R
001617  021662          ,LDB  ,POLY-3
001620  006010          ,LDAI ,040000
001621  040000
001622  161662          ,MUL  ,POLY-3
001623  051663          ,STA  ,POLY-2
001624  005001          ,TZA  ,
001625  051665     POLL ,STA  ,POLY
```

```
001626  005144          ,IXR  ,
001627  015000          ,LDA  ,0,1
001630  001010          ,JAZ  ,POL2
001631  001640 R
001632  121665          ,ADD  ,POLY
001633  005012          ,TAB  ,
001634  005001          ,TZA  ,
001635  161663          ,MUL  ,POLY-2
001636  001000          ,JMP  ,POLL
001637  001625 R
001640  005144    POL2  ,IXR  ,
001641  015000          ,LDA  ,0,1
001642  001010          ,JAZ  ,POL3
001643  001651 R
001644  121665          ,ADD  ,POLY
001645  005012          ,TAB  ,
001646  005001          ,TZA  ,
001647  161662          ,MUL  ,POLY-3
001650  005144          ,IXR  ,
001651  003010    POL3  ,XAZ  ,POLY-1
001652  001664 R
001653  125000          ,ADD  ,0,1
001654  005144          ,IXR  ,
001655  071665          ,STX  ,POLY
001656  031661          ,LDX  ,*+3
001657  001000          ,JMP* ,POLY
001660  101665 R
001661  000000          ,DATA ,0,0,0,014012
001662  000000
001663  000000
001664  014012
001665  000000    POLY  ,ENTR ,
001666  001000          ,JMP  ,POL1
001667  001610 R
*
* DF 1.6 (EC118) (12)
*
* XDAB: DBL PREC ABS+SIGN
*
001670  000000    XDAB  ,ENTR ,
001671  037025 I        ,LDX* ,XDAB
001672  015000          ,LDA  ,0,RX
001673  055002          ,STA  ,2,RX
001674  041670          ,INR  ,XDAB
001675  001002          ,JAP* ,XDAB
001676  101670 R
001677  025001          ,LDB  ,1,RX
001700  002000          ,CALL ,XDCO
001701  001366 R
001702  055000          ,STA  ,0,RX
001703  065001          ,STB  ,1,RX
001704  001000          ,RETURN* ,XDAB
001705  101670 R
*
```

```
* XFLT: DBL PREC TO FLT
*
001706  000000     XFLT ,ENTR ,
001707  037026 I         ,LDX* ,XFLT
001710  015000          ,LDA  ,0,RX
001711  025001          ,LDB  ,1,RX
001712  005004          ,TZX  ,
001713  002000          ,CALL ,FNMZ
001714  001323 R
001715  027026 I         ,LDB* ,XFLT
001716  056000          ,STA  ,0,RB
001717  076001          ,STX  ,1,RB
001720  041706          ,INR  ,XFLT
001721  001000          ,RETU* ,XFLT
001722  101706 R
*
* XSIN: FIXED POINT SINE
*
001723  000000     XSIN ,ENTR ,
001724  001002          ,JAP  ,*+10
001725  001736 R
001726  121761          ,ADD  ,*+27
001727  001002          ,JAP  ,*+4
001730  001733 R
001731  005211          ,CPA  ,
001732  005111          ,IAR  ,
001733  141761          ,SUB  ,*+22
001734  001000          ,JMP  ,*+8
001735  001744 R
001736  141761          ,SUB  ,*+19
001737  001004          ,JAN  ,*+4
001740  001743 R
001741  005211          ,CPA  ,
001742  005111          ,IAR  ,
001743  121761          ,ADD  ,*+14
001744  004201          ,ASLA ,1
001745  002000          ,CALL ,POLY
001746  001665 R
001747  000001          ,DATA ,1,027,-0650,010421,-052525
001750  000027
001751  177130
001752  010421
001753  125253
001754  000000          ,DATA ,0,077777,0
001755  077777
001756  000000
001757  001000          ,JMP* ,XSIN
001760  101723 R
001761  031104          ,DATA ,031104
*
* DF 1.6 (EC118) (13)
*
* XCOS: FIXED POINT COSINE
*
```

```
001762  000000    XCOS ,ENTR ,
001763  001004         ,JAN  ,*+4
001764  001767 R
001765  005211         ,CPA  ,
001766  005111         ,IAR  ,
001767  006120         ,ADDI ,031104
001770  031104
001771  004201         ,ASLA ,1
001772  002000         ,CALL ,POLY
001773  001665 R
001774  000001         ,DATA ,1,027,-0650,010421,-052525
001775  000027
001776  177130
001777  010421
002000  125253
002001  000000         ,DATA ,0,077777,0
002002  077777
002003  000000
002004  001000         ,JMP* ,XCOS
002005  101762 R
*
* AVG: ROUTINE TO DO AVERAGING
*
002006  000000    AVG  ,ENTR ,         NEW VALUE IN A
002007  072015         ,STX  ,*+6      OLD (PREV AVG) VALUE IN B
002010  005344         ,DXR  ,         WEIGHT (N) IN X
002011  072013         ,STX  ,*+2      RETURN VALUE IN B
002012  006160         ,MULI ,0
002013  000000
002014  006170         ,DIVI ,0        B=(B*(X-1)+A)/X
002015  000000
002016  001000         ,JMP* ,AVG
002017  102006 R
*
*  INITIALIZATION
*
002020  100540    INIT ,EXC  ,PII
002021  100047         ,EXC  ,CLKF
002022  100055         ,EXC  ,PDF
002023  007400         ,ROF  ,
002024  030044         ,LDX  ,=TOS
002025  070277         ,STX  ,TOSI
002026  070300         ,STX  ,TOSP
002027  005301         ,DECR ,01       (A=-1)
002030  055000         ,STA  ,0,RX
002031  103150         ,OAR  ,DISA
002032  103151         ,OAR  ,DISE
002033  010065         ,LDA  ,=0177720
002034  050255         ,STA  ,IMSK
002035  002000         ,CALL ,TCW,0224 (PCH OFF)
002036  001115 R
002037  000224
002040  002000         ,CALL ,TCW,0223 (RDR OFF)
002041  001115 R
```

```
002042  000223
002043  005004          ,TZX  ,
002044  070351          ,STX  ,TOCH
002045  070346          ,STX  ,INUM
002046  070347          ,STX  ,INUM+1
002047  070350          ,STX  ,INUM+2
002050  070276          ,STX  ,SZCT
002051  070256          ,STX  ,CCTR
002052  020050          ,LDB  ,=ATAB
002053  060275          ,STB  ,APTR
002054  010255          ,LDA  ,IMSK
002055  103140          ,OAR  ,PIM
002056  100340          ,EXC  ,PICN
002057  001000          ,JMP  ,MLOOP
002060  002061 R
*
* DF 1.6 (EC118) (14)
*
002061  002000    MLOOP ,CALL ,TTIN
002062  003000 R
002063  001100          ,JSS1 ,ML1
002064  002077 R
002065  001200          ,JSS2 ,*+4
002066  002071 R
002067  001000          ,JMP  ,MLOOP
002070  002061 R
002071  005001          ,TZA  ,
002072  050230          ,STA  ,MLC
002073  002000          ,CALL ,TTIN
002074  003000 R
002075  001200          ,JSS2 ,*-2
002076  002073 R
*
* PROCESS ANTENNA DATA
*
002077  030050    ML1   ,LDX  ,=ATAB   MOVE FROM ATAB TO BTAB
002100  020240          ,LDB  ,NANT    AND SET ANY NEGATIVE VALUES TO Z
002101  015000          ,LDA  ,0,RX
002102  001002          ,JAP  ,*+3
002103  002105 R
002104  005001          ,TZA  ,
002105  055021          ,STA  ,17,RX
002106  005322          ,DBR  ,
002107  005144          ,IXR  ,
002110  001020          ,JBZ  ,*+4
002111  002114 R
002112  001000          ,JMP  ,*-9
002113  002101 R
*
002114  005002          ,TZB  ,
002115  030066          ,LDX  ,=BTAB
002116  005021          ,TBA  ,        LOOP TO FIND LARGEST SIGNAL
002117  145000          ,SUB  ,0,RX
002120  001002          ,JAP  ,*+3
```

```
002121  002123 R
002122  025000          ,LDB   ,0,RX
002123  005145          ,INCR  ,045
002124  140066          ,SUB   ,=BTAB
002125  140240          ,SUB   ,NANT
002126  001004          ,JAN   ,*-8
002127  002116 R
*
002130  005021          ,TBA   ,
002131  140333          ,SUB   ,T1+4
002132  001004          ,JAN   ,LOSG     JMP IF SIGNAL TOO LOW
002133  002405 R
002134  010337          ,LDA   ,T1+8
002135  050340          ,STA   ,T1+9
*
002136  005001          ,TZA   ,
002137  160334          ,MUL   ,T1+5
002140  170067          ,DIV   ,=1000
002141  060335          ,STB   ,T1+6     LOW ANTENNA VALUE CUTOFF
*
002142  030066          ,LDX   ,=BTAB
002143  020240          ,LDB   ,NANT
002144  005322          ,DBR   ,
002145  015000          ,LDA   ,0,RX
002146  140335          ,SUB   ,T1+6
002147  001002          ,JAP   ,*+4
002150  002153 R
002151  005001          ,TZA   ,
002152  055000          ,STA   ,0,RX     ZERO FOR LOW VALUE
002153  005144          ,IXR   ,
002154  005323          ,DECR  ,023
002155  001002          ,JAP   ,*-8
002156  002145 R
*
* DF 1.6 (EC118) (15)
*
002157  030066          ,LDX   ,=BTAB
002160  070332    AVG1  ,STX   ,T1+3     AVERAGE ANTENNA VALUES
002161  015000          ,LDA   ,0,RX
002162  004205          ,ASLA  ,~~5~~ 4
002163  025146          ,LDB   ,102,RX   (IN UTAB)
002164  030336          ,LDX   ,T1+7
002165  002000          ,CALL  ,AVG
002166  002006 R
002167  030332          ,LDX   ,T1+3
002170  065146          ,STB   ,102,RX
002171  004105          ,ASRB  ,~~5~~ 4
002172  065000          ,STB   ,0,RX
002173  005145          ,INCR  ,045
002174  140066          ,SUB   ,=BTAB
002175  140240          ,SUB   ,NANT
002176  001004          ,JAN   ,AVG1
002177  002160 R
*
```

```
002200  005004          ,TZX  ,          ZERO SUMS
002201  070354          ,STX  ,XSUM
002202  070355          ,STX  ,XSUM+1
002203  070357          ,STX  ,YSUM
002204  070360          ,STX  ,YSUM+1
002205  070362          ,STX  ,ZSUM
002206  070363          ,STX  ,ZSUM+1
*
002207  030066          ,LDX  ,=BTAB
002210  005001    SZ3   ,TZA  ,          FORM X,Y,Z SUMS
002211  025000          ,LDB  ,0,RX
002212  165021          ,MUL  ,17,RX
002213  002000          ,CALL ,XDAD,XSUM
002214  001463 R
002215  000354 R
002216  050354          ,STA  ,XSUM
002217  060355          ,STB  ,XSUM+1
002220  005001          ,TZA  ,
002221  025000          ,LDB  ,0,RX
002222  165042          ,MUL  ,34,RX
002223  002000          ,CALL ,XDAD,YSUM
002224  001463 R
002225  000357 R
002226  050357          ,STA  ,YSUM
002227  060360          ,STB  ,YSUM+1
002230  005001          ,TZA  ,
002231  025000          ,LDB  ,0,RX
002232  165063          ,MUL  ,51,RX
002233  002000          ,CALL ,XDAD,ZSUM
002234  001463 R
002235  000362 R
002236  050362          ,STA  ,ZSUM
002237  060363          ,STB  ,ZSUM+1
002240  005145          ,INCR ,045
002241  140066          ,SUB  ,=(BTAB)
002242  140240          ,SUB  ,NANT
002243  001004          ,JAN  ,SZ3
002244  002210 R
*
002245  002000          ,CALL ,XDAB,XSUM
002246  001670 R
002247  000354 R
002250  002000          ,CALL ,XDAB,YSUM
002251  001670 R
002252  000357 R
002253  002000          ,CALL ,XDAB,ZSUM
002254  001670 R
002255  000362 R
002256  002000          ,CALL ,XFLT,XSUM
002257  001706 R
002260  000354 R
002261  002000          ,CALL ,XFLT,YSUM
002262  001706 R
002263  000357 R
```

```
002264  002000          ,CALL ,XFLT,ZSUM
002265  001706 R
002266  000362 R
*
* DF 1.6 (EC118) (16)
*
* MAIN (CONT.)
*
002267  002000          ,CALL ,FMPY,XSUM,XSUM
002270  001343 R
002271  000354 R
002272  000354 R
002273  050366          ,STA  ,HYP+1
002274  060365          ,STB  ,HYP
002275  005001          ,TZA  ,
002276  050367          ,STA  ,HYP+2
002277  002000          ,CALL ,FMPY,YSUM,YSUM
002300  001343 R
002301  000357 R
002302  000357 R
002303  050330          ,STA  ,T1+1
002304  060327          ,STB  ,T1
002305  002000          ,CALL ,FADD,HYP,T1
002306  001403 R
002307  000365 R
002310  000327 R
002311  050365          ,STA  ,HYP
002312  060366          ,STB  ,HYP+1
002313  002000          ,CALL ,FSQT,HYP
002314  001274 R
002315  000365 R
*
002316  002000          ,CALL ,FATN,YSUM,XSUM COMPUTE AZIM.
002317  001135 R
002320  000357 R
002321  000354 R
002322  050257          ,STA  ,SVD
*
002323  002000          ,CALL ,FATN,HYP,ZSUM COMPUTE ELEV.
002324  001135 R
002325  000365 R
002326  000362 R
002327  030070          ,LDX  ,=WTAB   DO ELEV CORRECTION
002330  145000          ,SUB  ,0,RX
002331  001004          ,JAN  ,*+5
002332  002336 R
002333  005144          ,IXR  ,
002334  001000          ,JMP  ,*-4
002335  002330 R
002336  125000          ,ADD  ,0,RX
002337  005012          ,TAB  ,
002340  005001          ,TZA  ,
002341  165004          ,MUL  ,4,RX
002342  175010          ,DIV  ,8,RX
```

```
002343  004201          ,ASLA ,1
002344  145010          ,SUB  ,8,RX
002345  001004          ,JAN  ,*+3
002346  002350 R
002347  005122          ,IBR  ,         (ROUND UP)
002350  005021          ,TBA  ,
002351  125014          ,ADD  ,12,RX
002352  050260          ,STA  ,SVD+1
*
002353  010230          ,LDA  ,MLC
002354  005311          ,DAR  ,         ('M' COUNTER)
002355  001002          ,JAP  ,ML2
002356  002370 R
002357  010257          ,LDA  ,SVD
002360  002000          ,CALL ,BNBC
002361  001070 R
002362  103250          ,OBR  ,DISA
002363  010260          ,LDA  ,SVD+1
002364  002000          ,CALL ,BNBC
002365  001070 R
002366  103251          ,OBR  ,DISE
002367  010231          ,LDA  ,MLC+1    ('M' VALUE)
002370  050230    ML2   ,STA  ,MLC
*
* DF 1.6 (EC118) (17)
*
* MAIN (CONCL.)
*
002371  010242          ,LDA  ,SPTR     SAVE AZIM & ELEV IN AEST
002372  005014          ,TAX  ,.
002373  140071          ,SUB  ,=(AEST+10)
002374  001002          ,JAP  ,MLOOP    (DON'T SAVE)
002375  002061 R
002376  010257          ,LDA  ,SVD
002377  055000          ,STA  ,0,RX
002400  010260          ,LDA  ,SVD+1
002401  055012          ,STA  ,10,RX
002402  040242          ,INR  ,SPTR
002403  001000          ,JMP  ,MLOOP
002404  002061 R
*
* LOSG: HERE IS SIGNAL TOO LOW
*
002405  010340    LOSG  ,LDA  ,T1+9
002406  005311          ,DAR  ,         ('Q' COUNTER)
002407  001002          ,JAP  ,*+5
002410  002414 R
002411  005301          ,DECR ,01
002412  103150          ,OAR  ,DISA     (BLANK AZIM)
002413  103151          ,OAR  ,DISE     (BLANK ELEV)
002414  050340          ,STA  ,T1+9
002415  001000          ,JMP  ,MLOOP
002416  002061 R
*
```

```
PAGE    000026

  003000                    ,ORG   ,03000
  003000  000000     TTIN  ,ENTR  ,          (DUMMY)
  003001  001000           ,JMP*  ,TTIN
  003002  103000 R
  *
          000200           ,END   ,0200

LITERALS
  000040  000201
  000041  000031
  000042  000233
  000043  000326
  000044  000301
  000045  001007
  000046  000003
  000047  000736
  000050  000416
  000051  000004
  000052  000012
  000053  000017
  000054  004117
  000055  000345
  000056  000132
  000057  000264
  000060  000550
  000061  001034
  000062  000055
  000063  077777
  000064  004317
  000065  177720
  000066  000437
  000067  001750
  000070  000626
  000071  000404

POINTERS
  000020  101115
  000021  101135
  000022  101274
  000023  101343
  000024  101403
  000025  101670
  000026  101706


SYMBOLS

1  003000 R  TTIN
1  002405 R  LOSG
1  002370 R  ML2
1  002210 R  SZ3
1  002160 R  AVG1
1  002077 R  ML1
1  002061 R  ML00
```

```
1  002020 R  INIT
1  002006 R  AVG
1  001762 R  XCOS
1  001723 R  XSIN
1  001706 R  XFLT
1  001670 R  XDAB
1  001665 R  POLY
1  001651 R  POL3
1  001640 R  POL2
1  001625 R  POLL
1  001610 R  POL1
1  001571 R  XATN
1  001554 R  XSQT
1  001523 R  SQT1
1  001470 R  BSQT
1  001463 R  XDAD
1  001420 R  FAD1
1  001407 R  FAD2
1  001403 R  FADD
1  001366 R  XDCO
1  001343 R  FMPY
1  001340 R  FNM1
1  001323 R  FNMZ
1  001313 R  FSQ1
1  001274 R  FSQT
1  001260 R  FAT1
1  001220 R  FAT3
1  001151 R  FAT2
1  001135 R  FATN
1  001124 R  TCAW
1  001115 R  TCW
1  001075 R  BNB5
1  001070 R  BNBC
1  001050 R  ECON
1  001037 R  SWPZ
1  001031 R  AUT1
1  001020 R  AUT2
1  001007 R  AUTT
1  000757 R  SWP
1  000745 R  CLK1
1  000736 R  CLOK
1  000715 R  TTY1
1  000660 R  TTYH
1  000646 R  ERHL
1  000626 R  WTAB
1  000437 R  BTAB
1  000416 R  ATAB
1  000372 R  AEST
1  000370 R  FATT
1  000365 R  HYP
1  000362 R  ZSUM
1  000357 R  YSUM
1  000354 R  XSUM
1  000351 R  TOCH
```

```
1  000346 R  INUM
0  000341 R  T2
1  000327 R  T1
1  000326 R  TOSL
1  000301 R  TOS
1  000300 R  TOSP
1  000277 R  TOSI
1  000276 R  SZCT
1  000275 R  APTR
1  000272 R  ESVR
1  000267 R  TSVR
1  000264 R  ISVR
1  000261 R  SAVR
1  000257 R  SVD
1  000256 R  CCTR
1  000255 R  IMSK
1  000242 R  SPTR
1  000241 R  AUTC
1  000240 R  NANT
1  000235 R  EL
1  000233 R  NCS
1  000232 R  TPSF
1  000230 R  MLC
1  000000 R  ILOC
1  000050    DISA
1  000051    DISE
1  000047    CLKF
1  000046    CLKN
1  000055    PDF
1  000054    PDN
0  000044    ADCB
1  000056    ADN
1  000057    ADC
1  000540    PII
0  000440    PIF
1  000340    PICN
1  000240    PIN
0  000140    PIC
1  000040    PIM
1  000002    RB
1  000001    RX
```

```
*
* DF 2.6 (EC118) (1)
*
* EQU'S
*
        000001    RX    ,EQU  ,01
        000002    RB    ,EQU  ,02
        000040    PIM   ,EQU  ,040
        000240    PIN   ,EQU  ,0240
        000440    PIF   ,EQU  ,0440
        000340    PICN  ,EQU  ,0340
*
        000110    IAOR  ,BEGI ,0110
        000120    LTOR  ,BEGI ,0120
*
000230                  ,ORG  ,0230
000230            MLC   ,BSS  ,2
000232            TPSF  ,BSS  ,1
000233            NCS   ,BSS  ,2
000235            EL    ,BSS  ,3
000240            NANT  ,BSS  ,1
000241            AUTC  ,BSS  ,1
000242            SPTR  ,BSS  ,1
000243                  ,BSS  ,10
000255            IMSK  ,BSS  ,2
000257            SVD   ,BSS  ,2
000261            SAVR  ,BSS  ,14
000277            TOSI  ,BSS  ,1
000300            TOSP  ,BSS  ,1
000301            TOS   ,BSS  ,20
000326            TOSL  ,BES  ,2
000327            T1    ,BSS  ,10
000341            T2    ,BSS  ,5
000346            INUM  ,BSS  ,3
000351            TOCH  ,BSS  ,3
000354                  ,BSS  ,14
000372            AEST  ,BSS  ,20
000416            ATAB  ,BSS  ,17
*
* LINKER
*
003000                  ,ORG  ,03000
003000  000000    LINK  ,ENTR ,         LINK WITH PART 1
003001  033000          ,LDX  ,LINK
003002  005144          ,IXR  ,
003003  025000          ,LDB  ,0,RX     (INIT)
003004  063437          ,STB  ,LAD1+1
003005  010120          ,LDA  ,=TTIN
003006  005144          ,IXR  ,
003007  025000          ,LDB  ,0,RX
003010  001020          ,JBZ  ,*+5
003011  003015 R
003012  056000          ,STA  ,0,RB     (REF TO TTIN)
003013  001000          ,JMP  ,*-5
```

```
003014  003006 R
003015  025001          ,LDB   ,1,RX     (BNBC)
003016  063174          ,STB   ,LAD2+1
003017  025002          ,LDB   ,2,RX     (XCOS)
003020  063245          ,STB   ,LAD3+1
003021  025003          ,LDB   ,3,RX     (XSIN)
003022  063251          ,STB   ,LAD4+1
003023  001000          ,JMP*  ,LAD1+1   (TO INIT)
003024  103437 R
*
* DF 2.6 (EC118) (2)
*
        003025 R  INIT  ,EQU   ,*
        003025 R  BNBC  ,EQU   ,*
        003025 R  XCOS  ,EQU   ,*
003025  000000      XSIN  ,ENTR  ,
003026  000000            ,HLT   ,
003027  001000            ,JMP*  ,*-2
003030  103025 R
*
* TTIN
*
003031  000000      TTIN  ,ENTR  ,          TTY INPUT PROCESSOR
003032  010351            ,LDA   ,TOCH
003033  001010            ,JAZ   ,*+4
003034  003037 R
003035  001000            ,JMP   ,TCA1
003036  003137 R
003037  010277            ,LDA   ,TOSI
003040  140300            ,SUB   ,TOSP
003041  001010            ,JAZ*  ,TTIN     (NO INPUT)
003042  103031 R
003043  030277            ,LDX   ,TOSI
003044  025000            ,LDB   ,0,RX
003045  005145            ,INCR  ,045      (X+1 TO A & X)
003046  140121            ,SUB   ,=TOSL
003047  001004            ,JAN   ,*+3
003050  003052 R
003051  030122            ,LDX   ,=TOS
003052  070277            ,STX   ,TOSI
*
003053  005021            ,TBA   ,
003054  140123            ,SUB   ,=0272    (='9'+1)
003055  001002            ,JAP   ,*+5
003056  003062 R
003057  140124            ,SUB   ,=0260-0272
003060  001002            ,JAP   ,DIG      CHAR WAS DIGIT
003061  003570 R
003062  030125            ,LDX   ,=TTAB
003063  060341            ,STB   ,T2
003064  015000            ,LDA   ,0,RX     LOOK FOR CHAR IN TTAB
003065  001010            ,JAZ   ,DRTN+2   (END OF TTAB)
003066  003106 R
003067  130341            ,ERA   ,T2
```

```
003070  001010          ,JAZ  ,*+6
003071  003076 R
003072  005144          ,IXR  ,
003073  005144          ,IXR  ,
003074  001000          ,JMP  ,*-8
003075  003064 R
003076  035001          ,LDX  ,1,RX     GET PROC ROUTINE ADDR
003077  073102          ,STX  ,*+3
003100  030350          ,LDX  ,INUM+2
003101  001000          ,JMP  ,**0      GO TO PROCESSOR
003102  000000 R
003103  000000          ,HLT  ,
003104  001000    DRTN  ,JMP* ,TTIN
003105  103031 R
003106  005021          ,TBA  ,
003107  140126          ,SUB  ,=0241
003110  001004          ,JAN  ,*+5
003111  003115 R
003112  140127          ,SUB  ,=0340-0241
003113  001004          ,JAN* ,TTIN     TYPE ONLY NON-PRINTING CHARS
003114  103031 R
003115  002000    DCD1  ,CALL ,TCBR
003116  003151 R
003117  001000          ,JMP* ,TTIN
003120  103031 R
*
* DF 2.6 (EC118) (3)
*
* TCAR: TYPE CHAR IN A REG
*
003121  000000    TCAR  ,ENTR ,
003122  101101          ,SEN  ,0101,*+7 (TTY WTE RDY)
003123  003131 R
003124  050351          ,STA  ,TOCH
003125  060352          ,STB  ,TOCH+1
003126  070353          ,STX  ,TOCH+2
003127  001000          ,JMP* ,TTIN
003130  103031 R
003131  103101          ,OAR  ,01       (TTY)
003132  004350          ,LSRA ,8
003133  001010          ,JAZ* ,TCAR
003134  103121 R
003135  001000          ,JMP  ,TCAR+1
003136  003122 R
003137  101101    TCA1  ,SEN  ,0101,*+4
003140  003143 R
003141  001000          ,JMP* ,TTIN
003142  103031 R
003143  005002          ,TZB  ,
003144  060351          ,STB  ,TOCH
003145  020352          ,LDB  ,TOCH+1
003146  030353          ,LDX  ,TOCH+2
003147  001000          ,JMP  ,TCAR+1
003150  003122 R
```

```
*
* TCBR: TYPE CHAR IN B REG
*
003151  000000     TCBR ,ENTR ,
003152  004460          ,LLRL ,16
003153  002000          ,CALL ,TCAR
003154  003121 R
003155  004460          ,LLRL ,16
003156  001000          ,JMP* ,TCBR
003157  103151 R
*
* PRAD: PRINT A REG DECIMAL
*
003160  000000     PRAD ,ENTR ,
003161  001002          ,JAP  ,*+7
003162  003170 R
003163  005211          ,CPA  ,
003164  005111          ,IAR  ,
003165  020130          ,LDB  ,='-'
003166  002000          ,CALL ,TCBR
003167  003151 R
003170  005104          ,INCR ,04       (X=1)
003171  001010          ,JAZ  ,*+7
003172  003200 R
003173  002000     LAD2 ,CALL ,BNBC
003174  003025 R
003175  030131          ,LDX  ,=5
003176  001010          ,JAZ  ,*+12
003177  003212 R
003200  120132          ,ADD  ,=0260
003201  002000          ,CALL ,TCAR
003202  003121 R
003203  005344          ,DXR  ,
003204  001040          ,JXZ* ,PRAD
003205  103160 R
003206  005001          ,TZA  ,
003207  004444          ,LLRL ,4
003210  001000          ,JMP  ,*-8
003211  003200 R
003212  004444          ,LLRL ,4
003213  005344          ,DXR  ,
003214  001000          ,JMP  ,*-14
003215  003176 R
*
* DF 2.6 (EC118) (4)
*
* SNCS: SIN/COS FOR THETA/PHI
*
003216  000000     SNCS ,ENTR ,
003217  050327          ,STA  ,T1
003220  005001          ,TZA  ,
003221  020133          ,LDB  ,=040000
003222  170232          ,DIV  ,TPSF
003223  160327          ,MUL  ,T1
```

```
003224  004407          ,LASL ,7
003225  001002          ,JAP  ,*+3
003226  003230 R
003227  120134          ,ADD  ,=055000 (2PI)
003230  140135          ,SUB  ,=026400 (PI)
003231  001004          ,JAN  ,*+5
003232  003236 R
003233  140135          ,SUB  ,=026400
003234  001000          ,JMP  ,*+3
003235  003237 R
003236  120135          ,ADD  ,=026400
003237  005012          ,TAB  ,
003240  005001          ,TZA  ,
003241  160136          ,MUL  ,=043575
003242  004402          ,LASL ,2
003243  050327          ,STA  ,T1
003244  002000    LAD3  ,CALL ,XCOS
003245  003025 R
003246  050263          ,STA  ,SAVR+2
003247  010327          ,LDA  ,T1
003250  002000    LAD4  ,CALL ,XSIN
003251  003025 R
003252  020263          ,LDB  ,SAVR+2
003253  001000          ,JMP* ,SNCS
003254  103216 R
*
* GADR: GET TABLE ADDRESS
*
003255  000000    GADR  ,ENTR ,
003256  010235          ,LDA  ,EL
003257  005311          ,DAR  ,
003260  001004          ,JAN  ,GAD1
003261  003275 R
003262  140240          ,SUB  ,NANT
003263  001002          ,JAP  ,GAD1
003264  003275 R
003265  120240          ,ADD  ,NANT
003266  120236          ,ADD  ,EL+1
003267  120137          ,ADD  ,=ATAB
003270  005014          ,TAX  ,
003271  040235          ,INR  ,EL
003272  043255          ,INR  ,GADR
003273  001000          ,JMP* ,GADR
003274  103255 R
003275  033255    GAD1  ,LDX  ,GADR
003276  035000          ,LDX  ,0,RX
003277  073301          ,STX  ,*+2
003300  001000          ,JMP  ,**0
003301  000000 R
*
* CRLF: TYPE CR-LF
*
003302  000000    CRLF  ,ENTR ,
003303  010140          ,LDA  ,=0105215
```

```
003304  002000          ,CALL ,TCAR
003305  003121 R
003306  001000          ,JMP* ,CRLF
003307  103302 R
*
* DF 2.6 (EC118) (5)
*
* GTNM: GET INPUT NUMBER
*
003310  000000    GTNM  ,ENTR ,
003311  010346          ,LDA  ,INUM
003312  020347          ,LDB  ,INUM+1  (SIGN)
003313  001020          ,JBZ  ,*+4
003314  003317 R
003315  005211          ,CPA  ,
003316  005111          ,IAR  ,
003317  005002          ,TZB  ,
003320  060346          ,STB  ,INUM
003321  060347          ,STB  ,INUM+1
003322  060350          ,STB  ,INUM+2
003323  001000          ,JMP* ,GTNM
003324  103310 R
*
* SACN: STORE 'A' REGISTER AS INPT NR & PRINT
*
003325  000000    SACN  ,ENTR ,
003326  050346          ,STA  ,INUM
003327  002000          ,CALL ,PRAD
003330  003160 R
003331  010346          ,LDA  ,INUM
003332  005002          ,TZB  ,
003333  001002          ,JAP  ,*+6
003334  003341 R
003335  005211          ,CPA  ,
003336  005111          ,IAR  ,
003337  005222          ,CPB  ,
003340  050346          ,STA  ,INUM
003341  060347          ,STB  ,INUM+1
003342  040350          ,INR  ,INUM+2
003343  001000          ,JMP* ,SACN
003344  103325 R
*
* VSOP: STORE OR PRINT A VARIABLE
*
003345  004460    VSOP  ,LLRL ,16
003346  001040          ,JXZ  ,*+10
003347  003360 R
003350  002000          ,CALL ,TCAR    TYPE CHAR
003351  003121 R
003352  005024          ,TBX  ,
003353  002000          ,CALL ,GTNM
003354  003310 R
003355  055000          ,STA  ,0,RX    STORE VALUE
003356  001000          ,JMP  ,DRTN
```

```
003357  003104 R
*
003360  016000          ,LDA  ,0,RB     GET VALUE
003361  002000          ,CALL ,PRAD     PRINT IT
003362  003160 R
003363  010341          ,LDA  ,T2
003364  002000          ,CALL ,TCAR     TYPE CHAR
003365  003121 R
003366  001000          ,JMP  ,DRTN
003367  003104 R
*
* TTAB: TTY CHAR TABLE
*
003370  000215     TTAB ,DATA ,0215,CR,0212,DRTN,',',COMM,'-',MINU
003371  003513 R
003372  000212
003373  003104 R
003374  000254
003375  003507 R
003376  000255
003377  003517 R
003400  000275          ,DATA ,'=',CNM,'/',STV,'?',EQLS,'A',A,'B',A-1
003401  003526 R
003402  000257
003403  003541 R
003404  000277
003405  003600 R
003406  000301
003407  003645 R
003410  000302
003411  003644 R
003412  000303          ,DATA ,'C',C,'D',D,'E',E,0204,DBUG,'H',H
003413  003701 R
003414  000304
003415  003735 R
003416  000305
003417  003745 R
003420  000204
003421  003755 R
003422  000310
003423  004045 R
003424  000337          ,DATA ,0337,DLN,'N',N,'P',A-5,'I',I,'Z',A-4
003425  003766 R
003426  000316
003427  004011 R
003430  000320
003431  003640 R
003432  000311
003433  003763 R
003434  000332
003435  003641 R
003436  000322     LAD1 ,DATA ,'R',INIT,'S',S,'T',A-6,'X',A-2,'Y',A-3
003437  003025 R
003440  000323
```

```
003441  004033 R
003442  000324
003443  003637 R
003444  000330
003445  003643 R
003446  000331
003447  003642 R
003450  000326          ,DATA ,'V',V,'U',A-7,'W',A-8,'M',M,'L',L
003451  003656 R
003452  000325
003453  003636 R
003454  000327
003455  003635 R
003456  000315
003457  004005 R
003460  000314
003461  004001 R
003462  000321          ,DATA ,'Q',Q,'J',J,'F',F,'G',G,'K',K,0
003463  004065 R
003464  000312
003465  004051 R
003466  000306
003467  004061 R
003470  000307
003471  004071 R
003472  000313
003473  004055 R
003474  000000
003475                  ,BSS  ,10
*
* DF 2.6 (EC118) (6)
*
* COMM: SET TABLE ELEMENT PTR
*
003507  006010    COMM ,LDAI ,EL
003510  000235 R
003511  001000         ,JMP  ,VSOP
003512  003345 R
*
* CR: TTY RETURN
*
003513  002000    CR   ,CALL ,CRLF
003514  003302 R
003515  001000         ,JMP  ,I1
003516  003773 R
*
* MINU: SET SIGN
*
003517  002000    MINU ,CALL ,TCBR
003520  003151 R
003521  010347         ,LDA  ,INUM+1
003522  005211         ,CPA  ,
003523  050347         ,STA  ,INUM+1
003524  001000         ,JMP  ,DRTN
```

```
003525  003104 R
*
* CNM: TYPE CURRENT NBR
*
003526  001040     CNM   ,JXZ   ,DRTN
003527  003104 R
003530  010141           ,LDA   ,=' ='
003531  002000           ,CALL  ,TCAR
003532  003121 R
003533  002000           ,CALL  ,GTNM
003534  003310 R
003535  002000           ,CALL  ,SACN
003536  003325 R
003537  001000           ,JMP   ,DRTN
003540  003104 R
*
* STV: STORE OR PRINT TABLE ENTRY
*
003541  001040     STV   ,JXZ   ,*+12
003542  003555 R
003543  002000           ,CALL  ,TCBR
003544  003151 R
003545  002000           ,CALL  ,GADR,TIER
003546  003255 R
003547  004037 R
003550  002000           ,CALL  ,GTNM
003551  003310 R
003552  055000           ,STA   ,0,RX
003553  001000           ,JMP   ,DRTN
003554  003104 R
003555  002000           ,CALL  ,GADR,TIER
003556  003255 R
003557  004037 R
003560  015000           ,LDA   ,0,RX
003561  002000           ,CALL  ,SACN
003562  003325 R
003563  010235           ,LDA   ,EL
003564  005311           ,DAR   ,
003565  050235           ,STA   ,EL
003566  001000           ,JMP   ,DRTN
003567  003104 R
*
* DIG: ACCUMULATE NBR
*
003570  002000     DIG   ,CALL  ,TCBR
003571  003151 R
003572  020346           ,LDB   ,INUM
003573  160142           ,MUL   ,=10
003574  060346           ,STB   ,INUM
003575  040350           ,INR   ,INUM+2
003576  001000           ,JMP   ,DRTN
003577  003104 R
*
* DF 2.6 (EC118) (7)
```

```
*
* EQLS: TTY QUEST MARK PROC
*
003600  002000     EQLS ,CALL ,CRLF
003601  003302 R
003602  010237          ,LDA  ,EL+2
003603  002000          ,CALL ,TCAR
003604  003121 R
003605  020143          ,LDB  ,='',1'
003606  002000          ,CALL ,TCBR
003607  003151 R
003610  005101          ,INCR ,01       (A=1)
003611  050235          ,STA  ,EL
003612  002000     EQL1 ,CALL ,GADR,CR
003613  003255 R
003614  003513 R
003615  015000          ,LDA  ,0,RX
003616  002000          ,CALL ,PRAD
003617  003160 R
003620  020144          ,LDB  ,='/'
003621  002000          ,CALL ,TCBR
003622  003151 R
003623  010235          ,LDA  ,EL
003624  140142          ,SUB  ,=10
003625  001010          ,JAZ  ,*+4
003626  003631 R
003627  001000          ,JMP  ,EQL1
003630  003612 R
003631  002000          ,CALL ,CRLF
003632  003302 R
003633  001000          ,JMP  ,EQL1
003634  003612 R
*
* A: SELECT TABLE
*
003635  005111          ,IAR  ,         (W)
003636  005111          ,IAR  ,         (U)
003637  005111          ,IAR  ,         (T)
003640  005111          ,IAR  ,         (P)
003641  005111          ,IAR  ,         (Z)
003642  005111          ,IAR  ,         (Y)
003643  005111          ,IAR  ,         (X)
003644  005111          ,IAR  ,         (B)
003645  050236     A    ,STA  ,EL+1     (A)
003646  004204          ,ASLA ,4
003647  120236          ,ADD  ,EL+1     (MUL BY 17)
003650  050236          ,STA  ,EL+1
003651  060237          ,STB  ,EL+2     SAVE CHAR
003652  002000          ,CALL ,TCBR
003653  003151 R
003654  001000          ,JMP  ,DRTN
003655  003104 R
*
* V: TYPE AZIM. & ELEV.
```

```
*
003656  002000     V     ,CALL ,CRLF
003657  003302 R
003660  010145           ,LDA  ,=':A'
003661  002000           ,CALL ,TCAR
003662  003121 R
003663  010257           ,LDA  ,SVD
003664  002000           ,CALL ,PRAD
003665  003160 R
003666  010146           ,LDA  ,=' '
003667  002000           ,CALL ,TCAR
003670  003121 R
003671  010147           ,LDA  ,=':E'
003672  002000           ,CALL ,TCAR
003673  003121 R
003674  010260           ,LDA  ,SVD+1
003675  002000           ,CALL ,PRAD
003676  003160 R
003677  001000           ,JMP  ,CR
003700  003513 R
*
* DF 2.6 (EC118) (8)
*
* C: CALC X,Y,Z COEF
*
003701  002000     C     ,CALL ,TCBR
003702  003151 R
003703  030137           ,LDX  ,=ATAB
003704  015146           ,LDA  ,102,RX  (THETA)
003705  002000           ,CALL ,SNCS
003706  003216 R
003707  050261           ,STA  ,SAVR    (SIN[THETA])
003710  065104           ,STB  ,68,RX   (Z=COS[THETA])
003711  015125           ,LDA  ,85,RX   (PHI)
003712  002000           ,CALL ,SNCS
003713  003216 R
003714  050262           ,STA  ,SAVR+1  (SIN[PHI])
003715  005001           ,TZA  ,
003716  160261           ,MUL  ,SAVR
003717  004401           ,LASL ,1
003720  055042           ,STA  ,34,RX   (X)
003721  005001           ,TZA  ,
003722  020262           ,LDB  ,SAVR+1
003723  160261           ,MUL  ,SAVR
003724  004401           ,LASL ,1
003725  055063           ,STA  ,51,RX   (Y)
003726  005145           ,INCR ,045     (X+1 TO X & A)
003727  140137           ,SUB  ,=ATAB
003730  140240           ,SUB  ,NANT
003731  001004           ,JAN  ,C+3
003732  003704 R
003733  001000           ,JMP  ,I1
003734  003773 R
*
```

```
* D: DISABLE SWITCH INTERRUPTS
*
003735  002000    D     ,CALL ,TCBR
003736  003151 R
003737  010255          ,LDA  ,IMSK
003740  110150          ,ORA  ,=06
003741  103140          ,OAR  ,PIM      (DISABLE SWITHCES)
003742  050255          ,STA  ,IMSK
003743  001000          ,JMP  ,DRTN
003744  003104 R
*
* E: ENABLE SWITCH INTERRUPTS
*
003745  002000    E     ,CALL ,TCBR
003746  003151 R
003747  010255          ,LDA  ,IMSK
003750  150151          ,ANA  ,=0177771
003751  103140          ,OAR  ,PIM      (ENABLE SWITCHS)
003752  050255          ,STA  ,IMSK
003753  001000          ,JMP  ,DRTN
003754  003104 R
*
* DBUG: (CTRL-D) GO TO DBUG ROUTINE
*
003755  100440    DBUG  ,EXC  ,PIF
003756  001000          ,JMP  ,*+2      ENTER DBUG ROUTINE ADDR WHEN NEE
003757  003760 R
003760  100340          ,EXC  ,PICN
003761  001000          ,JMP  ,I1
003762  003773 R
*
* DF 2.6 (EC118) (9)
*
* I: SET AUTO CYCLE
*
003763  010126    I     ,LDA  ,=AUTC
003764  001000          ,JMP  ,VSOP
003765  003345 R
*
* DLN: DELETE CURRENT NBR
*
003766  001040    DLN   ,JXZ  ,DRTN
003767  003104 R
003770  010152          ,LDA  ,=0120337 (SP+LFT AR0)
003771  002000          ,CALL ,TCAR
003772  003121 R
003773  005001    I1    ,TZA  ,
003774  050346          ,STA  ,INUM
003775  050347          ,STA  ,INUM+1
003776  050350          ,STA  ,INUM+2
003777  001000          ,JMP  ,DRTN
004000  003104 R
*
* L: SET FIXED PDN TIME
```

```
*
004001  006010      L     ,LDAI  ,NCS+1
004002  000234 R
004003  001000            ,JMP   ,VSOP
004004  003345 R
*
* M: SET MLOOP CYCLE COUNTER
*
004005  006010      M     ,LDAI  ,MLC+1
004006  000231 R
004007  001000            ,JMP   ,VSOP
004010  003345 R
*
* N: SET NBR ANTENNAS
*
004011  006010      N     ,LDAI  ,NANT
004012  000240 R
004013  001040            ,JXZ   ,VSOP
004014  003345 R
004015  002000            ,CALL  ,TCBR
004016  003151 R
004017  002000            ,CALL  ,GTNM
004020  003310 R
004021  005012            ,TAB   ,
004022  005311            ,DAR   ,
004023  001004            ,JAN   ,TIER
004024  004037 R
004025  140153            ,SUB   ,=17
004026  001002            ,JAP   ,TIER
004027  004037 R
004030  060240            ,STB   ,NANT
004031  001000            ,JMP   ,DRTN
004032  003104 R
*
* S: SET THEAT/PHI SCALE FACTOR
*
004033  006010      S     ,LDAI  ,TPSF
004034  000232 R
004035  001000            ,JMP   ,VSOP
004036  003345 R
*
* TIER: TTY ERR PRINT
*
004037  006010      TIER  ,LDAI  ,'!'
004040  000241
004041  002000            ,CALL  ,TCAR
004042  003121 R
004043  001000            ,JMP   ,CR
004044  003513 R
*
* DF 2.6 (EC118) (10)
*
* H: HALT (PUSH 'RUN' TO RESTART)
*
```

```
004045  100440     H     ,EXC  ,PIF
004046  000000           ,HLT  ,
004047  001000           ,JMP  ,0200
004050  000200
*
* J: SET/PRINT LOW SIGNAL CUTOFF
*
004051  006010     J     ,LDAI ,T1+4
004052  000333 R
004053  001000           ,JMP  ,VSOP
004054  003345 R
*
* K: SET/PRINT LOW ANTENNA LEVEL CUTOFF
*
004055  006010     K     ,LDAI ,T1+5
004056  000334 R
004057  001000           ,JMP  ,VSOP
004060  003345 R
*
* F: SET/PRINT NUMBER CYCLES AVERAGED
*
004061  006010     F     ,LDAI ,T1+7
004062  000336 R
004063  001000           ,JMP  ,VSOP
004064  003345 R
*
* Q: SET/PRINT DISPLAY HOLD COUNT
*
004065  006010     Q     ,LDAI ,T1+8
004066  000337 R
004067  001000           ,JMP  ,VSOP
004070  003345 R
*
* G: PRINT HI,LO,AVG OF 10 CYCLES
*
004071  010154     G     ,LDA  ,=AEST
004072  050242           ,STA  ,SPTR
004073  002000           ,CALL ,CRLF
004074  003302 R
004075  010242           ,LDA  ,SPTR
004076  140155           ,SUB  ,=(AEST+10)
004077  001002           ,JAP  ,*+8
004100  004107 R
004101  006010           ,LDAI ,0377
004102  000377
004103  002000           ,CALL ,TCAR
004104  003121 R
004105  001000           ,JMP  ,*-8
004106  004075 R
004107  006010           ,LDAI ,'A':A'
004110  ~~000145 R~~ 135301
004111  002000           ,CALL ,TCAR
004112  003121 R
004113  010154           ,LDA  ,=AEST
```

```
004114  002000          ,CALL ,PHLA
004115  004127 R
004116  006010          ,LDAI ,'G':E'
004117  000147 R 135305
004120  002000          ,CALL ,TCAR
004121  003121 R
004122  010155          ,LDA  ,=(AEST+10)
004123  002000          ,CALL ,PHLA
004124  004127 R
004125  001000          ,JMP  ,DRTN
004126  003104 R
*
* PHLA: HI,LO,AVG ROUTINE FOR 'G'
*
004127  000000    PHLA  ,ENTR ,
004130  005014          ,TAX  ,
004131  120142          ,ADD  ,=10
004132  050342          ,STA  ,T2+1     (END PTR)
004133  005001          ,TZA  ,
004134  050343          ,STA  ,T2+2     (SUM)
004135  050344          ,STA  ,T2+3     (HI)
*
* DF 2.6 (EC118) (11)
*
* PHLA (CONCL.)
*
004136  010156          ,LDA  ,=077777
004137  050345          ,STA  ,T2+4     (LOW)
*
004140  015000    PHL1  ,LDA  ,0,RX
004141  005012          ,TAB  ,
004142  120343          ,ADD  ,T2+2
004143  050343          ,STA  ,T2+2     (SUM)
004144  005021          ,TBA  ,
004145  140344          ,SUB  ,T2+3
004146  001004          ,JAN  ,*+3
004147  004151 R
004150  060344          ,STB  ,T2+3     (HI)
004151  005021          ,TBA  ,
004152  140345          ,SUB  ,T2+4
004153  001002          ,JAP  ,*+3
004154  004156 R
004155  060345          ,STB  ,T2+4     (LO)
004156  005145          ,INCR ,045
004157  140342          ,SUB  ,T2+1     (END PTR)
004160  001004          ,JAN  ,PHL1
004161  004140 R
*
004162  010344          ,LDA  ,T2+3
004163  002000          ,CALL ,PRAD     PRINT HI
004164  003160 R
004165  010146          ,LDA  ,=' '
004166  002000          ,CALL ,TCAR
004167  003121 R
```

```
004170  010345          ,LDA  ,T2+4
004171  002000          ,CALL ,PRAD
004172  003160 R
004173  010146          ,LDA  ,=' '
004174  002000          ,CALL ,TCAR
004175  003121 R
004176  005001          ,TZA  ,
004177  020343          ,LDB  ,T2+2
004200  170142          ,DIV  ,=10      CALC AV
004201  140131          ,SUB  ,=5
004202  001004          ,JAN  ,*+3
004203  004205 R
004204  005122          ,IBR  ,         (ROUND UP)
004205  005021          ,TBA  ,
004206  002000          ,CALL ,PRAD
004207  003160 R
004210  002000          ,CALL ,CRLF
004211  003302 R
004212  001000          ,JMP* ,PHLA
004213  104127 R
*
        000200          ,END  ,0200

LITERALS
000120  003031
000121  000326
000122  000301
000123  000272
000124  177766
000125  003370
000126  000241
000127  000077
000130  000255
000131  000005
000132  000260
000133  040000
000134  055000
000135  026400
000136  043575
000137  000416
000140  105215
000141  120275
000142  000012
000143  126261
000144  000257
000145  135301
000146  000240
000147  135305
000150  000006
000151  177771
000152  120337
000153  000021
000154  000372
000155  000404
```

000156 077777

POINTERS

SYMBOLS

```
1  004140 R  PHL1
1  004127 R  PHLA
1  004071 R  G
1  004065 R  Q
1  004061 R  F
1  004055 R  K
1  004051 R  J
1  004045 R  H
1  004037 R  TIER
1  004033 R  S
1  004011 R  N
1  004005 R  M
1  004001 R  L
1  003773 R  I1
1  003766 R  DLN
1  003763 R  I
1  003755 R  DBUG
1  003745 R  E
1  003735 R  D
1  003701 R  C
1  003656 R  V
1  003645 R  A
1  003612 R  EQL1
1  003600 R  EQLS
1  003570 R  DIG
1  003541 R  STV
1  003526 R  CNM
1  003517 R  MINU
1  003513 R  CR
1  003507 R  COMM
1  003436 R  LAD1
1  003370 R  TTAB
1  003345 R  VSOP
1  003325 R  SACN
1  003310 R  GTNM
1  003302 R  CRLF
1  003275 R  GAD1
1  003255 R  GADR
1  003250 R  LAD4
1  003244 R  LAD3
1  003216 R  SNCS
1  003173 R  LAD2
1  003160 R  PRAD
1  003151 R  TCBR
1  003137 R  TCA1
1  003121 R  TCAR
1  003115 R  DCD1
```

```
1  003104 R  DRTN
1  003031 R  TTIN
1  003025 R  XSIN
1  003025 R  XCOS
1  003025 R  BNBC
1  003025 R  INIT
1  003000 R  LINK
1  000416 R  ATAB
1  000372 R  AEST
1  000351 R  TOCH
1  000346 R  INUM
1  000341 R  T2
1  000327 R  T1
1  000326 R  TOSL
1  000301 R  TOS
1  000300 R  TOSP
1  000277 R  TOSI
1  000261 R  SAVR
1  000257 R  SVD
1  000255 R  IMSK
1  000242 R  SPTR
1  000241 R  AUTC
1  000240 R  NANT
1  000235 R  EL
1  000233 R  NCS
1  000232 R  TPSF
1  000230 R  MLC
1  000340    PICN
1  000440    PIF
0  000240    PIN
1  000040    PIM
1  000002    RB
1  000001    RX
```

SOURCE TAPE LISTINGS

```
*
* DF 1.6 (EC118) (1)
*
* EQU'S
*
RX    ,EQU  ,01
RB    ,EQU  ,02
PIM   ,EQU  ,040      PGM INT MSK
PIC   ,EQU  ,0140     CLR INT MODULE
PIN   ,EQU  ,0240     PGM INT ON
PICN  ,EQU  ,0340     PGM INT CLR/ON
PIF   ,EQU  ,0440     PGM INT OFF
PII   ,EQU  ,0540     INIT PGM INT MOD
ADC   ,EQU  ,057      A/D (INPT)
ADN   ,EQU  ,056      A/D ON
ADCB  ,EQU  ,044      A/D BUSY (SEN)
PDN   ,EQU  ,054      PEAK DET. ON
PDF   ,EQU  ,055      P/D OFF
CLKN  ,EQU  ,046      CLOCK ON
CLKF  ,EQU  ,047      CLOCK OFF
DISE  ,EQU  ,051      ELEV DISPLAY
DISA  ,EQU  ,050      AZIM DISPLAY
*
* INTERRUPT LOCS
*
      ,ORG  ,0
ILOC  ,JMPM ,CLOK     LINE 01 - CLOCK
      ,JMPM ,SWP      02 - ANTENNA SW
      ,JMPM ,SWPZ     03 - ZERO SW
      ,JMPM ,ECON     04 - A/D DONE
      ,NOP  ,         05 - TTY DONE (IGNORED)
      ,NOP  ,
      ,JMPM ,TTYH     06 - TTY HIT
*
IAOR  ,BEGI ,020      POINTERS
LTOR  ,BEGI ,040      LITERALS
*
      ,ORG  ,0200
      ,CALL ,03000    (LINK WITH PART 2)
      ,JMP  ,INIT     BEGIN SCAN
      ,DATA ,MLOOP+1,MLOOP+11,0 (REF TO TTIN)
      ,DATA ,BNBC,XCOS,XSIN,0 (ADR NEEDED BY PART 2)
      ,ORG  ,0230
      ,MORE ,
```

```
*
* DF 1.6 (EC118) (2)
*
* STORAGE
*
MLC   ,DATA ,0,0      MLOOP COUNTER
TPSF  ,DATA ,1        THETA/PHI SCALE FACTOR
NCS   ,DATA ,100,0    NBR CLOCK CYCLES FOR PDN
EL    ,DATA ,0,0,0    ELEMENT NR,TABLE,LETTER
NANT  ,DATA ,1        NBR ANTENNAS
AUTC  ,DATA ,0        NBR CLK CYCLES FOR AUTO CYCLE
SPTR  ,DATA ,AEST     AZIM, ELEV SAVE TABLE PTR
      ,BSS  ,10
IMSK  ,BSS  ,1        INTERRUPT MASK
CCTR  ,BSS  ,1        CLK CNTR
SVD   ,BSS  ,2        SAVED AZIM. & ELEV.
SAVR  ,BSS  ,3        SAVE REG
ISVR  ,BSS  ,3        SAVE REG
TSVR  ,BSS  ,3        SAVE REG
ESVR  ,BSS  ,3        SAVE REG
APTR  ,BSS  ,1        ATAB PTR
SZCT  ,BSS  ,1        ZERO SW CTR
TOSI  ,BSS  ,1        TOS PTR OUT
TOSP  ,BSS  ,1        TOS PTR IN
TOS   ,BSS  ,20       TYPE IN STACK
TOSL  ,BES  ,2
T1    ,BSS  ,10       TEMP
T2    ,BSS  ,5        TEMP
INUM  ,BSS  ,3        INPUT NR, SIGN & COUNT
TOCH  ,BSS  ,3        TTY OUT CHAR & REG SAVE
XSUM  ,BSS  ,3
YSUM  ,BSS  ,3
ZSUM  ,BSS  ,3
HYP   ,BSS  ,3
FATT  ,BSS  ,2        FATN TEMP
AEST  ,BSS  ,20       AZIM, ELEV SAVE TABLE
ATAB  ,BSS  ,17       INPUT TABLE
BTAB  ,BSS  ,17       WORK TABLE (ATAB+17)
      ,BSS  ,17       X COEF TABLE (+34)
      ,BSS  ,17       Y COEF TABLE (+51)
      ,BSS  ,17       Z COEF TABLE (+68)
      ,BSS  ,17       PHI TABLE    (+85)
      ,BSS  ,17       THETA TABLE (+102)
      ,BSS  ,17       U TABLE     (+119) ANTENNA AVGS
*     ,BSS  ,17       W TABLE     (+136) ELEV CORR TABLE
WTAB  ,DATA ,10,30,20,077777 BREAK POINT (INCREMENTS)
      ,DATA ,1,3,7,0 MULTIPLY (NUMERATOR)
      ,DATA ,1,2,4,1 DIVIDE (DENOMINATOR)
      ,DATA ,0,10,55,90 ADD
      ,MORE ,
```

```
*
* DF 1.6 (EC118) (3)
*
* ERHLT
*
ERHLT ,ENTR ,         ERROR HALT
      ,STA  ,ESVR
      ,STB  ,ESVR+1
      ,STX  ,ESVR+2
      ,HLT  ,0111     PUSH 'RUN' TO RESTART
      ,LDA  ,ESVR
      ,LDB  ,ESVR+1
      ,LDX  ,ESVR+2
      ,RETU* ,ERHLT
*
* TTY INTERPT PROC
*
TTYH ,ENTR ,          HERE IF TTY KEY HIT
      ,STA  ,TSVR
      ,CIA  ,01       (TTY)
      ,SUB  ,=0201    (201=CTL-A)
      ,JAZ  ,TTY1
      ,SUB  ,=031     (232=CTL-Z)
      ,JAZ  ,TTY1+5
      ,DAR  ,         (233=ESC)
      ,JAZ  ,TTY1+10
      ,EXC  ,PIN
      ,JSS3 ,TTY1-3   (IGNORE CHAR IF SS3 IS ON)
      ,STX  ,TSVR+2
      ,LDX  ,TOSP
      ,ADD  ,=0233
      ,STA  ,0,RX     SAVE CHARACTER
      ,INCR ,045      (X+1 TO X & A)
      ,SUB  ,=TOSL
      ,JAN  ,*+3
      ,LDX  ,=TOS
      ,STX  ,TOSP
      ,LDX  ,TSVR+2
      ,LDA  ,TSVR
      ,JMP* ,TTYH
*
TTY1 ,LDA  ,TSVR      FAKE A SWITCH INTERRUPT
      ,CALL ,SWP
      ,JMP* ,TTYH
*
      ,LDA  ,TSVR     FAKE A ZERO SW INT (CTL-Z)
      ,CALL ,SWPZ
      ,JMP* ,TTYH
*
      ,LDA  ,TOSP     CLEAR TTY BUFFERS (ESC)
      ,STA  ,TOSI
      ,TZA  ,
      ,STA  ,TOCH
      ,EXC  ,PIN
      ,JMP  ,TTY1-3
      ,MORE ,
```

```
*
* DF 1.6 (EC118) (4)
*
* CLOCK IN PROC
*
CLOK ,ENTR ,
     ,STA  ,ISVR
     ,INR  ,CCTR
     ,LDA  ,CCTR
     ,SUB  ,NCS
     ,JAP  ,*+6
CLK1 ,LDA  ,ISVR
     ,EXC  ,PIN
     ,JMP* ,CLOK
     ,EXC  ,PDF
     ,LDA  ,=AUTT
     ,STA  ,1
     ,EXC  ,ADN
     ,JMP  ,CLK1
*
* ANTENNA SWITCH INTERRUPT PROCESSOR
*
SWP  ,ENTR ,
     ,EXC  ,PDN
     ,EXC  ,CLKF
     ,STA  ,ISVR
     ,STB  ,ISVR+1
     ,LDB  ,NCS+1
     ,TZA  ,
     ,JBZ  ,*+5
     ,STA  ,CCTR
     ,JMP  ,*+5
     ,LDB  ,CCTR
     ,STA  ,CCTR
     ,DIV  ,=3
     ,EXC  ,CLKN
     ,STB  ,NCS
     ,LDB  ,=CLOK
     ,STB  ,1
     ,LDA  ,ISVR
     ,LDB  ,ISVR+1
     ,EXC  ,PIN
     ,JMP* ,SWP
*
* AUTT: AUTO CYCLE
*
AUTT ,ENTR ,
     ,STA  ,ISVR
     ,INR  ,CCTR
     ,LDA  ,AUTC
     ,JAZ  ,AUT1
     ,SUB  ,CCTR
     ,JAN  ,*+6
AUT2 ,LDA  ,ISVR
     ,EXC  ,PIN
     ,JMP* ,AUTT
     ,MORE ,
```

```
*
* DF 1.6 (EC118) (4A)
*
* AUTT (CONCL.)
*
      ,LDA   ,ISVR
      ,CALL  ,SWP
      ,JMP*  ,AUTT
AUT1  ,LDA   ,NCS+1
      ,JAZ   ,AUT2
      ,EXC   ,CLKF
      ,JMP   ,AUT2
*
* SWPZ: ZERO SWITCH INT PROC
*
SWPZ  ,ENTR  ,
      ,STA   ,ISVR
      ,INR   ,SZCT
      ,LDA   ,=ATAB
      ,STA   ,APTR
      ,LDA   ,ISVR
      ,EXC   ,PIN
      ,RETU* ,SWPZ
      ,MORE  ,
```

```
*
* DF 1.6 (EC118) (5)
*
* A/D CONV INT PROC
*
ECON ,ENTR ,          HERE WHEN A/D CONV DONE
     ,STA  ,ISVR
     ,CIA  ,ADC
     ,STA* ,APTR
     ,INR  ,APTR
     ,LDA  ,APTR
     ,SUB  ,=ATAB
     ,SUB  ,NANT
     ,JAN  ,*+4
     ,LDA  ,=ATAB
     ,STA  ,APTR
     ,LDA  ,ISVR
     ,EXC  ,PIN
     ,RETU* ,ECON
*
* BNBC - BIN TO BCD CONV
*
BNBC ,ENTR ,          'A' REG HAS BIN NBR WHICH
     ,STA  ,SAVR      IS TO BE CONVERTED
     ,STX  ,SAVR+2    TO BCD
     ,LDX  ,=4
     ,TZB  ,
BNB5 ,TZA  ,
     ,STB  ,SAVR+1
     ,LDB  ,SAVR
     ,DIV  ,=10
     ,STB  ,SAVR
     ,LDB  ,SAVR+1
     ,LLSR ,4
     ,DXR  ,
     ,JXZ  ,*+4
     ,JMP  ,BNB5
     ,LDA  ,SAVR      RETURN BCD RESULT IN A
     ,LDX  ,SAVR+2    AND B REGS
     ,RETU* ,BNBC     X REG UNCHANGED
*
* TCW: WAIT & TYPE CHAR
*
TCW  ,ENTR ,          CHAR IN LOC AFTER CALL
     ,LDA* ,TCW       IS TYPED
     ,CALL ,TCAW
     ,INR  ,TCW
     ,RETU* ,TCW
*
* TCAW: WAIT & TYPE CHAR FROM 'A' REG
*
TCAW ,ENTR ,
     ,SEN  ,0101,*+5 WAIT FOR TTY TO FINISH
     ,NOP  ,          (ALLOW INTERRUPTS)
     ,JMP  ,*-3
     ,OAR  ,01        TYPE CHAR
     ,JMP* ,TCAW
     ,MORE ,
```

```
*
* DF 1.6 (EC118) (6)
*
* FATN: FLOAT ATAN
*
FATN ,ENTR ,
     ,LDB* ,FATN
     ,INR  ,FATN
     ,LDX* ,FATN
     ,INR  ,FATN
     ,LDA  ,1,RB
     ,SUB  ,1,RX
     ,JAZ  ,FAT1
     ,STA  ,FATT
     ,JAP  ,*+5
FAT2 ,TBA  ,
     ,TXB  ,
     ,TAX  ,
     ,LDA  ,0,RB
     ,STB  ,FATT+1
     ,TZB  ,
     ,LASR ,1
     ,DIV  ,0,RX
     ,STB  ,T1
     ,LDB  ,FATT+1
     ,LDA  ,1,RB
     ,LDB  ,T1
     ,DAR  ,
     ,SUB  ,1,RX
     ,JAP  ,*+6
     ,ASLB ,1
     ,IAR  ,
     ,JMP  ,*-4
     ,SUB  ,=15
     ,JAN  ,*+3
     ,TZA  ,
     ,ADD  ,=04117  (ASRB 15)
     ,STA  ,*+1
     ,ASRB ,**0
     ,TBA  ,
     ,CALL ,XATN
     ,TAB  ,
     ,TZA  ,
     ,MUL  ,=229
     ,LASR ,2
     ,ASRB ,14
     ,JBZ  ,*+3
     ,IAR  ,
     ,LDB  ,FATT+1
FAT3 ,STA  ,T1
     ,LDA  ,FATT
     ,JAP  ,*+8
     ,TBA  ,
     ,TXB  ,
     ,TAX  ,
     ,LDA  ,=90
     ,SUB  ,T1
     ,STA  ,T1
     ,MORE ,
```

```
*
* DF 1.6 (EC118) (7)
*
* FATN (CONCL)
*
      ,LDA   ,2,RB
      ,JAN   ,*+12
      ,LDA   ,2,RX
      ,JAN   ,*+5
      ,LDA   ,T1
      ,JMP*  ,FATN
      ,LDA   ,=180
      ,SUB   ,T1
      ,JMP*  ,FATN
      ,LDA   ,=360
      ,SUB   ,T1
      ,STA   ,T1
      ,LDA   ,2,RX
      ,JAP   ,*-11
      ,LDA   ,=540
      ,JMP   ,*-10
FAT1  ,LDA   ,0,RX
      ,SUB   ,0,RB
      ,STA   ,FATT
      ,JAZ   ,*+6
      ,JAP   ,FAT2+3
      ,JMP   ,FAT2
      ,LDA   ,=45
      ,JMP   ,FAT3
*
* FSQT: FLTNG SQRT
*
FSQT  ,ENTR  ,
      ,LDX*  ,FSQT
      ,INR   ,FSQT
      ,LDA   ,0,RX
      ,JAZ*  ,FSQT
      ,LDA   ,1,RX
      ,TZB   ,
      ,LASR  ,1
      ,STA   ,1,RX
      ,JBZ   ,FSQ1
      ,LDA   ,0,RX
      ,ASRA  ,1
      ,STA   ,0,RX
FSQ1  ,LDA   ,0,RX
      ,CALL  ,XSQT
      ,CALL  ,ERHLT
      ,STA   ,0,RX
      ,RETU* ,FSQT
      ,MORE  ,
```

```
*
* DF 1.6 (EC118) (8)
*
* FNMZ: FLTNG NORMALIZE
*
FNMZ  ,ENTR ,
      ,JIF  ,030,FNM1 (A=B=0)
      ,LRLB ,1
      ,LLRL ,1
      ,IXR  ,
      ,JAP  ,*-2
      ,DXR  ,
      ,LLRL ,31
      ,LSRB ,1
      ,RETU* ,FNMZ
FNM1  ,LDX  ,=077777
      ,RETU* ,FNMZ
*
* FMPY: FLTNG MUL
*
FMPY  ,ENTR ,
      ,LDX* ,FMPY
      ,INR  ,FMPY
      ,LDB* ,FMPY
      ,LDB  ,0,RB
      ,TZA  ,
      ,MUL  ,0,RX
      ,LDX  ,1,RX
      ,CALL ,FNMZ
      ,TAB  ,
      ,TXA  ,
      ,JBZ  ,*+4
      ,LDX* ,FMPY
      ,ADD  ,1,RX
      ,INR  ,FMPY
      ,RETU* ,FMPY
*
* XDCO: DBL PREC COMP
*
XDCO  ,ENTR ,
      ,CPA  ,
      ,JBZ  ,*+8
      ,CPB  ,
      ,IBR  ,
      ,LRLB ,1
      ,LSRB ,1
      ,JMP* ,XDCO
      ,IAR  ,
      ,JMP* ,XDCO
      ,MORE ,
```

```
*
* DF 1.6 (EC118) (9)
*
* FADD: FLTNG ADD
*
FADD ,ENTR ,
     ,LDB* ,FADD
     ,INR  ,FADD
     ,LDX* ,FADD
FAD2 ,LDA  ,1,RB
     ,SUB  ,1,RX
     ,JAP  ,FAD1
     ,TBA  ,
     ,TXB  ,
     ,TAX  ,
     ,JMP  ,FAD2
FAD1 ,SUB  ,=15
     ,JAN  ,*+3
     ,TZA  ,
     ,ADD  ,=04317  (ASRA 15)
     ,STA  ,*+2
     ,LDA  ,0,RB
     ,ASRA ,**0
     ,ADD  ,0,RX
     ,LDB  ,1,RX
     ,INR  ,FADD
     ,JAP* ,FADD
     ,LSRA ,1
     ,DBR  ,
     ,RETU* ,FADD
*
* XDAD: DBL PREC ADD
*
     ,STX  ,XDAD+3
     ,ROF  ,
     ,LDX  ,XDAD
     ,LDX  ,0,1
     ,STA  ,XDAD+4
     ,TBA  ,
     ,ADD  ,1,1
     ,ANAI ,077777
     ,TAB  ,
     ,TZA  ,
     ,AOFA ,
     ,ROF  ,
     ,ADD  ,XDAD+4
     ,ADD  ,0,1
     ,INR  ,XDAD
     ,LDX  ,XDAD+3
     ,JMP  ,0
XDAD ,EQU  ,*-1
     ,JMP  ,*-19
     ,DATA ,0,0
     ,MORE ,
```

```
*
* DF 1.6 (EC118) (10)
*
* XSQT: DBL PREC SQRT
*
BSQT ,INR   ,XSQT
     ,INR   ,XSQT
     ,ROF   ,
     ,JAZ*  ,XSQT
     ,STB   ,XSQT+11
     ,ERA   ,XSQT+12
     ,JAZ   ,*+4
     ,JMP   ,*+5
     ,ERA   ,XSQT+12
     ,JMP*  ,XSQT
     ,ERA   ,XSQT+12
     ,STX   ,XSQT+7
     ,ZERO  ,06
     ,IXR   ,
     ,LLRL  ,2
     ,JIF   ,022,*-2
     ,DXR   ,
     ,LLRL  ,14
     ,STB   ,XSQT+6
     ,STX   ,XSQT+10
     ,LDA   ,XSQT+12
     ,STA   ,XSQT+8
SQT1 ,LDA   ,XSQT+6
     ,DIV   ,XSQT+8
     ,TBA   ,
     ,SUB   ,XSQT+8
     ,STA   ,XSQT+9
     ,ASRA  ,1
     ,ADD   ,XSQT+8
     ,STA   ,XSQT+8
     ,LDA   ,XSQT+9
     ,ADDI  ,0377
     ,JAN   ,SQT1
     ,LDX   ,XSQT+7
     ,LDB   ,XSQT+10
     ,LDA   ,XSQT+8
     ,JBZ   ,XSQT-3
     ,ASRA  ,1
     ,DBR   ,
     ,JMP   ,*-4
     ,LDX   ,XSQT+7
     ,LDB   ,XSQT+11
     ,JMP   ,XSQT
XSQT ,EQU   ,*-1
     ,STA   ,*+5
     ,JAN*  ,XSQT
     ,JMP   ,BSQT
     ,BSS   ,6
     ,DATA  ,077777
     ,MORE  ,
```

```
*
* DF 1.6 (EC118) (11)
*
* XATN: FIXED POINT ATAN
*
XATN ,ENTR ,
     ,CALL ,POLY
     ,DATA ,1,0272,-01725,04633,-010226,014500
     ,DATA ,-025242,0,077777,0
     ,JMP* ,XATN
*
* POLY: POLYNOMIAL EVALUATOR
*
POL1 ,STX  ,POLY-4
     ,STA  ,POLY-3
     ,STA  ,POLY-2
     ,LDX  ,POLY
     ,LDA  ,0,1
     ,JAZ  ,POLL
     ,LDB  ,POLY-3
     ,LDAI ,040000
     ,MUL  ,POLY-3
     ,STA  ,POLY-2
     ,TZA  ,
POLL ,STA  ,POLY
     ,IXR  ,
     ,LDA  ,0,1
     ,JAZ  ,POL2
     ,ADD  ,POLY
     ,TAB  ,
     ,TZA  ,
     ,MUL  ,POLY-2
     ,JMP  ,POLL
POL2 ,IXR  ,
     ,LDA  ,0,1
     ,JAZ  ,POL3
     ,ADD  ,POLY
     ,TAB  ,
     ,TZA  ,
     ,MUL  ,POLY-3
     ,IXR  ,
POL3 ,XAZ  ,POLY-1
     ,ADD  ,0,1
     ,IXR  ,
     ,STX  ,POLY
     ,LDX  ,*+3
     ,JMP* ,POLY
     ,DATA ,0,0,0,014012
POLY ,ENTR ,
     ,JMP  ,POL1
     ,MORE ,
```

```
*
* DF 1.6 (EC118) (12)
*
* XDAB: DBL PREC ABS+SIGN
*
XDAB ,ENTR ,
     ,LDX* ,XDAB
     ,LDA  ,0,RX
     ,STA  ,2,RX
     ,INR  ,XDAB
     ,JAP* ,XDAB
     ,LDB  ,1,RX
     ,CALL ,XDC0
     ,STA  ,0,RX
     ,STB  ,1,RX
     ,RETURN* ,XDAB
*
* XFLT: DBL PREC TO FLT
*
XFLT ,ENTR ,
     ,LDX* ,XFLT
     ,LDA  ,0,RX
     ,LDB  ,1,RX
     ,TZX  ,
     ,CALL ,FNMZ
     ,LDB* ,XFLT
     ,STA  ,0,RB
     ,STX  ,1,RB
     ,INR  ,XFLT
     ,RETU* ,XFLT
*
* XSIN: FIXED POINT SINE
*
XSIN ,ENTR ,
     ,JAP  ,*+10
     ,ADD  ,*+27
     ,JAP  ,*+4
     ,CPA  ,
     ,IAR  ,
     ,SUB  ,*+22
     ,JMP  ,*+8
     ,SUB  ,*+19
     ,JAN  ,*+4
     ,CPA  ,
     ,IAR  ,
     ,ADD  ,*+14
     ,ASLA ,1
     ,CALL ,POLY
     ,DATA ,1,027,-0650,010421,-052525
     ,DATA ,0,077777,0
     ,JMP* ,XSIN
     ,DATA ,031104
     ,MORE ,
```

```
*
* DF 1.6 (EC118) (13)
*
* XCOS: FIXED POINT COSINE
*
XCOS  ,ENTR ,
      ,JAN  ,*+4
      ,CPA  ,
      ,IAR  ,
      ,ADDI ,031104
      ,ASLA ,1
      ,CALL ,POLY
      ,DATA ,1,027,-0650,010421,-052525
      ,DATA ,0,077777,0
      ,JMP* ,XCOS
*
* AVG: ROUTINE TO DO AVERAGING
*
AVG   ,ENTR ,         NEW VALUE IN A
      ,STX  ,*+6      OLD (PREV AVG) VALUE IN B
      ,DXR  ,         WEIGHT (N) IN X
      ,STX  ,*+2      RETURN VALUE IN B
      ,MULI ,0
      ,DIVI ,0        B=(B*(X-1)+A)/X
      ,JMP* ,AVG
*
*  INITIALIZATION
*
INIT  ,EXC  ,PII
      ,EXC  ,CLKF
      ,EXC  ,PDF
      ,ROF  ,
      ,LDX  ,=TOS
      ,STX  ,TOSI
      ,STX  ,TOSP
      ,DECR ,01       (A=-1)
      ,STA  ,0,RX
      ,OAR  ,DISA
      ,OAR  ,DISE
      ,LDA  ,=0177720
      ,STA  ,IMSK
      ,CALL ,TCW,0224 (PCH OFF)
      ,CALL ,TCW,0223 (RDR OFF)
      ,TZX  ,
      ,STX  ,TOCH
      ,STX  ,INUM
      ,STX  ,INUM+1
      ,STX  ,INUM+2
      ,STX  ,SZCT
      ,STX  ,CCTR
      ,LDB  ,=ATAB
      ,STB  ,APTR
      ,LDA  ,IMSK
      ,OAR  ,PIM
      ,EXC  ,PICN
      ,JMP  ,MLOOP
      ,MORE ,
```

```
*
* DF 1.6 (EC118) (14)
*
MLOOP ,CALL ,TTIN
      ,JSS1 ,ML1
      ,JSS2 ,*+4
      ,JMP  ,MLOOP
      ,TZA  ,
      ,STA  ,MLC
      ,CALL ,TTIN
      ,JSS2 ,*-2
*
* PROCESS ANTENNA DATA
*
ML1   ,LDX  ,=ATAB   MOVE FROM ATAB TO BTAB
      ,LDB  ,NANT    AND SET ANY NEGATIVE VALUES TO ZERO
      ,LDA  ,0,RX
      ,JAP  ,*+3
      ,TZA  ,
      ,STA  ,17,RX
      ,DBR  ,
      ,IXR  ,
      ,JBZ  ,*+4
      ,JMP  ,*-9
*
      ,TZB  ,
      ,LDX  ,=BTAB
      ,TBA  ,        LOOP TO FIND LARGEST SIGNAL
      ,SUB  ,0,RX
      ,JAP  ,*+3
      ,LDB  ,0,RX
      ,INCR ,045
      ,SUB  ,=BTAB
      ,SUB  ,NANT
      ,JAN  ,*-8
*
      ,TBA  ,
      ,SUB  ,T1+4
      ,JAN  ,LOSG    JMP IF SIGNAL TOO LOW
      ,LDA  ,T1+8
      ,STA  ,T1+9
*
      ,TZA  ,
      ,MUL  ,T1+5
      ,DIV  ,=1000
      ,STB  ,T1+6    LOW ANTENNA VALUE CUTOFF
*
      ,LDX  ,=BTAB
      ,LDB  ,NANT
      ,DBR  ,
      ,LDA  ,0,RX
      ,SUB  ,T1+6
      ,JAP  ,*+4
      ,TZA  ,
      ,STA  ,0,RX    ZERO FOR LOW VALUE
      ,IXR  ,
      ,DECR ,023
      ,JAP  ,*-8
      ,MORE ,
```

```
*
* DF 1.6 (EC118) (15)
*
      ,LDX   ,=BTAB
AVG1  ,STX   ,T1+3     AVERAGE ANTENNA VALUES
      ,LDA   ,0,RX
      ,ASLA  ,4
      ,LDB   ,102,RX   (IN UTAB)
      ,LDX   ,T1+7
      ,CALL  ,AVG
      ,LDX   ,T1+3
      ,STB   ,102,RX
      ,ASRB  ,4
      ,STB   ,0,RX
      ,INCR  ,045
      ,SUB   ,=BTAB
      ,SUB   ,NANT
      ,JAN   ,AVG1
*
      ,TZX   ,         ZERO SUMS
      ,STX   ,XSUM
      ,STX   ,XSUM+1
      ,STX   ,YSUM
      ,STX   ,YSUM+1
      ,STX   ,ZSUM
      ,STX   ,ZSUM+1
*
      ,LDX   ,=BTAB
SZ3   ,TZA   ,         FORM X,Y,Z SUMS
      ,LDB   ,0,RX
      ,MUL   ,17,RX
      ,CALL  ,XDAD,XSUM
      ,STA   ,XSUM
      ,STB   ,XSUM+1
      ,TZA   ,
      ,LDB   ,0,RX
      ,MUL   ,34,RX
      ,CALL  ,XDAD,YSUM
      ,STA   ,YSUM
      ,STB   ,YSUM+1
      ,TZA   ,
      ,LDB   ,0,RX
      ,MUL   ,51,RX
      ,CALL  ,XDAD,ZSUM
      ,STA   ,ZSUM
      ,STB   ,ZSUM+1
      ,INCR  ,045
      ,SUB   ,=(BTAB)
      ,SUB   ,NANT
      ,JAN   ,SZ3
*
      ,CALL  ,XDAB,XSUM
      ,CALL  ,XDAB,YSUM
      ,CALL  ,XDAB,ZSUM
      ,CALL  ,XFLT,XSUM
      ,CALL  ,XFLT,YSUM
      ,CALL  ,XFLT,ZSUM
      ,MORE  ,
```

```
*
* DF 1.6 (EC118) (16)
*
* MAIN (CONT.)
*
      ,CALL ,FMPY,XSUM,XSUM
      ,STA  ,HYP+1
      ,STB  ,HYP
      ,TZA  ,
      ,STA  ,HYP+2
      ,CALL ,FMPY,YSUM,YSUM
      ,STA  ,T1+1
      ,STB  ,T1
      ,CALL ,FADD,HYP,T1
      ,STA  ,HYP
      ,STB  ,HYP+1
      ,CALL ,FSQT,HYP
*
      ,CALL ,FATN,YSUM,XSUM COMPUTE AZIM.
      ,STA  ,SVD
*
      ,CALL ,FATN,HYP,ZSUM COMPUTE ELEV.
      ,LDX  ,=WTAB   DO ELEV CORRECTION
      ,SUB  ,0,RX
      ,JAN  ,*+5
      ,IXR  ,
      ,JMP  ,*-4
      ,ADD  ,0,RX
      ,TAB  ,
      ,TZA  ,
      ,MUL  ,4,RX
      ,DIV  ,8,RX
      ,ASLA ,1
      ,SUB  ,8,RX
      ,JAN  ,*+3
      ,IBR  ,        (ROUND UP)
      ,TBA  ,
      ,ADD  ,12,RX
      ,STA  ,SVD+1
*
      ,LDA  ,MLC
      ,DAR  ,        ('M' COUNTER)
      ,JAP  ,ML2
      ,LDA  ,SVD
      ,CALL ,BNBC
      ,OBR  ,DISA
      ,LDA  ,SVD+1
      ,CALL ,BNBC
      ,OBR  ,DISE
      ,LDA  ,MLC+1   ('M' VALUE)
ML2   ,STA  ,MLC
      ,MORE ,
```

```
*
* DF 1.6 (EC118) (17)
*
* MAIN (CONCL.)
*
      ,LDA   ,SPTR     SAVE AZIM & ELEV IN AEST
      ,TAX   ,
      ,SUB   ,=(AEST+10)
      ,JAP   ,MLOOP    (DON'T SAVE)
      ,LDA   ,SVD
      ,STA   ,0,RX
      ,LDA   ,SVD+1
      ,STA   ,10,RX
      ,INR   ,SPTR
      ,JMP   ,MLOOP
*
* LOSG: HERE IS SIGNAL TOO LOW
*
LOSG  ,LDA   ,T1+9
      ,DAR   ,         ('Q' COUNTER)
      ,JAP   ,*+5
      ,DECR  ,01
      ,OAR   ,DISA     (BLANK AZIM)
      ,OAR   ,DISE     (BLANK ELEV)
      ,STA   ,T1+9
      ,JMP   ,MLOOP
*
      ,ORG   ,03000
TTIN  ,ENTR  ,         (DUMMY)
      ,JMP*  ,TTIN
*
      ,MORE  ,
      ,END   ,0200
```

```
*
* DF 2.6 (EC118) (1)
*
* EQU'S
*
RX    ,EQU  ,01
RB    ,EQU  ,02
PIM   ,EQU  ,040
PIN   ,EQU  ,0240
PIF   ,EQU  ,0440
PICN  ,EQU  ,0340
*
IAOR  ,BEGI ,0110
LTOR  ,BEGI ,0120
*
      ,ORG  ,0230
MLC   ,BSS  ,2
TPSF  ,BSS  ,1
NCS   ,BSS  ,2
EL    ,BSS  ,3
NANT  ,BSS  ,1
AUTC  ,BSS  ,1
SPTR  ,BSS  ,1
      ,BSS  ,10
IMSK  ,BSS  ,2
SVD   ,BSS  ,2
SAVR  ,BSS  ,14
TOSI  ,BSS  ,1
TOSP  ,BSS  ,1
TOS   ,BSS  ,20
TOSL  ,BES  ,2
T1    ,BSS  ,10
T2    ,BSS  ,5
INUM  ,BSS  ,3
TOCH  ,BSS  ,3
      ,BSS  ,14
AEST  ,BSS  ,20
ATAB  ,BSS  ,17
*
* LINKER
*
      ,ORG  ,03000
LINK  ,ENTR ,         LINK WITH PART 1
      ,LDX  ,LINK
      ,IXR  ,
      ,LDB  ,0,RX     (INIT)
      ,STB  ,LAD1+1
      ,LDA  ,=TTIN
      ,IXR  ,
      ,LDB  ,0,RX
      ,JBZ  ,*+5
      ,STA  ,0,RB     (REF TO TTIN)
      ,JMP  ,*-5
      ,LDB  ,1,RX     (BNBC)
      ,STB  ,LAD2+1
      ,LDB  ,2,RX     (XCOS)
      ,STB  ,LAD3+1
      ,LDB  ,3,RX     (XSIN)
      ,STB  ,LAD4+1
      ,JMP* ,LAD1+1   (TO INIT)
      ,MORE ,
```

```
*
* DF 2.6 (EC118) (2)
*
INIT ,EQU  ,*
BNBC ,EQU  ,*
XCOS ,EQU  ,*
XSIN ,ENTR ,
     ,HLT  ,
     ,JMP* ,*-2
*
* TTIN
*
TTIN ,ENTR ,         TTY INPUT PROCESSOR
     ,LDA  ,TOCH
     ,JAZ  ,*+4
     ,JMP  ,TCA1
     ,LDA  ,TOSI
     ,SUB  ,TOSP
     ,JAZ* ,TTIN     (NO INPUT)
     ,LDX  ,TOSI
     ,LDB  ,0,RX
     ,INCR ,045      (X+1 TO A & X)
     ,SUB  ,=TOSL
     ,JAN  ,*+3
     ,LDX  ,=TOS
     ,STX  ,TOSI
*
     ,TBA  ,
     ,SUB  ,=0272    (='9'+1)
     ,JAP  ,*+5
     ,SUB  ,=0260-0272
     ,JAP  ,DIG      CHAR WAS DIGIT
     ,LDX  ,=TTAB
     ,STB  ,T2
     ,LDA  ,0,RX     LOOK FOR CHAR IN TTAB
     ,JAZ  ,DRTN+2   (END OF TTAB)
     ,ERA  ,T2
     ,JAZ  ,*+6
     ,IXR  ,
     ,IXR  ,
     ,JMP  ,*-8
     ,LDX  ,1,RX     GET PROC ROUTINE ADDR
     ,STX  ,*+3
     ,LDX  ,INUM+2
     ,JMP  ,**0      GO TO PROCESSOR
     ,HLT  ,
DRTN ,JMP* ,TTIN
     ,TBA  ,
     ,SUB  ,=0241
     ,JAN  ,*+5
     ,SUB  ,=0340-0241
     ,JAN* ,TTIN     TYPE ONLY NON-PRINTING CHARS
DCD1 ,CALL ,TCBR
     ,JMP* ,TTIN
     ,MORE ,
```

```
*
* DF 2.6 (EC118) (3)
*
* TCAR: TYPE CHAR IN A REG
*
TCAR ,ENTR ,
     ,SEN  ,0101,*+7 (TTY WTE RDY)
     ,STA  ,TOCH
     ,STB  ,TOCH+1
     ,STX  ,TOCH+2
     ,JMP* ,TTIN
     ,OAR  ,01       (TTY)
     ,LSRA ,8
     ,JAZ* ,TCAR
     ,JMP  ,TCAR+1
TCA1 ,SEN  ,0101,*+4
     ,JMP* ,TTIN
     ,TZB  ,
     ,STB  ,TOCH
     ,LDB  ,TOCH+1
     ,LDX  ,TOCH+2
     ,JMP  ,TCAR+1
*
* TCBR: TYPE CHAR IN B REG
*
TCBR ,ENTR ,
     ,LLRL ,16
     ,CALL ,TCAR
     ,LLRL ,16
     ,JMP* ,TCBR
*
* PRAD: PRINT A REG DECIMAL
*
PRAD ,ENTR ,
     ,JAP  ,*+7
     ,CPA  ,
     ,IAR  ,
     ,LDB  ,='-'
     ,CALL ,TCBR
     ,INCR ,04       (X=1)
     ,JAZ  ,*+7
LAD2 ,CALL ,BNBC
     ,LDX  ,=5
     ,JAZ  ,*+12
     ,ADD  ,=0260
     ,CALL ,TCAR
     ,DXR  ,
     ,JXZ* ,PRAD
     ,TZA  ,
     ,LLRL ,4
     ,JMP  ,*-8
     ,LLRL ,4
     ,DXR  ,
     ,JMP  ,*-14
     ,MORE ,
```

```
*
* DF 2.6 (EC118) (4)
*
* SNCS: SIN/COS FOR THETA/PHI
*
SNCS ,ENTR ,
     ,STA  ,T1
     ,TZA  ,
     ,LDB  ,=040000
     ,DIV  ,TPSF
     ,MUL  ,T1
     ,LASL ,7
     ,JAP  ,*+3
     ,ADD  ,=055000 (2PI)
     ,SUB  ,=026400 (PI)
     ,JAN  ,*+5
     ,SUB  ,=026400
     ,JMP  ,*+3
     ,ADD  ,=026400
     ,TAB  ,
     ,TZA  ,
     ,MUL  ,=043575
     ,LASL ,2
     ,STA  ,T1
LAD3 ,CALL ,XCOS
     ,STA  ,SAVR+2
     ,LDA  ,T1
LAD4 ,CALL ,XSIN
     ,LDB  ,SAVR+2
     ,JMP* ,SNCS
*
* GADR: GET TABLE ADDRESS
*
GADR ,ENTR ,
     ,LDA  ,EL
     ,DAR  ,
     ,JAN  ,GAD1
     ,SUB  ,NANT
     ,JAP  ,GAD1
     ,ADD  ,NANT
     ,ADD  ,EL+1
     ,ADD  ,=ATAB
     ,TAX  ,
     ,INR  ,EL
     ,INR  ,GADR
     ,JMP* ,GADR
GAD1 ,LDX  ,GADR
     ,LDX  ,0,RX
     ,STX  ,*+2
     ,JMP  ,**0
*
* CRLF: TYPE CR-LF
*
CRLF ,ENTR ,
     ,LDA  ,=0105215
     ,CALL ,TCAR
     ,JMP* ,CRLF
     ,MORE ,
```

```
*
* DF 2.6 (EC118) (5)
*
* GTNM: GET INPUT NUMBER
*
GTNM ,ENTR ,
     ,LDA  ,INUM
     ,LDB  ,INUM+1  (SIGN)
     ,JBZ  ,*+4
     ,CPA  ,
     ,IAR  ,
     ,TZB  ,
     ,STB  ,INUM
     ,STB  ,INUM+1
     ,STB  ,INUM+2
     ,JMP* ,GTNM
*
* SACN: STORE 'A' REGISTER AS INPT NR & PRINT
*
SACN ,ENTR ,
     ,STA  ,INUM
     ,CALL ,PRAD
     ,LDA  ,INUM
     ,TZB  ,
     ,JAP  ,*+6
     ,CPA  ,
     ,IAR  ,
     ,CPB  ,
     ,STA  ,INUM
     ,STB  ,INUM+1
     ,INR  ,INUM+2
     ,JMP* ,SACN
*
* VSOP: STORE OR PRINT A VARIABLE
*
VSOP ,LLRL ,16
     ,JXZ  ,*+10
     ,CALL ,TCAR    TYPE CHAR
     ,TBX  ,
     ,CALL ,GTNM
     ,STA  ,0,RX    STORE VALUE
     ,JMP  ,DRTN
*
     ,LDA  ,0,RB    GET VALUE
     ,CALL ,PRAD    PRINT IT
     ,LDA  ,T2
     ,CALL ,TCAR    TYPE CHAR
     ,JMP  ,DRTN
*
* TTAB: TTY CHAR TABLE
*
TTAB ,DATA ,0215,CR,0212,DRTN,',',COMM,'-',MINU
     ,DATA ,'=',CNM,'/',STV,'?',EQLS,'A',A,'B',A-1
     ,DATA ,'C',C,'D',D,'E',E,0204,DBUG,'H',H
     ,DATA ,0337,DLN,'N',N,'P',A-5,'I',I,'Z',A-4
LAD1 ,DATA ,'R',INIT,'S',S,'T',A-6,'X',A-2,'Y',A-3
     ,DATA ,'V',V,'U',A-7,'W',A-8,'M',M,'L',L
     ,DATA ,'Q',Q,'J',J,'F',F,'G',G,'K',K,0
     ,BSS  ,10
     ,MORE ,
```

```
*
* DF 2.6 (EC118) (6)
*
* COMM: SET TABLE ELEMENT PTR
*
COMM ,LDAI ,EL
     ,JMP  ,VSOP
*
* CR: TTY RETURN
*
CR   ,CALL ,CRLF
     ,JMP  ,I1
*
* MINU: SET SIGN
*
MINU ,CALL ,TCBR
     ,LDA  ,INUM+1
     ,CPA  ,
     ,STA  ,INUM+1
     ,JMP  ,DRTN
*
* CNM: TYPE CURRENT NBR
*
CNM  ,JXZ  ,DRTN
     ,LDA  ,=' ='
     ,CALL ,TCAR
     ,CALL ,GTNM
     ,CALL ,SACN
     ,JMP  ,DRTN
*
* STV: STORE OR PRINT TABLE ENTRY
*
STV  ,JXZ  ,*+12
     ,CALL ,TCBR
     ,CALL ,GADR,TIER
     ,CALL ,GTNM
     ,STA  ,0,RX
     ,JMP  ,DRTN
     ,CALL ,GADR,TIER
     ,LDA  ,0,RX
     ,CALL ,SACN
     ,LDA  ,EL
     ,DAR  ,
     ,STA  ,EL
     ,JMP  ,DRTN
*
* DIG: ACCUMULATE NBR
*
DIG  ,CALL ,TCBR
     ,LDB  ,INUM
     ,MUL  ,=10
     ,STB  ,INUM
     ,INR  ,INUM+2
     ,JMP  ,DRTN
     ,MORE ,
```

```
*
* DF 2.6 (EC118) (7)
*
* EQLS: TTY QUEST MARK PROC
*
EQLS ,CALL ,CRLF
     ,LDA  ,EL+2
     ,CALL ,TCAR
     ,LDB  ,='?',1'
     ,CALL ,TCBR
     ,INCR ,01       (A=1)
     ,STA  ,EL
EQL1 ,CALL ,GADR,CR
     ,LDA  ,0,RX
     ,CALL ,PRAD
     ,LDB  ,='/'
     ,CALL ,TCBR
     ,LDA  ,EL
     ,SUB  ,=10
     ,JAZ  ,*+4
     ,JMP  ,EQL1
     ,CALL ,CRLF
     ,JMP  ,EQL1
*
* A: SELECT TABLE
*
     ,IAR  ,         (W)
     ,IAR  ,         (U)
     ,IAR  ,         (T)
     ,IAR  ,         (P)
     ,IAR  ,         (Z)
     ,IAR  ,         (Y)
     ,IAR  ,         (X)
     ,IAR  ,         (B)
A    ,STA  ,EL+1     (A)
     ,ASLA ,4
     ,ADD  ,EL+1     (MUL BY 17)
     ,STA  ,EL+1
     ,STB  ,EL+2     SAVE CHAR
     ,CALL ,TCBR
     ,JMP  ,DRTN
*
* V: TYPE AZIM. & ELEV.
*
V    ,CALL ,CRLF
     ,LDA  ,=':A'
     ,CALL ,TCAR
     ,LDA  ,SVD
     ,CALL ,PRAD
     ,LDA  ,=' '
     ,CALL ,TCAR
     ,LDA  ,=':E'
     ,CALL ,TCAR
     ,LDA  ,SVD+1
     ,CALL ,PRAD
     ,JMP  ,CR
     ,MORE ,
```

```
*
* DF 2.6 (EC118) (8)
*
* C: CALC X,Y,Z COEF
*
C     ,CALL ,TCBR
      ,LDX  ,=ATAB
      ,LDA  ,102,RX  (THETA)
      ,CALL ,SNCS
      ,STA  ,SAVR    (SIN[THETA])
      ,STB  ,68,RX   (Z=COS[THETA])
      ,LDA  ,85,RX   (PHI)
      ,CALL ,SNCS
      ,STA  ,SAVR+1  (SIN[PHI])
      ,TZA  ,
      ,MUL  ,SAVR
      ,LASL ,1
      ,STA  ,34,RX   (X)
      ,TZA  ,
      ,LDB  ,SAVR+1
      ,MUL  ,SAVR
      ,LASL ,1
      ,STA  ,51,RX   (Y)
      ,INCR ,045     (X+1 TO X & A)
      ,SUB  ,=ATAB
      ,SUB  ,NANT
      ,JAN  ,C+3
      ,JMP  ,I1
*
* D: DISABLE SWITCH INTERRUPTS
*
D     ,CALL ,TCBR
      ,LDA  ,IMSK
      ,ORA  ,=06
      ,OAR  ,PIM     (DISABLE SWITHCES)
      ,STA  ,IMSK
      ,JMP  ,DRTN
*
* E: ENABLE SWITCH INTERRUPTS
*
E     ,CALL ,TCBR
      ,LDA  ,IMSK
      ,ANA  ,=0177771
      ,OAR  ,PIM     (ENABLE SWITCHS)
      ,STA  ,IMSK
      ,JMP  ,DRTN
*
* DBUG: (CTRL-D) GO TO DBUG ROUTINE
*
DBUG  ,EXC  ,PIF
      ,JMP  ,*+2     ENTER DBUG ROUTINE ADDR WHEN NEEDED
      ,EXC  ,PICN
      ,JMP  ,I1
      ,MORE ,
```

```
*
* DF 2.6 (EC118) (9)
*
* I: SET AUTO CYCLE
*
I     ,LDA   ,=AUTC
      ,JMP   ,VSOP
*
* DLN: DELETE CURRENT NBR
*
DLN   ,JXZ   ,DRTN
      ,LDA   ,=0120337 (SP+LFT ARO)
      ,CALL  ,TCAR
I1    ,TZA   ,
      ,STA   ,INUM
      ,STA   ,INUM+1
      ,STA   ,INUM+2
      ,JMP   ,DRTN
*
* L: SET FIXED PDN TIME
*
L     ,LDAI  ,NCS+1
      ,JMP   ,VSOP
*
* M: SET MLOOP CYCLE COUNTER
*
M     ,LDAI  ,MLC+1
      ,JMP   ,VSOP
*
* N: SET NBR ANTENNAS
*
N     ,LDAI  ,NANT
      ,JXZ   ,VSOP
      ,CALL  ,TCBR
      ,CALL  ,GTNM
      ,TAB   ,
      ,DAR   ,
      ,JAN   ,TIER
      ,SUB   ,=17
      ,JAP   ,TIER
      ,STB   ,NANT
      ,JMP   ,DRTN
*
* S: SET THEAT/PHI SCALE FACTOR
*
S     ,LDAI  ,TPSF
      ,JMP   ,VSOP
*
* TIER: TTY ERR PRINT
*
TIER  ,LDAI  ,'!'
      ,CALL  ,TCAR
      ,JMP   ,CR
      ,MORE  ,
```

```
*
* DF 2.6 (EC118) (10)
*
* H: HALT (PUSH 'RUN' TO RESTART)
*
H     ,EXC  ,PIF
      ,HLT  ,
      ,JMP  ,0200
*
* J: SET/PRINT LOW SIGNAL CUTOFF
*
J     ,LDAI ,T1+4
      ,JMP  ,VSOP
*
* K: SET/PRINT LOW ANTENNA LEVEL CUTOFF
*
K     ,LDAI ,T1+5
      ,JMP  ,VSOP
*
* F: SET/PRINT NUMBER CYCLES AVERAGED
*
F     ,LDAI ,T1+7
      ,JMP  ,VSOP
*
* Q: SET/PRINT DISPLAY HOLD COUNT
*
Q     ,LDAI ,T1+8
      ,JMP  ,VSOP
*
* G: PRINT HI,LO,AVG OF 10 CYCLES
*
G     ,LDA  ,=AEST
      ,STA  ,SPTR
      ,CALL ,CRLF
      ,LDA  ,SPTR
      ,SUB  ,=(AEST+10)
      ,JAP  ,*+8
      ,LDAI ,0377
      ,CALL ,TCAR
      ,JMP  ,*-8
      ,LDAI ,':A'
      ,CALL ,TCAR
      ,LDA  ,=AEST
      ,CALL ,PHLA
      ,LDAI ,':E'
      ,CALL ,TCAR
      ,LDA  ,=(AEST+10)
      ,CALL ,PHLA
      ,JMP  ,DRTN
*
* PHLA: HI,LO,AVG ROUTINE FOR 'G'
*
PHLA  ,ENTR ,
      ,TAX  ,
      ,ADD  ,=10
      ,STA  ,T2+1     (END PTR)
      ,TZA  ,
      ,STA  ,T2+2     (SUM)
      ,STA  ,T2+3     (HI)
      ,MORE ,
```

```
*
* DF 2.6 (EC118) (11)
*
* PHLA (CONCL.)
*
      ,LDA   ,=077777
      ,STA   ,T2+4     (LOW)
*
PHL1  ,LDA   ,0,RX
      ,TAB   ,
      ,ADD   ,T2+2
      ,STA   ,T2+2     (SUM)
      ,TBA   ,
      ,SUB   ,T2+3
      ,JAN   ,*+3
      ,STB   ,T2+3     (HI)
      ,TBA   ,
      ,SUB   ,T2+4
      ,JAP   ,*+3
      ,STB   ,T2+4     (LO)
      ,INCR  ,045
      ,SUB   ,T2+1     (END PTR)
      ,JAN   ,PHL1
*
      ,LDA   ,T2+3
      ,CALL  ,PRAD     PRINT HI
      ,LDA   ,=' '
      ,CALL  ,TCAR
      ,LDA   ,T2+4
      ,CALL  ,PRAD
      ,LDA   ,=' '
      ,CALL  ,TCAR
      ,TZA   ,
      ,LDB   ,T2+2
      ,DIV   ,=10      CALC AV
      ,SUB   ,=5
      ,JAN   ,*+3
      ,IBR   ,         (ROUND UP)
      ,TBA   ,
      ,CALL  ,PRAD
      ,CALL  ,CRLF
      ,JMP*  ,PHLA
*
      ,MORE  ,
      ,END   ,0200
```