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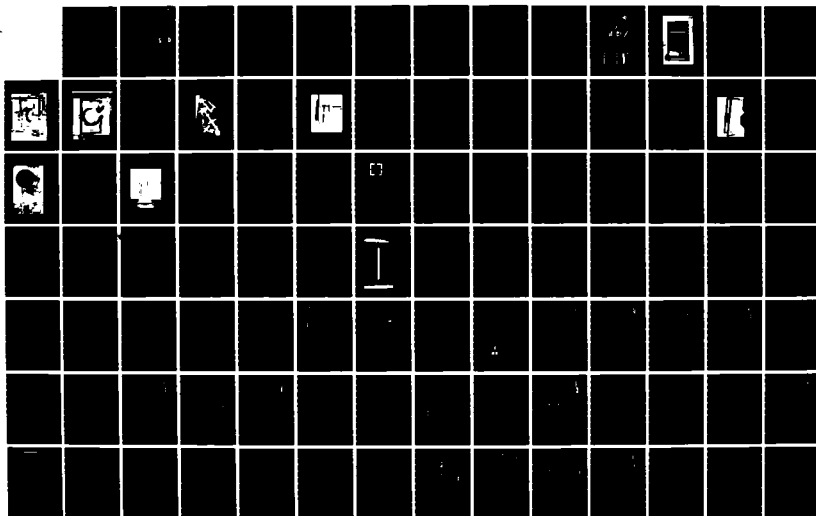
RADOME POSITIONER FOR THE RFSS (RADIO FREQUENCY
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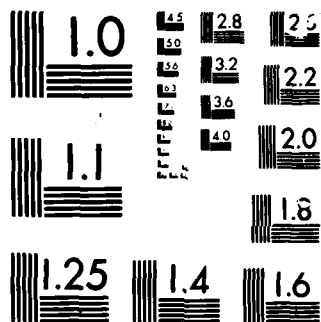
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Final Report

RADOME
POSITIONER FOR THE RFSS

D. O. Gallentine,
J. A. Stratigos, J. M. Schuchardt
C. J. Bowick, R. W. Bird
31 December 1977

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A second element used is a sturdy hinged seeker antenna mount that will permit accurate positioning of the seeker antenna when the radome is mounted or removed from the gimbal. The third element used is a movable cart that can lift the entire assembly off the door frame and carry it out of the way. A fourth element used is a specially designed cart to remove the aperture door and store it while the radome positioner is being used.

The radome positioner is controlled by a microcomputer that permits manual operation and the selection of one of several raster scan patterns to ease data taking. Precision speed and position controlling is accomplished by a closed-loop servo approach where the loop is closed via the computer.

The positioner provides additional capability to perform antenna pattern measurements using the RFSS array and anechoic chamber and may possibly function as a general purpose gimbal permitting closed-loop tracking of the array by experimental RF seekers.

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Pages 120 and 121 do not contain proprietary information.

Per Mr. Kevin Jackson, Army Missile Comd,
Systems Simulation Dir.

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1.0 INTRODUCTION

As originally designed, the Radio Frequency Simulation System (RFSS) provides a unique capability for closed-loop testing of RF guidance systems. The elements of the RFSS, notably the multi-element target array and the large anechoic chamber, can service three test point locations - the main central flight table and two off-axis aperture rooms. The two-axis gimbal described in this report is intended to be a portable structure that can be installed when needed in the West Aperture Room* providing the RFSS with an expanded capability for radome and RF seeker testing and for other uses such as microwave antenna testing and RF seeker evaluations.

The new radome positioner shown in Figure 1 utilizes a heavy duty structure capable of handling missile radomes from a variety of Army missiles from the large Pershing to the smaller Patriot and Hawk radomes. Other radomes from a variety of systems can also be handled. The positioner operation is controlled by a microcomputer providing two-axis closed-loop control via a simple keyboard and digital display. These elements are shown in Figure 2. The operator proceeds through a few simple steps to bring the unit to operational readiness and then selects one of several preprogrammed raster scan patterns, or complete manual positioning is possible.

The positioner then moves the radome while the RF seeker antenna remains stationary. This approach is based on the fundamental concept that if only the radome is moving, only the radome is contributing to the indicated bore-sight error. As a result, even small radome errors can be conveniently and accurately ascertained.

The following sections describe in detail background information associated with the positioner and the mechanical, electrical and software portions of the radome positioner.

*Only minor modifications would be required to install the radome positioner in the East Aperture Room.

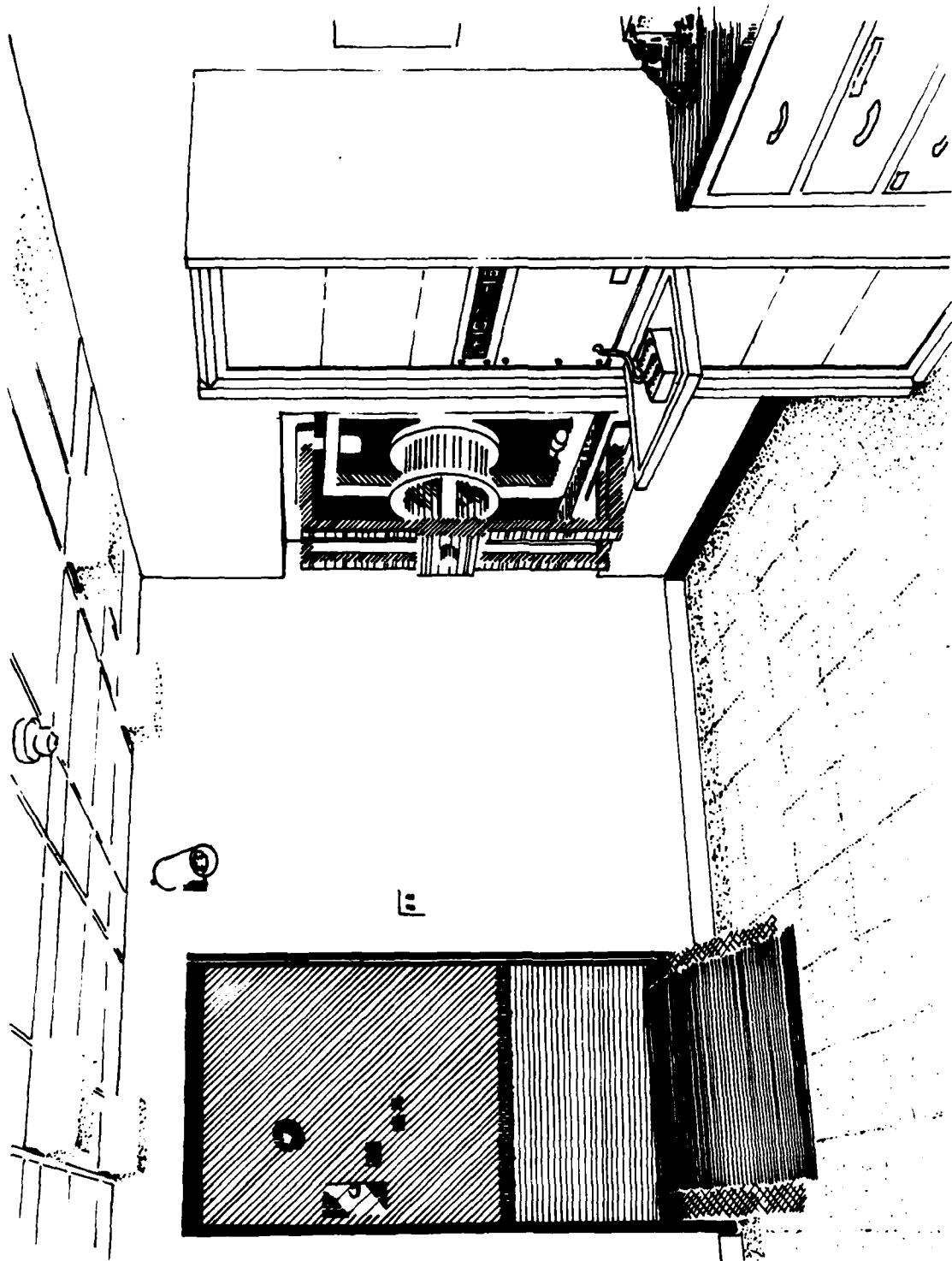


Figure 1. Sketch Showing the Radome Positioner and Electronics Installed in the West Aperture Room of the RFSS.

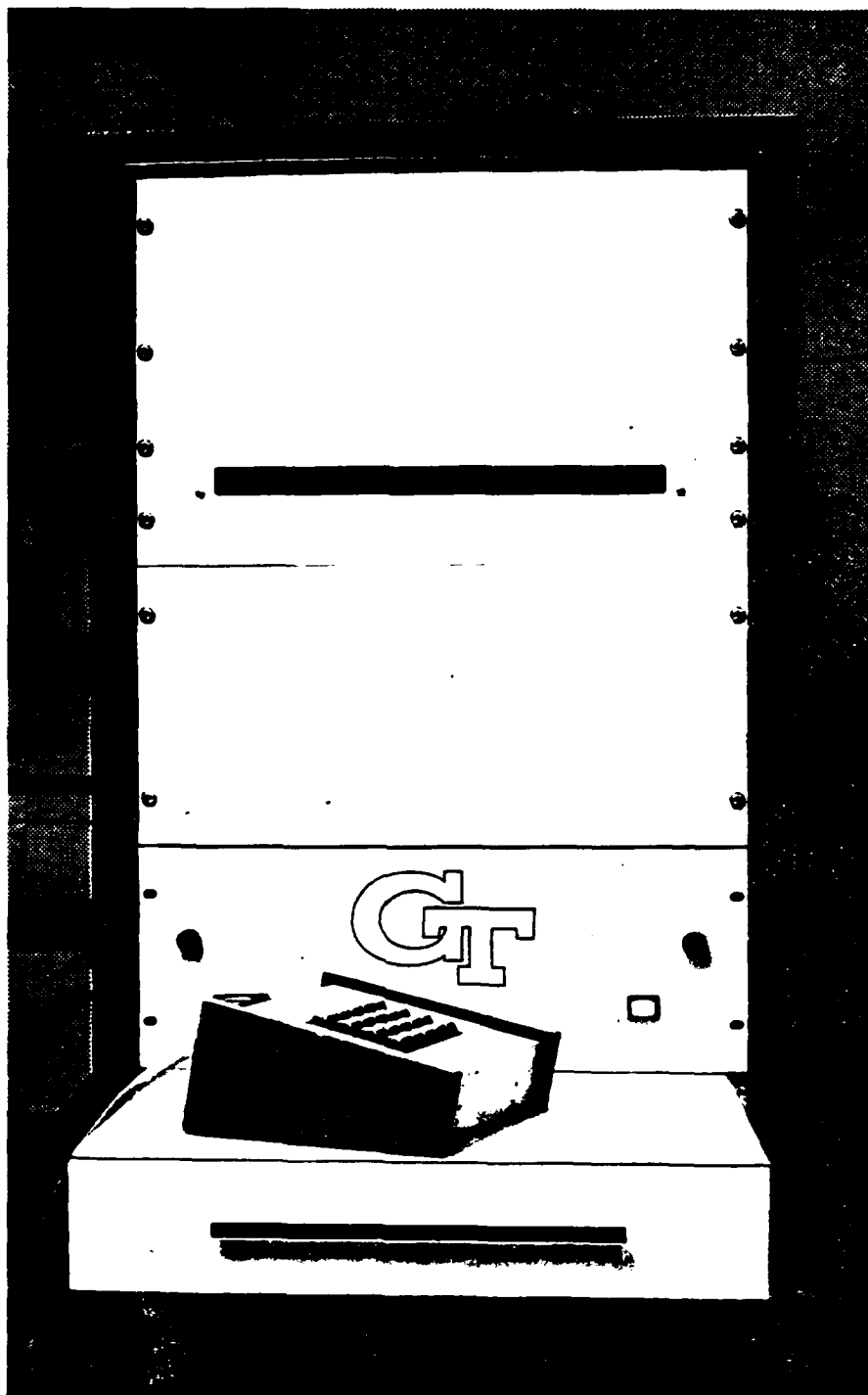


Figure 2. Microcomputer Rack and Control
Console for the RFSS Radome Positioner

2.0 BACKGROUND

In the past few years, closed-loop tests of RF seekers in the RFSS with and without radomes have suggested the need for a separate portion of the facility be made available for convenient radome and seeker evaluations that do not tie up the main flight table. The term convenience as used here has several meanings:

1. It is certainly desirable to make things easier for the designer and evaluator to install the bulky and typically awkward missile radome with ease and, above all, accurately and repeatably. This factor improves operator morale and the quality of test data.
2. It is desirable to have a unit that is capable of automatic operation since a large amount of angle space must be sampled to fully characterize the nature of the radome under evaluation and manual operations are not geared to taking a lot of data.
3. A versatile implementation is needed to permit the operator to examine in minute detail peculiarities that might be uncovered in an initial screening of a production or unusual radome specimen.
4. It is desirable for a government agency to have a facility capable of independent evaluation of radomes and RF sensors in a complementary manner to their existing facilities and with known radome test procedures as are used by radome manufacturers.

Thus, the current design described in this report was conceived and developed to meet the needs. Further, the unit as implemented is fully compatible with other Army RFSS computers and offers addition flexibility for testing in the RFSS itself, perhaps allowing improved facility utilization in the future.

3.0 MECHANICAL DESCRIPTION

The radome positioner consists of a large two-axis gimbal assembly designed to fit into the current opening in the west aperture room upon removal of the shielded door. Figures 3 and 4 show the final unit prior to installation. The mechanical design philosophy used to meet the positioner requirements listed in Table 1 was to use large standard size ball and thrust bearings, steel pins compatible with the bearings, aluminum alloys, and standard structural members. Previous experience has shown these methods improve operational reliability and are cost effective.

The inner gimbal is a ring 18 inches inside diameter with a 3-inch square tubular cross-section. This inner gimbal is supported by the outer gimbal through two 0.984 inch diameter steel pins and four single row, deep groove ball bearings. The outer gimbal is a rectangular structure 26 inches by 38.5 inches inside dimensions with a 3-inch square tubular cross-section. It is supported in the azimuth axis with two 0.984 inch diameter steel pins and four single row, deep groove ball bearings. There is also a thrust ball bearing mounted below the outer gimbal to carry the vertical loads of the entire gimbal system. The entire elevation and azimuth gimbal system is mounted to an external frame. This external frame is aluminum angle 4 inches by 3 inches by 0.250 inch thick and is mounted into the opening of the West Aperture Room of the RFSS. The entire gimbal and outer frame assembly is clamped to the internal edge of the aperture opening with eight special design C-clamps (Figure 5). The C-clamps have a large clamping surface to spread the clamping pressure over a broad area, thereby preventing local distortion to the contact finger brass extrusion mounted on the inner edge of the aperture opening.

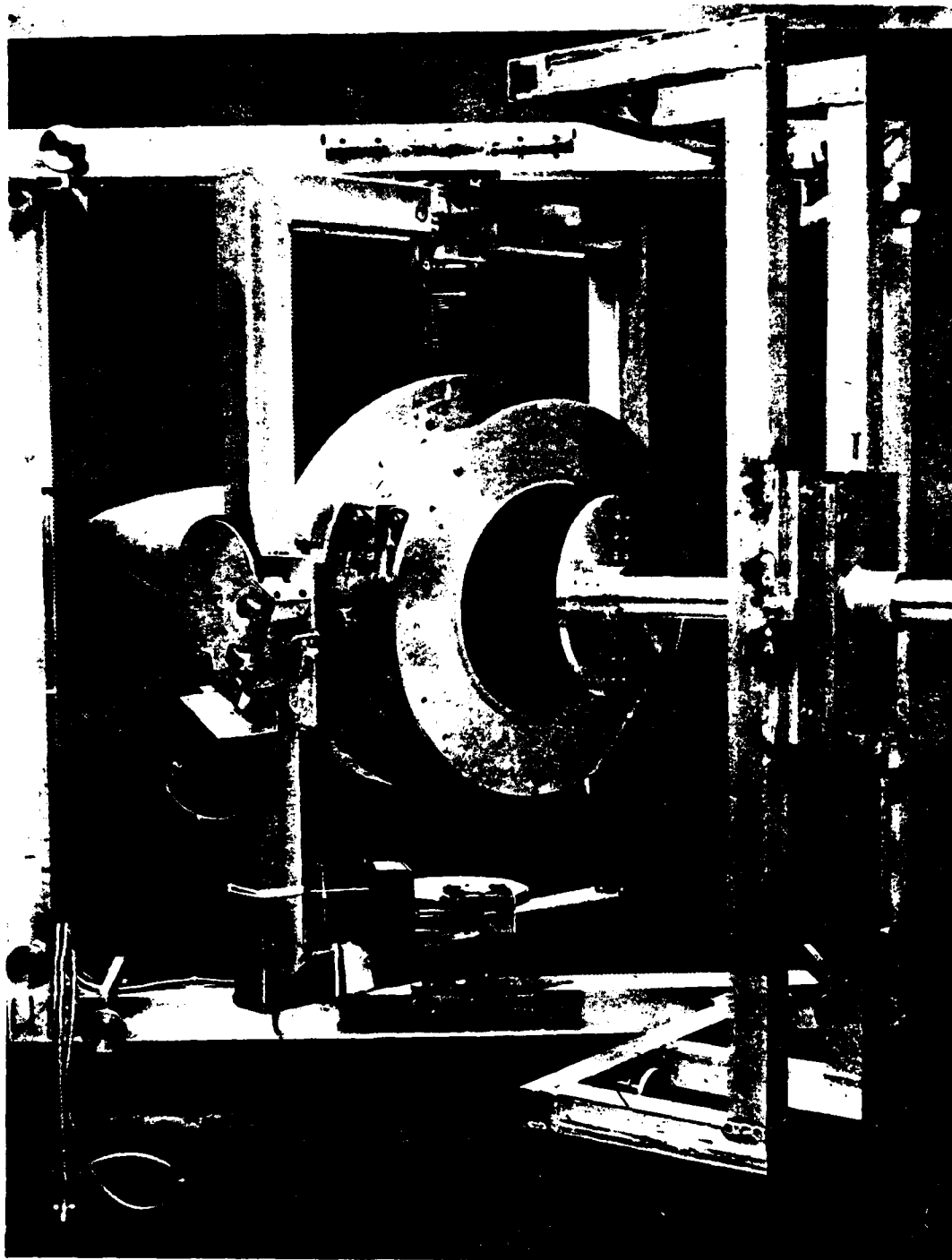


Figure 3. Radome and Gimbals and Seeker Mount Rear View.



Figure 4. Radome and Gimbals Front View.

TABLE 1

RFSS RADOME POSITIONER REQUIREMENTS

Radome Diameter	18 inches, maximum
Radome Weight	50 pounds, maximum
Seeker Antenna Weight	20 pounds, maximum
Readout Accuracy	± 0.1 degrees
Scan Angle Elevation	± 40 degrees
Scan Angle Azimuth	± 40 degrees
Scan Rate (AZ or EL)	2 degrees/sec, nominal
Repositioning Accuracy	± 0.1 degrees
Seeker Repositioning after Boresighting	± 0.005 inches
Sign of Angle (When Looking Toward the RFSS Array)	Up and to the Right (1st Quadrant) +AZ, +EL
	Up and to the Left (2nd Quadrant) -AZ, +EL
	Down to the Left (3rd Quadrant) -AZ, -EL
	Down to the Right (4th Quadrant) +AZ, -EL

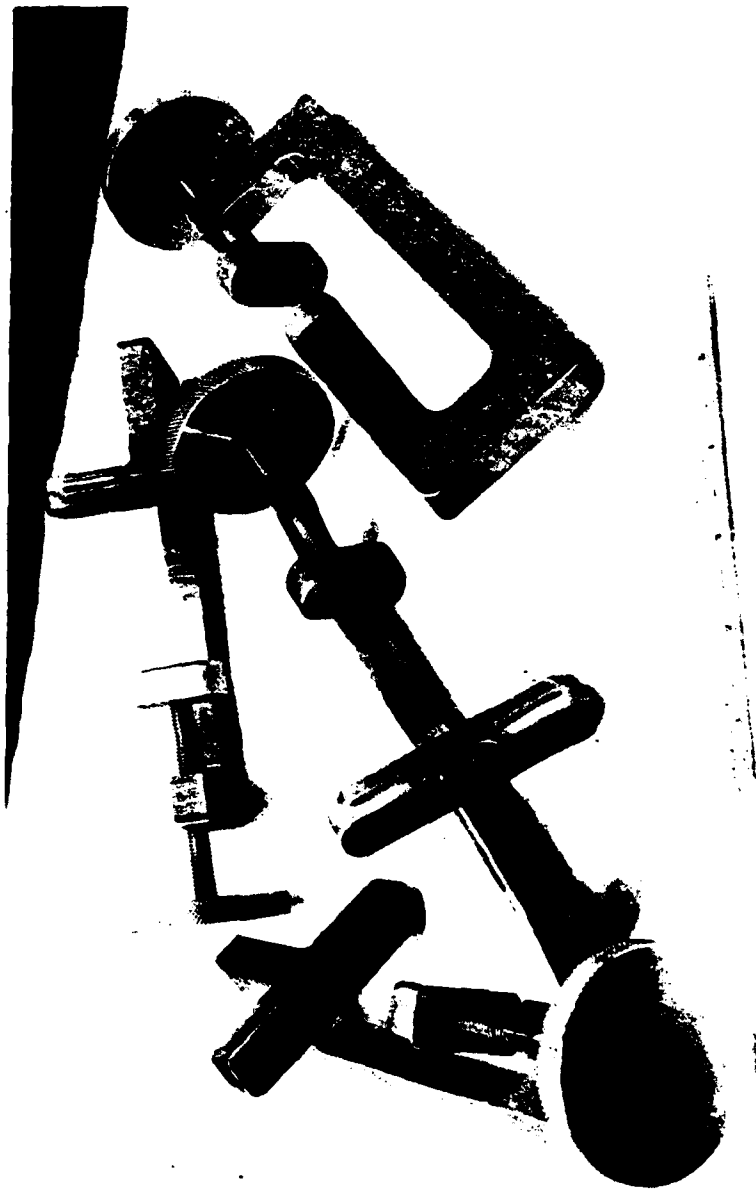


Figure 5. Special C-Clamps for Attaching to RFSS Frame.

The seeker antenna mount and boresight adjustment mechanism is mounted directly to the external frame independent of the radome gimbal system mounting. The seeker antenna is located at the intersection of the gimbal's azimuth and elevation axis. It is mounted on a cantilevered 2-inch diameter aluminum tube supported at the rear-end by a plate which is attached to the boresight adjustment mechanism. This mechanism is an integral part of a stiff tubular structure that is attached to the external frame. Attachment to the external frame is accomplished through two large hand-operated screw locks. There are also four precision steel guide pins with stops located near the screw locks to act as precision references for the repositioning of the seeker antenna and its supporting structure after the test radome is installed. A hinge mechanism is used to swing the seeker antenna and its supporting structure out of the way while the test radome is being installed. This technique allows the seeker antenna to be installed or removed from the inside of the radome.

Associated with the positioner is a separate cart shown in Figure 6 used only for installation, removal and storage of the entire gimbal system. The cart is a modified commercial unit having a hydraulic lift and is mounted on wheels for ease of movement.

3.1 Design Approach

Three basic methods were used to design a gimbal assembly capable of meeting the requirements: 1 structural analysis was performed to select materials and geometries capable of meeting the desired very low deflections that occur as seeker and radome are mounted and moved, 2 basic drive train components were selected to have sufficient inherent accuracy needed to position the gimbal axes

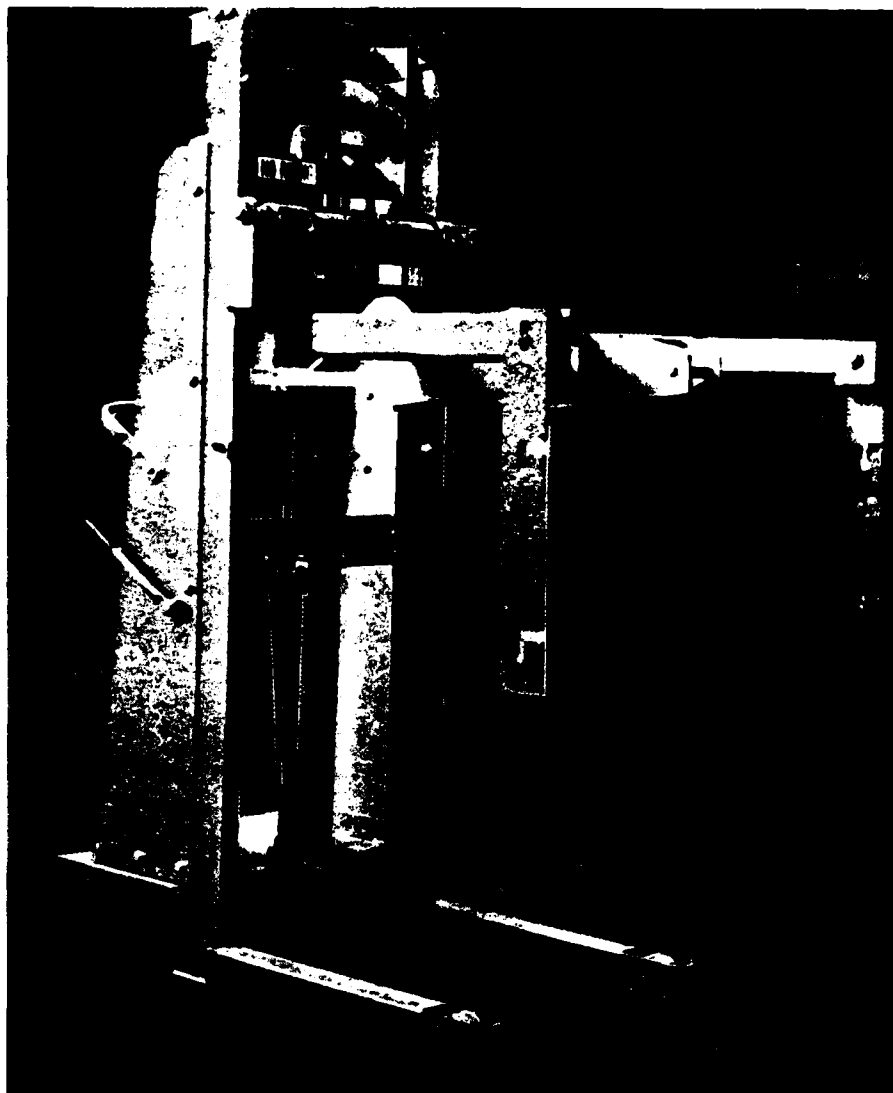


Figure 6 . Cart Used to Install, Remove
and Store the RFSS Radome Positioner

accurately, and 3 critical components were accurately machined and when precise alignment was needed stainless steel was used for improved ruggedness.

Structural Analysis

During the design study phase preceeding the hardware fabrication a structural analysis of this approach was completed. This analysis indicates the following:

- a] The maximum possible rotation of the outer gimbal frame at the location of the optical encoder is less than 0.00367 degrees. This is based on a maximum external moment of 525 pounds/inch caused by a 50 pound radome with a lever arm of 10.5 inches. This is not a system error, because it can be calibrated out at assembly and periodically thereafter.
- b] The maximum possible vertical deflection of the outer gimbal frame with reference to the thrust bearing is less than 8×10^{-4} inches. This deflection is based on the addition of a 50 pound radome.
- c] The vibration frequency of the positioner structure is calculated to be a minimum of 170 Hz.

Readout Accuracy

Readout accuracy is a summation of the errors of the various elements of the system; these include the encoders, perpendicularity of the azimuth and elevation axis and the deflections within the structure that are caused by the installation of the test radome after the seeker antenna has been boresighted. A discussion of how each of these error sources is minimized is given below.

The encoders selected for this system are Itek Ra13/23C with an accuracy of plus or minus 0.03 degrees (1/3 bit). The encoder is an absolute type that is connected directly to the shaft in each axis.

(The encoder is described in detail in Appendix C.)

The error caused by the perpendicularity of the azimuth and elevation axes is dependent on the error (tolerance) in machining of the two axes in the outer gimbal. A typical machine tolerance would be approximately ± 0.005 inches which would result in an angular error of about 0.02° .

The error caused by the installation of the radome after the seeker antenna has been boresighted is dependent on the deflection of the entire gimbal system with reference to the seeker antenna mount. In this case, the calculated deflection caused by the installation of a 50 pound radome is 0.0008 inches. The readout error caused by this deflection divided by the distance (48 feet) from the seeker antenna to the source array antenna at the far end of the microwave chamber is negligible (less than 1.5×10^{-3} milliradians).

Other sources of error are an accumulation of miscellaneous machining and assembly tolerances which are estimated to be less than $\pm 0.015^\circ$ (see Table 2).

Repositioning Accuracy of the Seeker Antenna and Radome

The seeker antenna must be swung out of the way while the test radome is being installed and must be repositioned to its original boresighted position to within ± 0.005 inches. This repositioning accuracy is built into the basic structure and is dependent on the machine tolerances of the location precision reference guide pins. This tolerance can be easily held to less than ± 0.005 inches by proper machining methods.

The seeker antenna will sag when placed on the 2 inch diameter attachment. The total calculated deflection caused by a 20 pound antenna system is less than 0.001 inches producing an angular rotation of less than 0.5 milliradians in the apparent antenna boresight axis..

The angular location of the test radome must be positioned to within ± 0.1 degree. This is accomplished by the use of an accurately machined adapter/fixture that attaches the test radome to the inner gimbal ring. Normal machining methods to tolerances of ± 0.005 inches with well-made radomes will be adequate. Alignment dowel pins are also located on the

$$* \quad \tan \theta_{\text{error}} = \frac{\text{Machine Tolerance}}{\text{Smallest Width}/2} \quad (\text{See Figure 7})$$

$$\tan \theta_{\text{error}} = \frac{0.005}{24.5/2} = 0.00041$$

$$\theta_{\text{error}} = 0.023^\circ$$

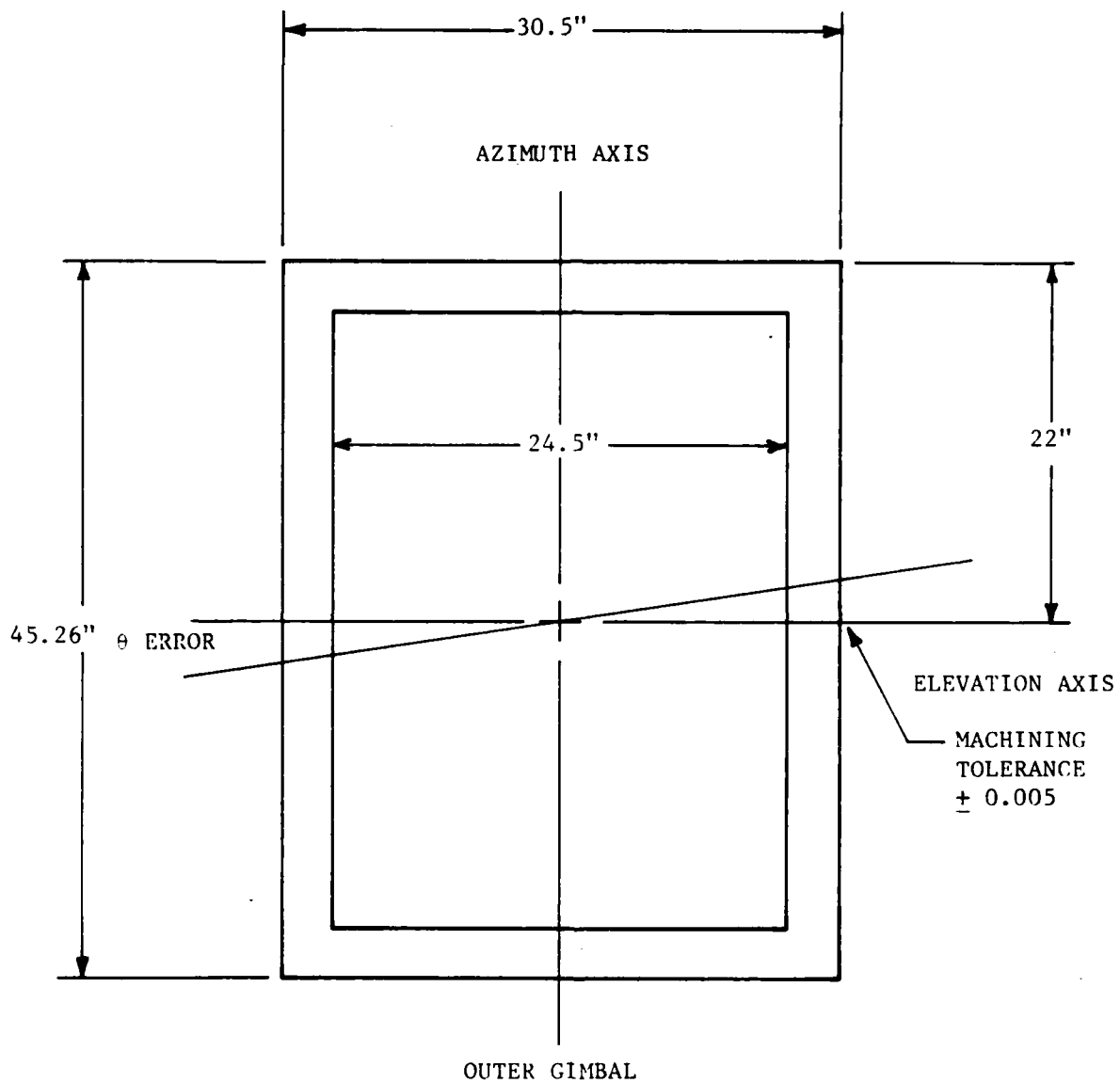


Figure 7. Diagram Illustrating Gimbal Misalignment Factors due to Machining Tolerances.

TABLE 2
TOTAL READOUT ACCURACIES

<u>Error Source</u>	<u>Error Degrees</u>
Encoder Readout	± 0.030
Outer Gimbal/Perpendicularity	± 0.023
Structure Deflection	Negligible (1.5×10^{-3} milliradian)
Structure Twisting	Negligible (0.004 degrees)
Miscellaneous Machining & Assembly Tolerances	± 0.015
TOTAL SINGLE PLANE ERROR	± 0.065 peak
	± 0.056 RMS

fixture so that the radome can be removed and re-attached to the inner gimbal ring and maintain the same rotation position relative to the azimuth and elevation axes to within ± 0.1 degree.

The weight of radome positioner less radome, seeker antenna and counter weights is:

Inner Gimbal		43.67 pounds
Gimbal Ring	19.01	
Radome Adapter	14.17	
Radome Mount	6.79	
Elevation Shafts	3.70	
Outer Gimbal		84.62
Gimbal Frame	41.59	
Bearings Az and El	5.40	
Azimuth Shafts	3.98	
Drive Motors	10.00	
Gear Trains	7.00	
Encoders	2.00	
Motor Mounting Brackets	4.65	
Miscellaneous Brackets and Clamps	10.00	
Outer Frame		30.83
Outer Frame	23.53	
Alignment Plate	3.20	
Antenna Mount Hinge Brackets	4.10	
Seeker Antenna Mount		50.88
Antenna Mount	48.98	
Dowel Pins, Hand Screw Lock, Hinge Pins	1.90	
Miscellaneous Hardware and Wiring		5.00
Total Weight Less Radome Seeker Antenna and Counter Weights		215.00 pounds

Note this weight is less than the door (~400pounds) used to seal the West Aperture Room of the RFSS.

3.2 Mechanical Components

The overall design of the radome positioner system is based on a two axis system (elevation over azimuth) mounted in an aluminum angular outer frame designed to closely fit the aperture door opening. A rigid seeker antenna mounting frame shown in Figure 8 is also attached directly to the angular outer frame.

The outer mounting frame (See Drawing 5*) is fabricated from 4" by 4" by 3/8" aluminum angle-alloy 6061T6. The angle is welded into a rectangular frame and machined to fit the aperture opening, allowing a nominal 1/16" clearance on all four sides. During the machining operations the mounting surfaces for the azimuth upper and lower gimbal shaft (See Encoder Mounting Shaft Drawing 25) are machined parallel to each other to within 0.002". Also, the surfaces for mounting the seeker antenna alignment plates (See Drawing 6) and the seeker antenna support bracket hinges are machined perpendicular to the gimbal shaft mounting surfaces to within 0.002" and parallel to each other to within 0.002". Holes are also provided for mounting the four lifting buttons (See Drawing 28) on the sides.

The outer gimbal (Drawing 8) is fabricated from 3" readily available square aluminum of alloy 6061-T6. Solid aluminum blocks are also incorporated into the overall weldment at the azimuth and elevation bearing axis to provide solid cross-sections sufficiently large to support the large azimuth and elevation bearings. During the machining operation, the perpendicularity of the two axes was maintained to within $\pm 0.005"$. The main drive motor mounting brackets in both axes are also mounted on the outer gimbal. The mounting surfaces for these brackets are machined on the sides of the gimbal to be parallel to the appropriate axis within $\pm 0.005"$. The encoder mounting surfaces are also located on the outer gimbal. These encoder mounting surfaces are machined to locate encoders concentric and perpendicular to the center lines of the azimuth and elevation axis to within 0.001 inches to prevent excessive side loading on the encoder bearings.

*All mechanical and electrical drawings appear in Appendix A.



Figure 8. Seeker Antenna Mounting Frame Prior to Installation

The inner gimbal (See Drawing 9) is a total weldment fabricated from various thicknesses of aluminum sheet and solid aluminum blocks. Excess stock is left on all surfaces of the weldment to allow machining to final dimensions. General tolerances are held to ± 0.005 inches although clearance between the radome mounting ring (See Drawing 27) and the inner gimbal is held to less than 0.002 inches by hand fitting during the machining operations.

The seeker antenna bracket (See Drawing 11) is a machined weldment fabricated from standard 2 inch by 2 inch by 1/8 inch square aluminum tubing alloy 6061-T6. Solid aluminum sections are added where compression loading is required to prevent localized distortions of the tubing wall. Parallel tolerances of mounting surfaces are held to 0.002 inches. The location of main alignment dowel pin holes is accomplished by transferring the holes to the antenna alignment plate (See Drawing 6) after attachment to the outer frame. The seeker adjustment mechanism (See Drawings 22, 23, and 24) attaches directly to the seeker antenna mount and provides vertical and horizontal adjustments in both planes up to ± 0.750 inches. Adjustments in the third plane are accomplished with the 2 inch diameter round tube located at the center of the adjustment mechanism.

Drive motors and worm gear assemblies shown in Figure 9 are identical in both azimuth and elevation axis. There is an additional thrust bearing located in the worm gear mounting block (See Drawing 15) for the elevation axis. This thrust bearing is located above the worm to accept the loads of the radome when insufficient counter weight is applied.

The counter weights (See Drawing 41) are located on each side of the radome mounting. Eight counter weights are supplied and can be applied in increments of 10 pounds up to 80 pounds.

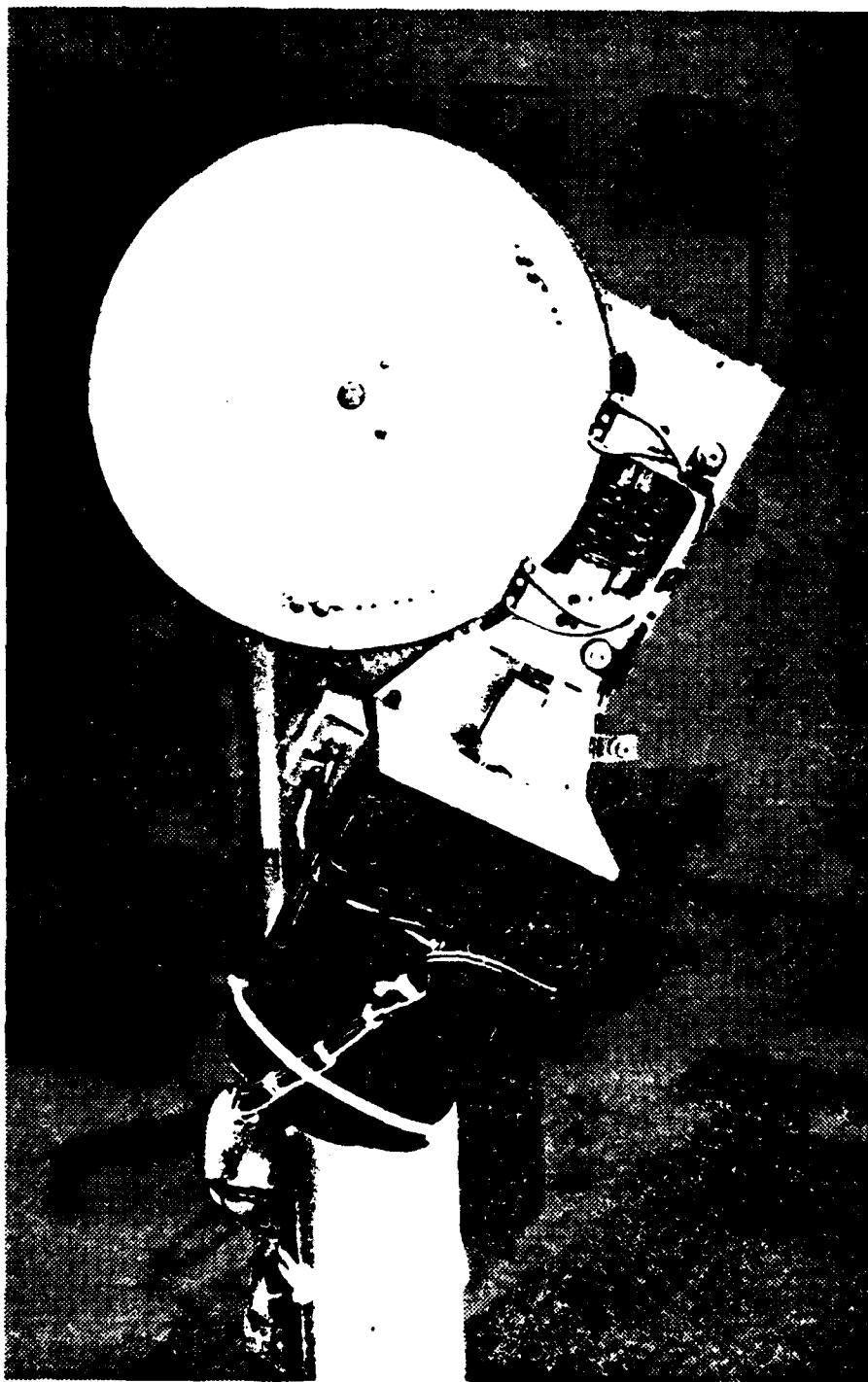


Figure 9 . Elevation Axis Motor and Worm Gear Drive Assembly.

3.3 Installation Procedures

In order to install the Radome Positioner in the aperture door opening, the aperture door and its associated parts including door latch, limit stops, etc., must first be removed and stored for future replacement. The door removal is accomplished with a special cart shown in Figure 10 that is fabricated for that purpose.

The suggested procedure for removal of the door and installation of the Radome Positioner is:

- A. Remove door closure mechanism from both the door and the wall above the door. Also remove the door latch and the electrical door-closed indicator switch from the wall on the right side of the door. (Save all of the hardware for reinstallation of the door.) Open the door to approximately 45° angle.
- B. Manually move the door-removal hand cart under the door until the approximate center of gravity of the door is aligned with the approximate center of the platform on the cart. Align the edge of the door with groove on the top of the platform. With the foot lever raise the platform until the weight of the door is being supported by the cart. Tighten the upper door clamp. With the foot lever raise the door until the door hinges are separated (approximately 2 inches). Move the cart, with the door attached, away from the door opening until the door clears the wall. Slowly lower the platform with the door attached by releasing the hydraulic valve. The door and cart can now be moved for storage.
- C. Manually move the Radome Positioner cart, with the Radome Positioner attached, into position in front of the aperture opening. Raise the Radome Positioner until the outer frame

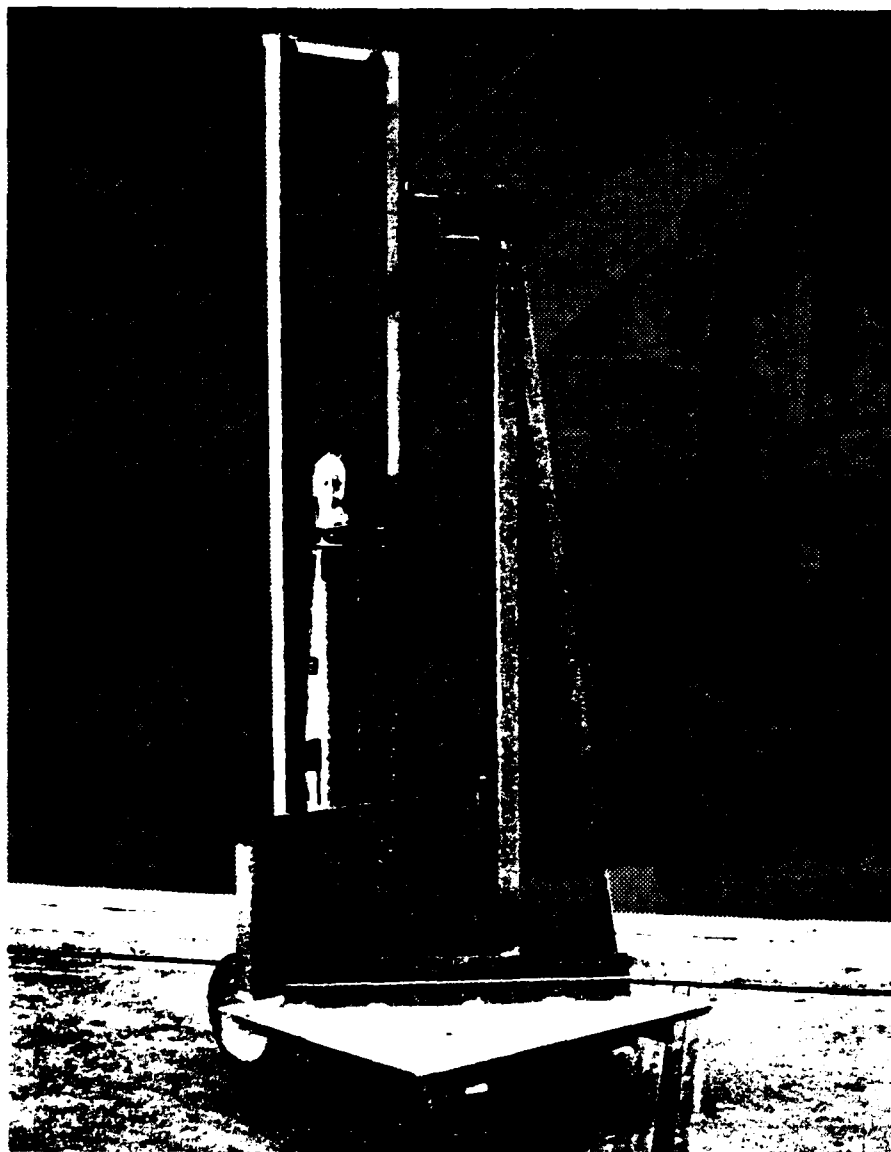


Figure 10. Cart Used to Remove the RFSS West Aperture Room Door.

aligns with the aperture opening. Lock the foot brake on the cart and move the Radome Positioner forward into the opening by rotating the hand wheel located between the forks at the cart.

- D. Install and tighten the eight special C-clamps around the periphery of the outer frame.
- E. Remove the cart by lowering the forks with the lifting books approximately 1.5 inches. Release the foot brake and move the cart backward separating the lifting hooks from the lifting buttons located on the outer frame.
- F. After completing the electrical connections to the drive motor and readout devices, the system is ready for the electrical check-out and operation.
- G. Calibration adjustments and zero alignment of the optical encoders can also then be made.

To reinstall the aperture room door, the procedure given above is carried-out essentially in reverse.

4.0 ELECTRONICS

The basic requirement of the radome positioner electronics is to allow an operator to accurately position the azimuth and elevation gimbals. A simple solution would be a manual control of the motors for each axis and a calibrated scale to indicate angle. A more sophisticated system eases the operator's task permitting the taking of a lot of data from many radomes. Until recently the conventional approach to the problem involved a complex servo feedback system and electro-mechanical indicators and position control. With the introduction of the microprocessor in 1971, the means to implement a programmable and sophisticated control system with a minimum of hardware became readily available. In addition, a microprocessor is capable of performing a wide variety of complex logical operations under control of an easily modified program stored in digital memory.

The use of a microprocessor and its associated components forming a microcomputer, as the basis of the radome positioner electronics, results in a very flexible and easy to use system. To implement a similar system with conventional digital logic would require 400 - 500 integrated circuits compared to the 30 integrated circuits which actually comprise the heart of the microcomputer. This dramatic reduction in parts count results in a similar reduction in cost and power consumption and an increase in reliability and flexibility.

A block diagram of the radome positioner electronics is shown in Figure 11. The microcomputer closes a digital control loop between each shaft angle encoder and the azimuth or elevation motor and displays the current gimbal position. Commands from the keyboard or serial ASCII (American Standard Code for Information Interchange) data from an external source cause the microcomputer to update angle inputs to the control loop and to open or close the loop as required. Internally stored programmable raster patterns are provided for automatic positioning.

With the exception of the display and motor controller interface, all of the positioner electronics are contained on 5 plug-in circuit boards located in the main electronics chassis. Four of these boards, the enclosure,

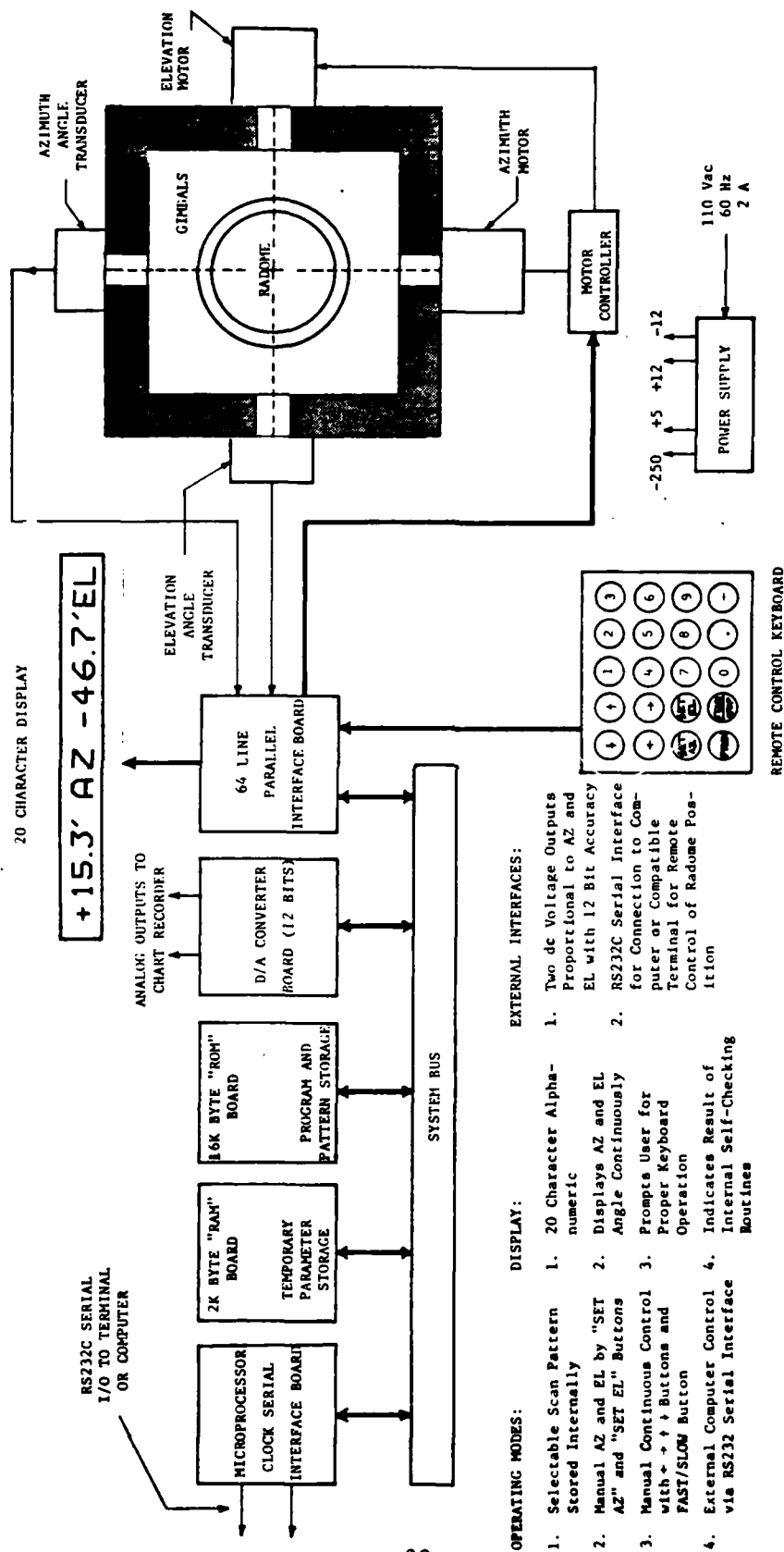


Figure 11. Block Diagram of RFSS Radome Positioner.

and power supply are commercially available microcomputer and peripheral circuit cards that have been modified slightly for this particular application. A fifth wire-wrap board in the main chassis contains miscellaneous interface circuits for the keyboard, display and analog angle outputs. The only other non-standard electronics assembly is the dual, optically isolated D/A converter and amplifiers which are used to convert digital information from the microcomputer into isolated dc signals used to control the speed and direction of the gimbal motors. This is referred to as the motor controller and is contained in an enclosure mounted behind a rack panel in the bottom of the rack.

4.1 Electronics Components

The positioner electronics are comprised of several distinct components, each of which will be described individually. These components are: microprocessor board, RAM board, ROM board, parallel I/O board, I/O buffer circuits, display, keyboard, power supplies, shaft encoders, motors, and motor controller.

Microprocessor Board

The heart of the entire controller is a Motorola M6800 microprocessor and its associated circuits contained on the Motorola M68MM01A-1 micro-module (See Drawing 64). This board contains the 6800 microprocessor, 1k bytes of RAM, provisions for up to 4k bytes of ROM, two 20 bit parallel I/O ports and an RS232 serial I/O port. The controller software is contained in the four 2708 EPROMS located on this board. The two parallel I/O ports are used to operate the display and keyboard.

2k Static RAM

The Motorola M68MM06 board holds 2048 bytes of RAM that are used for temporary variable storage by the positioner software. (See Drawing 66) Sixteen 2102-1 1k bit static RAMs and their associated buffering and address decoding logic are contained on this board.

16k ROM Board

As additions are made to the software and if new rasters are added the 4k bytes of ROM space available on the microprocessor board may not be adequate. The 16k ROM board M68MM04 (See Drawing 67) has room for 16 1k byte EPROMS should additional memory be required.

32/32 Parallel I/O Board

The M68MM03-1 32/32 parallel I/O board (See Drawing 68) provides 32 parallel inputs and 32 parallel outputs to the microprocessor. These inputs and outputs appear as four memory locations beginning at address 8E00 and are used for motor speed and direction control and to read the two 13 bit shaft angle encoders. All inputs and outputs are buffered.

I/O Buffer Board

This board is a custom wire-wrapped board containing miscellaneous interface circuitry for the keyboard and display as well as a modular dc/dc converter and two 12 bit D/A converters used to provide analog azimuth and elevation angle outputs. A schematic and parts placement for these circuits are shown in Drawings 67 and 70.

Display

A Burroughs Self-Scan II 20 character alphanumeric display (See Appendix C) is used to output messages and position information to the operator. This display was chosen because it is entirely self-contained and required only power supply voltages and parallel ASCII data. The display requires +5 Vdc, -12 Vdc and -250 Vdc to operate. The -250 Vdc is provided by a modular dc/dc converter mounted on the rear inside wall of the main chassis. Characters in the display are multiplexed and thus require a periodic "refresh". This is provided by an external 100 ns clock on the I/O buffer board and appropriate interrupt driven software (See Section 4.3).

Keyboard

Commands to the positioner are entered via a custom 20-key keyboard attached to the front of the main chassis (See Drawing 71). Hall-effect switches were used to minimize key bounce problems. Integrated circuit U1 generates an interrupt to the microprocessor whenever a key is pressed causing the positioner software to execute a keyboard parsing routine which reads the switch closure via PIA lines PA0-PA7 and PB0-PB7 from the I/O buffer board.

Power Supplies

A power supply (See Drawing 75) within the main electronic chassis supplies +5 Vdc, and ± 12 Vdc to the microcomputer components, keyboard, display and motor control electronics. A dc/dc converter located on the I/O buffer board converts 5 Vdc to ± 15 Vdc for the D/A converters used to produce analog angle outputs and to the D/A converters in the motor speed controller. Another dc/dc converter in the rear of the main electronic chassis supplies 250 Vdc to the display.

Shaft Encoders

Two identical 13 bit shaft angle encoders located on the azimuth and elevation gimbal shafts converts angular displacement to parallel binary data used by the microcomputer to read the gimbal angles to within 0.09 degrees. +5 Vdc is supplied to each encoder via the 50 conductor cable connecting the encoders and microcomputer (See Appendix C for a complete description of the shaft angle encoders).

Motors

Identical 1/25 horsepower ac motors (See Figure 9) and gear reduction boxes are used to drive each gimbal axis. Motor speed is regulated by a triac speed controller which in turn is driven by optically isolated control signals from the motor controller. A tachometer on the motor shaft provides an ac voltage proportional to speed which is fed back to the motor speed controller to maintain constant torque under varying load conditions over a wide range of speeds.

4.2 Motor Control Electronics

A block diagram of the electronics utilized for motor speed and direction control (azimuth and elevation) is shown in Figure 12. The electronics perform three basic functions. They are:

1. Control of the rotational speed of the motor on each axis.
2. Directional control for each motor.
3. Manual over-ride control.

The heart of the motor control electronics is the Q-CON C-10P-4 variable speed motor control. A block diagram of this motor controller is shown in Figure 13.

The controller maintains constant speed over a wide range of load torque by means of a feedback loop between the tachometer and a triac operated motor driver. The amplifier amplifies the error signal received from the tachometer in the feedback loop and drives the motor. The effective gain in the loop can be adjusted to be sufficiently high so that even a small error voltage will initiate a corrective action. The effective gain in the loop when using the C-10P-4 controller approaches 100 causing the speed of the motor to change a few percent with changes in the load.

Separate C-10P-4 motor speed controllers are used for the azimuth and elevation axes motors. The only modification made to the controller was to bring out a connection to allow motor speed to be controlled (V_1) externally by a D/A converter which is driven by an output of the micro-computer.

Details of the controller are discussed below.

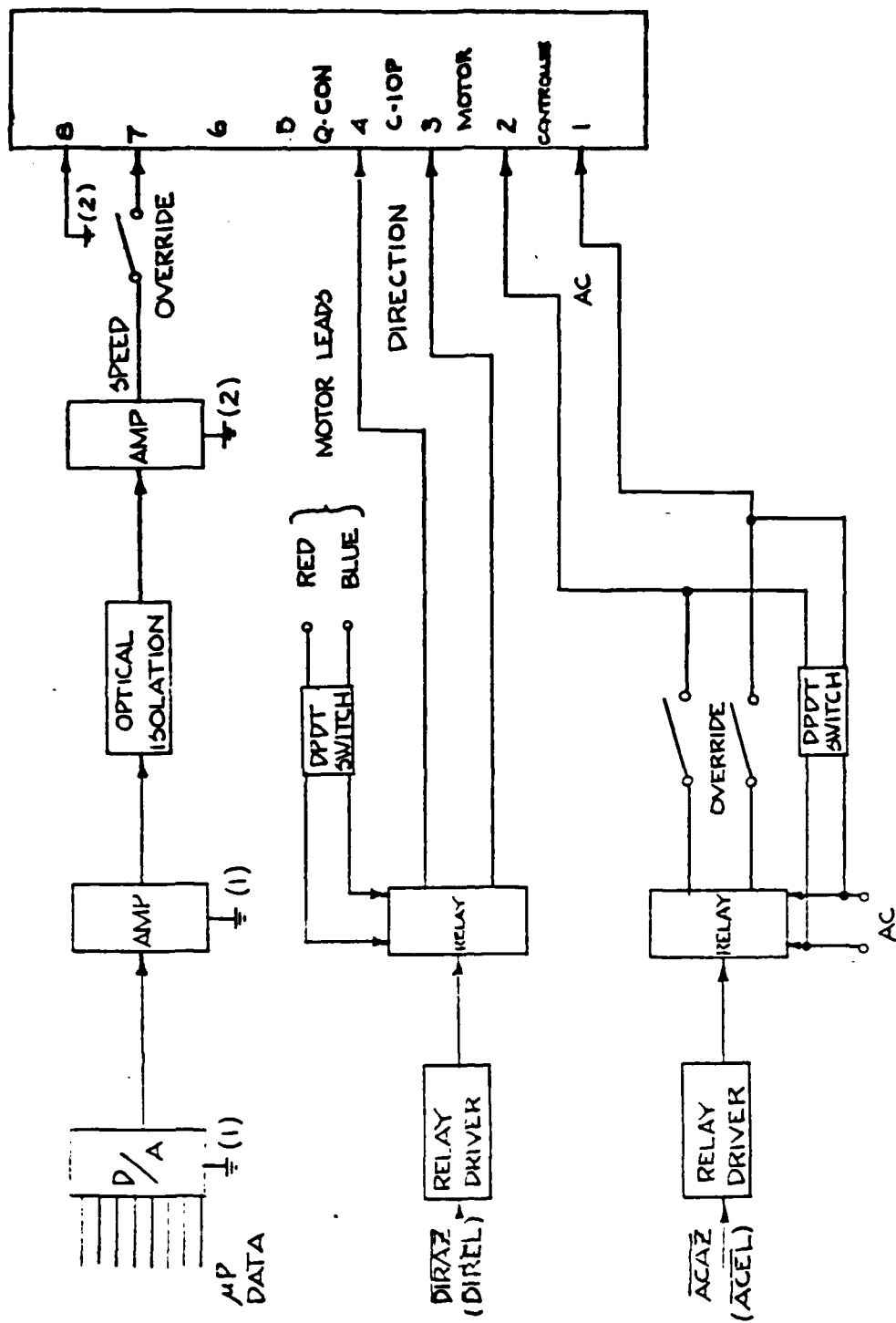


Figure 12. Motor Direction and Speed Control Block Diagram.

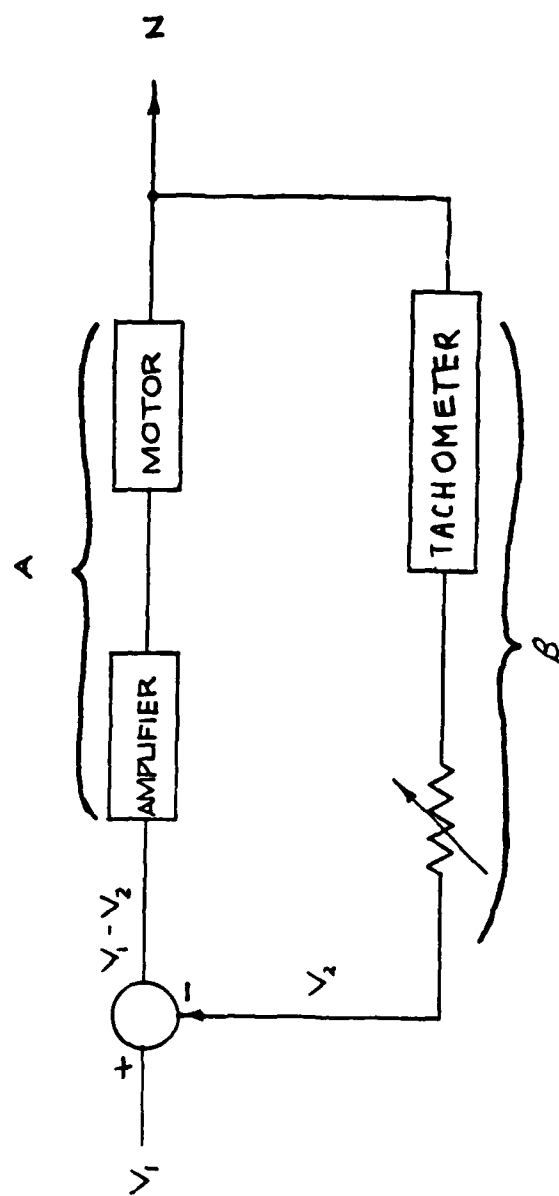


Figure 13. Motor Controller Feedback Loop.

Control of Motor Speed

Control of the rotational speed for each motor (azimuth and elevation) is accomplished by applying positive dc voltage reference (V_1) to pin 7 of the respective Q-CON C-10P-4 controller (See Figure 14). The motor's rotational speed is proportional to the reference voltage V_1 , and at a reference voltage of zero (0) volts, each motor will be stopped. Maximum rotational speed is obtained with an input voltage of approximately 20 volts.

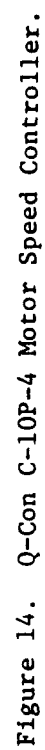
When the microcomputer issues a speed command to a motor (azimuth or elevation) it delivers an 8-bit digital word to its respective digital to analog D/A converter (Figure 12). The D/A then translates this digital word into a corresponding dc voltage level. This dc level is then amplified by U1 and applied to an optically coupled isolator through U2. The isolator's function is to isolate the C-10P-4 controller from the microcomputer and its associated components, thus providing protection against ground loops, power line transients, and noise. The isolated dc signal is then amplified by U2 and U3 and applied as the reference voltage (V_1) to pin 7 of the C-10P-4 controller.

The D/A used in this design is the Datal model 98BIR. Its 8 inputs provide for 2^8 or 256 different dc voltage levels which are used to control the motor speed.

Directional Control

Directional Control of the rotation of each motor is accomplished by:

1. Disconnecting ac power from the C-10P-4 controller.



2. Reversing the red and blue motor leads between pins 3 and 4 of the controller.
3. Reapplying the ac power.

The sequence must be followed as it is stated above. MOTOR DIRECTION MUST NOT BE CHANGED WITH POWER APPLIED TO THE CONTROLLER.

During program control, if the microcomputer determines the need for direction reversal, it first sets ACEZ (ACEL) high turning off relay RY1 (RY2) and disconnecting power from the controller. Once ac power is disconnected, the motor's direction may be reversed. To do this the microcomputer complements DIRAZ (DIREL) reversing the red and blue motor leads between pins 3 and 4 of the C-10P-4 controller. Power is then re-applied to the controller by the microcomputer, and the direction reversal is complete. This is all done through program control and takes place automatically.

Manual Over-ride Control

During its normal operation, the microcomputer software will not allow the radome to be positioned at an angle greater than ± 40 degrees with respect to its center position in either azimuth or elevation. Should the microcomputer fail however, a standby method of shutting down the system, if it tries to rotate beyond its ± 40 degree limit, has been installed. This standby system is a set of four limit switches, two for each axis, which will interrupt the ac power to the C-10P-4 controllers if ± 40 degrees in either direction is reached by the radome. If this occurs, there is no way of returning the radome to within its boundaries through microcomputer control. For this reason, manually operated override switches have been provided to reposition the radome to within its boundaries so the microcomputer can regain control. THE OVERRIDE SWITCHES SHOULD NEVER BE OPERATED WHILE THE POSITIONER IS UNDER MICROCOMPUTER CONTROL.

Should the microcomputer software limits fail, and the limit switches engage, then the following directions apply:

1. Determine which limit has been reached (Azimuth or Elevation)
2. Throw the OVERRIDE switch to OVERRIDE.
3. Throw the switch corresponding to the limited position (Azimuth or Elevation) to its position opposite NORMAL. The radome will then reverse direction and proceed into its normal operating boundary.
4. When the radome has reached the desired position, return the switch thrown in step 3 to its NORMAL position. This will stop the radome.
5. If it is desired to reposition the other axis at this time, throw the appropriate switch (azimuth or elevation) to the position opposite its normal position. This axis will then reverse from the direction it was going when limiting occurred. When the radome is in the desired position on this axis, return the switch to its NORMAL position.
6. After repositioning the radome, return the OVERRIDE switch to its NORMAL position. The radome is then again under microcomputer control.

CAUTION

NEVER TRY TO MANUALLY REPOSITION THE RADOME WITH THE OVERRIDE SWITCH IN ITS NORMAL POSITION.

It should be noted here that once the OVERRIDE switch is returned to NORMAL, the microcomputer is again in control of the positioner. The possibility therefore exists that whatever caused limiting in the first place, could again cause limiting to occur. If this is the case, manually reposition the radome as in steps 1 thru 5 above, but do not carry out step 6. This will prevent the microcomputer from taking

control of the positioner and thus prevents limiting from again occurring.

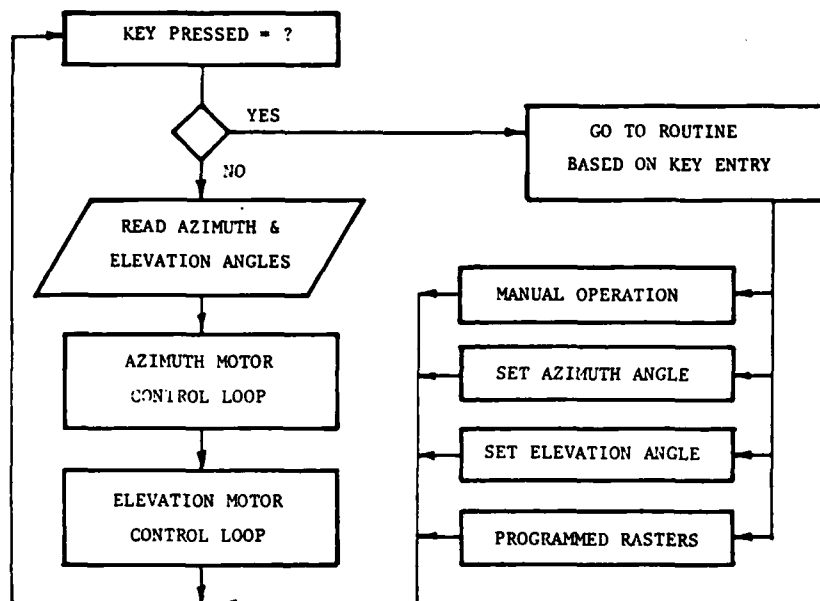
Provision for manual control of the positioner was not meant as a secondary positioning system. Its sole purpose is to place the radome back within its boundary should the microcomputer software limits ever fail. It should be used only for this purpose.

4.3 Microcomputer Software

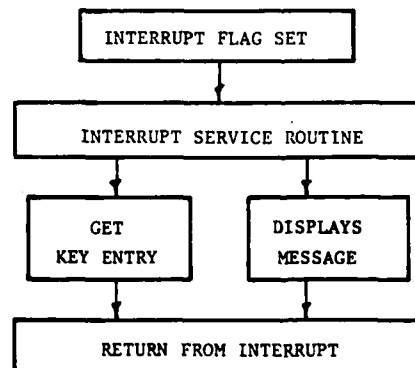
Operation of the Radome Positioner is controlled by a program which is stored in 6k bytes of Read Only Memory (ROM). This program is executed by the 6800 microprocessor and defines all the operations of the positioner. Logical operations defined by the program along with inputs from the shaft angle encoders, keyboard, limit switches and in the case of remote operation, serial ASCII data from an external source, completely specify the motion of the gimbals.

The controller software was written in assembly language for the 6800 microprocessor and converted into machine language instructions by a cross assembler on the Georgia Tech CDC CYBER 74 computer. A listing of this program appears in Appendix B. Each line of the listing consists of a line number followed by an address and either one, two, or three hex bytes corresponding to the machine language equivalent of the assembly language statement on the remainder of the line.

A simple flow chart of the positioner software is shown in Figure 15. This diagram represents the logical flow of the program with each block corresponding to several subroutines of from 10 to 100 lines of program. Program operation can best be understood by considering the main task of the microprocessor as the azimuth and elevation control loop. This portion of the software is constantly comparing the actual position of the gimbals with the desired position which is stored in Random Access Memory (RAM) that is accessed by the microprocessor and is modified by a number of other subroutines. The control loop program can alter the speed and



a. Main Program Loop



b. Interrupt Service Routines

Figure 15. RFSS Radome Positioner
Microcomputer Software Flow Chart

direction of each gimbal in order to make the actual and desired angles equal. This digital control loop is analogous to a conventional analog servo control system with the servo amplifiers and loop filters replaced by a microprocessor program.

While the control loop program is operating, it is periodically briefly "interrupted" from one of three sources. An interrupt results in the execution of the current program being briefly suspended while the microprocessor executes another program called the Interrupt Service Routine. After the service routine is completed, the microprocessor resumes execution of the main program (in this case the control loop) at the exact place it was interrupted. The system is designed so that the interrupt service routines take only a few hundred microseconds to complete so in effect the processor's time is "shared" by more than one program without degrading its performance on the main program. The three interrupting devices in the case of the radome positioner are the display, the keyboard and the serial interface for remote operation. Since the display requires periodic refreshing, an interrupt from a 100 μ s clock causes the microprocessor to transfer the contents of a specific 20 byte portion of RAM at the rate of one character (1 byte) every 100 μ s. Thus the entire display is updated or "refreshed" every 2 ms, which is faster than the flicker response of the eye resulting in a display that appears to be continuous. (See Figure 16).

An interrupt is also generated whenever a key on the positioner keyboard is pressed. The keyboard interrupt service routine decodes the key that was pressed and determines what action to take by means of a key state table within the program. This table specifies what action the program will take based on which key was pressed and the current status or "state" of the program. For example, a particular state is associated with the prompt "Enter Azimuth Angle" which results from pressing the "SET AZ" key. If a number key is pressed, the keyboard service routine

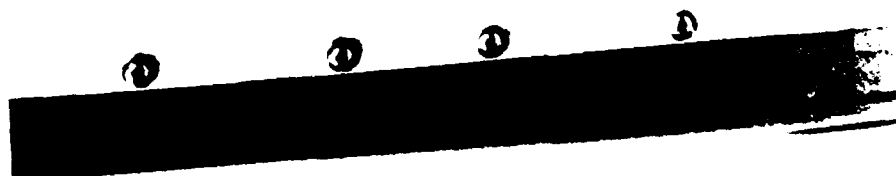


Figure 16. Alphanumeric Display Showing Angle Readout.

recognizes it as a proper response and stores it as the first digit of the desired angle. If, however, the "SET EL" key or one of the manual direction keys are pressed, the keyboard program will recognize it as an invalid key resulting in the display of an "Invalid Entry" message and will then return to state 0 which is the "Resting State" and display the current azimuth and elevation angle.

A similar sequence of operations results from commands that are received via the serial interface from a remote device in the Remote Operation Mode. In this case the interrupts are generated by the interface each time a valid ASCII character is received. Error messages and prompts are sent over the interface as well as being displayed.

5.0 POSITIONER OPERATION

The radome positioner is capable of four basic modes of operation: manual azimuth and elevation movement, preset azimuth and elevation angles, internally stored raster patterns, and external computer control via a serial interface. The first three modes are accessed via the controller keyboard and the fourth via an RS232C serial interface when the local/remote switch is in the REMOTE position. The alphanumeric display will prompt the operator for any required keyboard inputs and provide error messages if any invalid key sequence is entered. In addition, failure of any one of several self-test programs will be indicated by an appropriate message. The display will also echo numeric entries and indicate the present azimuth and elevation angle.

System Initialization

When power is applied to the positioner by pressing the power switch located in the lower right-hand corner of the controller front panel, the button will be illuminated and an automatic reset sequence will be initiated in the microcomputer. This will cause the microcomputer to begin executing the controller program. A power-up message will be displayed on the controller's display indicating successful system initialization. See Table 3 for a complete list of system messages.

Manual Operation

Manual control of gimbal position is available via the four arrow keys on the keyboard. Depressing any of these keys will cause the gimbals to move in the indicated direction. Only one key at a time may be depressed. The azimuth and elevation angles will be displayed on the controller display. Gimbal motion will continue as long as the key is depressed or until the gimbal angle limit is exceeded.

TABLE 3. SYSTEM MESSAGES

<u>MESSAGE</u>	<u>MEANING</u>
THE GA. TECH - RFSS RADOME POSITIONER VERSION 1.0.	Power on message giving current software version number.
RADOME POS. READY	Indicates proper initialization sequence complete.
XX.X' AZIMUTH XX.X' ELEVATION	Present azimuth and elevation angle. Denotes idle state if constant or follows gimball motion.
ENTER ELEVATION ANGLE { ENTER AZIMUTH ANGLE }	Prompt for angle entry after pressing SET AX or SET EL key.
ERROR-INVALID ENTRY	Improper key sequence entered.
ANGLE TOO LARGE . . .	Entry of angle greater than azimuth or elevation angle limit.
POSITIONER HALTED	Result of pressing $\frac{\text{START}}{\text{STOP}}$ key when gimbals are in motion.
ANGLE LIMIT EXCEEDED	Azimuth or elevation gimbal has reached preset limit.
ENTER "PROGRAM" NUMBER	Response to PGRM key (see raster pattern descriptions).

Preset Angle Mode

The gimbals may be commanded to any azimuth and elevation angle via the SET EL and SET AZ keys. When either of these keys are depressed the operator will be prompted to enter the desired angle. Each angle may be set independently of the other. Gimbal motion will begin when the START
STOP key is depressed following the angle entry. The gimbals may be halted at any time by pressing the START
STOP key again. If entry of an angle greater than the gimbal angle limit is attempted, an error message will be displayed (See Table 3).

Internally Stored Patterns

Several commonly used raster pattern programs are stored internally in the controller's microcomputer. These programs may be accessed via the PRGM key on the controller keyboard followed by a program number. Each program will prompt the operator to enter any required pattern variables. A complete description of each program is given in Appendix E. Briefly, the choice of rasters is vertical and horizontal linear rasters, or circle or star rasters.

External Computer Control

The radome positioner has the capability to be controlled by an external device such as a computer or computer terminal that has the capability to send and receive ASCII characters over an RS232C interface. When the local/remote switch located on the front panel is placed in the remote position all of the functions available through the keyboard can also be commanded over the RS232C interface. In addition, messages and prompts similar to those displayed on the controller display are sent over the interface. Thus, an operator or computer program can operate the positioner in essentially the same manner as when the keyboard and display are used. See Appendix E for a detailed description of the computer interface operation.

Gimbal Angle Limits

In order to prevent the gimbals from being moved past an angle that could cause damage to the seeker antenna and hit the sides of the aperture or gimbal frame, two limiting mechanisms were implemented. The first is a set of four "soft" limit angles that can be manually set from the keyboard. These angles correspond to the positive and negative extreme of each axis and are initially set to 40° when power is first applied to the system. They may be changed by entering the key sequence; "SET AZ (EL)" followed by one of the four manual direction controlled buttons; " $\uparrow$ ", " $\downarrow$ ", " $\rightarrow$ ", " $\leftarrow$ ". The display will then show the current limit and allow it to be changed. Attempting to set a limit greater than 40° or less than 1° for any axis will result in an error message and no change in the limit will occur. Should the angle reach the pre-set limit during positioner operation, the message ANGLE LIMIT EXCEEDED will be displayed and the gimbals will automatically move the opposite direction until within the limits.

A second fail-safe angle limit system consists of four micro-switches mounted on the azimuth and elevation axis gears. These switches will interrupt ac power to the motors should the gimbals ever exceed the angle at which they are set. They are adjustable from 20° to 40° and are normally set at 40° . See Section 4.2 for instructions on how to reposition the gimbals after these "hard" limits are exceeded.

Rear Panel Connections

The display, motor controller, shaft encoders, and an external RS232 device connect to the system via connectors located on the rear panel of the main chassis (See Drawing 81). The two BNC connectors labeled "Azimuth dc Out" and "Elevation dc Out" provide dc voltages proportional to gimbal position. From $+40^\circ$ to -40° on either axis corresponds to $+4$ Vdc to -4 Vdc output with $0^\circ = 0$ Vdc. These outputs are unbuffered D/A converter outputs and can provide up to 5 mA of drive current.

APPENDIX A

RADOME POSITIONER DRAWINGS

DRAWING LIST

Radome Positioner

Drawing No.

Title

1	Radome Positioner for the RFSS (Sheet 1 of 2)
2	Radome Positioner for the RFSS (Sheet 2 of 2)
3	Clamp for Radome Positioner
4	Screw Assembly for Radome Positioner Clamp
5	Outer Mounting Frame for Radome Positioner
6	Alignment Plate for Seeker Antenna
7	Alignment Pin for Seeker Antenna
8	Outer Gimbal Assembly
9	Outer Gimbal Assembly
10	Insert for Outer Gimbal
11	Seeker Antenna Support Bracket
12	Bearing Block and Motor Mtg. Plate for Azimuth Axis
13	Worm Shaft for Azimuth Axis
14	Bearing Block Mounting Bracket for Azimuth Axis
15	Encoder Mounting Block
16	Bearing Spacer - Az. & El. Axis
17	Encoder Mounting Shaft - Azimuth Axis
18	Bearing Clamp - El. Axis
19	Worm Gear Shaft - Azimuth Axis
20	Thrust Bearing Plate - Azimuth Axis
21	Top Seal Plate Worm Gear Shaft - Azimuth Axis
22	Seeker Antenna Alignment Assembly
23	Seeker Antenna Horizontal Adjustment Plate
24	Seeker Antenna Vertical Adjustment Plate
25	Encoder Mounting Shaft - El. Axis
26	Hinge for Seeker Antenna Mtg. Bracket
27	Radome Mounting Ring
28	Lifting Button for Outer Frame
29	Screw Lock for Seeker Antenna Mtg. Frame
30	Worm Gear Mounting Shaft - El. Axis
31	Worm Gear Modifications
32	14" Radome Adapter Ring
33	Bearing Block and Motor Mounting Plate - El. Axis
34	Bearing Block Mounting Bracket - El. Axis
35	Worm Shaft - El. Axis
36	Worm Gear Shaft Spacer - El. Axis
37	Hinge Pin for Seeker Antenna Bracket
38	Shaft Coupling Motor to Worm
39	Micro-Switch Actuator and Mounting Plate
40	Counter Weight Mounting Blocks

DRAWING LIST (CONTINUED)

Drawing No.

Title

41	Counter Weight
42	Encoder Clamp Ring
43	Modified Set Screw for Centering of Inner Gimbal
44	Modification of Front Panel M68MMLC1 Micro-Module
45	Modification of Back Panel M68MMLC1 Micro-Module
46	Keyboard Assembly
47	Box for Keyboard
48	Key Mounting Board and Bracket
49	Panel Modifications for Digital Readout

Cart for Positioner

50	Lifting Hook Assembly for Radome Positioner
51	Lifting Hook Details
52	Threaded Plate for Lifting Hook
53	Retractor Mechanism Components for Radome Positioner Removal Cart

Door Removal Cart

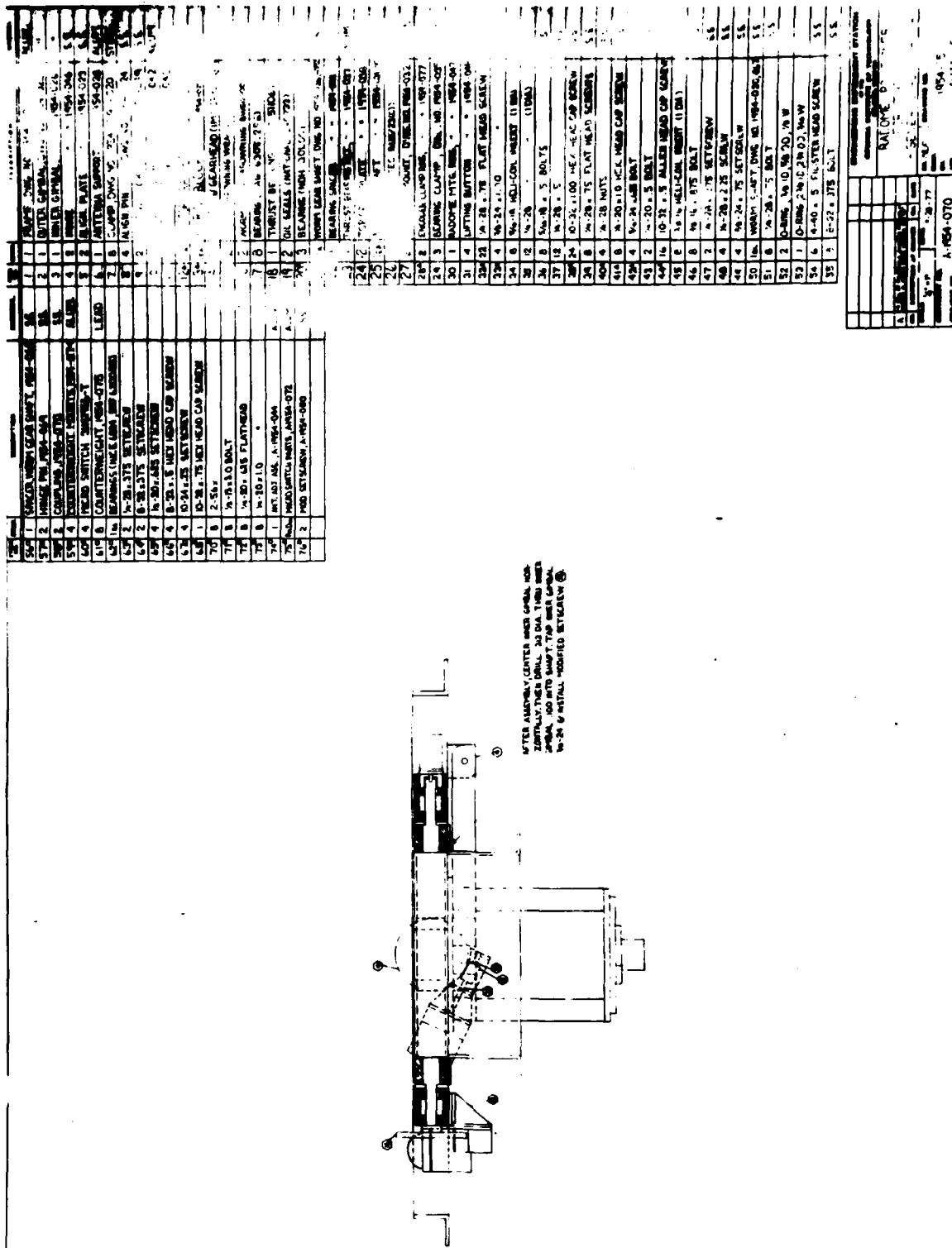
54	Modified Hand Truck for Removing Door of RFSS
55	Door Bottom Support Bracket
56	Door Clamp Screw Top
57	Door Clamp Top
58	Cap Support Bracket
59	Upright Support
60	Gusset Plate
61	Angle Support
62	Channel Support
63	Angle Stop

Electronics

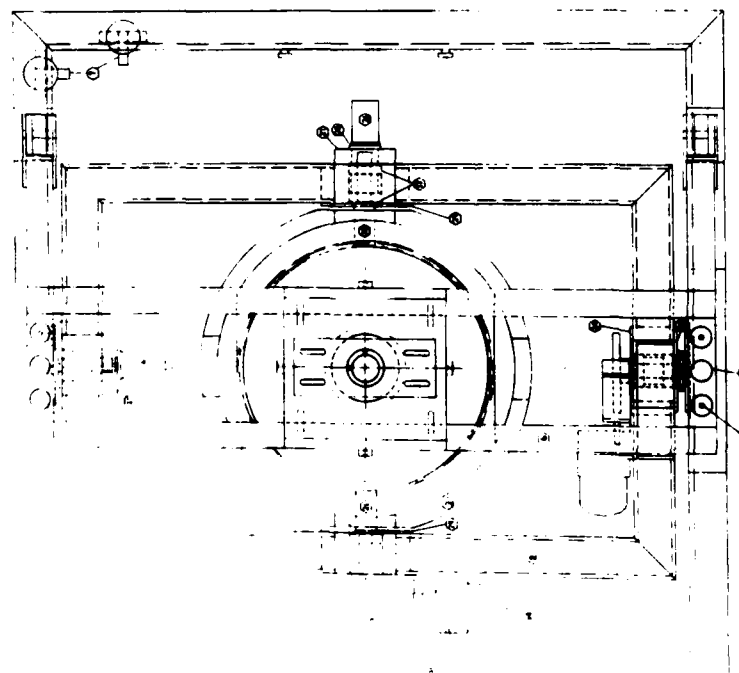
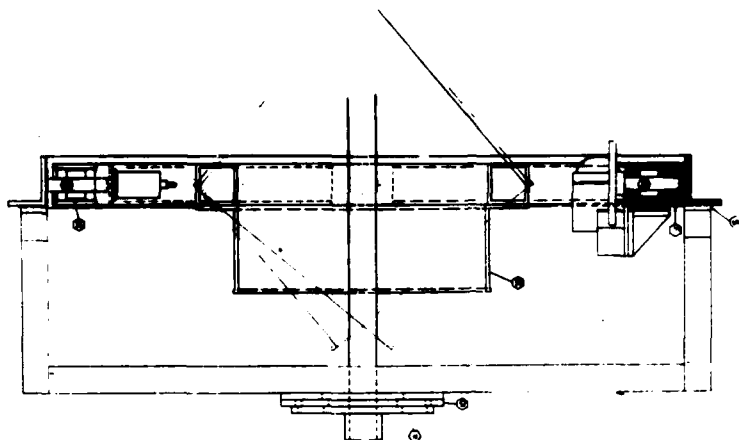
64	M68MM01A-1 Microcomputer Schematic
65	Parallel and Serial Interface Schematic for M68MM01A-1
66	M68MM06 2k Byte Static RAM Board Schematic
67	M68MM03 16k Byte EPROM Board Schematic
68	M68MM03 32 Channel I/O Board Schematic
69	I/O Buffer Board Schematic
70	I/O Buffer Board Parts Placement

DRAWING LIST (CONTINUED)

<u>Drawing No.</u>	<u>Title</u>
71	Keyboard Schematic
72	Motor Power and Direction Control
73	D/A Converter and Isolated Amplifier
74	Motor and Limit Switches Wiring
75	Motor Controller Panel Wiring
76	Microcomputer Power Supply Schematic
77	Main Chassis Wiring
78	Shaft Angle Encoder Cable
79	Motor to Controller Cable
80	Keyboard and Display Cables
81	Microcomputer Front Panel
82	Microcomputer Rear Panel

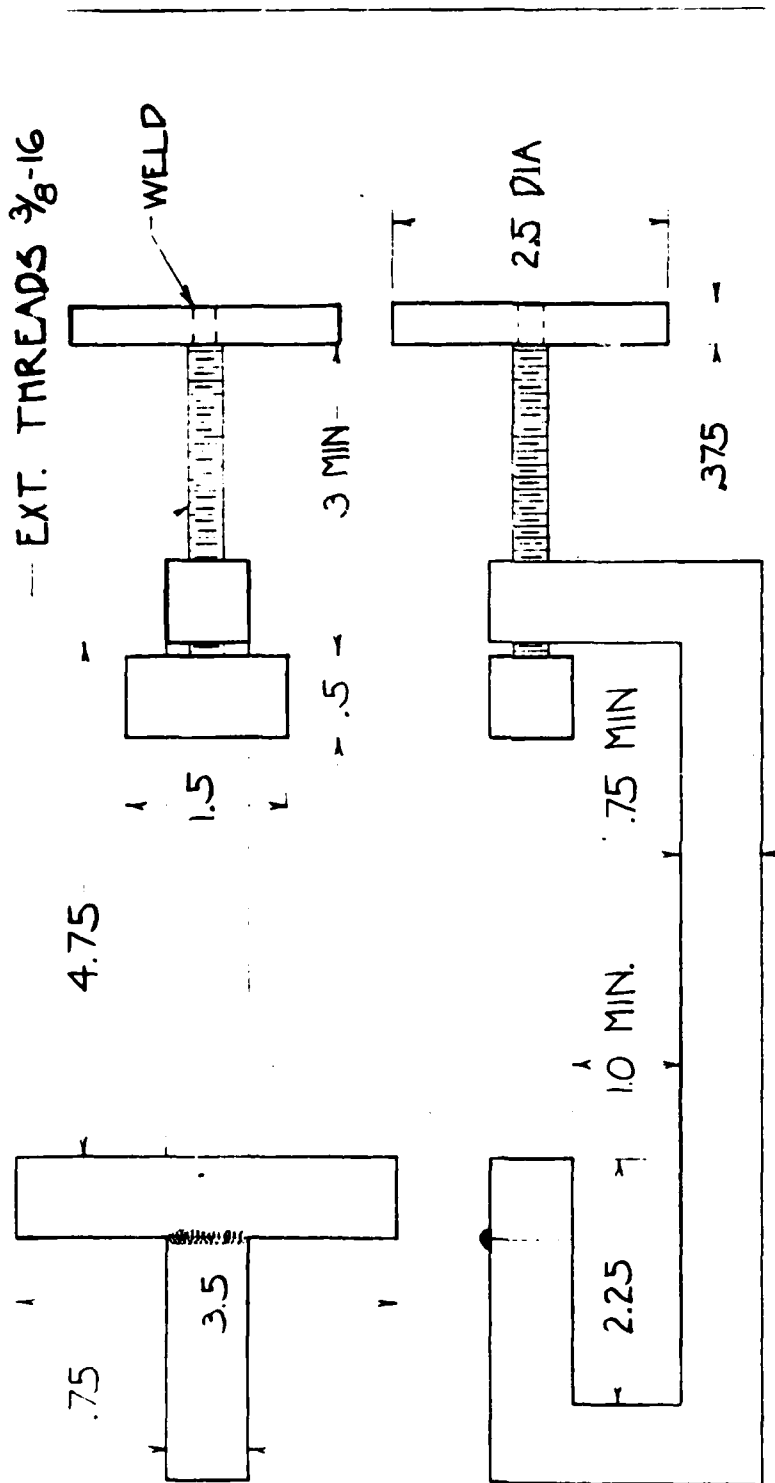


Drawing 1. Radome Positioner for the RFSS (Sheet 1 of 2)



REVISIONS		DATE		BY		APP'D	
1	REVISED	10/1/70	10/1/70	10/1/70	10/1/70	10/1/70	10/1/70
RADOME POSITIONER FOR THE RFSS -GENERAL ASSEMBLY-							
A-1054-370				A-1054-054			
REVISED				REVISED			

Drawing 2. Radome Positioner for the RFSS (Sheet 2 of 2)



TOLERANCES:
 X = ± .060
 XX = ± .030
 XXX = ± .010

3-MAKE 8

2-FINISH:

1-MATERIAL: STEEL

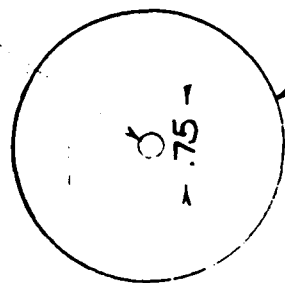
NOTES:

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		CLAMP FOR RADOME POSITIONER	
NO.	DESCRIPTION OF CHANGE	CH.	DATE
1	FULL	8-3-77	
CONTRACT NO. A 1954 070		DRAWING NO. A 1954 019	
PROJECT NO.		DR. O.C. BROWN	
		CH. APP.	

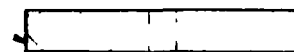
Drawing 3. Clamp for Radome Positioner

-DIAMOND KNURL
MEDIUM

.260 DIA



2.5 DIA



.250

.375

.260

.375

.625

.250

.375

.260

.375

.625

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.375

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3. MIN

.75

TOLERANCES:

XX = ±.060
XX = ±.030
XX = ±.010

3- MAKE 8 EA.

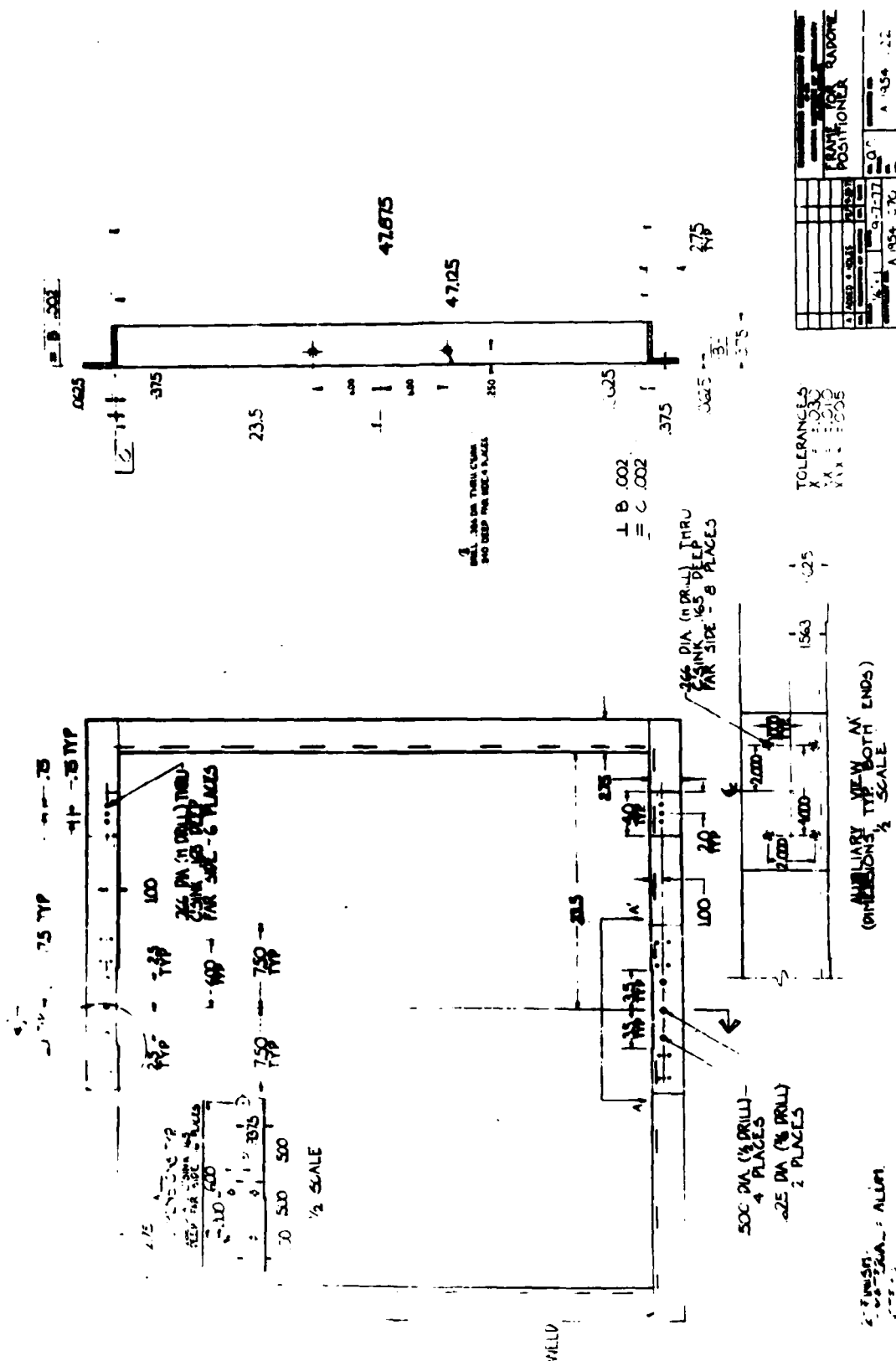
2- FINISH:

1- MATERIAL: STEEL

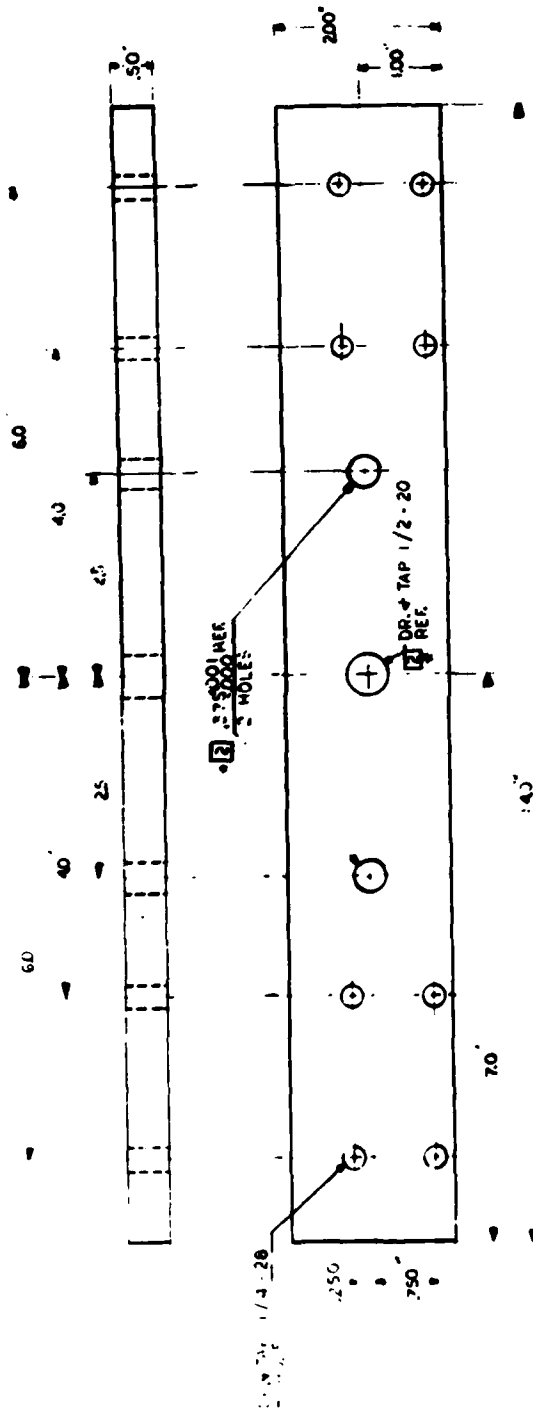
NOTES:

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		DRAWING NO. A 1954 020	
SCREW ASSEMBLY FOR RADOME CLAMP		DR. Q.C. ENGR. CH. APP.	
NO.	DESCRIPTION OF CHANGE	CH.	DATE
SCALE:	FULL	DATE:	5-3-77
CONTRACT NO. A 1954 370		PROJECT NO.	

Drawing 4. Screw Assembly for Radome Positioner Clamp



Drawing 5. Outer Mounting Frame for Radome Positioner

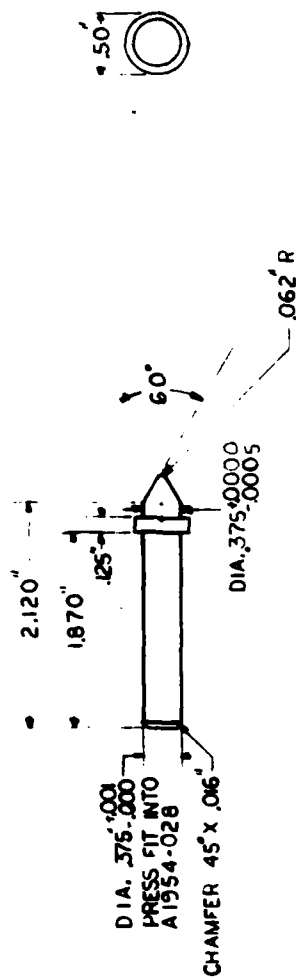


NOTE:
 MATERIAL: STAINLESS STEEL
 THE HOLES ARE FOR REFERENCE ONLY AND WILL
 BE LOCATED AND ALIGNED FROM MATING PARTS.

REVISIONS
 1030
 1010
 1005

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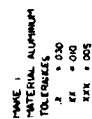
Drawing 6. Alignment Plate for Seeker Antenna.



ENGINEERING EXPERIMENT CENTER GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		ALIGNMENT PIN FOR ANTENNA PLANT ROOM	
NO.	DESCRIPTION OF CHANGE	DATE	BY
1	1	9.15.71	JAH
CONTRACT NO. A1954-028		PROJECT NO. A1954-024	
DRAWING NO. H 1954-024		APP. JAH	

Drawing 7. Alignment Pin for Seeker Antenna





Drawing 9. Inner Gimbal Assembly



2.5 4.5 1.0



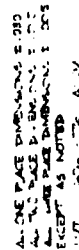
2.5 3.0 6.5

TOLERANCES
X = ±.030
XX = ±.010
XXX = ±.005

3-TRIM TO FIT INSIDE
3" SQ TUBING
2 ENDS NCNE

Drawing 10. Insert for Outer Gimbal.

ENGINEERING DEPARTMENT STATION		DATE	
GENERAL ENGINEERING		DATE	
ALUMINUM INSERT FOR THE OUTER GIMBAL		DATE	
A REMOVED HOLE PAT. 279,477		DATE	
DESCRIPTION OF DRAWING		DATE	
CONTRACT NO. A 30-227		PROJECT NO.	



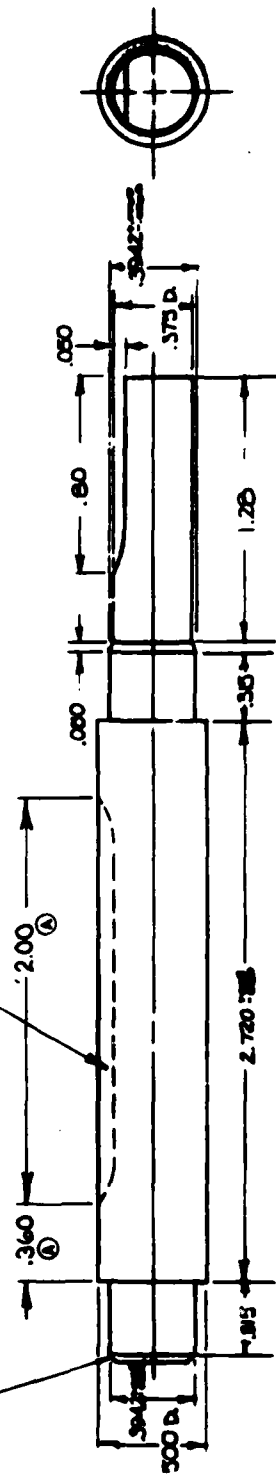
Drawing 12. Bearing Block and Motor Mtg. Plate for Azimuth Axis.

The diagram shows the orthographic projection of a cylinder. The top view is a circle with a diameter dimension of 400. The front view is a rectangle with a height dimension of 435. A horizontal centerline is shown in the front view, and a vertical centerline is shown in the top view. The distance from the top edge of the front view to the centerline is dimensioned as 175. The distance from the bottom edge of the front view to the centerline is dimensioned as 500.

MAKE-2

-SLOT, MIN. 1/8 WIDE,
1/16 DEEP

—CHAM 45° x .010



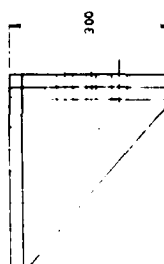
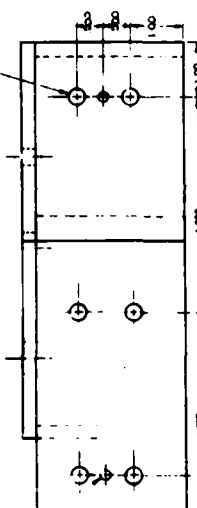
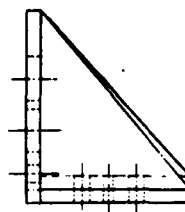
125

1.25 m

人34

[illegible]

Drawing 13. Worm Shaft for Azimuth Axis

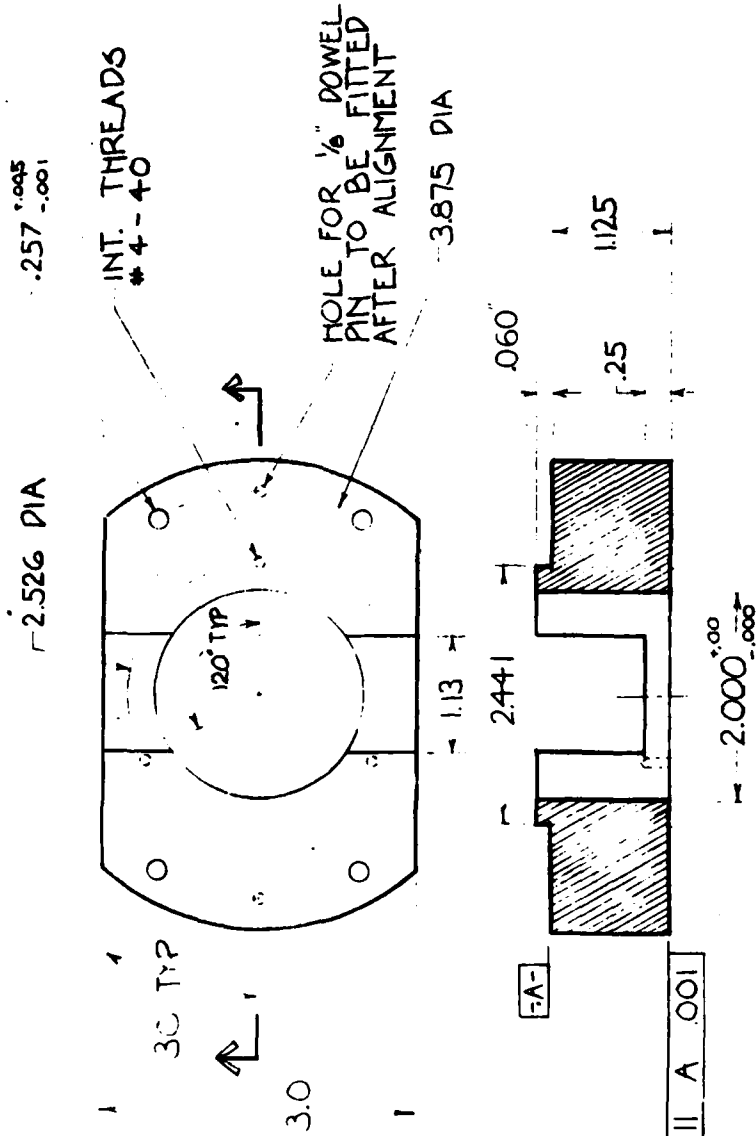


TOLERANCES
ALL TWO PLACE DIMENSIONS ± 0.10
ALL THREE PLACE DIMENSIONS ± 0.005

100-44388-1A

[illegible]

Drawing 14. . Bearing Block Mounting Bracket for Azimuth Axis

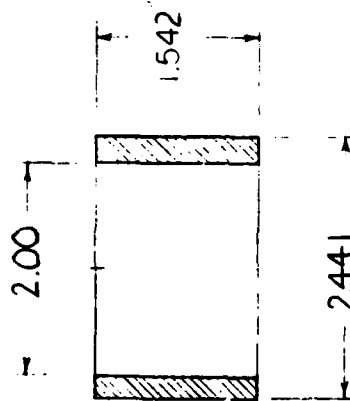
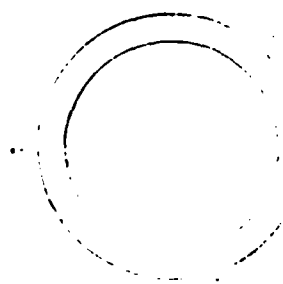


TOLERANCES
 X = ±0.30
 XX = ±0.10
 XXX = ±0.005

2-FINISH:
 1-MATERIAL: ALUM
 NOTES:

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA	
ENCODER MOUNT FOR THE RAPOME POSITIONER	
DR. O.C. BUREAU CH.	DRAWING NO. A 1954 032
CONTRACT NO. A 1954-070	PROJECT NO.
DATE 8-19-77	
SCALE FULL	
DESCRIPTION OF CHANGE	DATE
NO.	CH.

Drawing 15. Encoder Mounting Block



TOLERANCES:
 X = ± 0.30
 XX = ± 0.10
 XXX = ± 0.05

QTY. 4 EA.
 1- MATERIAL ALL.
 NOTES:

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA			
BEARING SPACER			
NO.	DESCRIPTION OF CHANGE	CH.	DATE
SCALE	FULL	DATE	8-23-77
CONTRACT NO.		A 1954 070	
PROJECT NO.		A 1954 033	
DR. A.C.	DR. A.C.	DR. A.C.	DR. A.C.
CH.	CH.	CH.	CH.
APP.	APP.	APP.	APP.

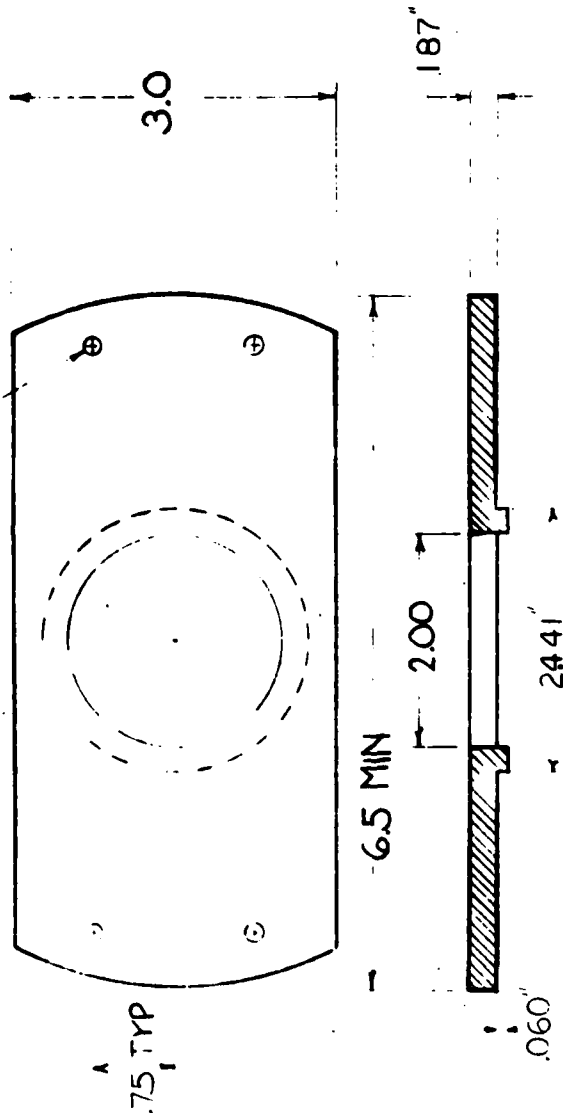
Drawing 16. Bearing Spacer - Az & El Axis



Drawing 17. Encoder Mounting Shaft - Azimuth Axis.

2.75 TYP

.196 DIA TYP

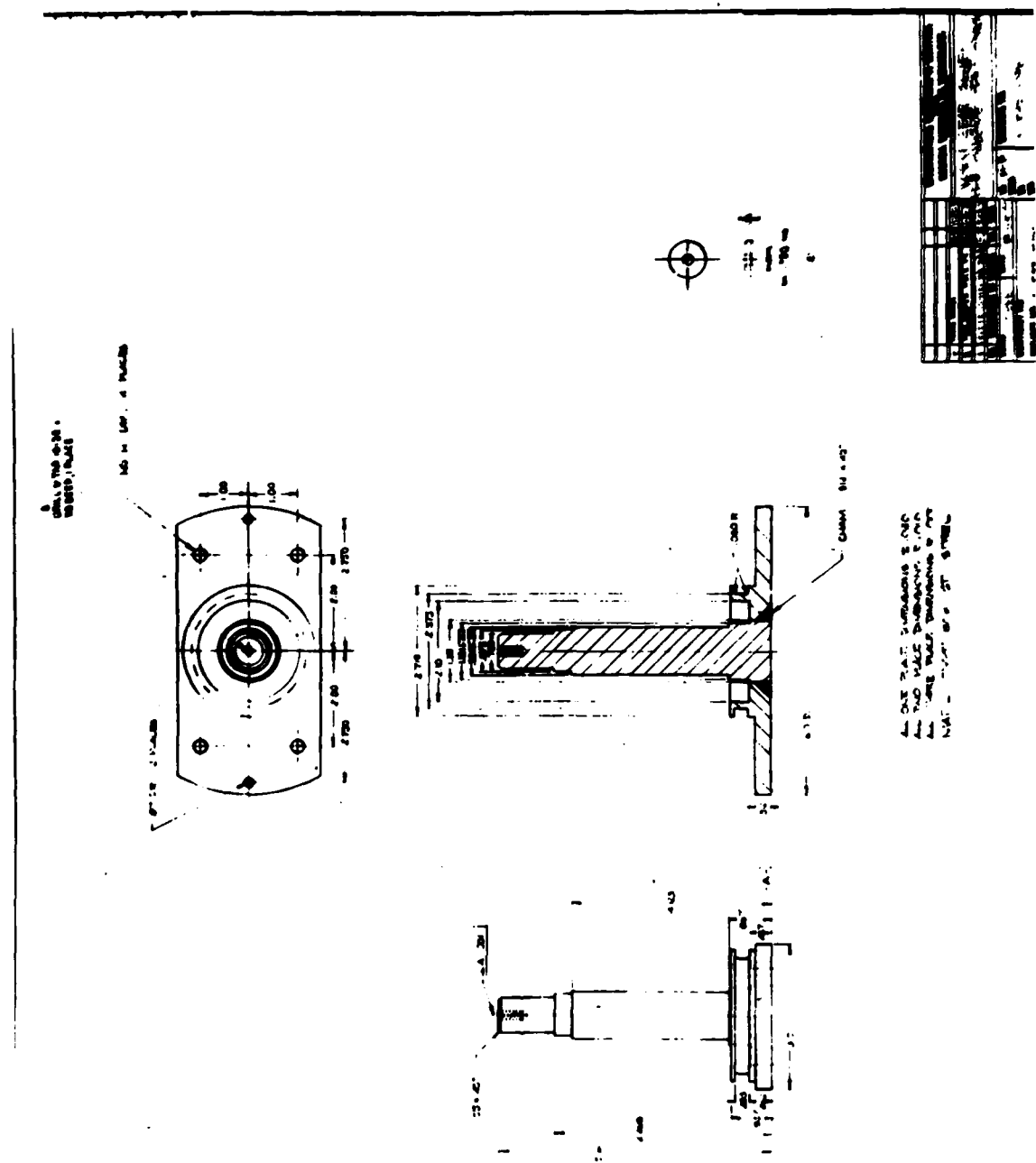


TOLERANCES:
 X = $\pm .030$
 XX = $\pm .010$
 XXX = $\pm .005$

1. MATERIAL: ALUM
 NOTES:

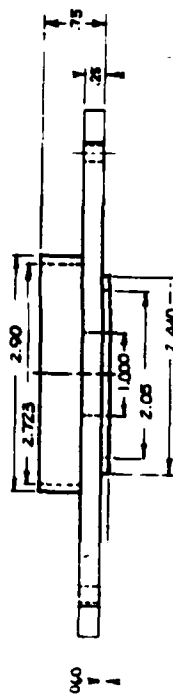
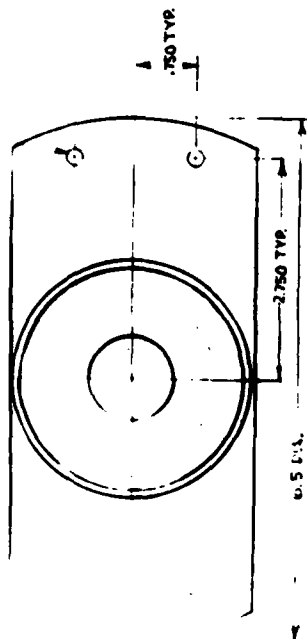
ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA			
BEARING CLAMP FOR THE RADOME POSITIONER			
NO.	DESCRIPTION OF CHANGES	DATE	BY
1	CHANGES TO TOLERANCES	9-24-77	CHL
SCALE	FULL	DATE	DATE
CONTRACT NO.	A 1954-C70	DES. Q.C.	9-24-77
PROJECT NO.	A 1954-035	DRWG. NO.	A 1954-035

Drawing 18. Bearing Clamp - El. Axis



Drawing 19. Worm Gear Shaft - Azimuth Axis

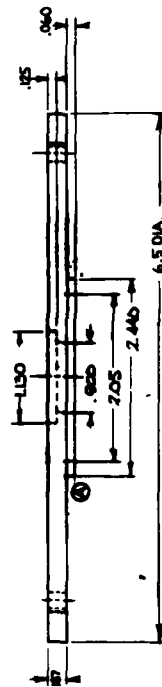
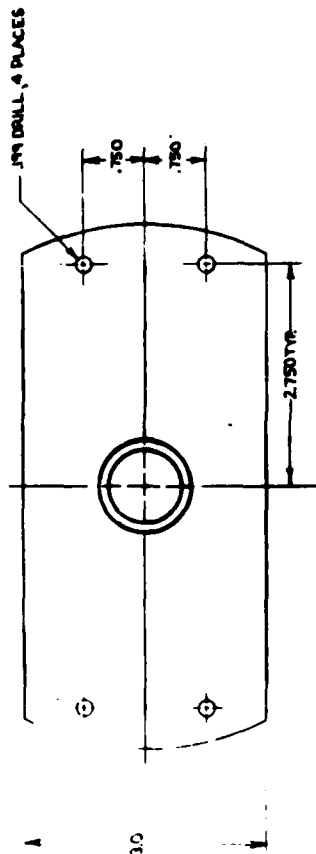
NO. 9 OR 10 PLACES



ALL ONE PLACE DIMENSIONS $\pm .020$
 ALL TWO PLACE DIMENSIONS $\pm .010$
 ALL THREE PLACE DIMENSIONS $\pm .005$
 MAT'L: 6061-T6 ALUM.

Drawing 20. Thrust Bearing Plate - Azimuth Axis.

ENGINEERING EXPERIMENT STATION		GEORGIA INSTITUTE OF TECHNOLOGY	
THURST BEARING		PLATE FOR	
THK OF BOT BOSS		RADOME POSITIONER	
SCALE: 1" = 1"	DATE: 5-6-77	DR. KCB	DR. KCB
CONTRACT NO. 15-10		PROJECT NO. A-55-237	

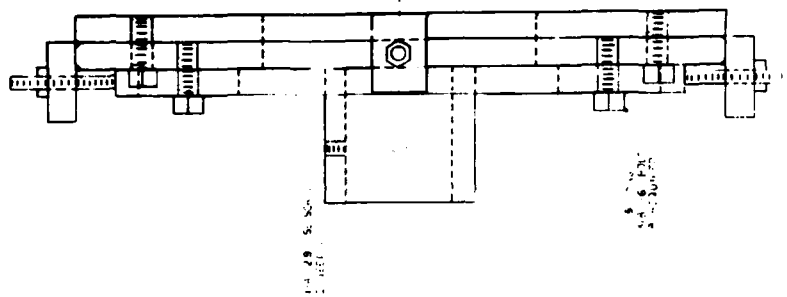
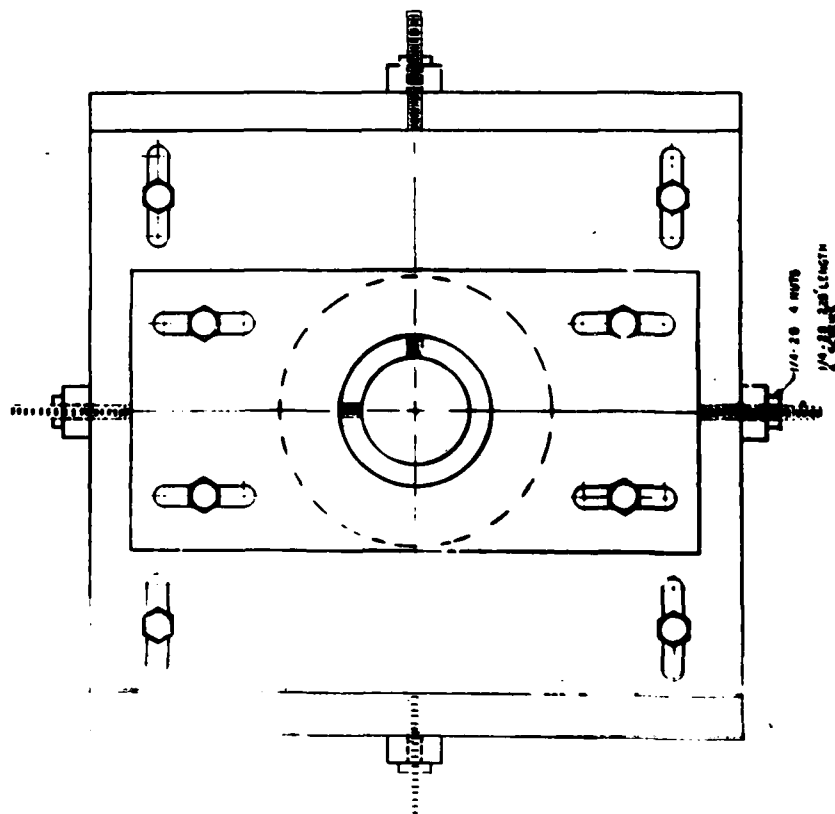


ALL ONE PLACE DIMENSIONS $\pm .020$
 ALL TWO PLACE DIMENSIONS $\pm .010$
 ALL THREE PLACE DIMENSIONS $\pm .005$

MAT'L: 6061-T6 ALUM.

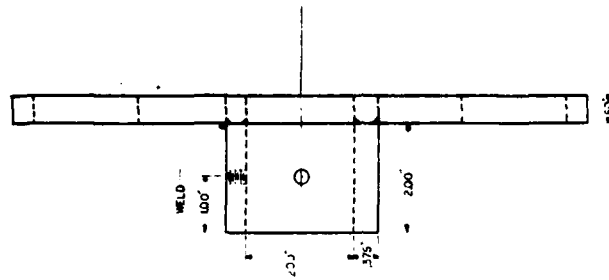
Drawing 21. Top Seal Plate Worm Gear Shaft - Azimuth Axis.

ENGINEERING EXPERIMENT STATION		GEORGIA INSTITUTE OF TECHNOLOGY		ATLANTA, GEORGIA	
PROJECT NO. 4 954 038		DATE 8-20-77		DRAWING NO. 4 954 038	
DESIGNED BY K.B.		CHECKED BY K.B.		APPROVED BY K.B.	
CALCULATED BY K.B.		DATE 8-20-77		DRAWING NO. 4 954 038	
MATERIAL 6061-T6 ALUM.		DATE 8-20-77		DRAWING NO. 4 954 038	
TOP SEAL PLATE FOR WORM GEAR SHAFT		DATE 8-20-77		DRAWING NO. 4 954 038	
RADIUS RY-1-DNER		DATE 8-20-77		DRAWING NO. 4 954 038	

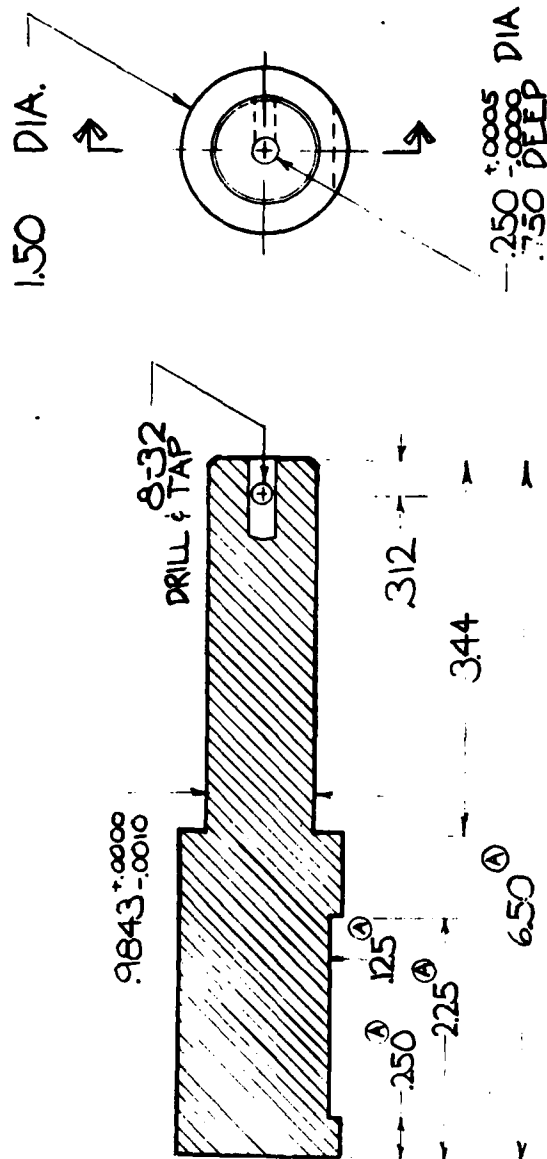


Part No.	Qty.	Notes
1	1	SEEKER ANTENNA ALIGNMENT ASSEMBLY
2	1	ALIGNMENT SCREW
3	1	ALIGNMENT SCREW
4	1	ALIGNMENT SCREW
5	1	ALIGNMENT SCREW
6	1	ALIGNMENT SCREW
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100	1	ALIGNMENT SCREW

Drawing 22. Seeker Antenna Alignment Assembly

[illegible]

MA 01901

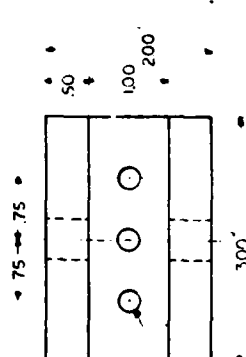


TOLERANCES:
 X = ± 0.30
 XX = ± 0.10
 XXX = ± 0.05

2-FINISH:
 1-MATERIAL: STAINLESS STEEL
 NOTES:

ENGINEERING EXPERIMENT STATION		GEORGIA INSTITUTE OF TECHNOLOGY	
		ATLANTA, GEORGIA	
		ENCODER MOUNTING	
		SHAFT FOR THE RADOME	
		POSITIONER (X AXIS)	
		DR. A.C. DRAWING NO.	
		CH. A 1954 045	
		PROJECT NO.	
		CONTRACT NO. A 1954 070	
		DATE 7-16-77	
		FULL	
		DESCRIPTION OF CHANGES	
		NO. 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000	

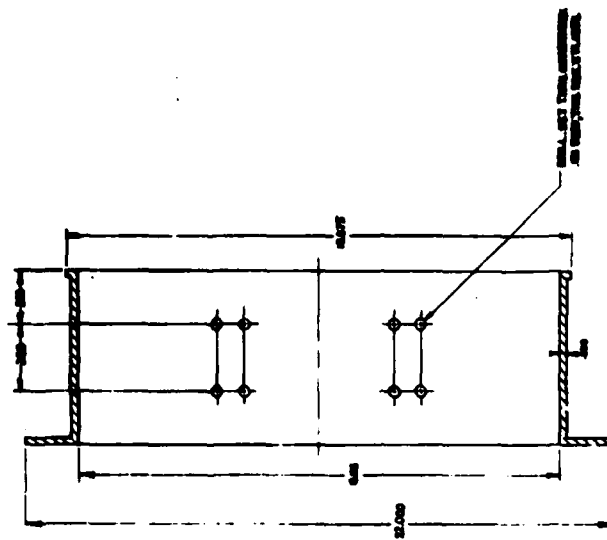
Drawing 25. Encoder Mounting Shaft - El. Axis



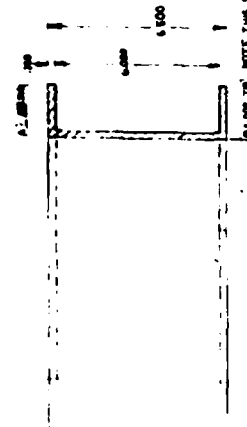
TOLERANCES
 .010 TO
 .001 TO
 .0001 TO
 MATERIAL: STAINLESS STEEL

[illegible]

Drawing 26. Hinge for Seeker Antenna Mtg. Bracket.



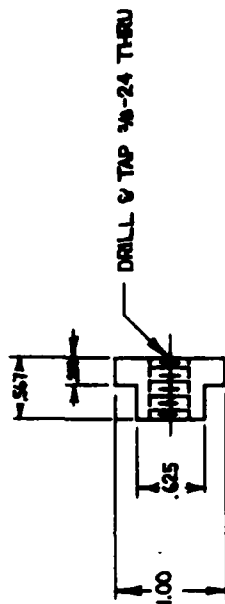
DRILL SET THIS ANGLE



NOTE THIS SPECIFICATION APPLIES ONLY TO PART 250 OF THE SURFACE

REVISIONS		DATE	BY	APP'D
1	INITIALS			
2	INITIALS			
3	INITIALS			
4	INITIALS			
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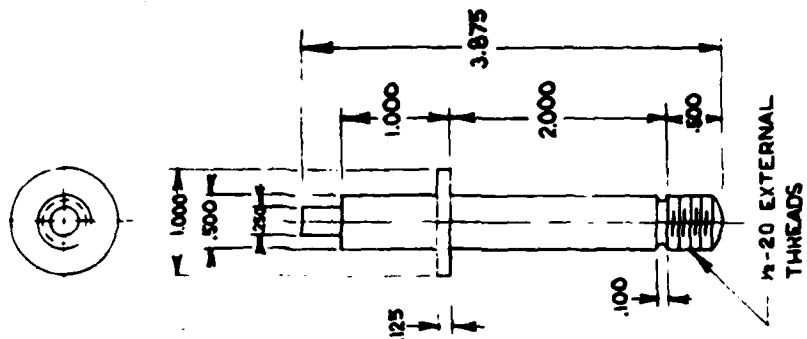
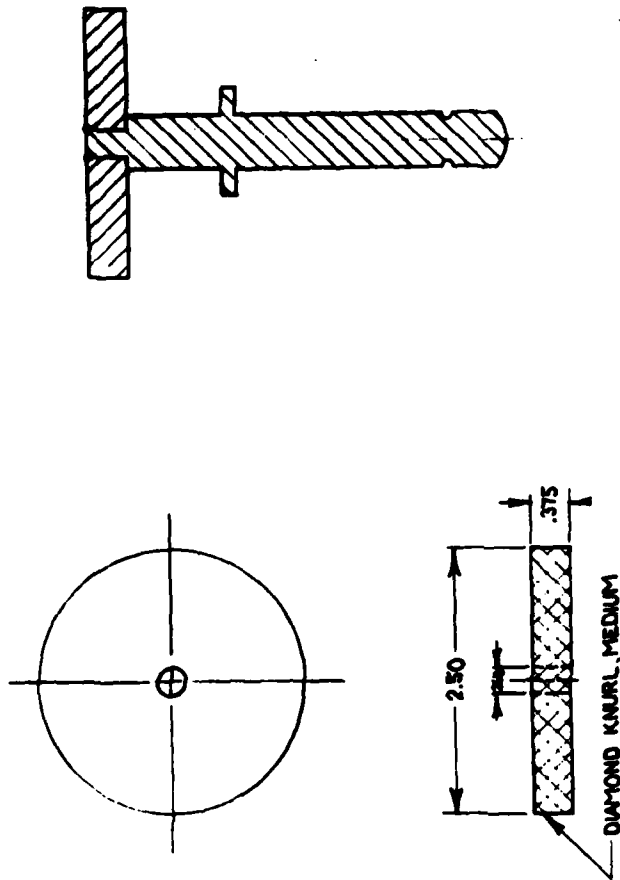
Drawing 27. Radome Mounting Ring



MAKE 4
MATERIAL - STAINLESS STEEL

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA	
LIFTING BUTTON FOR RADOME POSITIONER FRAME	
DR. MZF	DRAWING NO.
CH.	A-1954-048
APR.	
NO.	DESCRIPTION OF CHANGE
CH.	DATE
9-20-77	
FULL	
CONTRACT NO.	A-1954-070
PROJECT NO.	

Drawing 28. Lifting Button for Outer Frame



MAKE 2 EACH
MATERIAL-STAINLESS STEEL

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		SCREW LOCK FOR ANTENNA MOUNT FRAME		DRAWING NO. A-1954-049	
NO.	DESCRIPTION OF CHANGE	CH.	DATE	BY	CHK.
1	FULL		9-20-77		
CONTRACT NO.			A-1954-070		
PROJECT NO.					

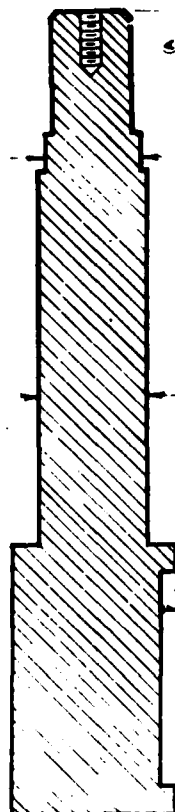
Drawing 29. Screw Lock for Seeker Antenna Mtg Frame

9843 ±.0000
- .0010

1.50 DIA.

-.875

⑥ DRILL & TAP 10-32
x .50 DEEP, PLACE



.125

4.977

5227

7227

7477

TOLERANCES:

X = ±.030

XX = ±.010

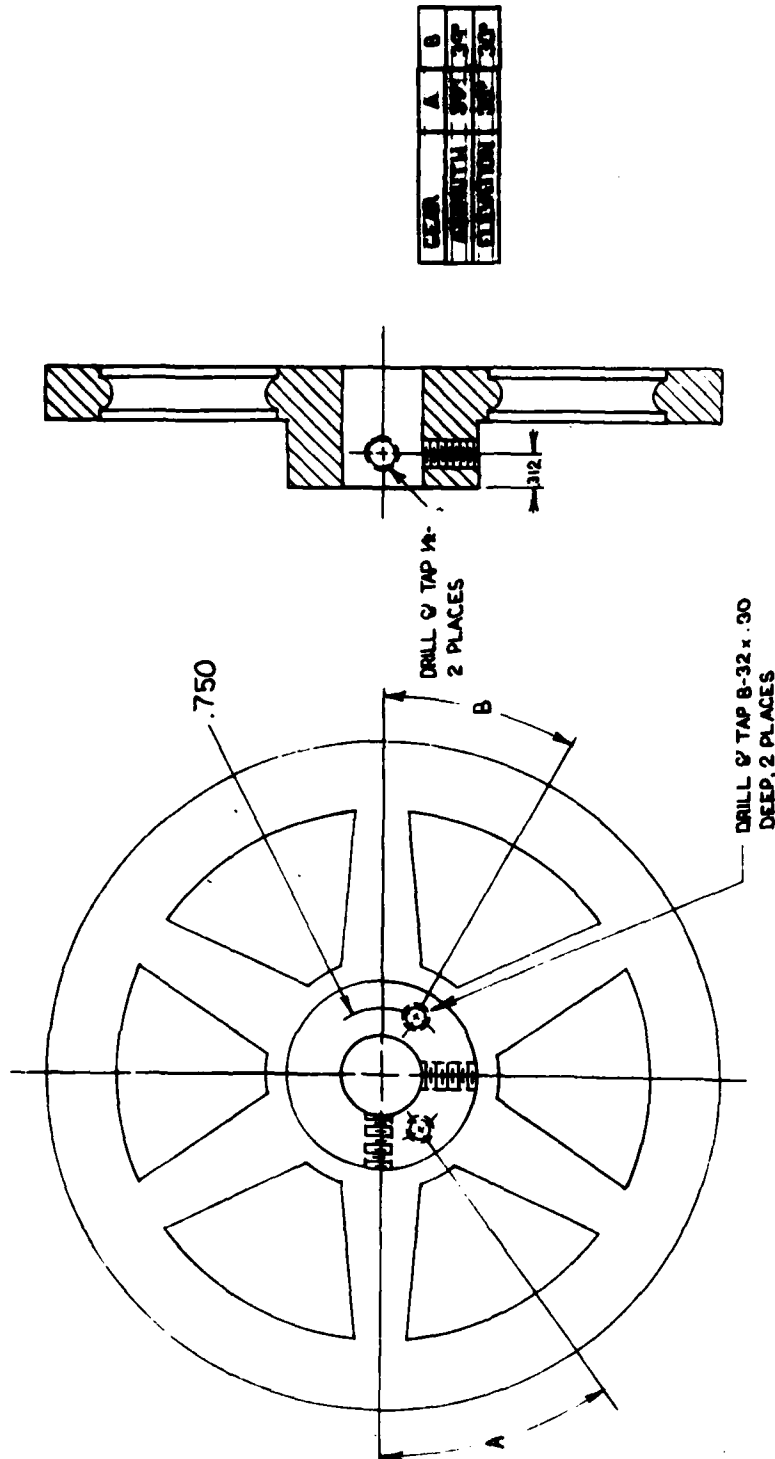
XXX = ±.005

2-FINISH:
1-MATL: STAINLESS STEEL
NOTES:

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA			
NO.	DESCRIPTION OF CHANGE	CH.	DATE
B	ADD TAPPED HOLE ON	MLF	11-8-77
A	DELETE PIN HOLE, CHANGED	MLF	10-19-77
NO.	DESCRIPTION OF CHANGE	CH.	DATE
SCALE:	FULL	DATE:	9-23-77
CONTRACT NO.	A 1954 C70	DR. O.C. NAME:	
PROJECT NO.		CH. APP.	
		DRAWING NO.	A 1954 C52

MOTOR MOUNTING
SHAFT FOR THE RADOME-
POSITIONER (X AXIS)

Drawing 30. Worm Gear Mounting Shaft - El. Axis



MODIFY 2 WORM GEARS (BROWNING PART NO. BWG2100-1) BY ADDING TAPPED HOLES FOR SETSCREWS

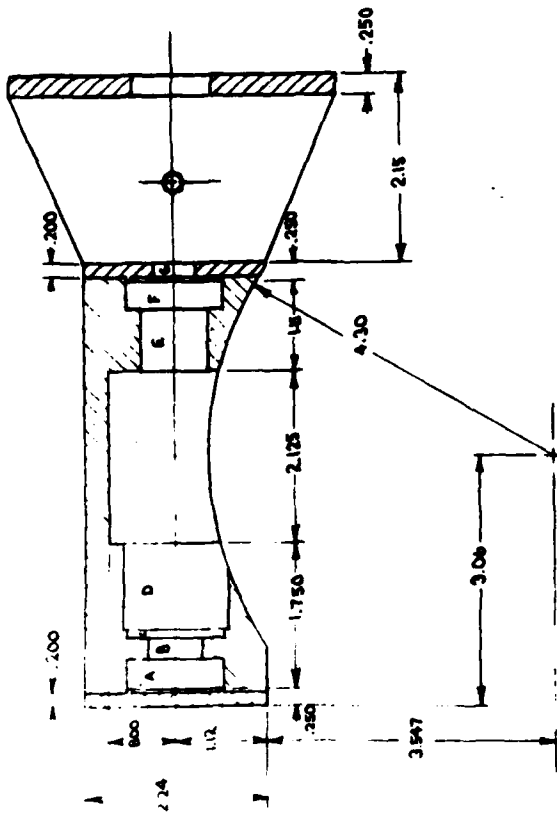
ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		MODIFIED WORM GEAR		DRAWING NO. A-1954-057	
DESIGNED BY M.F. 11-18-77	CHECKED BY M.F. 10-28-77	DATE 9-29-77	SCALE FULL	CONTRACT NO. A-1954-070	PROJECT NO.
DESCRIPTION OF CHANGE		DATE	BY	CHK.	APP.

Drawing 31. Worm Gear Modifications



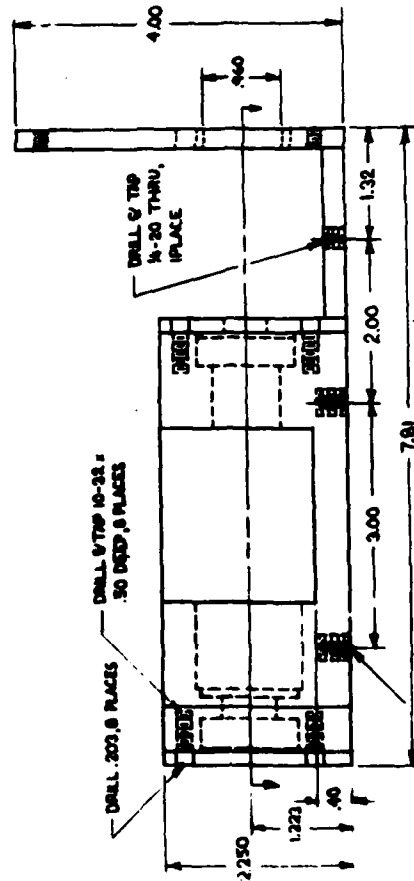
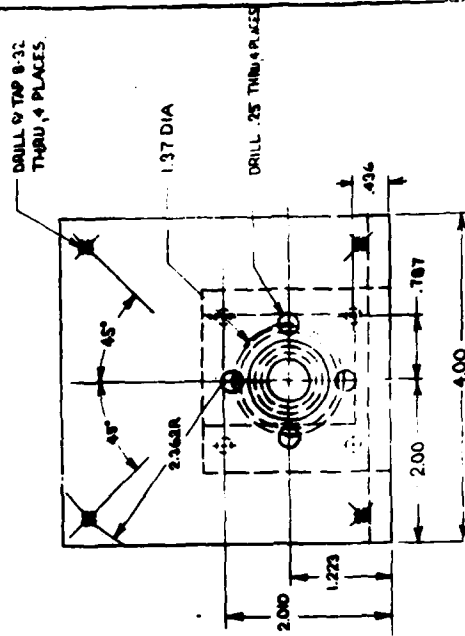
RIGHT HAND WORTH THREAD 4 THREADS
PER INCH FIT TO THREAD OF EXISTING
RADIOS NOT THAT MOUNT IN RADIOS
MUST ALIGN W/ 1/2" SCREW LOCATION

Drawing 32. 14" Radome Adapter Ring.



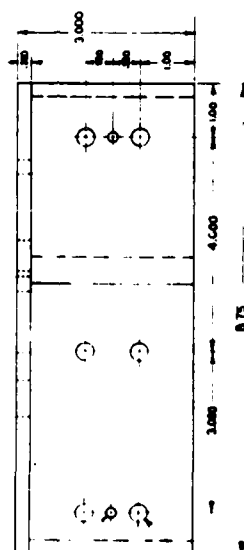
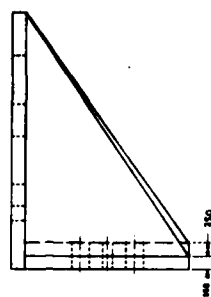
BASE	DIA.	DEPTH
A	1.181	.400
B	.560	.250
C	1.182	.100
D	1.750	1.750
E	.340	.250
F	1.024	.340
G	.500	1.180

NOTE: SEE DRAWING NO. A-1954-073 FOR LOCATION OF MICRO SWITCH MOUNTING HOLES IN BEARING BLOCK.



ENGINEERING EXPERIMENT STATION GENERAL INSTRUCTIONS		DRAWING NO.	
BEARING BLOCK & MOTOR MOUNTING PLATE FOR RADOME POSTIONER		1954-065	
DESIGNED BY	W. J. F.	CHECKED BY	W. J. F.
DATE	10-17-77	DATE	10-17-77
PROJECT NO.	A-1954-070	CONTRACT NO.	

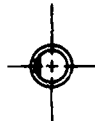
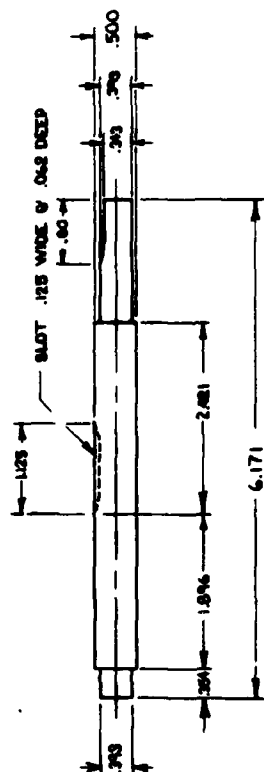
Drawing 33. Bearing Block and Motor Mounting Plate - El Axis.



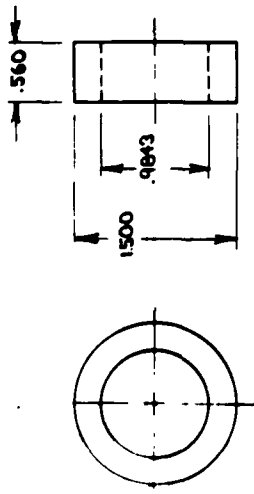
**MAKE 1
MATERIAL - ALUMINUM**



Drawing 34. Bearing Block Mounting Bracket - El Axis.

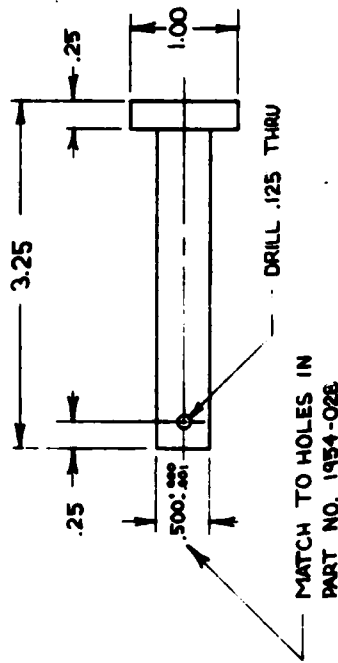
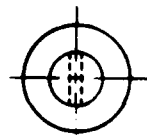


ENGINEERING EXPERIMENT SECTION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		WORM SHAFT FOR RADIO POSITIONER (X-AXIS)		DRAWING NO.		454-007	
				DR. OF SEAL.		CONTRACT NO.	
				ON ON.		A-1954-70	
				DATE		APR.	
		A. BROWN, ENGINEER IN CHARGE		DATE			
		JAN. 1954 DIS.		DATE			
		REWORKED BY CHANCE		DATE			
		FULL		DATE			



ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		DRAWING NO. 1954-068	
SPACER FOR WORM GEAR SHAFT (X-AXIS)		DR. /MLF ENGR. CH. APP.	
NO.	DESCRIPTION OF CHANGE	CH.	DATE
SCALE	FULL	DATE	10-19-77
CONTRACT NO. A-1954-070		PROJECT NO.	

Drawing 36. Worm Gear Shaft Spacer - El Axis.



MAKE 2
MATERIAL-STAINLESS STEEL

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		HINGE PIN FOR VERTICAL ANTENNA SUPPORT	
DR. M/LF	DRAWING NO.	1954-C69	
ENGR. CH.	APP.		
NO.	DESCRIPTION OF CHANGE	CH.	DATE
SCALE: FULL	DATE: 10-21-77		
CONTRACT NO.		A-1954-070	
PROJECT NO.			

Drawing 37. Hinge Pin for Seeker Antenna Bracket

AD-A166 021

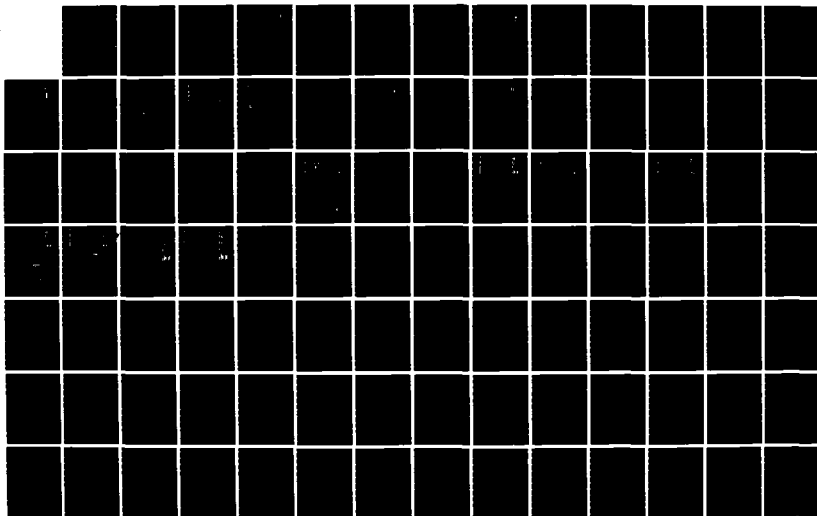
RADOME POSITIONER FOR THE RFSS (RADIO FREQUENCY
SIMULATION SYSTEM)(U) GEORGIA INST OF TECH ATLANTA
ENGINEERING EXPERIMENT STATION D O GALLENTINE ET AL.
27 FEB 78 DAKK40-77-C-0047

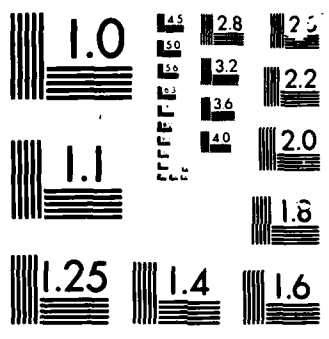
2/3

UNCLASSIFIED

F/G 17/9

NL

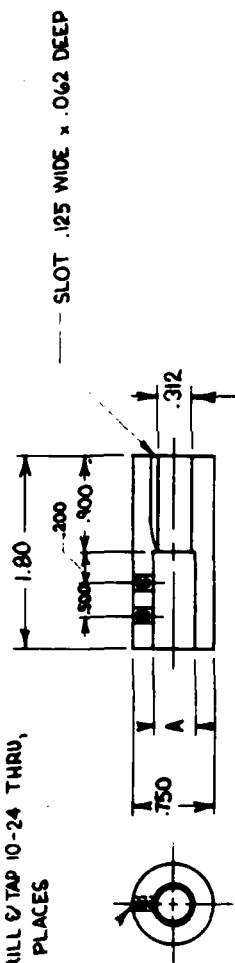




MICROCOPY

CHART

DRILL & TAP 10-24 THRU,
2 PLACES

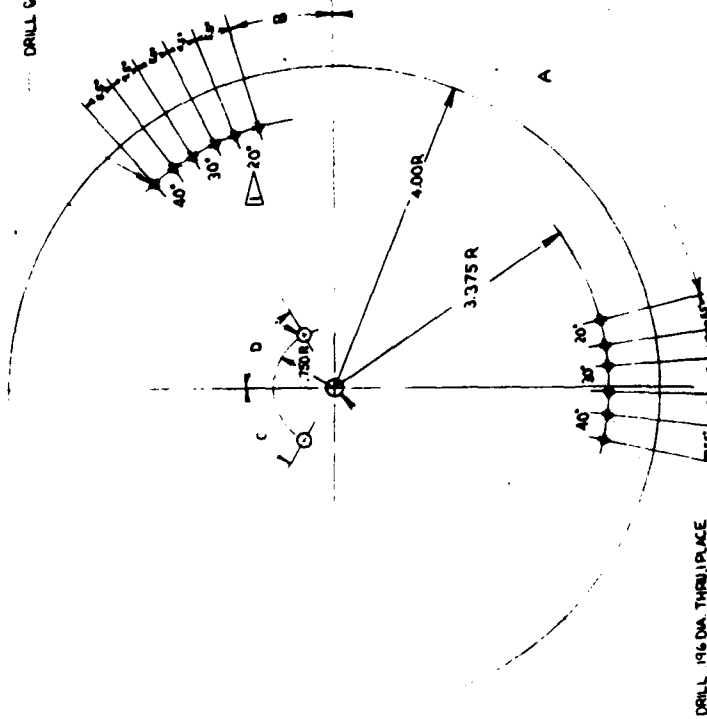


MAKE-2
MATERIAL-STAINLESS STEEL

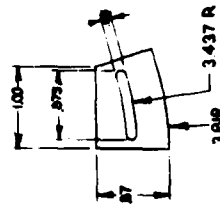
[illegible]

Drawing 38. Shaft Coupling Motor to Worm

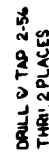
DRILL & TAP 4-40 THRU 12 PLACES



DRILL .116 DIA THRU, COUNT-
ERSINK .067 DEEP THIS
SIDE 2 PLACES



MAKE A



NOTES:

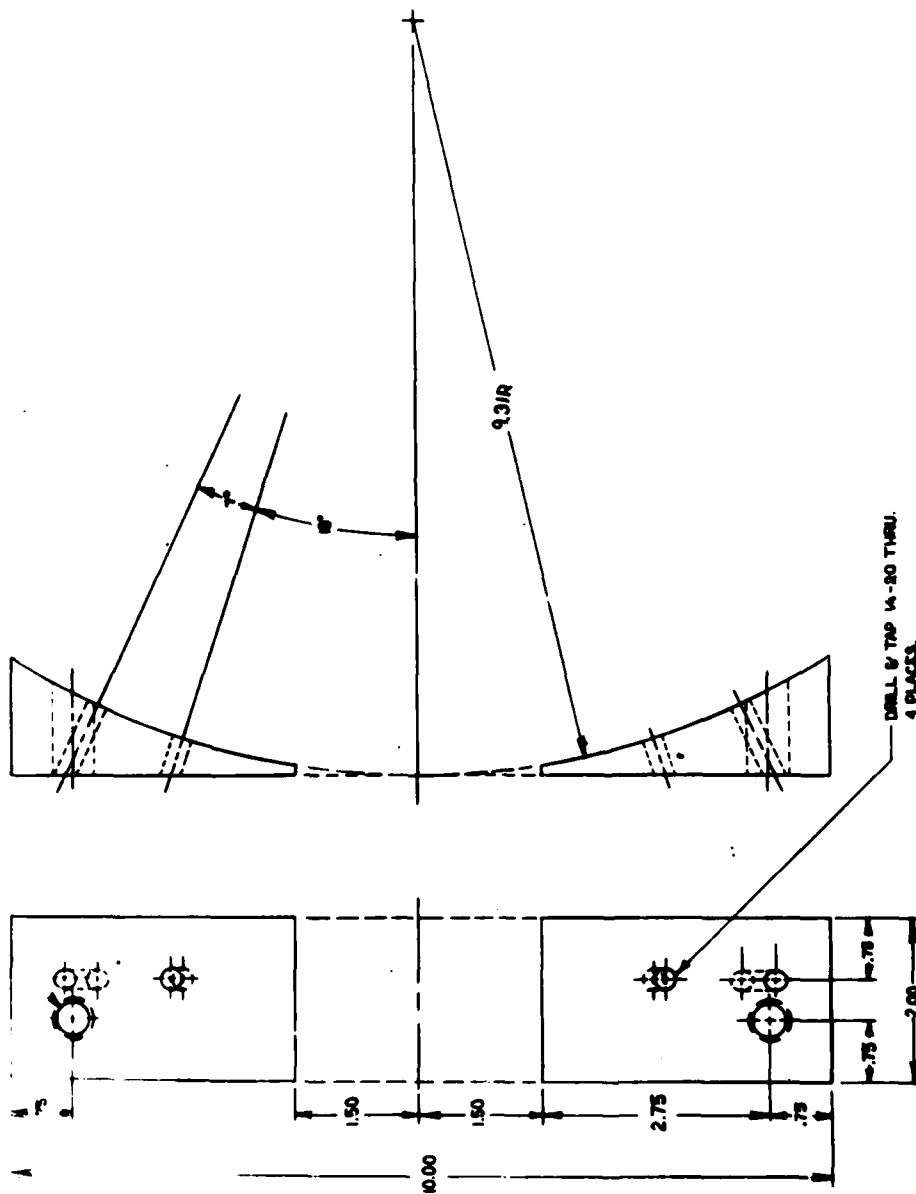
1. METAL STAMP & PLACES
2. MATERIAL - .125 ALUMINUM STOCK
3. TOLERANCES - .XXX - ±.005
.XX - ±.010
.X - ±.020
ANGLES - ±.5°

DIMENSION	AZIMUTH	ELEVATION
A		75°
B		15°
C	51°	60°
D	55°	53°

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA							MICRO-SWITCH ACTUATORS AND MOUNTING BRACKETS			
NO.						SUBSCRIPTION OF CHANGES		CH	DAYS	
SCALES.						FULL		DATE 12-5-77		
CONTRACT NO.								A-104		
PROJECT NO.										
DRAWING NO.								A-454-072		

Drawing 39. Micro-Switch Actuator and Mounting Plate.

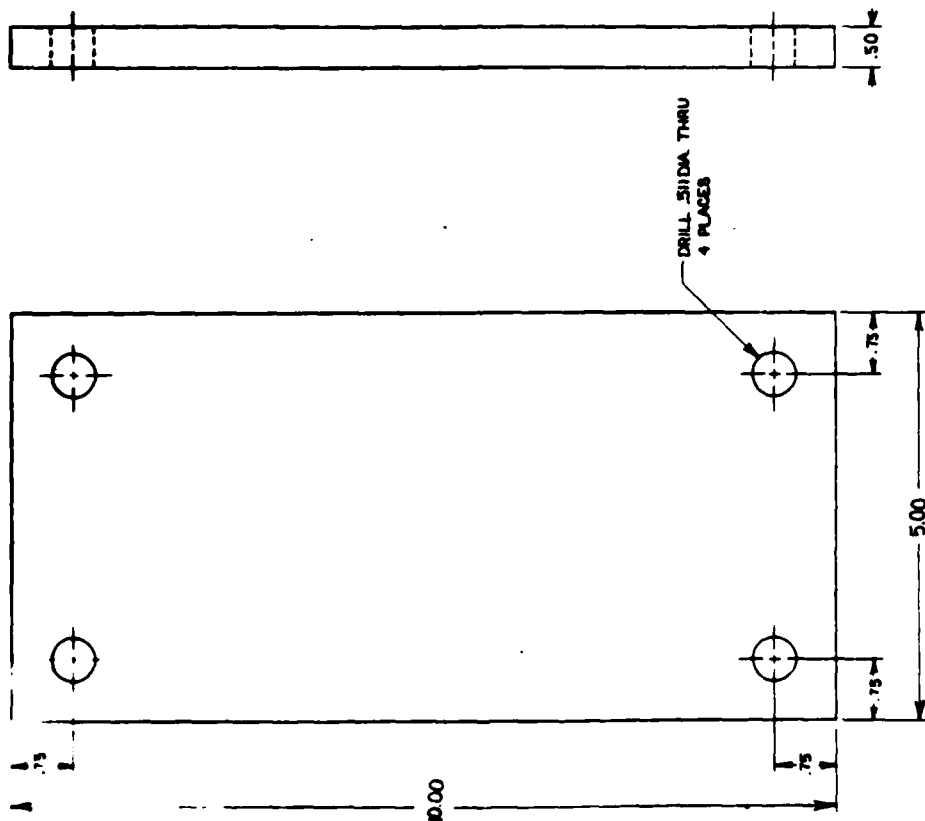
DRILL & TAP 1/8-13 THRU.
2 PLACES



MAKE 4 SETS
MATERIAL - ALUMINUM

Drawing 40. Counter Weight Mounting Blocks.

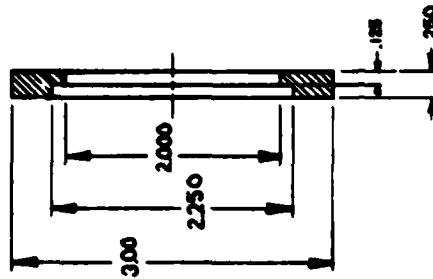
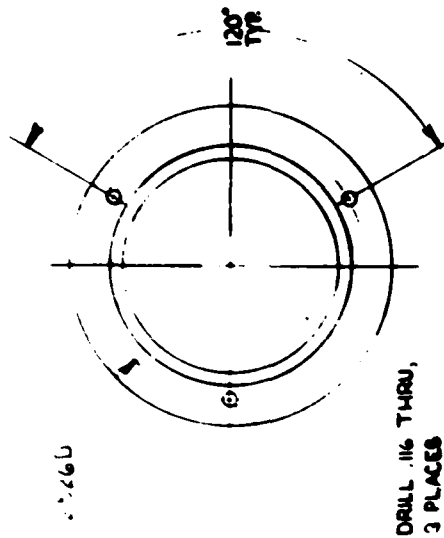
ENGINEERING DEPARTMENT STATION		DESIGN NO. 11-22-77		DRAWING NO. A-1954-070	
COUNTERWEIGHT MOUNTING BLOCKS		DATE 11-22-77		PROJECT NO. A-1954-070	
COUNTERWEIGHT MOUNTING BLOCKS		11-22-77		A-1954-070	
COUNTERWEIGHT MOUNTING BLOCKS		11-22-77		A-1954-070	
COUNTERWEIGHT MOUNTING BLOCKS		11-22-77		A-1954-070	
COUNTERWEIGHT MOUNTING BLOCKS		11-22-77		A-1954-070	
COUNTERWEIGHT MOUNTING BLOCKS		11-22-77		A-1954-070	
COUNTERWEIGHT MOUNTING BLOCKS		11-22-77		A-1954-070	
COUNTERWEIGHT MOUNTING BLOCKS		11-22-77		A-1954-070	
COUNTERWEIGHT MOUNTING BLOCKS		11-22-77		A-1954-070	



MAKE &
MATERIAL-LEAD

Drawing 41. Counter Weight.

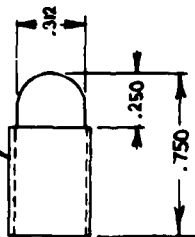
ENGINEERING DEPARTMENT		DESIGNED BY	
GENERAL ENGINEERING		DATE	
COUNTERWEIGHT		11-22-77	
CONTRACT NO.	PROJECT NO.	DATE	BY
A-1954-075	A-1954-075	11-22-77	W.F.F.
CHECKED BY		DATE	



ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		DRAWING NO. A-1954-077	
ENCODER MOUNT CLAMP RING		DR. / M.F. CH.	APP.
NO.	DESCRIPTION OF CHANGE	CH.	DATE
SCALE	FULL	DATE	11-30-77
CONTRACT NO.		A-1954-070	
PROJECT NO.		A-1954-070	

Drawing 42. Encoder Clamp Ring

3/8-24 EXTERNAL THREAD



MAKE 2

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		MODIFIED SETSCREW FOR HORIZONTAL POSITION- ING OF INNER GIMBAL		DR. M/LF ENGR. CH. APP.		DRAWING NO. A-1954-080	
NO.	DESCRIPTION OF CHANGE	CH.	DATE				
SCALES 2:1		DATE 12-7-77					
CONTRACT NO.		A-1954-070					
PROJECT NO.							

Drawing 43. Modified Set Screw for Centering of Inner Gimbal

500: 31N: 45

EXISTING PANEL
IN-SEC FINISH

W. L. WING

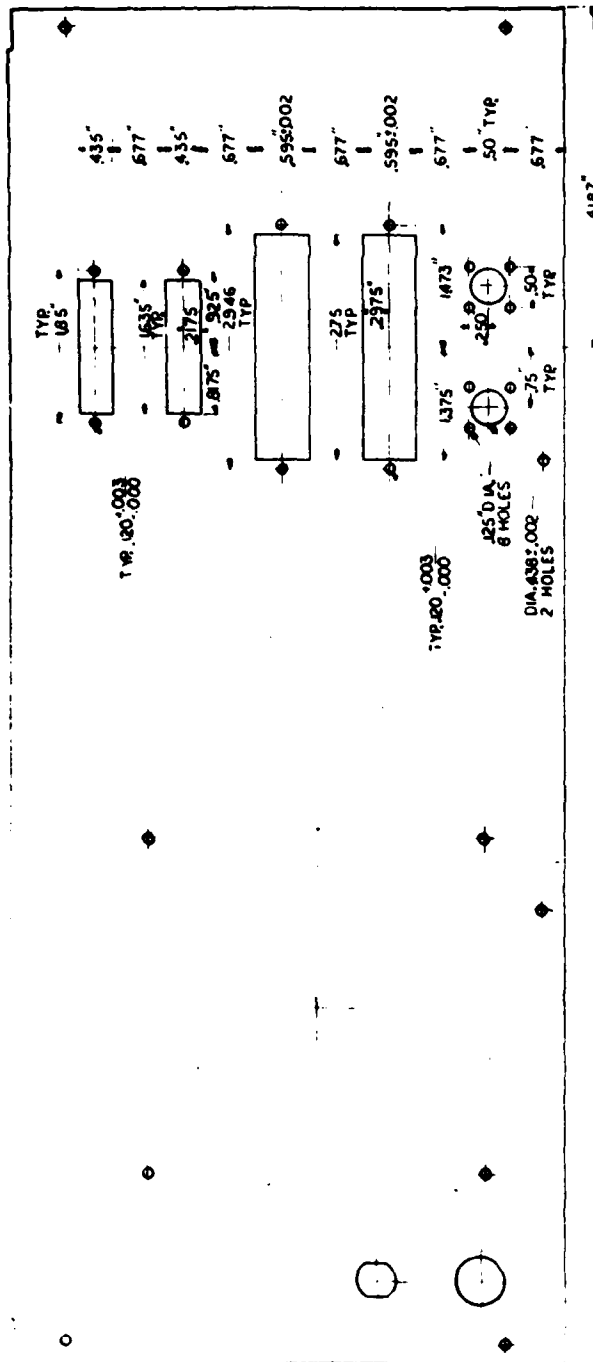
UNIMAR 01-262

66

3250

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1. Name of the person or organization 2. Address 3. City 4. State 5. Zip 6. Telephone 7. Fax 8. E-mail 9. Website 10. Other																																																																																																			

Drawing 44. Modification of Front Panel M68NMLC1 Micro-Module.



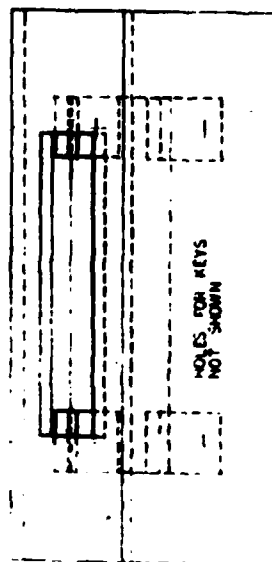
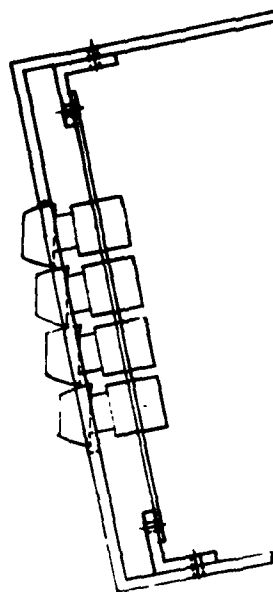
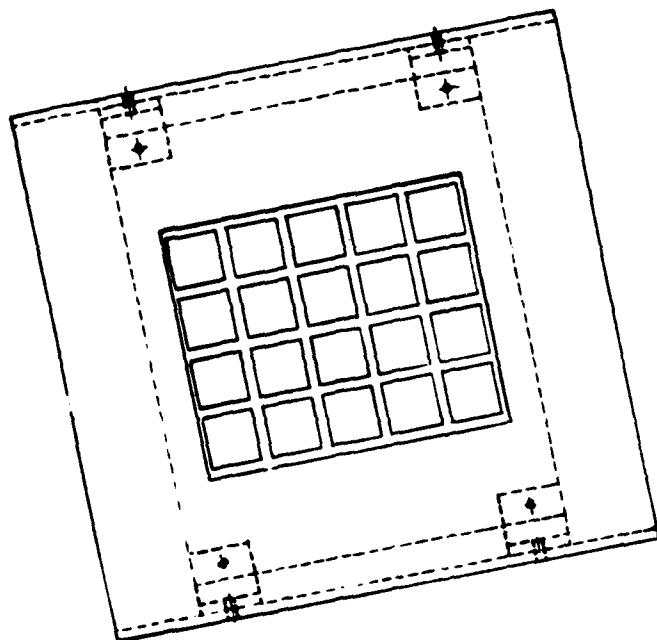
TOLERANCE: .005

NOTES
1. ALL HOLES TO EXISTING PANEL
2. MASH TO PROTECT FINISH

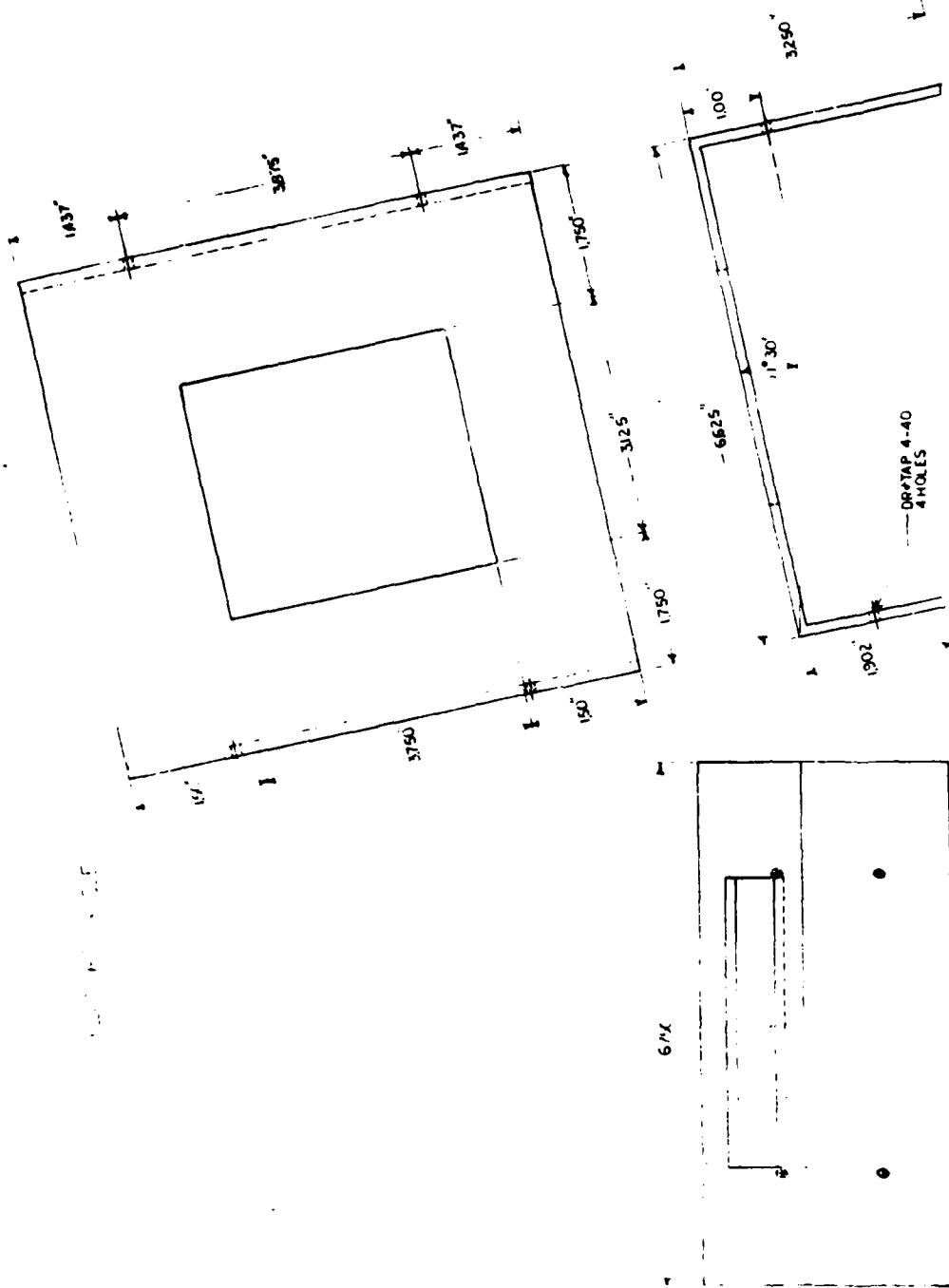
REVISIONS		DATE		BY		CHK	
1							
2							
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4							
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100							

Drawing 45. Modification of Back Panel M68MMLC1 Micro-Module.

A 1954-059

[illegible]

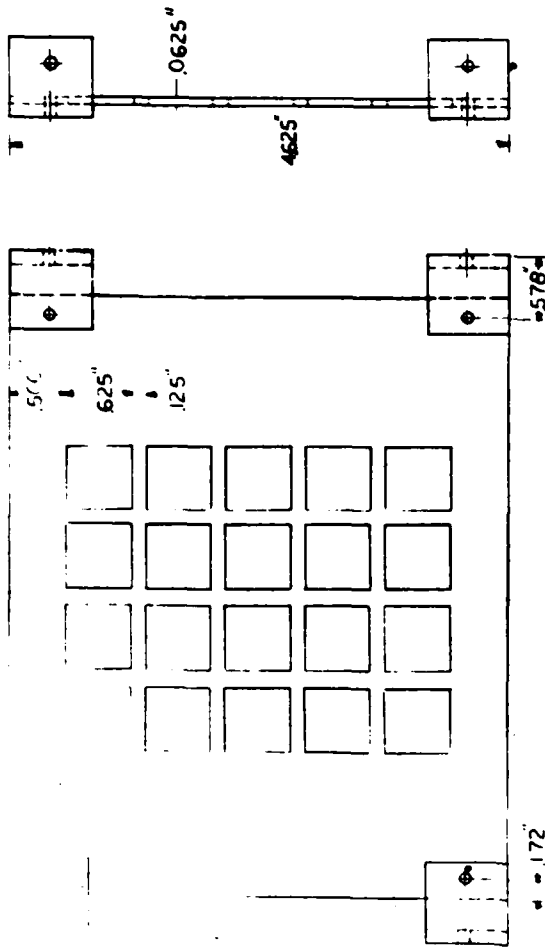
Drawing 46. Keyboard Assembly.



ENGINEERING DEPARTMENT		DESIGN	
PROJECT NO.		DATE	
DRAWING NO.		DATE	
DESIGNED BY		CHECKED BY	
F. J. KEYBARD			
CONTRACT NO.		PROJECT NO.	

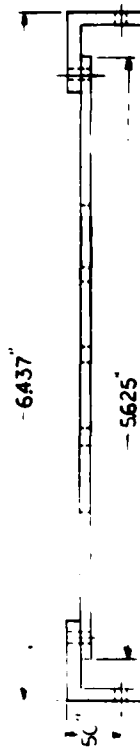
Drawing 47. Box for Keyboard

102



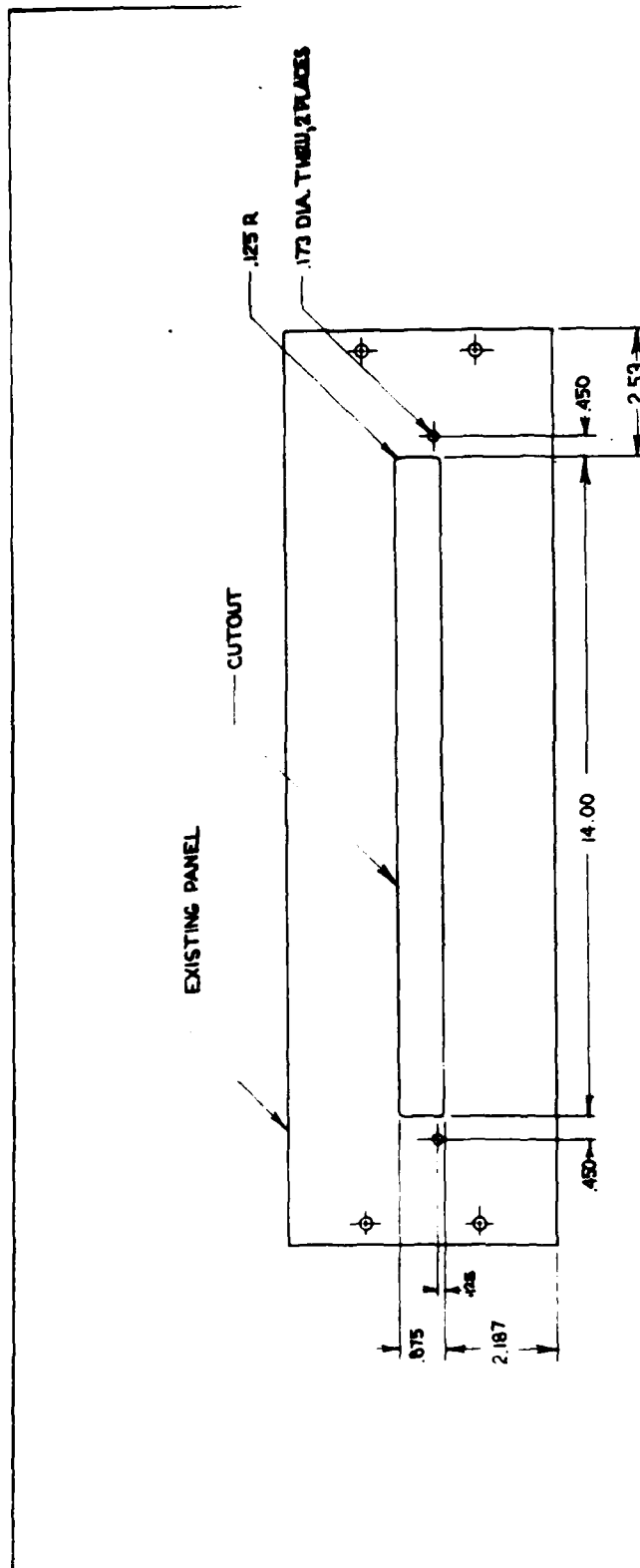
--- DRILL + TAP ALL HOLES 4-40

3/4 X 3/4 X 1/8 ALUM. ANGLE



ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		KEY MOUNTING BOARD	
1. Length 6437		11/11/54 E. R. KETT	
NO. DESCRIPTION OF CHANGE	CH.	DATE	DR. S. F. H.
10/11			DR. S. F. H.
CONTRACT NO. A-1944-07		DRAWING NO. A-1954-063	
PROJECT NO. A-1944-07		APP.	

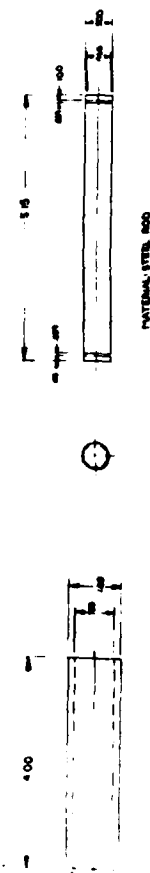
Drawing 48. Key Mounting Board and Bracket



NOTE: PAINTED SURFACE OF EXISTING
PANEL MUST BE PROTECTED
DURING MACHINING

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		MODIFICATION OF EQUIP- MENT RACK PANEL	
NO.	DESCRIPTION OF CHANGE	DATE	DATE
SCALE	HALF	DATE	10-26-77
CONTRACT NO.		A-1954-070	
PROJECT NO.		A-1954-071	
DRAWING NO.		1954-071	
DR.		APP.	

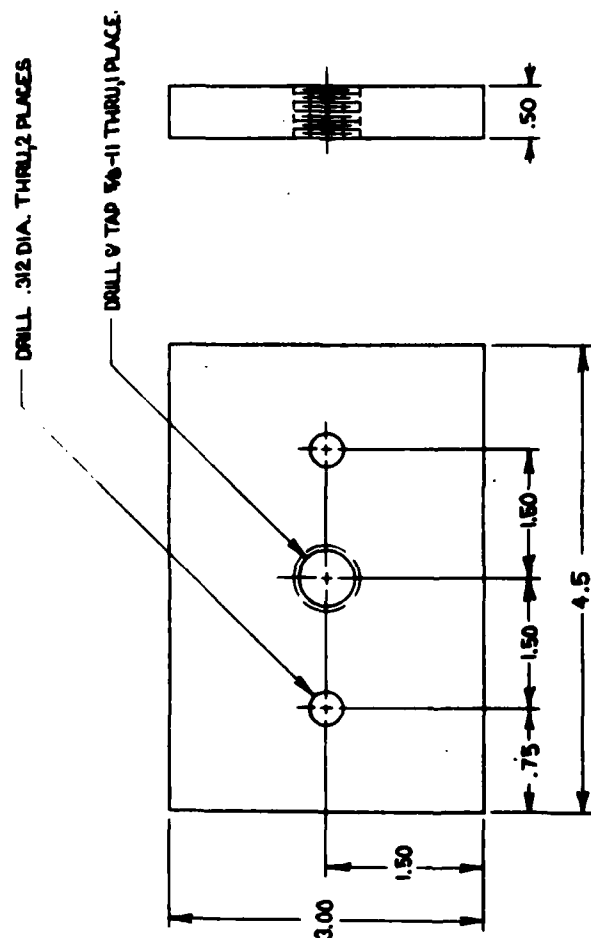
Drawing 49. Panel Modifications for Digital Readout



105

[illegible]

Drawing 51. Lifting Ilook Details

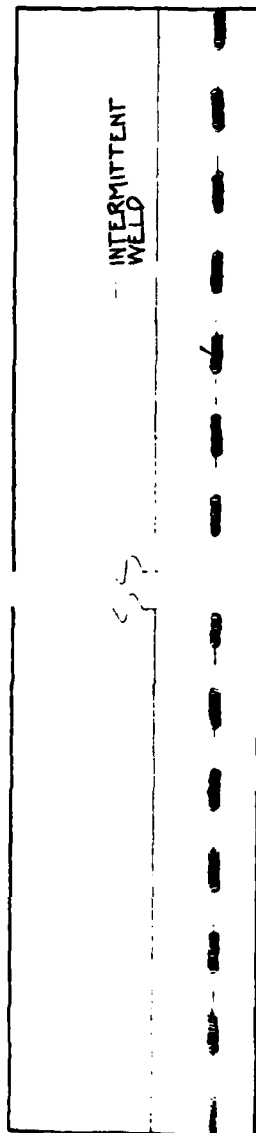
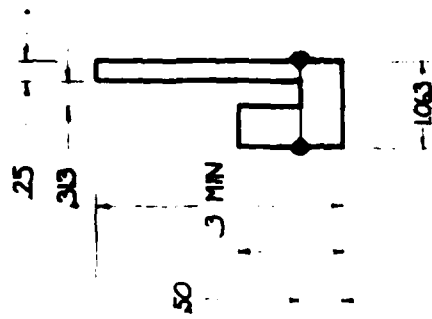


MAKE 1
MATERIAL: STEEL

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		DRAWING NO. A-1954-078	
THREADED PLATE FOR RADOME POSITIONER CART		CONTRACT NO. A-1954-070	
NO.	DESCRIPTION OF CHANGE	CH.	DATE
SCALE	FULL	DATE	12-1-77
PROJECT NO.		A-1954-070	
APPROVED		APPROVED	

Drawing 52. Threaded Plate for Lifting Hook



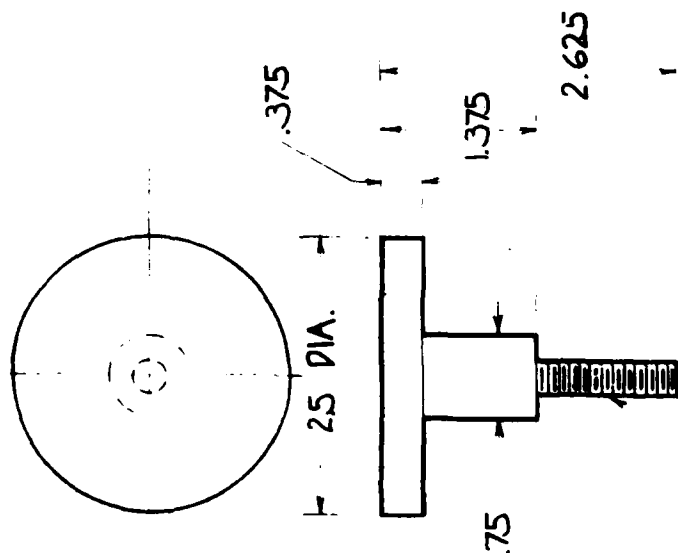


TOLERANCES:
 X = ±.060
 XX = ±.030
 XXX = ±.010

2- FINISH: NONE
 1- MATERIAL: STEEL
 NOTES:

ENGINEERING DEPARTMENT STATION		DATE	
GEORGIA INSTITUTE OF TECHNOLOGY		ATLANTA, GEORGIA	
BOTTOM BRACKET FOR MODIFIED TRUCK		PART 1	
DESIGNED BY	DATE	BY	DATE
Q.C.	7-27-77		
CONTRACT NO. A 1954-072		PROJECT NO.	
A-1954-009			

TOLERANCES:
 X = ±.060
 XX = ±.030
 XXX = ±.010



2-PAINT (PROTECT THREADS)
 1-MATERIAL: STEEL
 NOTES:

EXT. THREAD, $\frac{5}{16}$ -18

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		DRAWING NO. A-1954-010	
MODIFIED HAND TRUCK, DETAILS PART 2		DR. Q.C. DATE 7-27-77	
NO. DESCRIPTION OF CHANGE CH. DATE		CONTRACT NO. A 1954-070	
FULL		PROJECT NO.	

Drawing 56. Door Clamp Screw Top.

30

3.0

5

1.75

25

Y
Q
Y

TOLERANCES:

$$\bar{X} = \pm 0.060$$

XX
XX
XX

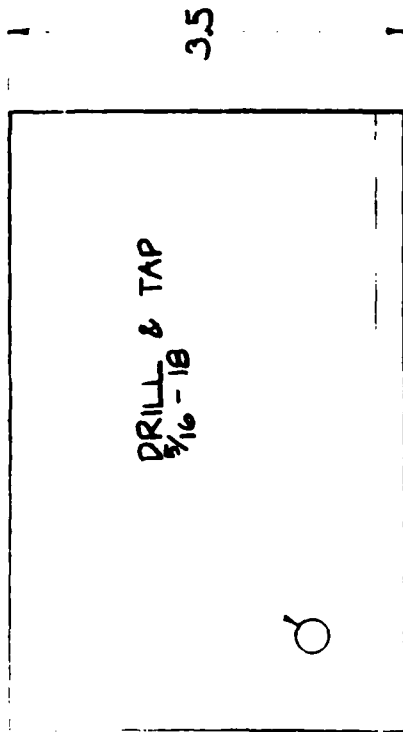
X
X
X
X

.010
= .010

3-30° CHAMFER
2.- FINISH :
1.- MATERIAL: STEEL
NOTES:

Drawing 57. Door Clamp Top

[illegible]



5.5 MIN

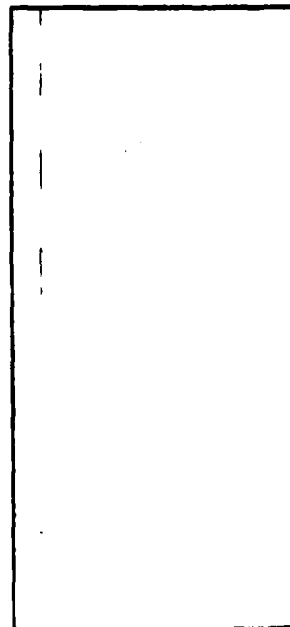
.875

.813

.25

.25

2.5

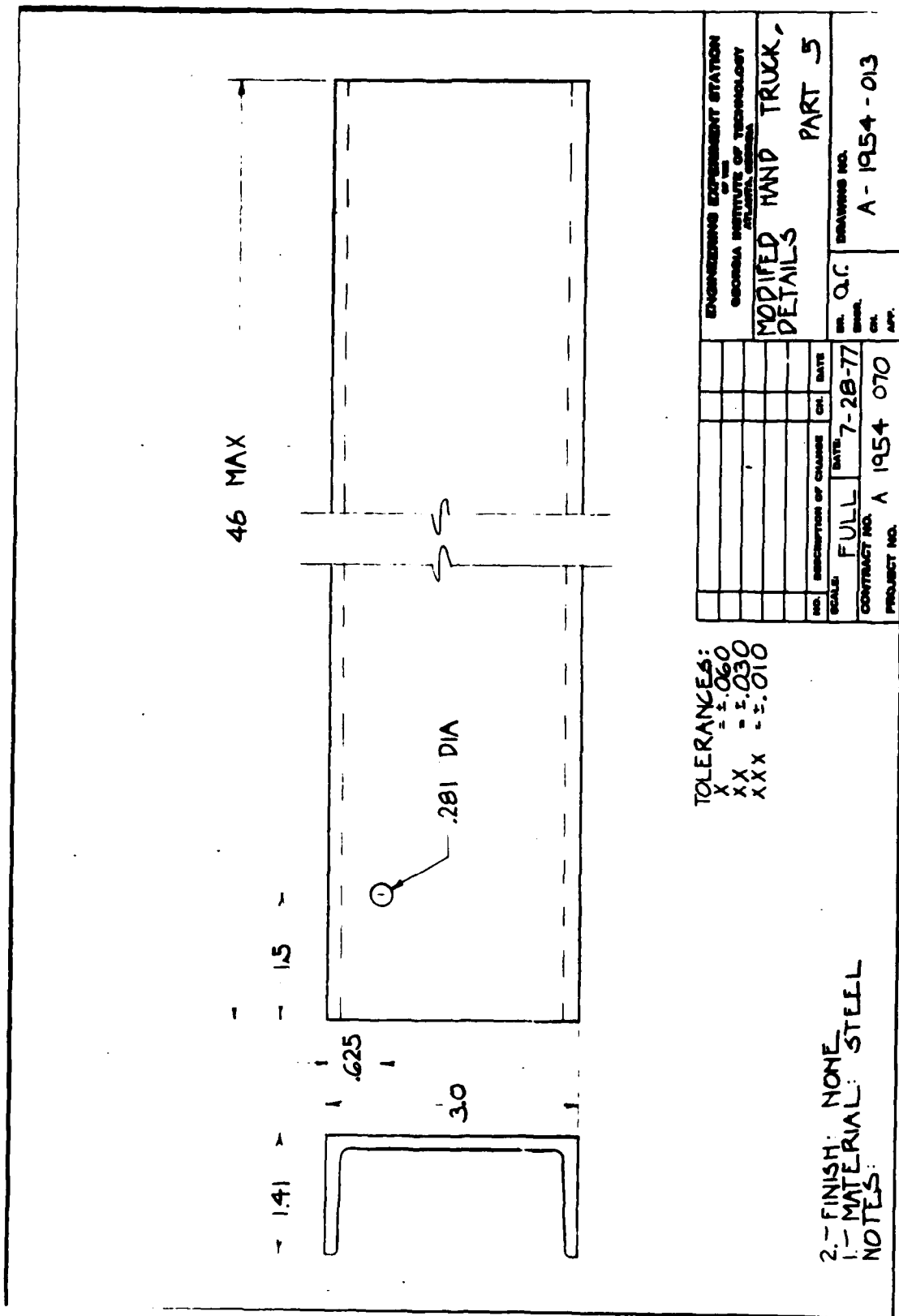


2.- FINISH: NONE
1.- MATERIAL: STEEL
NOTES:

TOLERANCES:
X ±.060
XX ±.030
XXX ±.010

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		MODIFIED HAND TRUCK, DETAILS		PART 4	
NO.	DESCRIPTION OF CHANGE	BY	DATE	DR. Q.C.	REVISION NO.
1	FULL	72B-77			
CONTRACT NO. A 1954 070				A-1954-012	
PROJECT NO.					

Drawing 58. Cap Support Bracket.



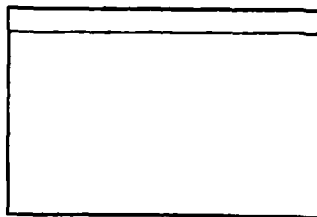
Drawing 59. Upright Support

-.25



1/45

2 MIN



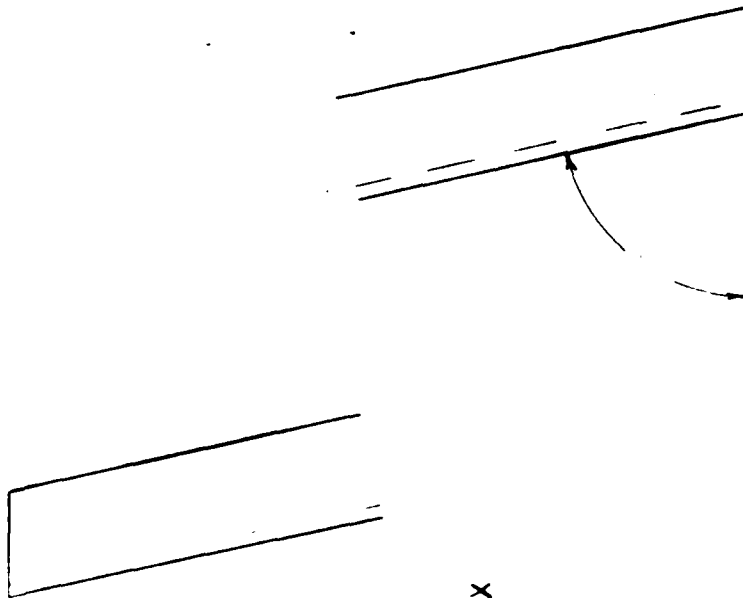
3 MIN

TOLERANCES:
X = ±.060
XX = ±.030

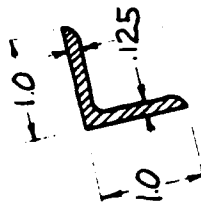
2-FINISH: NONE
1-MATERIAL: STEEL
NOTES:

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		MODIFIED HAND TRUCK PART 6	
NO.	DESCRIPTION OF CHANGE	CH.	DATE
SCALE: FULL		DATE: 7-29-77	
CONTRACT NO. A 1954 070		DRAWING NO. A 1954-014	
PROJECT NO.		APPROVED BY: [Signature]	

Drawing 60. Gusset Plate.



48 MAX

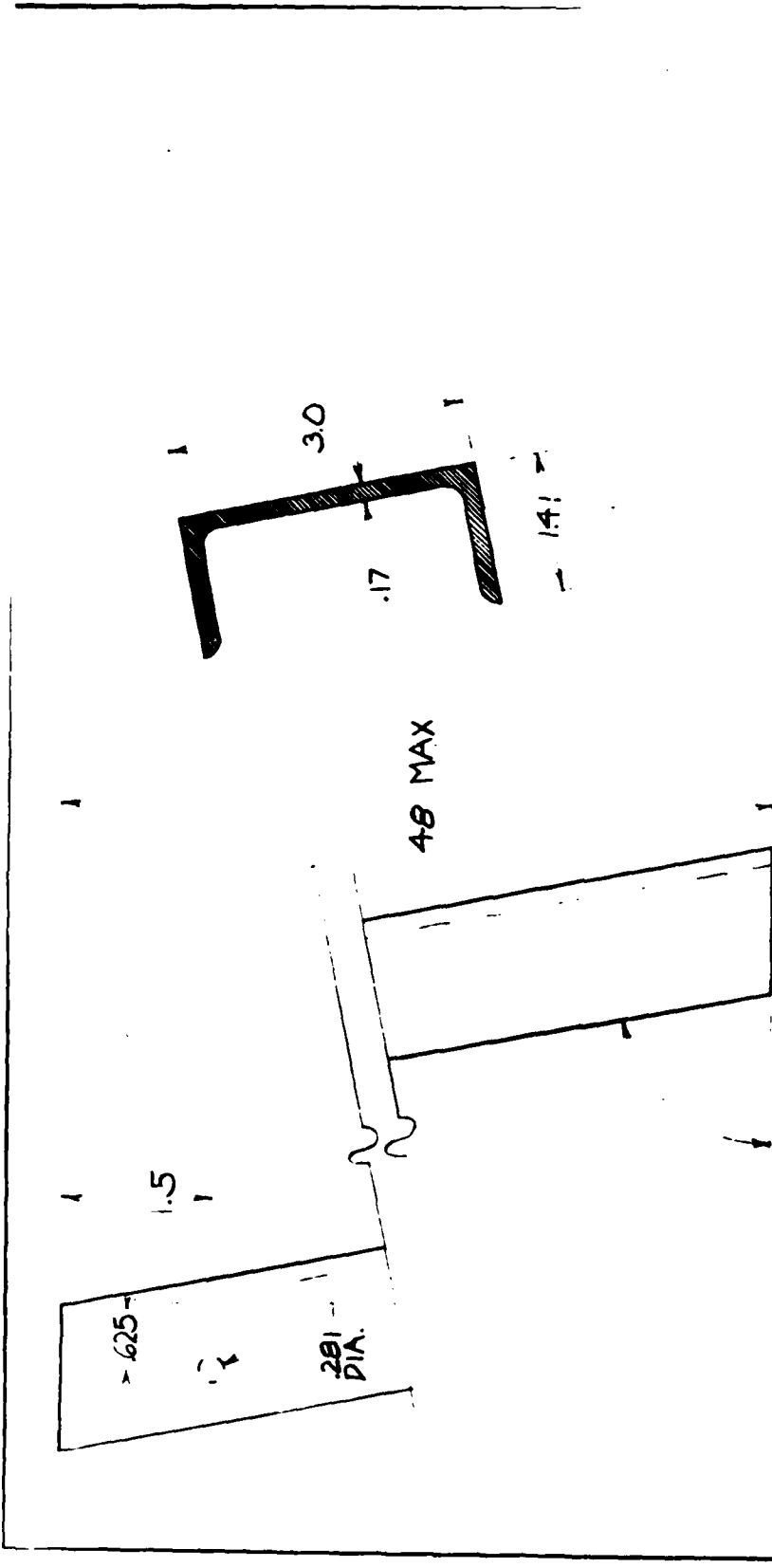


2-FINISH: NONE
1-MATERIAL: STEEL
NOTES:

TOLERANCES:
X $\pm .060$
XX $\pm .030$
XXX $\pm .010$

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		MODIFIED HAND TRUCK DETAILS PART 7	
NO.	DESCRIPTION OF CHANGE	CH.	DATE
1	NONE	8-1-77	
CONTRACT NO. A 1954 070		DRAWING NO. A 1954 015	
PROJECT NO.		APP.	

Drawing 61. Angle Support



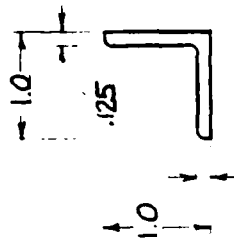
TOLERANCES:
 X = ±.060
 XX = ±.030
 XXX = ±.010

2-FINISH: NONE
 1-MATERIAL: STEEL
 NOTES:

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA			
MODIFIED HAND TRUCK, DETAILS			
PART 8			
NO.	DESCRIPTION OF CHANGE	DATE	BY
1	NONE	8-1-77	
CONTRACT NO. A 1954 070		DRAWING NO. A 1954-016	
PROJECT NO.		REV.	

Drawing 62. Channel Support

20

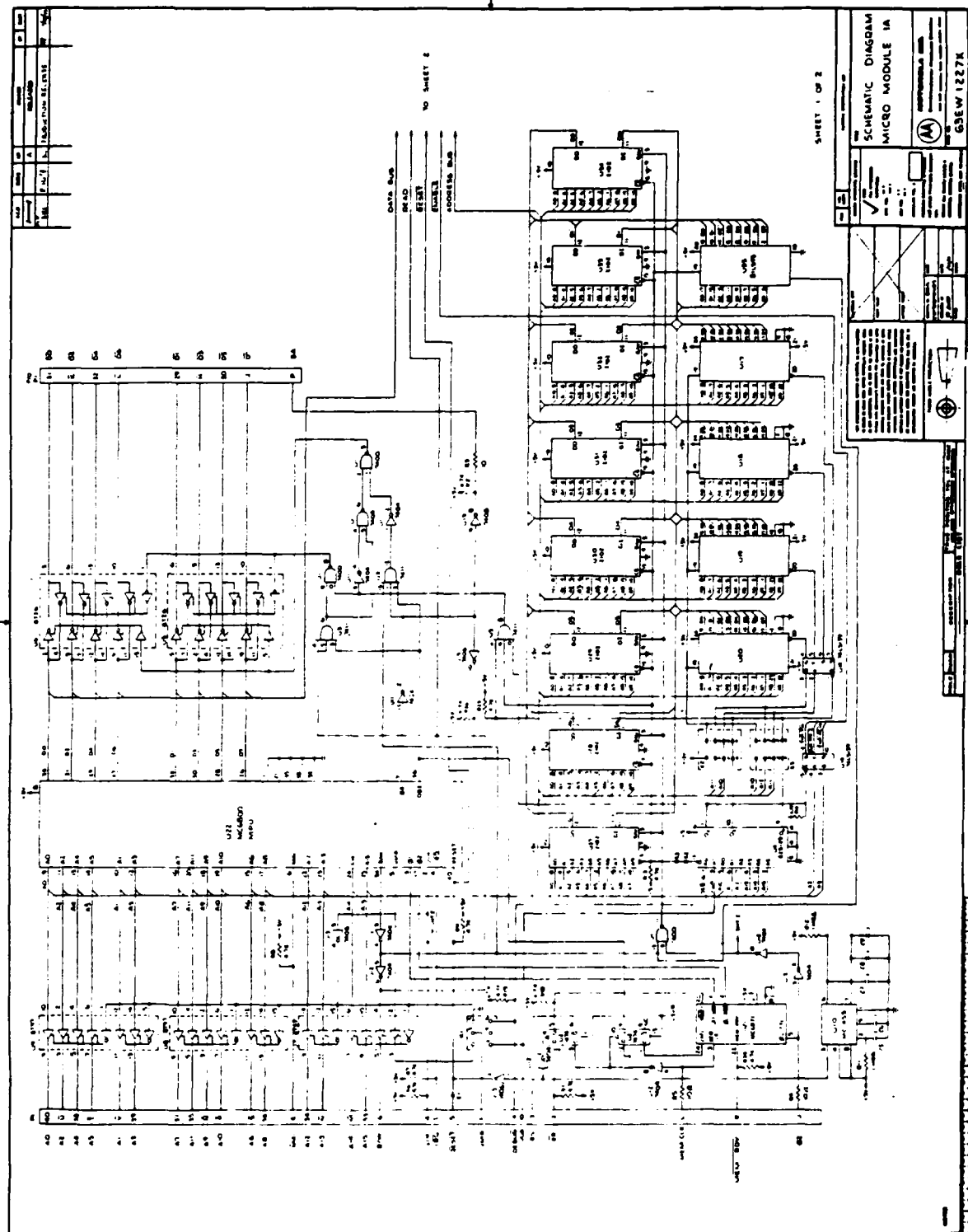


TOLERANCES:
X = ±.060
XX = ±.030
XXX = ±.010

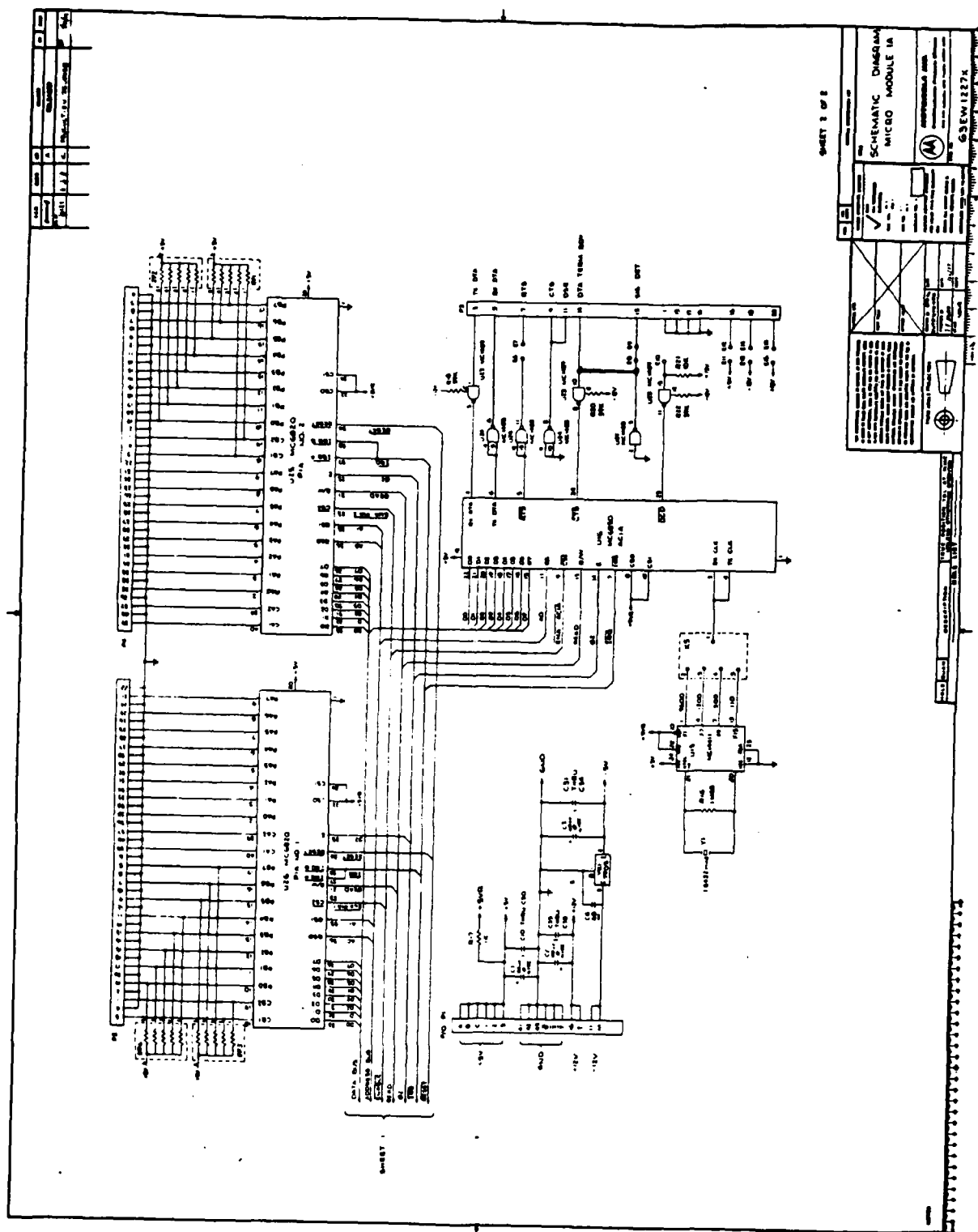
2-FINISH: NONE
1-MATERIAL: STEEL
NOTES:

ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		MODIFIED HAND TRUCK DETAILS PART 9	
DR. A.C.	DRAWING NO.	A 1954 017	
BY: R.	CH.	APP.	
NO.	DESCRIPTION OF CHANGE	CH.	DATE
SCALE: FULL	DATE: 7-29-77		
CONTRACT NO. A 1954 070		PROJECT NO.	

Drawing 63. Angle Stop



Drawing 64. Motorola M68M01A-1 Microcomputer.



Drawing 65. Parallel and Serial Interface Schematic for M68MM01A-1.

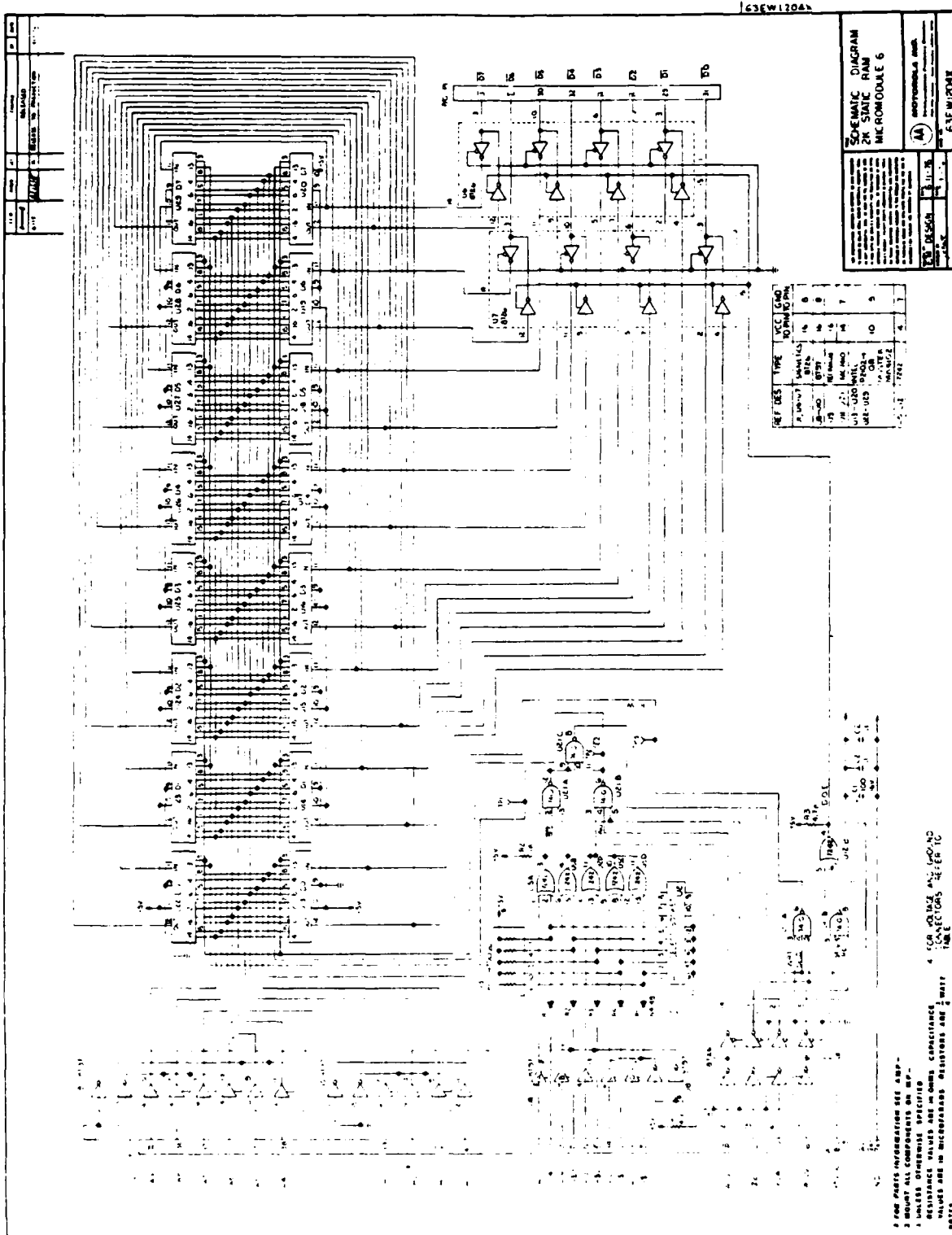
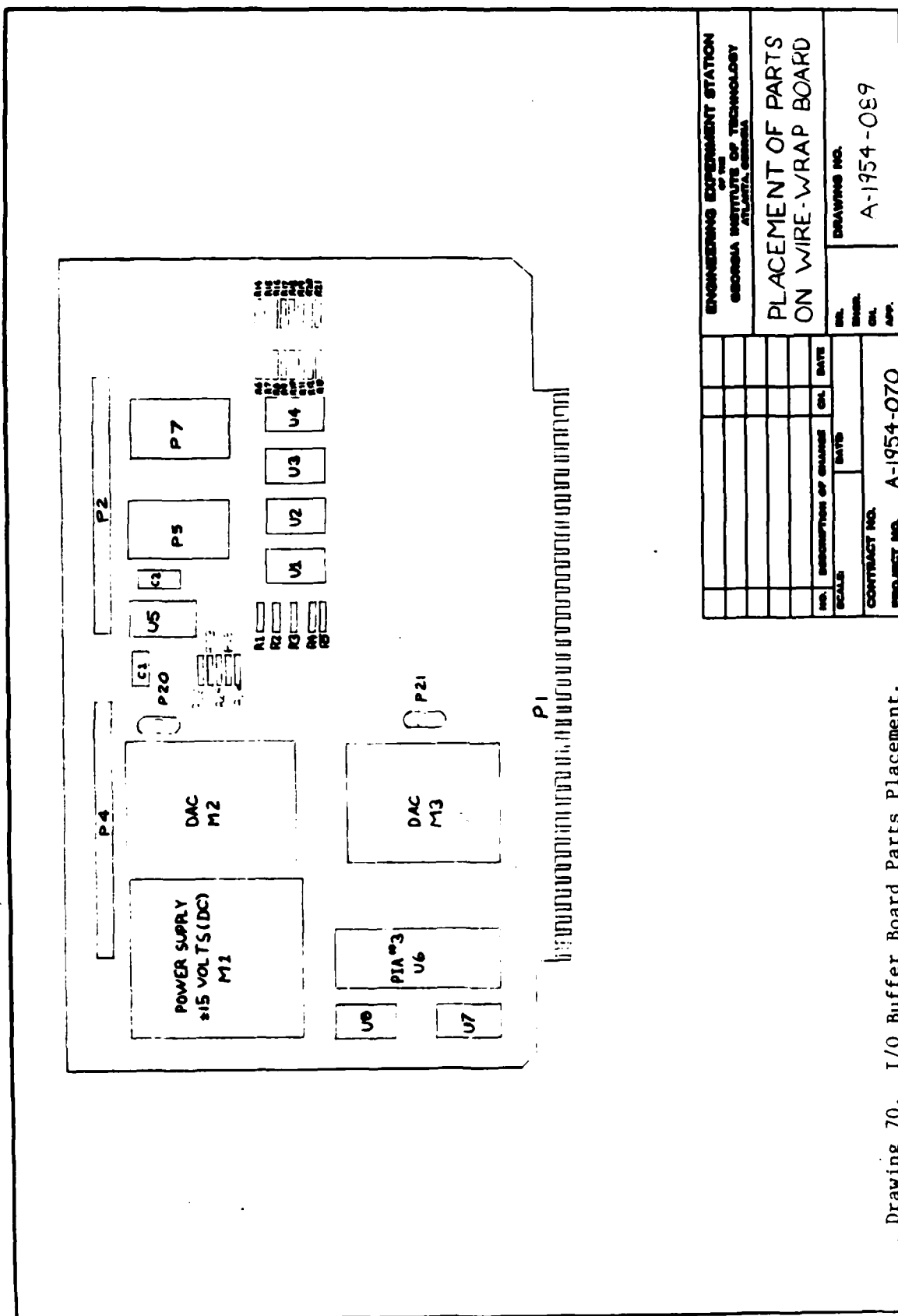


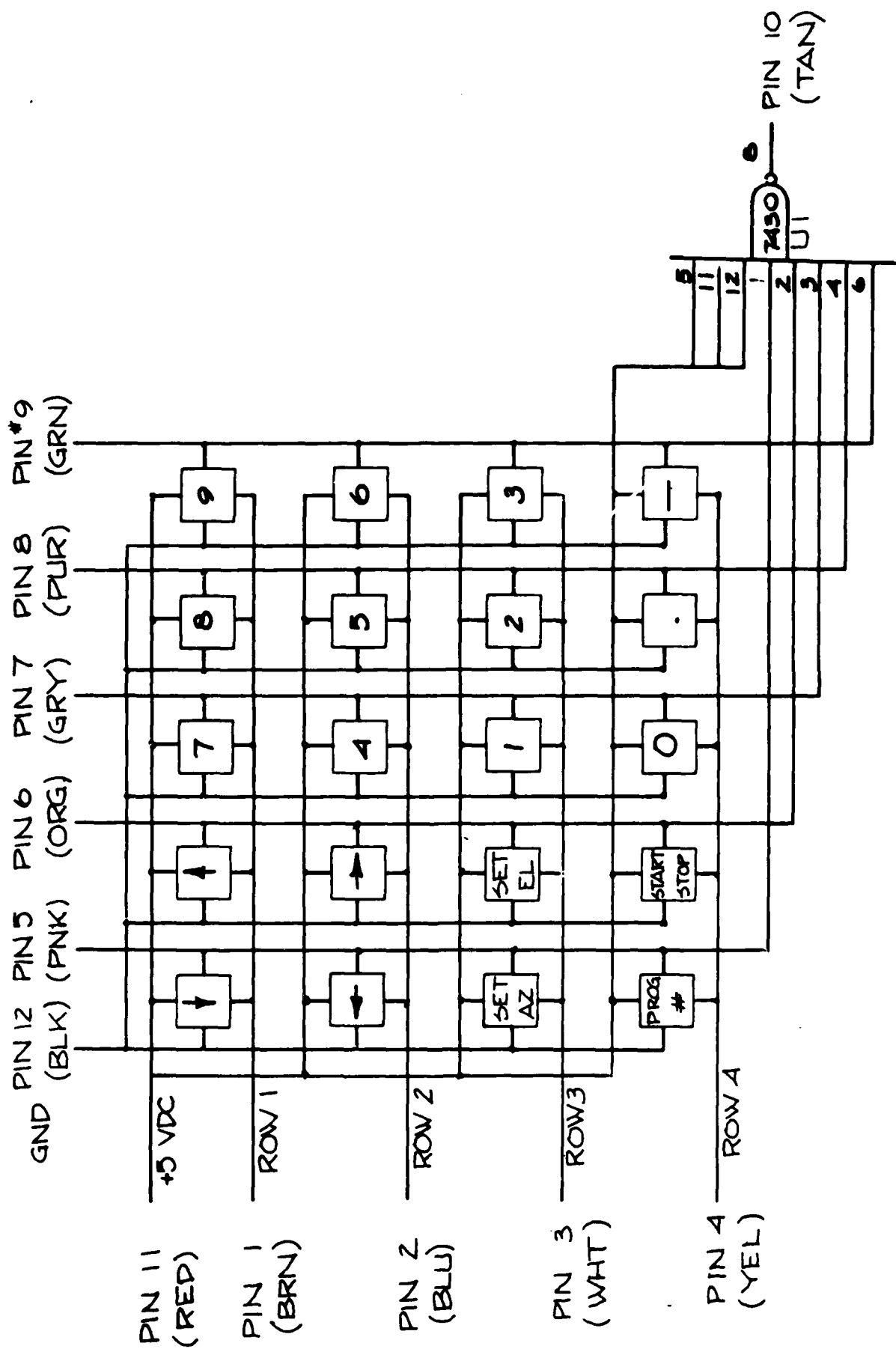
FIGURE 3-2. 2K Static RAM Module Schematic Diagram

Drawing 66. M68MM06 2k Byte Static RAM Board Schematic.

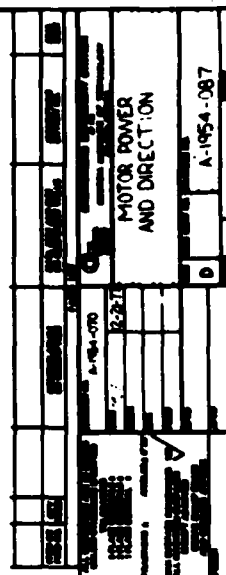


Drawing 70. I/O Buffer Board Parts Placement.

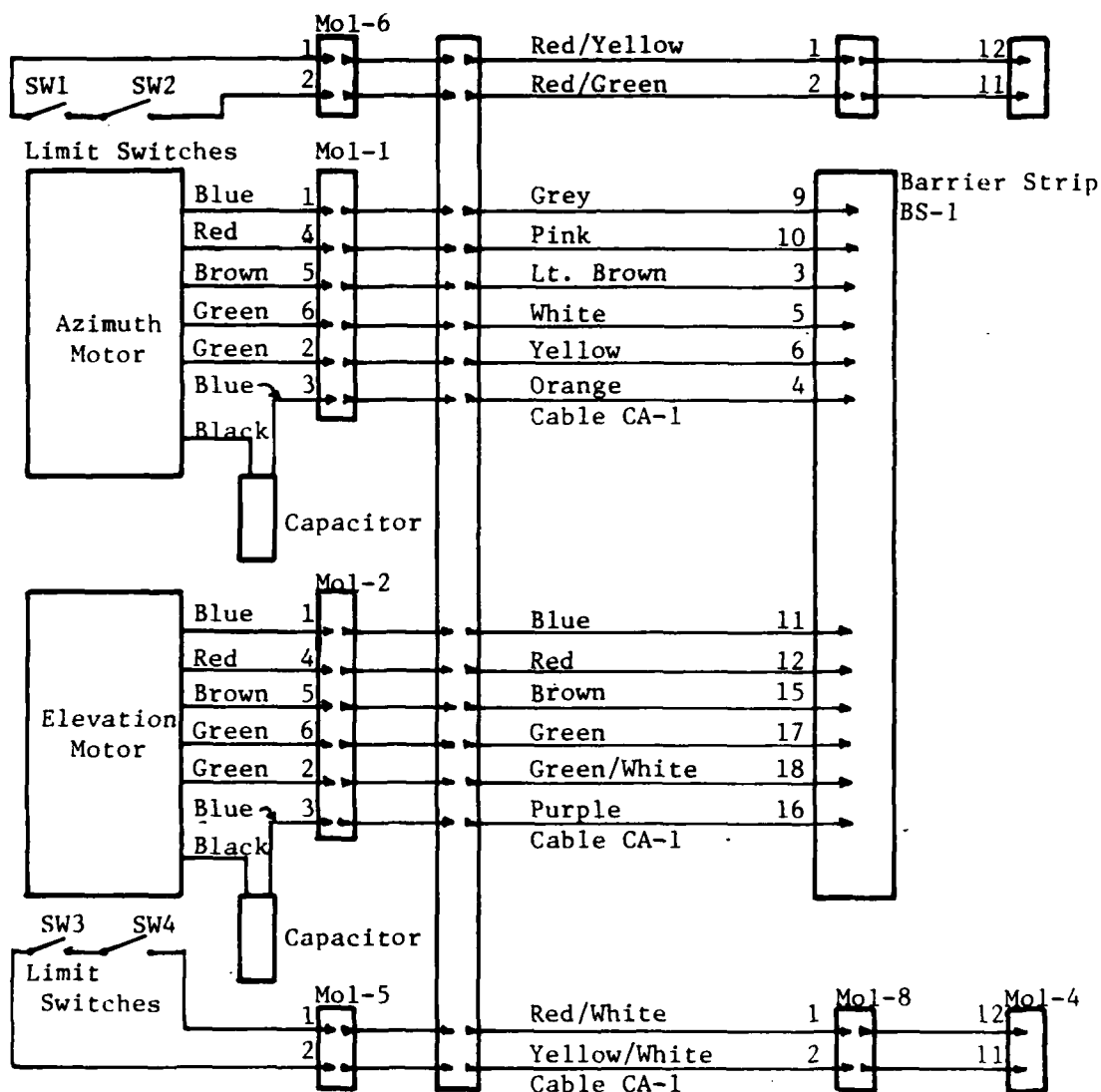
ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA		PLACEMENT OF PARTS ON WIRE-WRAP BOARD	
NO.	DESCRIPTION OF CHANGE	DATE	DRAWING NO.
SCALE	DATE	BY	A-1954-089
CONTRACT NO.		PROJECT NO.	
A-1954-070		A-1954-070	



Drawing 71. Keyboard Schematic.

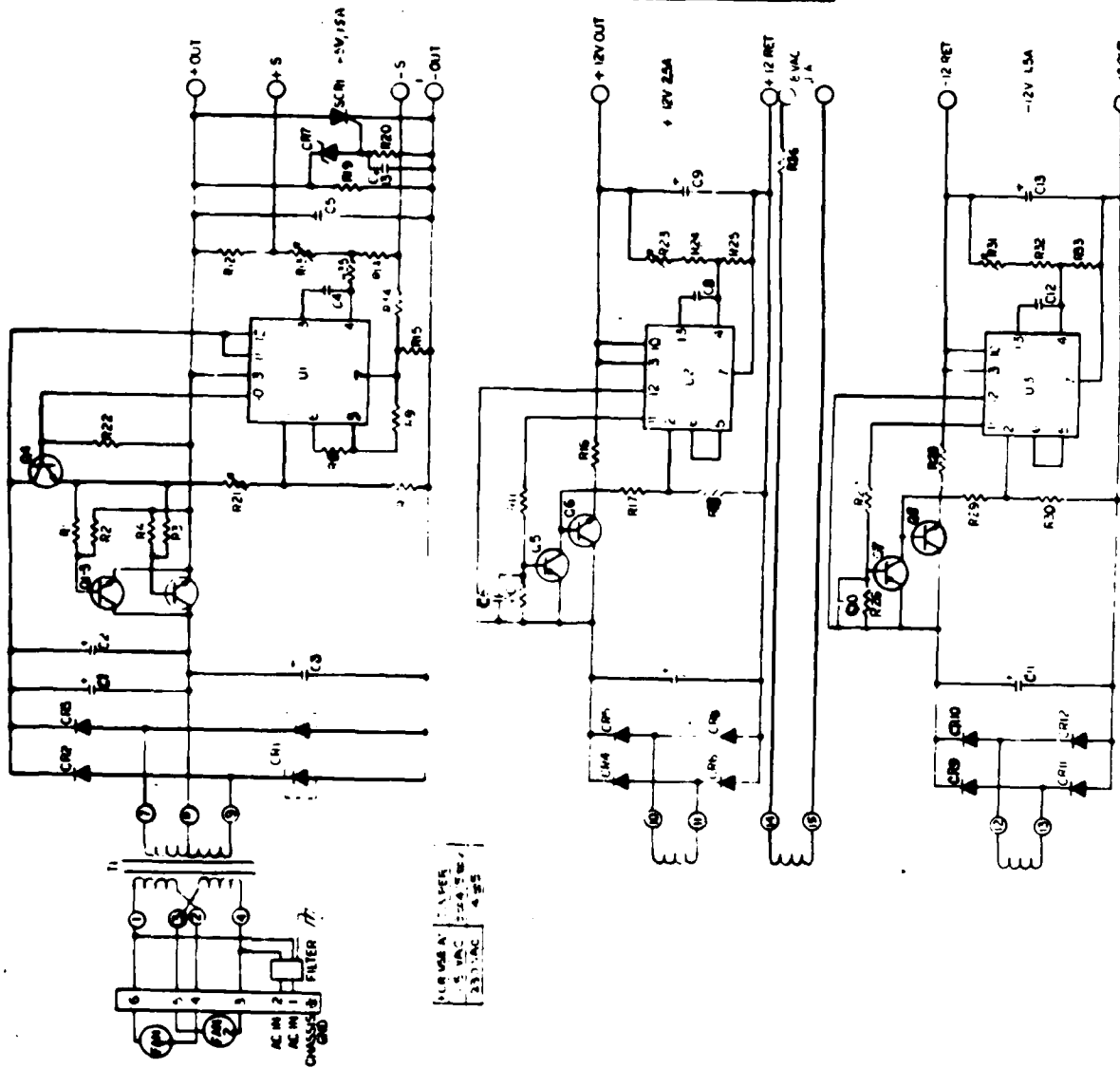


A-1954-087



Wiring Diagram-Motors
and Motor Control Panel

Drawing 74. Motors and Limit Switches Wiring.

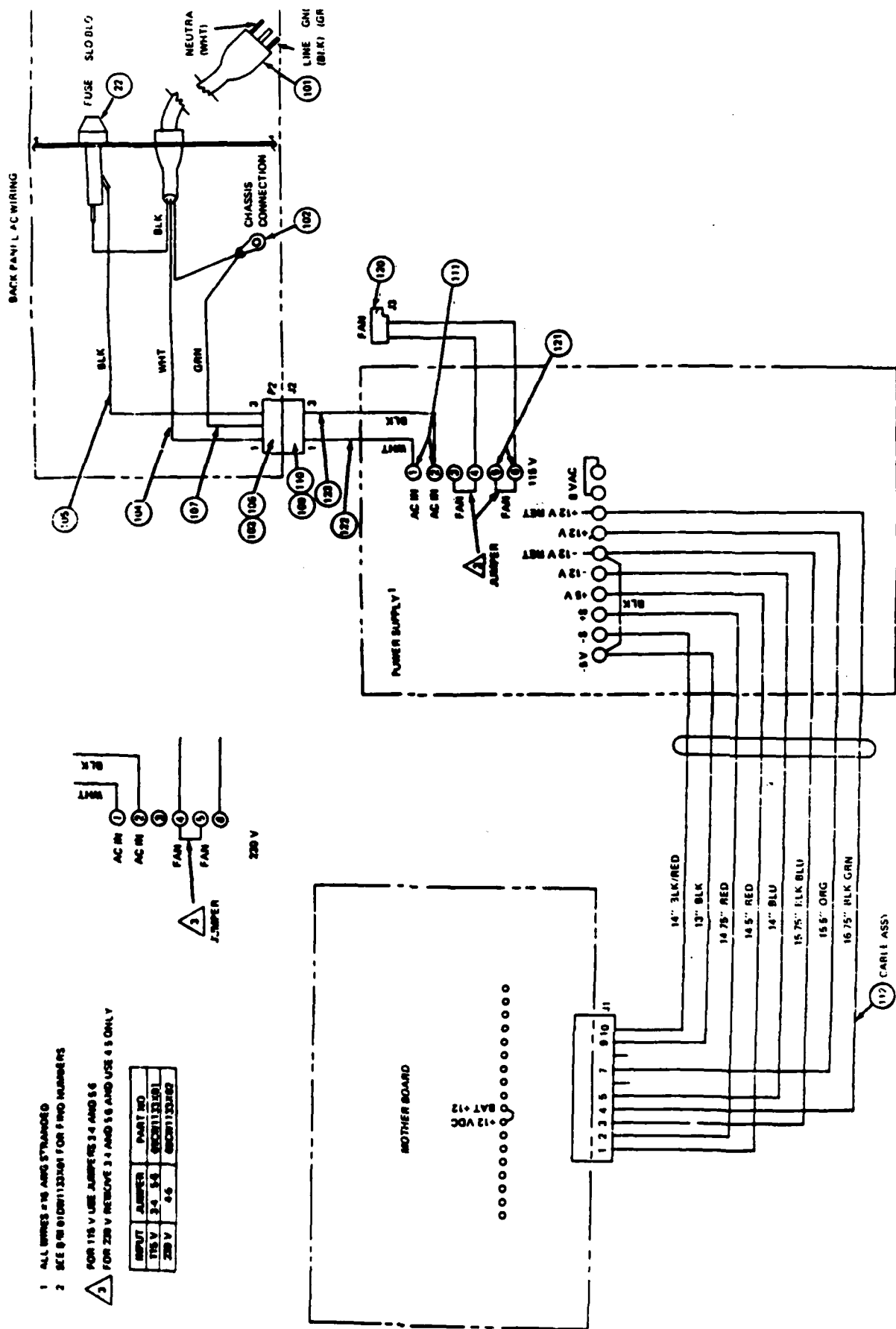


Drawing 76. Microcomputer Power Supply Schematic.

REF ID	QTY	DESCRIPTION	VALUE	UNIT
1	1	TRANSFORMER	1000/10	1000/10
2	1	DIODE BRIDGE	1000/10	1000/10
3	1	DIODE BRIDGE	1000/10	1000/10
4	1	DIODE BRIDGE	1000/10	1000/10
5	1	DIODE BRIDGE	1000/10	1000/10
6	1	DIODE BRIDGE	1000/10	1000/10
7	1	DIODE BRIDGE	1000/10	1000/10
8	1	DIODE BRIDGE	1000/10	1000/10
9	1	DIODE BRIDGE	1000/10	1000/10
10	1	DIODE BRIDGE	1000/10	1000/10
11	1	DIODE BRIDGE	1000/10	1000/10
12	1	DIODE BRIDGE	1000/10	1000/10
13	1	DIODE BRIDGE	1000/10	1000/10
14	1	DIODE BRIDGE	1000/10	1000/10
15	1	DIODE BRIDGE	1000/10	1000/10
16	1	DIODE BRIDGE	1000/10	1000/10
17	1	DIODE BRIDGE	1000/10	1000/10
18	1	DIODE BRIDGE	1000/10	1000/10
19	1	DIODE BRIDGE	1000/10	1000/10
20	1	DIODE BRIDGE	1000/10	1000/10
21	1	DIODE BRIDGE	1000/10	1000/10
22	1	DIODE BRIDGE	1000/10	1000/10
23	1	DIODE BRIDGE	1000/10	1000/10
24	1	DIODE BRIDGE	1000/10	1000/10
25	1	DIODE BRIDGE	1000/10	1000/10
26	1	DIODE BRIDGE	1000/10	1000/10
27	1	DIODE BRIDGE	1000/10	1000/10
28	1	DIODE BRIDGE	1000/10	1000/10
29	1	DIODE BRIDGE	1000/10	1000/10
30	1	DIODE BRIDGE	1000/10	1000/10
31	1	DIODE BRIDGE	1000/10	1000/10
32	1	DIODE BRIDGE	1000/10	1000/10
33	1	DIODE BRIDGE	1000/10	1000/10
34	1	DIODE BRIDGE	1000/10	1000/10
35	1	DIODE BRIDGE	1000/10	1000/10
36	1	DIODE BRIDGE	1000/10	1000/10
37	1	DIODE BRIDGE	1000/10	1000/10
38	1	DIODE BRIDGE	1000/10	1000/10
39	1	DIODE BRIDGE	1000/10	1000/10
40	1	DIODE BRIDGE	1000/10	1000/10
41	1	DIODE BRIDGE	1000/10	1000/10
42	1	DIODE BRIDGE	1000/10	1000/10
43	1	DIODE BRIDGE	1000/10	1000/10
44	1	DIODE BRIDGE	1000/10	1000/10
45	1	DIODE BRIDGE	1000/10	1000/10
46	1	DIODE BRIDGE	1000/10	1000/10
47	1	DIODE BRIDGE	1000/10	1000/10
48	1	DIODE BRIDGE	1000/10	1000/10
49	1	DIODE BRIDGE	1000/10	1000/10
50	1	DIODE BRIDGE	1000/10	1000/10
51	1	DIODE BRIDGE	1000/10	1000/10
52	1	DIODE BRIDGE	1000/10	1000/10
53	1	DIODE BRIDGE	1000/10	1000/10
54	1	DIODE BRIDGE	1000/10	1000/10
55	1	DIODE BRIDGE	1000/10	1000/10
56	1	DIODE BRIDGE	1000/10	1000/10
57	1	DIODE BRIDGE	1000/10	1000/10
58	1	DIODE BRIDGE	1000/10	1000/10
59	1	DIODE BRIDGE	1000/10	1000/10
60	1	DIODE BRIDGE	1000/10	1000/10
61	1	DIODE BRIDGE	1000/10	1000/10
62	1	DIODE BRIDGE	1000/10	1000/10
63	1	DIODE BRIDGE	1000/10	1000/10
64	1	DIODE BRIDGE	1000/10	1000/10
65	1	DIODE BRIDGE	1000/10	1000/10
66	1	DIODE BRIDGE	1000/10	1000/10
67	1	DIODE BRIDGE	1000/10	1000/10
68	1	DIODE BRIDGE	1000/10	1000/10
69	1	DIODE BRIDGE	1000/10	1000/10
70	1	DIODE BRIDGE	1000/10	1000/10
71	1	DIODE BRIDGE	1000/10	1000/10
72	1	DIODE BRIDGE	1000/10	1000/10
73	1	DIODE BRIDGE	1000/10	1000/10
74	1	DIODE BRIDGE	1000/10	1000/10
75	1	DIODE BRIDGE	1000/10	1000/10
76	1	DIODE BRIDGE	1000/10	1000/10
77	1	DIODE BRIDGE	1000/10	1000/10
78	1	DIODE BRIDGE	1000/10	1000/10
79	1	DIODE BRIDGE	1000/10	1000/10
80	1	DIODE BRIDGE	1000/10	1000/10
81	1	DIODE BRIDGE	1000/10	1000/10
82	1	DIODE BRIDGE	1000/10	1000/10
83	1	DIODE BRIDGE	1000/10	1000/10
84	1	DIODE BRIDGE	1000/10	1000/10
85	1	DIODE BRIDGE	1000/10	1000/10
86	1	DIODE BRIDGE	1000/10	1000/10
87	1	DIODE BRIDGE	1000/10	1000/10
88	1	DIODE BRIDGE	1000/10	1000/10
89	1	DIODE BRIDGE	1000/10	1000/10
90	1	DIODE BRIDGE	1000/10	1000/10
91	1	DIODE BRIDGE	1000/10	1000/10
92	1	DIODE BRIDGE	1000/10	1000/10
93	1	DIODE BRIDGE	1000/10	1000/10
94	1	DIODE BRIDGE	1000/10	1000/10
95	1	DIODE BRIDGE	1000/10	1000/10
96	1	DIODE BRIDGE	1000/10	1000/10
97	1	DIODE BRIDGE	1000/10	1000/10
98	1	DIODE BRIDGE	1000/10	1000/10
99	1	DIODE BRIDGE	1000/10	1000/10
100	1	DIODE BRIDGE	1000/10	1000/10

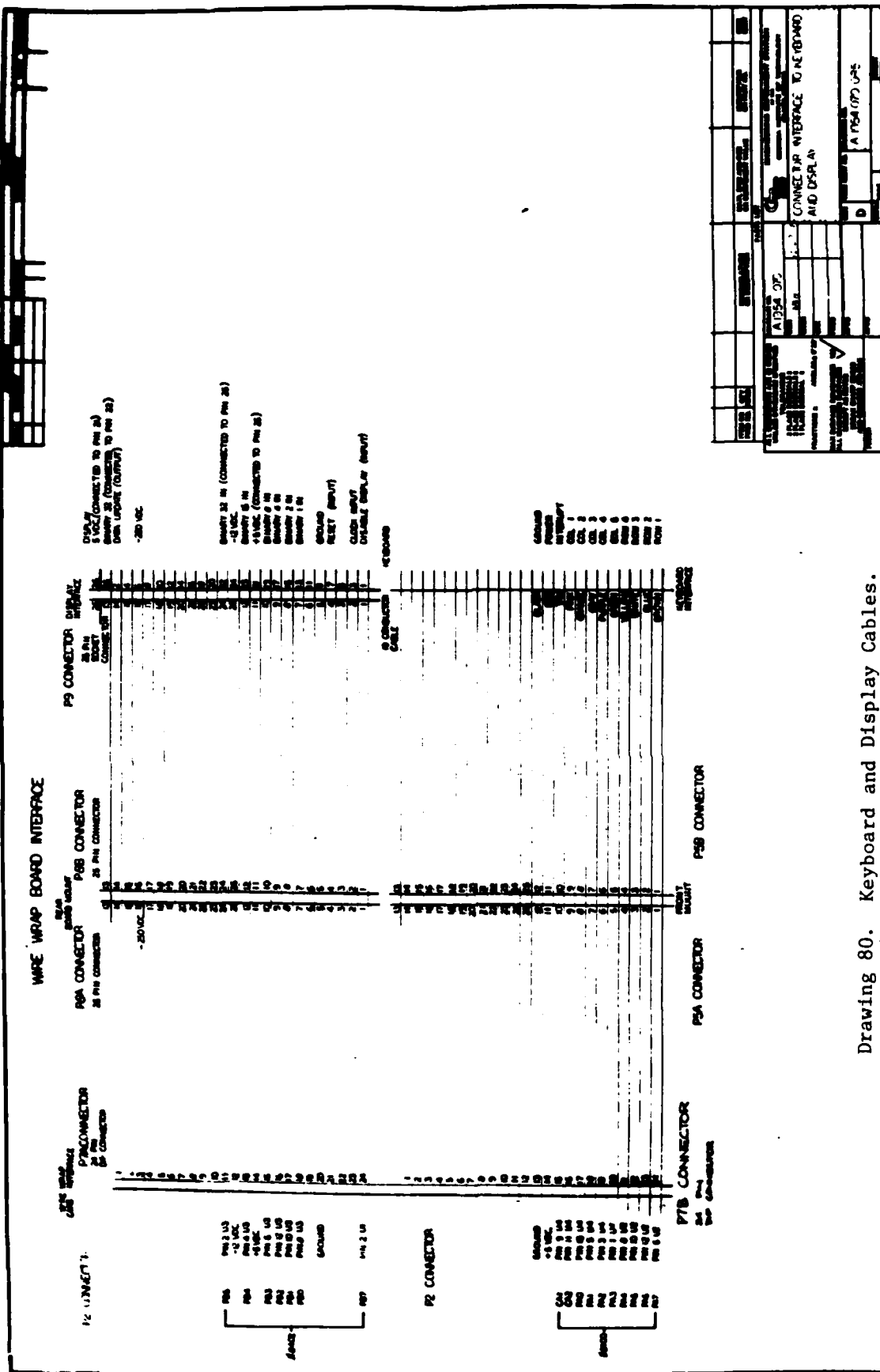
HEATSINK WITH 1/4" SPACER

POWER-ONE INC
SCHEMATIC - CPI90
5/20/74
13400 X1

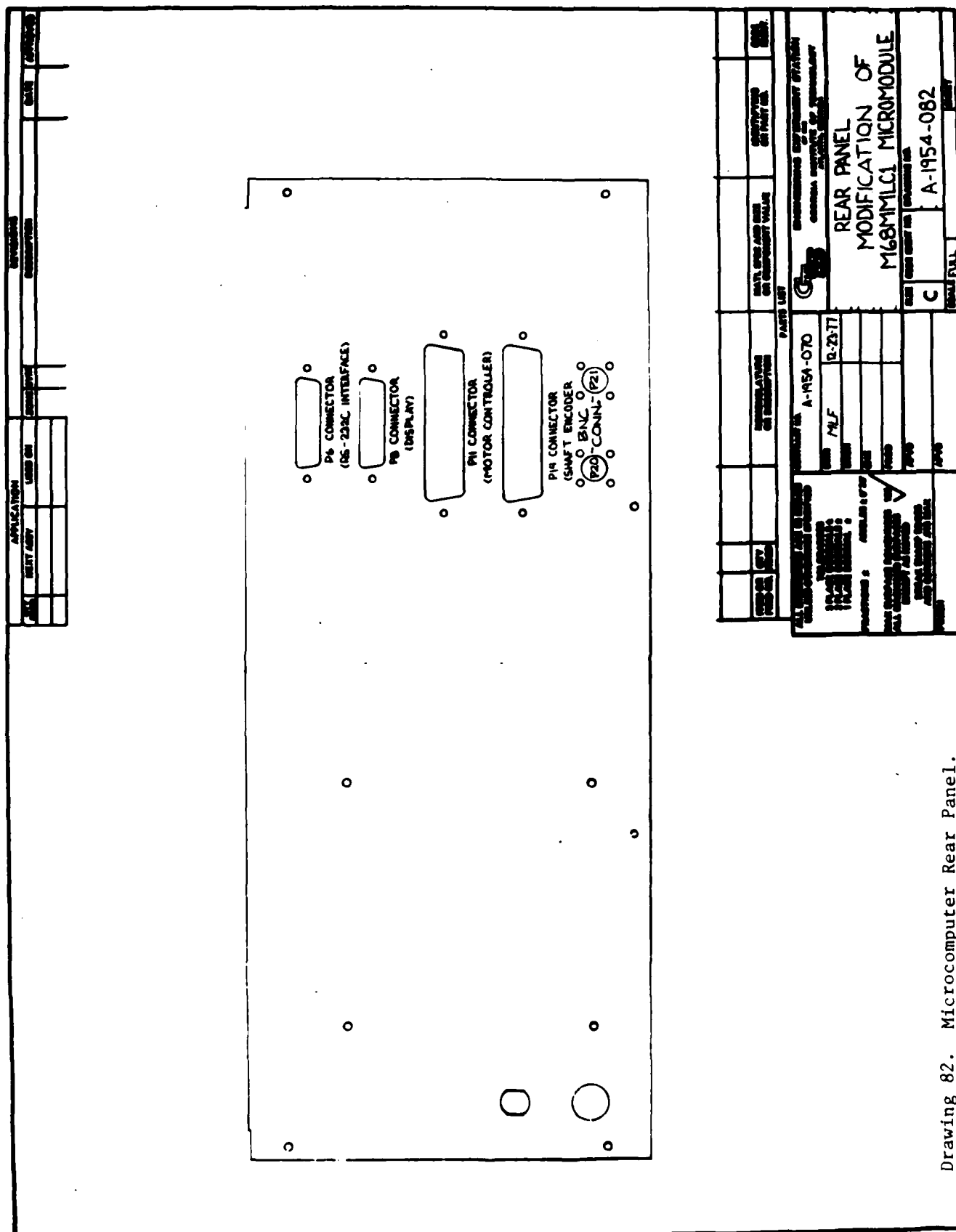


Drawing 77. Main Chassis Wiring.





Drawing 80. Keyboard and Display Cables.



APPENDIX B

RADOME POSITIONER SOFTWARE LISTING

139

00054	005D	0002	AZMAG	BLOCK	2	
00055	005F	0002	ELMAC	BLOCK	2	
00056	0061	0001	AZEL	BLOCK	1	
00057	0062	0001	TEMPS	BLOCK	1	
00058	0063	0001	PROGN	BLOCK	1	
00059	0064	0001	PROGL	BLOCK	1	
00060	0065	0002	PROGA	BLOCK	2	
00061	0067	0002	PROGB	BLOCK	2	
00062	0069	0002	PROGC	BLOCK	2	
00063	006B	0001	KFLAG	BLOCK	1	
00064	006C	0001	DFLAGA	BLOCK	1	
00065	006D	0001	PFLAGA	BLOCK	1	
00066	006E	0001	SFLAGA	BLOCK	1	
00067	006F	0001	CFLAGA	BLOCK	1	
00068	0070	0002	TEMPD	BLOCK	2	
00069	0072	0002	BCDVSR	BLOCK	2	
00070	0074	0002	FPTEL	BLOCK	2	
00071	0076	0002	FPTAZ	BLOCK	2	
00072	0078	0001	FPTELS	BLOCK	1	
00073	0079	0001	FPTAZS	BLOCK	1	
00074	007A	0001	PROCNT	BLOCK	1	
00075	007B	0002	STADDA	BLOCK	2	
00076	007D	0002	PFLAG	BLOCK	2	
00077	007F	0002	PROANG	BLOCK	2	
00078	0081	0002	BINANG	BLOCK	2	
00079	0083	0002	SINE	BLOCK	2	
00080	0085	0002	COSINE	BLOCK	2	
00081	0087	0001	SSIGN	BLOCK	1	
00082	0089	0001	CSIGN	BLOCK	1	
00083	008D	0001	SAVE1	BLOCK	1	
00084	008A	0001	BINUPR	BLOCK	1	
00085	008B	0002	PELLIM	BLOCK	2	
00086	008D	0002	NELLIM	BLOCK	2	
00087	008F	0002	PAZLIM	BLOCK	2	
00088	0091	0002	NAZLIM	BLOCK	2	
00089	0093	0001	LFLAGA	BLOCK	1	
00090	0094	0001	LFLAGA	BLOCK	1	
00091	0095	0001	NEGFLG	BLOCK	1	
00092	0096	0002	SAVEX2	BLOCK	2	
00093	0098	0001	CARRY	BLOCK	1	
00094	00D9		HAFSPD	EQU	00D9H	
00095	00E0		QUASPD	EQU	00E0H	
00096	8404		EDRA2	EQU	08404H	;MS 4 BITS OF DAC #1-AZIMUTH
00097	8405		CRA2	EQU	08405H	
00098	8406		DDR2	EQU	08406H	;LS 8 BITS OF DAC #1-AZIMUTH
00099	8407		CRB2	EQU	08407H	
00100	8300		EDRA3	EQU	08300H	;MS 4 BITS OF DAC #2-ELEVATION
00101	8301		CRA3	EQU	08301H	
00102	8302		DDR3	EQU	08302H	;LS 8 BITS OF DAC #2-ELEVATION
00103	8303		CRB3	EQU	08303H	
00104	0000		DISAZ	EQU	00000H	
00105	000A		DISSEL	EQU	0000AH	
00106	8E03		MERSSEL	EQU	08E03H	

TEKTRONIX M6800 ASM V2.2

```

00107      8E02      LSBSZL EQU      08E02H
00108      8E01      MSBSAZ EQU      08E01H
00109      8E00      LBSBAZ EQU      08E00H
00110      8400      DDFA EQU      08400H
00111      8401      CRA EQU      03401H
00112      8402      DDR3 EQU      03402H
00113      8403      CRB EQU      03403H
00114      8404      ACIAS EQU      8403H
00115      8409      ACIAD EQU      8409H
00116      00F0      ETHSPD EQU      0F0H
00117      2000      ORC      2000H

;
; PIA INITIALIZATION
;
00120      8E0FFF      GOE      LDS      #0FFFH
00121      2003      OF      SEI
00122      2004      8603      LDA A #3
00123      2006      B7B40B      STA A ACIAS
00124      2009      8631      LDA A #81H
00125      200B      B7E40B      STA A ACIAS
00126      200E      4F      CLR A
00127      200F      B7B401      STA A CPA
00128      2012      B7B403      STA A CRB
00129      2015      B7B405      STA A CRA2
00130      2018      B7B407      STA A CRB2
00131      201B      B7B401      STA A CRA3
00132      201E      B7B403      STA A CRB3
00133      2021      CEE400      LDX #8400H
00134      2024      6F0      LDA A #0F0H
00135      2026      A700      STA A 0.X
00136      2028      8607      LDA A #7
00137      202A      A701      STA A 1.X
00138      202C      860F      LDA A #0FH
00139      202E      A700      STA A 0.X
00140      2030      A704      STA A 4.X
00141      2032      86FF      LDA A #0FFH
00142      2034      A702      STA A 2.X
00143      2036      A706      STA A 6.X
00144      2038      B7B400      STA A DDR43
00145      203B      B7B402      STA A DDRB3
00146      203E      8604      LDA A #004H
00147      2040      B7B405      STA A CRA2
00148      2043      B7B407      STA A CRB2
00149      2046      B7B401      STA A CRA3
00150      2049      B7B403      STA A CRB3
00151      204C      863D      LDA A #03DH
00152      204E      B7B403      STA A CRB
00153      2051      CE0029      LDX #TEMPX
00154      2054      4F      CLR A
00155      2055      A700      STA A 0.X
00156      2057      2051      NEXTC
00157      2054      4F      NEXTC
00158      2055      A700      NEXTC
00159      2055      A700      NEXTC

```

;ACIA STATUS/CONTROL REGISTER
;ACIA DATA REGISTER

;"00000011" = MASTER RESET
;RESET ACIA
;"10000001" = 7 BITS, EVEN PARITY, AND 2 STOP BITS
;SET ACIA FOR RCVR INTERRUPT, TXMIT INTERRUPT OFF

;CLEARS CONTROL REGISTER A
;CLEARS CONTROL REGISTER B

;SELECTS OUTPUT REGISTER B
INITIALIZES MOTORS TO ZERO SPEED, ETC

```

00160 2057 08      INX
00161 2058 EC0009   #CARRY+1
00162 2059 26FB     NERTC
00163 205B CE2500   LDX #0000H
00164 2060 DF8E     STX PELLIM
00165 2062 DF8D     STX NELLIM
00166 2064 DF8F     STX PAZLIM
00167 2066 DF91     STX HAZLIM
00168 2068 860D     LDA A #0DH
00169 206A 9729     STA A SIBUF+21
00170 206C 86FF     LDA A #OFFH
00171 206E E78E92   STA A #0FFH
00172 2071 86FF     LDA A #0FFH
00173 2073 B78E00   STA A LSBSAZ
00174 2076 976E     STA A SFLACA
00175 2078 976F     STA A SFLACE
00176 207A 8601     LDA A #001H
00177 207C B78E01   STA A NSPGAZ
00178 207E B78E03   STA A MSBSEL
00179
00180
00181
00182
00183
00184 2082 BD2AFB     JSR SHAERC
00185 2085 DE45     LDX AZBCD
00186 2087 DF53     STX AZKEY
00187 2089 DE47     LDX ELBCD
00188 208B DF55     STX ELKEY
00189 208D 9643     LDA A AZSIGN
00190 208F 9757     STA A AZKEYS
00191 2091 9644     LDA A ELSIGN
00192 2093 9758     STA A ELKEYS
00193
00194 2095 0E        CLI
00195
00196
00197
00198 2096 CE3138     MSGA
00199 2099 ED2C22     JSR ASCDIS
00200 209C C614     LDA B #20
00201 209E ED2E3E     JSR WAITE
00202 20A1 CE314C     LDX #MSG13
00203 20A4 ED2C22     JSR ASCDIS
00204 20A7 C60A     LDA B #10
00205 20A9 ED2E3E     JSR WAITE
00206 20AC CE3160     LDX #MSG14
00207 20AF BD2C22     JSR ASCDIS
00208 20B2 C60A     LDA B #10
00209 20B4 ED2E3E     JSR WAITE
00210
00211
00212

```

; INITIALIZE (CR) IN SIBUF
 ; SETS AZ SPEED FLAG TO NOTE ZERO SPEED
 ; SETS EL SPEED FLAG TO NOTE ZERO SPEED
 ; TURNS ON POWER TO AZ MOTOR
 ; TURNS ON POWER TO EL MOTOR
 ; INITIALIZES CONTROL LOOP SUCH THAT POSITIONER
 ; WILL NOT MOVE UPON POWER-UP.
 ; (MODIFICATION 1.1)

JSR SHAERC ; READS ANGLES
 LDX AZBCD ; UPDATES AZIMUTH KEYENTRY WITH
 STX AZKEY ; CURRENT AZIMUTH LOCATION
 LDX ELBCD ; UPDATES EL KEYENTRY WITH CURRENT EL LOCATION
 STX ELKEY
 LDA A AZSIGN ; UPDATES AZIMUTH SIGN KEYENTRY WITH
 STA A AZKEYS ; CURRENT AZIMUTH SIGN STATUS
 LDA A ELSIGN ; UPDATES ELEVATION SIGN KEYENTRY WITH
 STA A ELKEYS ; CURRENT ELEVATION SIGN STATUS
 CLI ; CLEARS INTERRUPT MASK, CPU NOW READY FOR INTERRUPTS

BEGIN STATE TABLE
 LDX #MSG12 ; DISPLAYS "THE GA. TECH-RFSS"
 JSR ASCDIS
 LDA B #20 ; WAITE FOR 2 SECONDS
 JSR WAITE
 LDX #MSG13 ; DISPLAYS "RADOME POSITIONER"
 JSR ASCDIS
 LDA B #10 ; WAITE FOR 1 SECOND
 JSR WAITE
 LDX #MSG14
 JSR ASCDIS ; DISPLAYS " VERSION 1.0"
 LDA B #10
 JSR WAITE

MSGB
 LDX #MSG12
 JSR ASCDIS
 LDA B #20
 JSR WAITE
 LDX #MSG13
 JSR ASCDIS
 LDA B #10
 JSR WAITE

; BEGIN STATE ZERO, MAIN CONTROL LOOP

```

00213 20B7 966B ST0 LDA A KFLAG ; IDLE STATE
00214 20B9 2A0F BPL ST0A ; CLEARS KEY-PRESSED FLAG
00215 20BD 7F006B CLR KFLAG ; GETS KEYCODE OF KEY PRESSED
00216 20BE 964F LDA A KEYENT ; PUTS ZERO STATE POINTER IN INDEX REGISTER
00217 20C0 CE31FF LDX #SP0 ; JUMPS TO ROUTINE TO CALCULATE NEXT STATE
00218 20C3 BD2BEB JSR BD2BEB
00219 20C6 EE00 LDX 0,X
00220 20C8 6F00 JMP 0,X
00221
00222 ;
00223 ; AZIMUTH MOTOR CONTROL LOOP
00224 20CA B2CAF8 JSR SHANNC ; READS BOTH AZ AND EL ANGLES
00225 20CD 9659 LDA A NFLAG
00226 20CF 2BE6 PMI ST0
00227 20D1 E600 LDA A #0001
00228 20D3 975B STA A SPEEDA
00229 20D5 975C STA A SPEEDE
00230 20D7 9657 LDA A AZKEYS
00231 20D9 9143 CMP A AZSIGN
00232 20DB 2712 CEQ ST0X
00233 20DD 9654 LDA A AZKEY+1
00234 20DF 9B46 ADD A AZBCD+1 ; FIND LSBYTE OF AZ MAGNITUDE DIFF
00235 20E1 19 DAA
00236 20E2 975E STA A AZIAG+1
00237 20E4 9653 LDA A AZKEY
00238 20E6 5943 ADC A AZECD ; FIND MSBYTE OF AZ MAGNITUDE DIFF
00239 20E8 19 DAA
00240 20E9 D65E LDA B AZMAG+1
00241 20EB 975D STA A AZMAG
00242 20ED 209E BRA ST0X2
00243 20EF 9653 LDA A AZKEY
00244 20F1 D654 LDA B AZKEY+1
00245 20F3 CE0045 LDX #AZBCD
00246 20F6 BD2AF3 JSR BD2AF3
00247 20F9 975D STA A AZMAG
00248 20FB D75E STA B AZMAG+1
00249
00250 ;
00251 ; ADDITION TO TIGHTEN CONTROL LOOP (AZIMUTH) TO .1 DEGREE
00252 ; (MODIFICATION 1.1)
00253 ST0X2 CMP A #00H ; START <0.2 DEGREE TEST
00254 20FF 266D BNE ST0X1 ; BRANCHES TO <0.5 DEGREE TEST IF BCD WORD NOT <0.2
00255 2101 C129 CMP B #20H ; COMPARING TO 00.2 DEGREE
00256 2103 2299 BHI ST0X1 ; BRANCHES TO <0.5 DEGREE TEST IF BCD WORD NOT <0.2
00257 2105 86FF LDA A #0FFH ; CURRENT POSITION IS LESS THAN 0.2 DEGREE
00258 2107 976E LDX #LJAG ; SETS AZ SPEED FLAG WITH CORRECT SPEED
00259 2109 B7BE90 STA A LBJJAZ ; STOP AZ MOTOR WITH ZERO SPEED
00260 210C 204A BRA ST0E
00261 210E 8100 CMP A #0001 ; START <0.5 DEGREES TEST
00262 2110 206A BNE ST0B ; BRANCHES TO <5.0 DEG. TEST IF BCD WORD NOT <0.5
00263 2112 C150 CMP B #050H
00264 2114 2296 BHI ST0B ; BRANCHES TO <5.0 DEG. TEST IF BCD WORD NOT <0.5
00265 2116 86F0 LDA A #THSPD ; SET SPEED TO EIGHTH SPEED

```

```

00266 2118 975B STA A SPEEDA ;SET UP SPEED VARIABLE FOR USE LATER
00267 211A 2012 DRA ST0D
00268
00269 211C 8164 ST0B CMP A #004H ;START TEST FOR <5.0 DEG
00270 211E 2206 BHI ST0C ;BRANCHES TO <10.0 TEST IF <5.0 TEST FAILS
00271 2120 86E0 LDA A #QUASPD ;SET SPEED TO QUARTER SPEED
00272 2122 975B STA A SPEEDA ;SET UP SPEED VARIABLE FOR USE LATER
00273 2124 2098 BRA ST0D ;BRANCH TO DECISION ROUTINE
00274 2126 8109 ST0C CMP A #009H ;START <10.0 DEG. TEST
00275 2128 2204 BHI ST0D ;BRANCH TO DECISION ROUTINE IF TEST FAILS
00276 212A 86D0 LDA A #HAFSPD ;SET SPEED TO HALF SPEED
00277 212C 975B STA A SPEEDA ;SETS UP SPEED VARIABLE TO BE USED LATER
00278 212E 9657 LDA A #KEYS ;DESTINATION NOT REACHED, CHECKS SIGNS
00279 2130 9143 CMP A #SIGN ;DIFFERENT SIGNS
00280 2132 270A BEQ SAMEAZ
00281 2134 812B DIFFAZ CMP A #02BH ;SAME SIGNS, WHICH ONE IS PLUS
00282 2136 2703 BEQ LEFT
00283 2138 7E2C0E JMP LEFT
00284 213B 7E2C18 JMP RIGHT
00285 213E 812B SAMEAZ CMP A #02BH
00286 2140 2708 BEQ YESAZ
00287 2142 7D0098 NOAZ TST CARRY
00288 2145 2B03 BHI B3
00289 2147 7E2C0E JMP LEFT
00290 214A 7E2C18 JMP RIGHT
00291 214D 7D0098 YESAZ TST CARRY
00292 2150 2B03 BHI B4
00293 2152 7E2C18 JMP RIGHT
00294 2155 7E2C0E JMP LEFT
00295
00296 ; ELEVATION MOTOR CONTROL LOOP
00297 ;
00298 215D 9658 ST0E LDA A ELKEYS
00299 215A 9144 CMP A ELSIGN ;TEST TO SEE IF SIGNS ARE THE SAME
00300 215C 2712 BEQ ST0Y ;BRANCHES IF SIGNS ARE NOT THE SAME
00301 215E 9656 LDA A ELKEY+1
00302 2160 9B48 ADD A ELCD+1 ; FIND LSBYTE OF EL MAG. DIFFERENCE
00303 2162 19 DAA
00304 2163 9760 STA A ELNAG+1
00305 2165 9655 LDA A ELKEY
00306 2167 9947 ADC A ELCD
00307 2169 19 DAA
00308 216A D660 LDA B ELNAG+1
00309 216C 975F STA A ELNAG
00310 216E 200E BRA ST0Y1
00311 2170 CE0047 ST0Y LDX #ELCD ;PUT ADDRESS OF CURRENT ANGLE IN INDEX REG.
00312 2173 9655 LDA A ELKEY
00313 2175 D656 LDA B ELKEY+1
00314 2177 BD2AC4 JSR BCDSUB ;JUMPS TO ROUTINE THAT SUBTRACTS BCD NUMBERS
00315 217A 975F STA A ELNAG
00316 217C D760 STA B ELNAG+1
00317
00318 ; ADDITION TO TIGHTENED CONTROL LOOP (ELEVATION) TO .1 DEGREE

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00319      ; (MODIFICATION 1.1)
00320
00321      ST0Y1  CMP A #00H      ; START < 0.2 DEGREE TEST
00322      BNE  ST0Z              ; BRANCHES TO 0.3 DEGREE TEST IF ANGLE GREATER THAN 0.2 DEGREE
00323      CMP B #20H            ; COMPARES ANGLE TO 00.20 DEGREES
00324      BHI  ST0Z              ; BRANCHES TO < 0.3 DEGREE TEST IF ANGLE GREATER THAN 0.2 DEGREE
00325      LDA A #0FFH          ; POSITIONER NEEDS TO STOP VERY, VERY SOON
00326      STA A SFLAC          ; SETS SPEED FLAG
00327      STA A LBSSEL         ; STOPS ELEVATION MOTOR WITH ZERO SPEED
00328      JHP  CPFLAG           ; POSITION REACHED, CHECK PROGRAM FLAG
00329      ST0Z                  ; START < 0.5 DEG. TEST
00330      CMP A #000H           ; BRANCH TO < 5.0 DEG. TEST IF COMPARE FAILS
00331      BNE  ST0F              ; COMPLETES < 0.5 DEG. TEST
00332      CMP B #050H           ; BLANCH TO < 5.0 DEG. IF ACCB IS PLUS
00333      RHI  ST0F              ; SETS MOTOR SPEED TO EIGHTH SPEED
00334      LEA A #EIGHTSPD      ; SETS SPEED VARIABLE FOR USE LATER
00335      STA A SPEEDE          ; SETS SPEED VARIABLE FOR USE LATER
00336      BRA  ST0H
00337
00337      ST0F                  ; START < 5.0 DEG TEST
00338      BHI  ST0C              ; BRANCH TO < 10.0 DEG TEST IF ACCA IS PLUS
00339      LDA A #QUASPD         ; SET UP SPEED VARIABLE FOR EL MOTOR SPEED
00340      STA A SPEEDE          ; SET UP SPEED VARIABLE FOR EL MOTOR SPEED
00341      BRA  ST0H              ; BRANCH TO DECISION ROUTINE
00342      CMP A #009H           ; START < 10.0 DEG. TEST
00343      BHI  ST0H              ; BRANCH TO DECISION ROUTINE IF ACCA IS PLUS
00344      LDA A #HAFSPD        ; SET UP SPEED VARIABLE FOR HALF SPEED
00345      STA A SPEEDE          ; SET UP SPEED VARIABLE FOR HALF SPEED
00346      LDA A ELKEYS         ;
00347      CMP A ELSICE          ;
00348      BEQ  SAMEFL           ;
00349      DIFFEL  CMP A #02BH    ;
00350      BEQ  B3                ;
00351      BRA  L7                ;
00352      BRA  B3                ;
00353      SAMEEL  CMP A #0CBH    ;
00354      BEQ  YESFL           ;
00355      NOEL    TST  CARRY     ;
00356      BHI  B3              ;
00357      BRA  B7                ;
00358      B6        BRA  B3      ;
00359      YESSEL  TST  CARRY     ;
00360      BHI  B7                ;
00361      B5        JMT  B7      ;
00362      B7        JEP  DOWN    ;
00363
00364      ; BEGIN STATE ONE, MANUAL DOWN BUTTON
00365
00366      ST1        LDA A #00H    ; BEGIN STATE 1, MANUAL DOWN
00367      LBA  E #0FFH          ;
00368      JSR  B3              ; JUMPS TO ROUTINE TO COMMAND ELEVATION MOTOR
00369      ST1A      LDA A #001    ;
00370      STA A DDRA          ;
00371      LDA A DRA           ;

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00372 21E5 8177      CMP A #77H      ;HAS DOWN KEY BEEN LET UP
00373 21F7 2608      BNE ST1B      ;DOWN KEY IS NOT BEING PRESSED NOW
00374 21E9 BD2936     JSR RESTO     ;RESTORE KEYBOARD BEFORE READING ANGLES (MOD 1.1)
00375 21EC BD2AF8     JSR SHAENC    ;DOWN KEY HAS NOT BEEN LET UP, SO READ ANGLES
00376 21EF 20EC      BCA ST1A      ;
00377 21F1 710093     CLR LFLAGE    ;CLEAR LIMIT REACHED FLAG (MOD 1.1)
00378 21F4 65FF      LDA A #07FH    ;TURN OFF MOTOR
00379 21F6 C6FF      LDA B #0FFH    ;CLOCKWISE MOTION STILL SET
00380 21F8 E02DE2     JSR MOTEL    ;
00381 21FB BD2936     JSR RESTO     ;RESTORE KEYBD PIA, THEN BACK TO STATE ZERO
00382 21F5 7E2037     JMP ST0      ;
00383                ;
00384                ;
00385                ;
00386 2201 C600      LDA A #060H    ;BEGIN STATE TWO, LOAD A WITH SPEED
00387 2203 C600      LDA B #000H    ;LOAD B WITH DIRECTION
00388 2205 D2DE2      JSP MOTEL    ;
00389 2208 8670      LDA A #070H    ;
00390 220A B78430     STA A DDRA    ;
00391 220D B684C0     LDA A DDRA    ;
00392 2210 817B      CMP A #07BH    ;HAS UP KEY BEEN RELEASED?
00393 2212 C608      BNE ST3B      ;
00394 2214 BD2936     JSR RESTO     ;RESTORE KEYBOARD BEFORE READING ANGLES (MOD 1.1)
00395 2217 BD2AF8     JSR SHAENC    ;UP KEY IS STILL BEING PRESSED, READ ANGLES
00396 221A 20EC      BRA ST2A      ;
00397 221C 7F0393     CLR LFLAGE    ;CLEAR LIMIT REACHED FLAG
00398 221F 85FF      LDA A #0F7H    ;
00399 2221 C600      LDA B #000H    ;C-CLOCKWISE MOTION SET
00400 2223 BD2DE2     JSR MOTEL    ;
00401 2226 BD2936     JSR RESTO     ;RESTORE KEYBD PIA, THEN BACK TO STATE ZERO
00402 2229 7E20B7     JMP ST0      ;
00403                ;
00404                ;
00405                ;
00406 222C 8600      LDA A #000H    ;BEGIN STATE THREE, LOAD A WITH SPEED
00407 223E C600      LDA B #000H    ;LOAD B WITH DIRECTION
00408 2230 ED2D86     JSR NOTAZ     ;JUMP TO ROUTINE TO CONFIRM AZIMUTH MOTOR
00409 2233 86D6      LDA A #0B0H    ;
00410 2235 B784C0     STA A DDRA    ;
00411 2238 E63400     LDA A DDRA    ;
00412 223B 81B7      CMP A #037H    ;HAS RIGHT KEY BEEN RELEASED?
00413 223D 2608      BNE ST3B      ;
00414 223F BD2936     JSR RESTO     ;RESTORE KEYBOARD BEFORE READING ANGLES (MOD 1.1)
00415 2242 BD2AF8     JSR SHAENC    ;KEY HAS NOT BEEN RELEASED, SO READ ANGLES
00416 2245 20EC      BRA ST3A      ;
00417 2247 7F0094     CLR LFLAGE    ;CLEAR LIMIT REACHED FLAG (MOD 1.1)
00418 224A 86FF      LDA A #0FFH    ;TURN AZIMUTH MOTOR OFF
00419 224C C600      LDA B #000H    ;
00420 224E BD2D36     JSR NOTAZ     ;
00421 2251 BD2936     JSR RESTO     ;RESTORE KEYBD PIA, THEN BACK TO STATE ZERO
00422 2253 7E20B7     JMP ST0      ;
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00425      LDA A #000H      ;BEGIN STATE FOUR, LOAD A WITH SPEED
00426      LDA B #0FFH      ;LOAD B WITH DIRECTION
00427      JSR NOTAZ
00428      LDA A #0BOH
00429      STA A #0BOH
00430      LDA A #0BOH
00431      LDA A #0BOH
00432      CMP A #0BH
00433      BNE ST3B
00434      JSR RESTO
00435      JSR SHARC
00436      BNE ST4A
00437      CLR LFLAG
00438      LDA A #0FFH
00439      LDA B #0FFH
00440      JSR NOTAZ
00441      JSR RESTO
00442      JMP ST0
00443
00444      ; BEGIN STATE FIVE, ERROR STATE
00445
00446      LDX #MSC4      ;PRINTS "ERROR..INVALID ENTRY"
00447      JSR ASCDIS      ;PRINTS ASCII MESSAGE
00448      LDA B #10
00449      JSR WAITE
00450      JMP ST0
00451
00452      ; BEGIN STATE SIX, ERROR STATE
00453
00454      LDX #MSC3      ;PRINTS "ANGLE TOO LARGE....."
00455      JSR ASCDIS      ;WAIT 1 SECOND, THEN RETURN TO CONTROL LOOP
00456      JMP MSCB
00457
00458      ; BEGIN STATE SEVEN, MESSAGE STATE
00459
00460      LDX #MSC11
00461      JSR ASCDIS      ;PRINTS "POSITIONER HALTED "
00462      JMP MSCB        ;WAIT 1 SECOND, THEN RETURN TO CONTROL LOOP
00463
00464      ; BEGIN STATE TEN, SET AZ
00465
00466      STA A AZEL      ;REMEMBERS WHICH KEYCODE WAS PRESSED, SETAZ OR SETEL
00467      LDX #MSC2
00468      JSR ASCDIS      ;PRINTS "ENTER AZIMUTH ANGLE"
00469      LDX #DISSEL+1
00470      STX SAVEDX      ;KEEPS TRACK OF WHERE THINGS ARE ON THE DISPLAY
00471      LDA A KFLAG
00472      BPL ST10A
00473      CLR KFLAG
00474      LDA KFLAG
00475      JSR ASCDIS      ;PRINTS "AZIMUTH "
00476      CLR FLTPA
00477      CLR ENTCTB

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00478 2202 964F LDA A KEYENT ;GETS KEYENTRY/
00479 2204 C83C27 LDX #SP10
00480 2207 BD2B78 JSR ADDCAL
00481 220A 5E00 LDX 0,X
00482 220C 6E00 JIF 0,X ;JUMPS TO NEXT STATE DETERMINED BY KEYENTRY IN A
00483
00484 ;
00485 ; BEGIN STATE ELEVEN, SET EL
00486 220E 9761 STA A AZEL ;REMEMBERS WHICH KEYENTRY WAS MADE...SET EL
00487 2210 C8305C LDX #EL-1
00488 2213 BD2C22 JSR ASCDIS ;PRINTS "ENTR ELEVATION ANGLE"
00489 2216 C8000B LDX #DISL+1
00490 2219 FF32 STX SAVEX ;KEEPS TRACK OF WHERE THINGS ARE ON THE DISPLAY
00491 221B 966B LDA A KFLAG ;WAITS FOR NEXT KEYENTRY
00492 221D 2AFC BPL ST11A ;CLEARS KEYENTRY FLAG
00493 221F 7F006B CLR KFLAG
00494 2222 C830B4 LDX #ASC7
00495 2225 BD2C22 JSR ASCDIS ;PRINTS "ELEVATION"
00496 2228 7F004D CLR ENTRYA ;CLEARS BOTH REGISTERS WITH WHICH THE KEYENTRIES ARE PACKED
00497 222B 7F004E CLR ENTRYB
00498 222E 964F LDA A KEYENT ;GETS KEYENTRY
00499 2230 C8324F LDX #SP11
00500 2233 BD2BEB JSR ADDCAL
00501 2236 EF00 LDX 0,X
00502 2238 6E00 JMP 0,X ;JUMPS TO NEXT STATE AS DETERMINED BY LAST KEYENTRY
00503
00504 ;
00505 ; BEGIN STATE TWELVE, DISPLAYS ENTERED PLUS SIGN AND FIRST NUMBER
00506 223A C62B LDA B #02BH ;BEGINS STATE TWELVE, PLUS SIGN AND MAGNITUDE
00507 223C DE32 LDX SAVEX
00508 223E E700 STA B 0,X
00509 2300 08 INX ;DISPLAYS PLUS SIGN
00510 2301 D762 STA B TEMPS ;INCREMENTS TRACKING POINTING
00511 2303 44 LSR A ;REMEMBERS THE SIGN OF THE KEYENTRY
00512 2304 16 TAB ;CONVERTS KEYCODE TO BCD CODE
00513 2305 BD2A9E JSR PACK ;ROUTINE TO PACK KEYENTRY
00514 2308 CB30 ADD B #030H ;CONVERTS BCD CODE TO ASCII CODE
00515 230A E700 STA B 0,X ;ECODES KEYENTRY ON THE DISPLAY
00516 230C 08 INX ;INCREMENTS TRACKING POINTER
00517 230D DF32 STA B SAVEX ;REMEMBERS NEW VALUE OF TRACKING POINTER
00518 230F 966B LDA A KFLAG ;WAITS FOR ANOTHER KEYENTRY
00519 2311 2AFC BPL ST12A ;CLEARS KEYENTRY FLAG
00520 2313 7F006B CLR KFLAG
00521 2316 964F LDA A KEYENT ;GETS KEYENTRY
00522 2318 C83277 LDX #SP12 ;LOADS INDEX REGISTER WITH STATE 12 POINTER
00523 231B BD2BEB JSR ADDCAL ;CALCULATES THE NEXT ADDRESS
00524 231E EF00 LDX 0,X
00525 2320 6E00 JMP 0,X ;JUMPS TO THE NEXT STATE
00526
00527 ;
00528 ; BEGIN STATE THIRTEEN, DISPLAYS ENTERED MINUS SIGN
00529 2322 162D LDA B #02DH
00530 2324 DE32 LDX SAVEX

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00531 2326 E700      STA B 0,X      ;DISPLAYS THE ENTERED MINUS SIGN
00532 2329 08      INX             ;INCREMENTS TRACKING POINTER
00533 2329 D832     STX             ;STORES TRACKING POINTER
00534 2329 D762     STA B          ;REMEMBERS THE SIGN
00535 232D 966B     LDA A          ;WAITS FOR NEXT KEYENTRY
00536 232F 2AFC     BPL           ;CLEARS KEYENTRY FLAG
00537 2331 7F06B    CLR           ;GETS KEYENTRY
00538 2334 964F     LDA A          ;INCREMENTS TRACKING POINTER
00539 2336 CE329F   LDX #3713    ;STORES TRACKING POINTER
00540 2339 BD2EB    JSR           ;ECHOES THE ENTERED BCD NUMBER
00541 233C FE00     LDX 0,X       ;INCREMENTS TRACKING POINTER
00542 233E 6E00     JMP 0,X       ;STORES TRACKING POINTER
00543                ;
00544                ;
00545                ;
00546 2340 44      LSR A          ;PACKS THE ENTERED BCD NUMBERS
00547 2341 16      TAB           ;ECHOES THE ENTERED BCD CODE
00548 2342 BD2A9E   JSR           ;INCREMENTS TRACKING POINTER
00549 2345 CB30     ADD B #930H   ;KEEPS TRACK OF POINTER
00550 2347 DE32     LDX SAVEX     ;
00551 2349 E700     STA B 0,X     ;
00552 234B 03      INX           ;
00553 234C DF32     STX           ;
00554 234E 966B     LDA A          ;
00555 2350 2AFC     BPL           ;
00556 2352 7F06B    CLR           ;
00557 2355 964F     LDA A          ;
00558 2357 CE32C7   LDX #3714    ;
00559 235A BD2EB    JSR           ;
00560 235D FE00     LDX 0,X       ;
00561 235F 6E00     JMP 0,X       ;
00562                ;
00563                ;
00564                ;
00565 2361 44      LSR A          ;CONVERTS KEYCODE TO BCD CODE
00566 2362 16      TAB           ;
00567 2363 BD2A9E   JSR           ;
00568 2366 CB30     ADD B #930H   ;
00569 2368 DE32     LDX SAVEX     ;
00570 236A E700     STA B 0,X     ;
00571 236C 03      INX           ;
00572 236D DF32     STX           ;
00573 236F 966B     LDA A          ;
00574 2371 2AFC     BPL           ;
00575 2373 7F06B    CLR           ;
00576 2376 964F     LDA A          ;
00577 2378 CE32FF   LDX #3715    ;
00578 237B BD2EB    JSR           ;
00579 237E FE00     LDX 0,X       ;
00580 2380 6E00     JMP 0,X       ;
00581                ;
00582                ;
00583                ;

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00584 2332 C62E      ST16  LDA B #02EH      ; ECHOES THE DECIMAL POINT
00585 2334 DE32      LDX  SAVEN          ; INCREMENTS TRACKING POINTER
00586 2336 E700      STA B 0,X          ; STORES TRACKING POINTER
00587 2338 08        INX  SAVEN          ;
00588 2339 DF32      STX  SAVEN          ;
00589 233B 966B      LDA A KFLAG        ; CLEARS KEYENTRY FLAG
00590 233D 2AFC      EPL  ST16A        ; GETS KEYENTRY
00591 233F 7F006B    CLR  KFLAG        ;
00592 2342 964F      LDA A KEYENT      ; CALCULATES NEXT ADDRESS
00593 2344 CE3317    LDX  #SP16        ;
00594 2347 BE2BE8    JSR  ADDCAL        ;
00595 2349 EE00      LDX  0,X          ; JUMPS TO NEXT STATE
00596 234C 6E00      JEP  0,X          ;
00597
00598
00599      ; BEGIN STATE SEVENTEEN, DISPLAYS LAST ENTERED NUMBER
00600 235E 44        LSR A              ; BEGIN STATE 17, CONVERTS KEYCODE TO BCD CODE
00601 2360 16        TAB               ;
00602 23A0 BD2A9E    JSR  PACK          ; PACKS BCD NUMBERS
00603 23A3 CH30      ADD B #030H        ; CONVERTS BCD CODE TO ASCII CODE
00604 23A5 DE32      LDX  SAVEN          ;
00605 23A7 E700      STA B 0,X          ; ECHOES ENTERED BCD NUMBER
00606 23A9 08        INX  SAVEN          ; INCREMENTS TRACKING POINTER
00607 23AB B331FD    LDA A DECMAR      ; DISPLAYS DEGREE MARK AFTER LAST ENTERED NUMBER
00608 23AD A700      STA A 0,X          ; INCREMENTS TRACKING POINTER
00609 23AF 08        STX  SAVEN          ; STORES TRACKING POINTER
00610 23B0 DF32      LDA A AEEL        ;
00611 23B2 9661      CMP A #91EH        ; TEST TO SEE IF SET EL WAS ENTERED
00612 23B4 811E      BEQ A ST17A       ;
00613 23B6 2711      LDA A TEMPS       ; STORES ENTERED DATA INTO APPROPRIATE AZ REGISTERS
00614 23B8 9662      STA A AZKEYS      ;
00615 23BA 9757      LDA A ENTRYA      ;
00616 23BC 964D      LDA A ENTRYB      ;
00617 23BE B64E      JSR  ISTANG        ;
00618 23C0 DD295E    LDX  ENTRYA       ;
00619 23C3 DE4D      STX  AEKEY        ;
00620 23C5 753      BNA  ST17C        ;
00621 23C7 2011      LDA A TEMPS       ; STORES ENTERED DATA INTO APPROPRIATE EL REGISTERS
00622 23C9 9662      STA A ELKEYS      ;
00623 23CB 9753      LDA A ENTRYA      ;
00624 23CD 964F      JSR  TSTANG        ;
00625 23CF B64E      LDX  ENTRYA       ;
00626 23D1 DD295E    STX  ELKEY        ;
00627 23D3 B64D      BRA  ST17C        ;
00628 23D6 B755      LDA A KFLAG        ;
00629 23D9 2000      EPL  ST17C        ;
00630 23DB 966B      CLR  KFLAG        ;
00631 23DD 2AFC      LDA A KEYENT      ;
00632 23E0 7F006B    LDX  #SP17        ;
00633 23E3 964F      JSR  ADDCAL        ;
00634 23E6 CE333F    LDX  0,X          ;
00635 23E9 EF00      JEP  0,X          ;
00636 23EB EF00      ;

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00637 23EB 6E00      JMP      0,X      ; JUMPS TO NEXT STATE
00638                ;
00639                ; BEGIN STATE EIGHTEEN, GO TO MOTOR CONTROL LOOP
00640                ;
00641 23ED 7F0059      CLR      MFLAG    ; CLEARS MOTOR FLAG
00642 23F0 7F0093      CLR      LFLAG    ; CLEAR LIMIT REACHED FLAG
00643 23F3 7F0094      CLR      LFLAG
00644 23F6 7E20B7      JMP      ST0
00645                ;
00646                ; BEGIN STATE NINETEEN, DISABLES CONTROL LOOP
00647                ; (MODIFICATION 1.1)
00648                ;
00649 23F9 86FF          LDA      #OFFH
00650 23FB 9759          STA      MFLAG
00651 23FD BD2A3B      JSR      ALSTOP
00652 2400 7D0094      TST      LALAGA
00653 2403 2716      BEQ      ST19A
00654 2405 4F          CLR      A
00655 2406 D66C          LDA      B
00656 2408 53          COM      B
00657 2409 BD2D36      JSR      MOTAZ
00658 240C C60A          LDA      #10
00659 240E BD2E3E      JSR      WAITE
00660 2411 E5FF          LDA      #OFFH
00661 2413 D66C          LDA      B
00662 2415 BF2D36      JSR      MOTAZ
00663 2418 7E20B7      JMP      ST0
00664 241B 7F0094      CLR      LFLAG
00665 241E 7D0093      TST      LFLAG
00666 2421 2719      BEQ      ST19B
00667 2423 4F          CLR      A
00668 2424 D66D          LDA      B
00669 2426 53          COM      B
00670 2427 BD2DE2      JSR      MOTEL
00671 242A C60A          LDA      #10
00672 242C BD2E3E      JSR      WAITE
00673 242F E5FF          LDA      #OFFH
00674 2431 D66D          LDA      B
00675 2433 BD2DE2      JSR      MOTEL
00676 2436 7F0093      CLR      LFLAG
00677 2439 7E20B7      JMP      ST0
00678 243C 7E2299      JMP      ST7
00679                ;
00680                ; BEGIN STATE TWENTY, INPUT BCD PARAMETERS FOR PROGRAMMED RASTER SCANS
00681                ;
00682 243F CE30FC      LDX      #FSC0
00683 2442 ED2C22      JSR      ASNDIS    ; PRINTS "ENTER PROG NUMBER"
00684 2445 CE000F      LDX      #MSEL+3
00685 2448 0F32      STX      SAVEX
00686 244A 966B          LDA      KFLAG
00687 244C 2AFC          RPL      ST20A
00688 244E 7F006B      CLR      KFLAG
00689 2451 7F00AD      CLR      ENTURA

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; SETS THE MOTOR FLAG SO THAT THE CNT. LOOP IS DISABLED
 ; CHECK FOR AZIMUTH LIMIT REACHED
 ; BRANCHES IF AZ LIMIT NOT REACHED
 ; AZ LIMIT HAS BEEN REACHED
 ; GET CURRENT DIRECTION STATUS
 ; GET OPPOSITE DIRECTION
 ; AZ MOTOR CONTROL SUBROUTINE
 ; ALLOW TIME FOR AZ MOTOR TO REPOSITION GIMBAL
 ; STOP MOTORED LIMIT NOT EXCEEDED ANYMORE
 ; GO BACK TO CONTROL LOOP
 ; CHECK FOR ELEVATION LIMIT EXCEEDED
 ; BRANCHES IF EL LIMIT NOT EXCEEDED
 ; EL LIMIT HAS BEEN REACHED
 ; GET CURRENT DIRECTION STATUS
 ; GET OPPOSITE DIRECTION
 ; EL MOTOR CONTROL SUBROUTINE
 ; ALLOW TIME FOR EL MOTOR TO REPOSITION GIMBAL
 ; STOP EL MOTORED LIMIT NOT EXCEEDED ANYMORE
 ; RETURN CONTROL TO ST0
 ; DISPLAYS "POSITIONER HALTED ", WAITS 1 SEC., THEN ST0

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00690 2454 7F004E CLR EPT3VB
00691 2457 CE3110 LDX #CE310
00692 245A BD2C22 JSR A BD2C
00693 245D 964F LDA A KEYENT
00694 245F CE3367 LDX #CE320
00695 2462 DD2BEB JSR A DD2B
00696 2465 EEO0 LDX 0,X
00697 2467 6E00 JMP 0,X
00698
00699
00700
; BEGIN STATE TWENTY-ONE, DISPLAYS PROGRAM NUMBER
;
; ST21
00701 2469 44 LSR A
00702 246A 8B30 ADD A #030H
00703 246C 9765 STA A D1SAZ+5
00704 246E 9763 STA A PROCN
00705 2470 C641 LDA B #C41H
00706 2472 D705 STA B D1SEL+3
00707 2474 D764 STA B PROCL
00708 2476 966B LDA A KFLAG
00709 2478 2AFC BPL ST21A
00710 247A 7F006B CLR KFLAG
00711 247D 964F LDA A KEYENT
00712 247F CE33BF LDX #SP21
00713 2482 BD2BEB JSR A DD2B
00714 2485 EEO0 LDX 0,X
00715 2487 6E00 JMP 0,X
00716
00717
00718
00719
; BEGIN STATE TWENTY-TWO, DISPLAYS FIRST NUMBER OF ONE
; OF THREE INPUTS THAT MAKE UP THE RASTER SCAN
;
; ST22
00720 2489 44 LSR A
00721 248A 16 TAB
00722 248B BD2A9E JSR A BD2A
00723 248E CB30 ADD B #030H
00724 2490 DE32 LDX SAVEX
00725 2492 E700 STA B 0,X
00726 2494 08 INX
00727 2495 DF32 STX SAVEX
00728 2497 966B LDA A KFLAG
00729 2499 2AFC BPL ST22A
00730 249B 7F006B CLR KFLAG
00731 249E 964F LDA A KEYENT
00732 24A0 CE33BF LDX #SP22
00733 24A3 DD2BEB JSR A DD2B
00734 24A6 EEO0 LDX 0,X
00735 24A8 6E00 JMP 0,X
00736
00737
00738
00739
; BEGIN STATE TWENTY-THREE, DISPLAYS SECOND NUMBER OF ONE
; OF THREE INPUTS THAT MAKE UP THE RASTER SCAN
;
; ST23
00740 24AA 44 LSR A
00741 24AB 16 TAB
00742 24AC BD2A9E JSR A BD2A

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00743 24AF CB30      ADD B #030H
00744 24B1 DE32      LDR SAVEX
00745 24B3 E700      STA B 0,X
00746 24B5 08       INX
00747 24B5 LF3C      STX SAVEX
00748 24B5 966B      LDA A KFLAG
00749 24BA 2AFC      BPL ST23A
00750 24BC 7F0C5B      CLR KFLAG
00751 24BF 964F      LDA A KEYENT
00752 24C1 CE33DF      LDX #SP23
00753 24C4 BD2BE3      JSR ADPCAL
00754 24C7 EE00      LDX 0,X
00755 24C9 6E00      JMP 0,X
00756
00757
00758
00759 24CB C62E      LDA B #02EH
00760 24CD DE32      LDX SAVEX
00761 24CF E700      STA B 0,X
00762 24D1 08       INX
00763 24D2 DF32      STX SAVEX
00764 24D4 966B      LDA A KFLAG
00765 24D6 2AFC      BPL ST24A
00766 24D8 7F0C6B      CLR KFLAG
00767 24DB 964F      LDA A KEYENT
00768 24DD CE3407      LDX #SP24
00769 24F0 BD2BE3      JSR ADPCAL
00770 24F3 EE00      LDX 0,X
00771 24F5 6E00      JMP 0,X
00772
00773
00774
00775
00776 24E7 44       ST25
00777 24E8 16       TAB
00778 24E9 ED2A9E      JSR PACK
00779 24EC CB30      ADD B #030H
00780 24EE FE32      LDR SAVEX
00781 24F0 E700      STA B 0,X
00782 24F2 08       INX
00783 24F3 F631FD      LDA B DECMAR
00784 24F6 E700      STA B 0,X
00785 24F9 CE000F      LDX #DISEL+5
00786 24FB DF32      STX SAVEX
00787 24FD 9664      LDA A PROGL
00788 24FF 3142      CMP A #042H
00789 2501 2734      BEQ ST25B
00790 2503 3142      CMP A #043H
00791 2505 2756      BEQ ST25C
00792 2507 964D      LDA A ENTRYA
00793 2509 D64E      LDA B ENTRYB
00794 250B 9765      STA A PROGA
00795 250D D766      STA B PROGA+1

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; ECHOES ENTERED BCD NUMBER
 ; WAITS FOR ANOTHER KEYENTRY
 ; CLEARS KEYENTRY FLAG
 ; GETS KEYENTRY
 ; LOADS INDEX REGISTER WITH STATE 23 POINTER
 ; JUMPS TO NEXT STATE
 ; BEGIN STATE TWENTY-FOUR, DISPLAYS DECIMAL POINT
 ; ECHOES DECIMAL POINT
 ; CLEARS KEYENTRY FLAG
 ; GETS KEYENTRY
 ; CALCULATES NEXT ADDRESS
 ; JUMPS TO NEXT STATE
 ; BEGIN STATE TWENTY-FIVE, DISPLAYS LAST ENTERED NUMBER
 ; OF ONE OF THREE INPUTS THAT MAKE UP THE RASTER SCAN
 ; BEGIN STATE 25, CONVERTS KEYCODE TO BCD CODE
 ; PACKS BCD NUMBERS
 ; CONVERTS BCD TO ASCII
 ; ECHOES ENTERED NUMBER
 ; INCLUDES DEGREE MARK
 ; STORES TRACKING POINTER
 ; BRANCH IF PROGL IS A "B"
 ; BRANCH IF PROGL IS A "C"

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00796 250F C60A      LDA B #10
00797 2511 BD2E3E     JSR  WAIT     ; WAIT 1 SECOND
00798
00799
00800
00801
00802
00803 2514 D663      LLA B  PROCN   ; GET PROGRAM NUMBER
00804 2516 C133      CIP B  #33M
00805 2518 274B      BEQ  ST25A   ; BRANCHES IF STATE=PROGRAM #3
00806 251A C134      CIP B  #34H
00807 251C 2747      BEQ  ST25A   ; BRANCHES IF STATE=PROGRAM #4
00808
00809 251E CE3084     LDX  #MSG3
00810 2521 BD2C22     JSR  ASCDIS  ; BLANKS THE DISPLAY
00811 2523 CE3110     LDX  #MSG10
00812 2527 BD2C22     JSR  ASCDIS  ; DISPLAYS "PROC @ENTER"
00813 252A 9663      LDA A  PROCN
00814 252C 9705      LDA A  DISAZ+5 ; DISPLAYS THE PROGRAM NUMBER
00815 252E 8642      STA A  DISEL+3 ; DISPLAYS A "B" AFTER ENTER
00816 2530 970D      STA A  PROCL  ; STORES PROGRAM LETTER
00817 2532 9764      JMP  ST21A
00818 2534 7E2476     LLA A  ENTRYA
00819 2537 964D      LDA B  ENTRYB
00820 2539 D64E      STA A  PROCB
00821 253B 9767      STA B  PROCB+1 ; STORES WHAT WAS ENTERED AS "B"
00822 253D D768      LDA B  #10
00823 253F C60A      JSR  WAIT     ; WAIT 1 SECOND
00824 2541 BD2E3E     LDX  #MSG3
00825 2544 CE3084     JSR  ASCDIS  ; BLANKS THE DISPLAY
00826 2547 BD2C22     LDX  #MSG10
00827 254A CE3110     JSR  ASCDIS  ; DISPLAYS "PROC @ENTER"
00828 254D BD2C22     LDA A  PROCN
00829 2550 9663      STA A  DISAZ+5 ; DISPLAYS PROGRAM NUMBER
00830 2552 9705      LDA A  #043H
00831 2554 8643      STA A  DISEL+3 ; DISPLAYS A "C"
00832 2556 970D      STA A  PROCL  ; STORES THE CURRENT PROGRAM LETTER
00833 255B 9764      JMP  ST21A   ; JUMPS TO ENTER "C"
00834 255A 7E2476     LLA A  ENTRYA
00835 255D 964D      LDA B  ENTRYB
00836 255F D64E      STA A  PROCB
00837 2561 9769      STA B  PROCB+1 ; STORES WHAT WAS ENTERED AS "C"
00838 2563 D76A      LDA A  #10
00839 2565 966B      BPL  K7LAC
00840 2567 2AFC      CLR  K7LAC
00841 2569 7F006B     LLA A  KEVENT
00842 256C 964F      LDA A  #SP25
00843 256E CE342F     LDX  #SP25 ; LOADS INDEX REGISTER WITH STATE 25 POINTER
00844 2571 ED2DE9     JSR  ADDCAL  ; CALCULATES THE NEXT ADDRESS
00845 2574 EE00      LDX  0,X
00846 2576 6E00      JMP  0,X
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00849 ;
00850 ; (MODIFICATION 1.1)
00851 ST00 LDA A PROG# ;GET PROGRAM NUMBER
00852 CMP A #31H ;BRANCHES IF CURRENTLY IN PROG #1
00853 BEQ ST001
00854 CMP A #22H ;BRANCHES IF CURRENTLY IN PROG #2
00855 BEQ ST002
00856 CMP A #33H ;BRANCHES IF CURRENTLY IN PROG #3
00857 BEQ ST003
00858 JNP ST29 ;GO TO PROGRAM #1
00859 JNP ST26 ;GO TO PROGRAM #2
00860 JNP ST27 ;GO TO PROGRAM #3
00861 JNP ST33
00862 ;
00863 ; BEGIN STATE TWENTY-SIX, PATTERN NUMBER ONE
00864 ; (MODIFICATION 1.1)
00865 ;
00866 ST26 CLR MFLAG ;GETS TWO-BYTE RASTER PARAMETER " A "
00867 LDA A PROG#
00868 LDA B PROG#A+1 ;ENTERS AZIMUTH PART OF FIRST POINT
00869 STA A AZKEY
00870 STA B AZKEY+1
00871 LDA B MINUS ;ENTERS SIGN OF AZIMUTH PART OF FIRST POINT
00872 STA B AZKEYS
00873 LDA A PROG#
00874 LDA B PROG#A+1 ;SAVES TWO-BYTE ANSWER
00875 STA A FPTL+1
00876 STA B FPTL+1 ;ENTERS ELEVATION PART OF FIRST POINT
00877 STA A ELKEY
00878 STA B ELKEY+1
00879 LDA B PLUS
00880 STA B ELKEYS ;ENTER SCN OF ELEVATION PART OF FIRST POINT
00881 STA B FPTLS ;SAVES VALUE OF SIGN
00882 LDX #ST26A ;SAVES RETURN ADDRESS
00883 STX STADDR ;CLEARS PROGRAM STATE COUNTER
00884 CLR PROCHT
00885 LDA B #0FFH ;SETS PROGRAM FLAG
00886 STA B PFLAG ;GO TO CONTROL LOOP, ANTICIPATE RETURN
00887 JNP ST0 ;
00888 LDA B EL3IGN ;CHECKING CURRENT STATUS OF POSITION
00889 CMP B MINUS ;BRANCHES IF HAS RASTER IS NOT DONE
00890 BNE ST26A1
00891 LDA A FPTL
00892 LDA B FPTL+1
00893 LDX #0BCD ;COMPARES CURRENT POSITION TO RASTER LIMIT
00894 JSR BCD30B ;IF CARRY=0, SUBTRACTION OVERFLOW
00895 LDA A CARRY ;BRANCHES IF RASTER LIMIT REACHED
00896 BNE ST26A ;
00897 JNP ST26A1 ;CHECKS STATUS OF PROGRAM COUNTER
00898 CMP B #01H ;BRANCHES IF THIRD POINT OF SCAN NEEDED
00899 BEQ ST263
00900 CMP B #03 ;
00901 BEQ ST263 ;BRANCHES OF FIFTH POINT OF SCAN NEEDED

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00902 25E3 9643 LDA A AZSIGN
00903 25E5 012B CMP A #2BH
00904 25E7 2604 BNE NEGS
00905 25E9 862D LDA A #2DH
00906 25EB 2002 BRA FIN
00907 25ED 862B NEGS
00908 25EF 9757 FIN
00909 25F1 7C007A STA A AZKEYS
00910 25F4 7E20B7 INC PROCNT
00911 25F7 D644 JMP STO
00912 25F9 F131FB ST26B LDA B ELISGN
00913 25FC 261A CMP B PLUS
00914 25FE 9647 BNE ST26B1
00915 2600 D64B LDA A ELBCD
00916 2602 CE0067 LDA B ELBCD+1
00917 2605 BD2AC4 LDX #PROCB
00918 2608 9755 JSR R2DS03
00919 260A D756 STA A ELKEY
00920 260C 7D0098 STA B ELKEY+1
00921 260F 2724 TST CARRY
00922 2611 B631FA BEQ ST26B2
00923 2614 9758 LDA A MINUS
00924 2616 201D STA A ELKEYS
00925 2618 9643 BRA ST26B2
00926 261A 9B6B LDA A ELBCD+1
00927 261C 19 ADD A PROCB+1
00928 261D 9756 DAA
00929 261F 9647 STA A ELKEY+1
00930 2621 9967 LDA A ELBCD
00931 2623 19 ADC A PROCB
00932 2624 9755 DAA
00933 2626 9655 STA A ELKEY
00934 2628 D656 LDA A ELKEY
00935 262A CE0074 LDA B ELKEY+1
00936 262B BD2AC4 LDX #FTTEL
00937 2630 7D0098 JSR BCDSUB
00938 2633 261A TST CARRY
00939 2635 7C007A BNE ST26E
00940 2638 967A INC PROCNT
00941 263A 8104 LDA A PROCNT
00942 263C 2603 CMP A #04H
00943 263E 7F007A BNE ST26B3
00944 2641 7E20B7 CLR PROCNT
00945 2644 B631FA JMP STO
00946 2647 9757 ST26C LDA A MINUS
00947 2649 7C007A STA A AZKEYS
00948 264C 7E20B7 INC PROCNT
00949 264F 7F007D JMP STO
00950 2652 7E20B7 CLR PFLAG
00951 JNP STO
;
; BEGIN STATE TWENTY-SEVEN. PATTERN NUMBER TWO
; (MODIFICATION 1.1)
;
00953
00954

```

; INCREMENTS PROGRAM STATE COUNTER
 ; GO TO CONTROL LOOP, EXPECTING A RETURN

 ; BRANCHES IF IN THE PLUS SIDE
 ; ELISGN IS MINUS, SO SUBTRACT
 ; GET CURRENT POSITION

 ; ENTER IN THIRD POINT

 ; TEST TO SEE WHICH NUMBER IS BIGGER
 ; BRANCHES IF ANSWER STILL PLUS
 ; ANSWER IS MINUS

 ; ELISGN IS MINUS, SO ADD

 ; ENTER IN THIRD POINT

 ; ENTER IN THIRD POINT

 ; CHECK TO SEE IF RASTER IS FINISHED

 ; CHECK FOR SUBTRACTION OVERFLOW
 ; BRANCHES IF RASTER IS FINISHED
 ; INCREMENT PROGRAM STATE COUNTER

 ; IS THIS CALCULATING 5TH POINT
 ; BRANCHES IF CALCULATING 3TH POINT
 ; CLEAR COUNTER TO RESTART SCAN PERIOD
 ; GO TO CONTROL LOOP, EXPECT A RETURN
 ; CALCULATES 4TH POINT

 ; INCREMENT PROGRAM STATE COUNTER
 ; GO TO CONTROL LOOP, EXPECT A RETURN
 ; CLEAR PROGRAM FLAG
 ; GO TO CONTROL LOOP, DONT COME BACK

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00955 2653 7F0059          CLR          MFLAG
00956 2658 9663          LDA A      PROG4
00957 265A D666          LDA B      I30CA+1
00958 265C 9776          STA A      FPTAZ
00959 265E D777          STA B      FPTAZ+1
00960 2660 9753          STA A      AZKEY
00961 2662 D754          STA B      AZKEY+1
00962 2664 F631FA        LDA B      MINUS
00963 2667 D757          STA D      AZKEYS
00964 2669 D779          STA B      FPTAZS
00965 266B 9669          LDA A      PROG4
00966 266D D66A          LDA B      PROG4+1
00967 266F 9755          STA A      ELKEY
00968 2671 D756          STA B      ELKEY+1
00969 2673 F631FB        LDA B      PLUS
00970 2676 D758          STA B      ELKEYS
00971 2678 7F007A        CLR          PROCENT
00972 267B CE2687        LDX          #ST27A
00973 267E D77D          STX          STADDR
00974 2680 C6FF          LDA B      #OFFH
00975 2682 D77D          STA B      PFLAG
00976 2634 7E2037        JMP          ST0
00977 2687 D643          LDA B      AZSIGN
00978 2689 F131FB        CNF B      PLUS
00979 268C 260F          BNE          ST27A1
00980 268E 9676          LDA A      FPTAZ
00981 2690 D677          LDA B      FPTAZ+1
00982 2692 CE0045        LDX          #AZBCD
00983 2695 BD2AC4        JSR          B0SUB
00984 2698 7D0098        TST          CARRY
00985 269B 2674          BNE          ST27E
00986 269D D67A          LDA B      PROCENT
00987 269F C101          CNF B      #01H
00988 26A1 2713          BEQ          ST27B
00989 26A3 C102          CNF B      #2H
00990 26A5 275C          DEQ          ST27C
00991 26A7 C103          CNF B      #03
00992 26A9 270B          BEQ          ST27B
00993 26AB F631FA        LDA B      MINUS
00994 26AE D758          STA B      ELKEYS
00995 26B0 7C007A        INC          PROCENT
00996 26B3 7E2067        JMP          ST0
00997 26B6 D643          LDA B      AZSIGN
00998 26B8 F131FB        CNF B      PLUS
00999 26BE 271A          BEQ          ST27B1
01000 26C0 9643          LDA A      AZBCD
01001 26C2 D646          LDA B      AZBCD+1
01002 26C4 CE0067        LDX          #PR0CB
01003 26C6 BD2AC4        JSR          B0SUB
01004 26C8 26C7 9754          STA A      AZKEY
01005 26C9 D754          STA B      AZKEY+1
01006 26CB 7D0098        TST          CARRY
01007 26CE 2724          DEQ          ST27B2

```

;GETS TWO-BYTE RASTER PARAMETER " A "
 ;SAVES TWO-BYTE QUOTIENT
 ;ENTERS AZIMUTH PART OF FIRST POINT
 ;ENTERS SIGN OF AZIMUTH PART OF 1ST POINT
 ;SAVES AZIMUTH SIGN
 ;GETS TWO-BYTE RASTER PARAMETER " C "
 ;ENTERS ELEVATION PART OF FIRST POINT
 ;ENTERS SIGN OF ELEVATION PART OF FIRST POINT
 ;CLEARS PROGRAM STATE COUNTER
 ;SAVES RETURN ADDRESS
 ;SETS PROGRAM FLAG
 ;GO TO CONTROL LOOP, EXPECT A RETURN
 ;RETURN HERE FROM CONTROL LOOP
 ;CHECKING CURRENT STATUS OF POSITION
 ;GETS TWO-BYTE AZIMUTH PART OF FIRST PART
 ;COMPARES CURRENT POSITION TO RASTER LIMIT
 ;IF CARRY = 0, THEN OVERFLOW HAS OCCURRED
 ;BRANCHES IF RASTER LIMIT REACHED
 ;RASTER LIMIT NOT REACHED
 ;CHECKS STATUS OF PROGRAM STATE COUNTER
 ;BRANCHES IF THIRD POINT OF SCAN NEEDED
 ;BRANCHES IF FORTH POINT OF SCAN NEEDED
 ;BRANCHES IF FIFTH POINT OF SCAN NEEDED
 ;ENTERS AZIMUTH PART OF SECOND POINT
 ;INCREMENT PROGRAM STATE COUNTER
 ;GO TO CONTROL LOOP, EXPECTING A RETURN
 ;HANDLES CHANGE IN COORDINATE SYSTEM
 ;BRANCHES IF IN THE PLUS SIDE
 ;AZSIGN IS MINUS, SO SUBTRACT
 ;GET CURRENT POSITION
 ;GET " D " VALUE
 ;ENTER THIRD POINT
 ;TEST TO SEE WHICH ONE IS BIGGER
 ;BRANCHES IF ANSWER STILL PLUS

```

01008 26D9 B631FB      LDA A  PLUS      :ANSWER IS MINUS
01009 26D3 9757        STA A  AZKEYS
01010 26D5 201D        BRA  ST27B2 :BRANCH AROUND ADD ROUTINE
01011 26D7 9646        LDA A  AZBCD+1 :AZSIGN IS PLUS, SO ADD
01012 26D9 9B68        ADD A  PRGCB+1
01013 26DB 19          DAA
01014 26DC 9754        STA A  AZKEY+1 :ENTER IN THIRD POINT
01015 26DE 9645        LDA A  AZBCD
01016 26E0 9945        ADC A  AZBCD
01017 26E2 19          DAA
01018 26E3 9753        STA A  AZKEY :ENTER IN THIRD POINT
01019 26E5 9653        LDA A  AZKEY :BEGIN RASTER LIMIT TEST
01020 26E7 9654        LDA A  AZKEY+1 :GET NEXT POINT
01021 26E9 CE0076      LDX  *FPTAZ :GET END POINT
01022 26EC BD2AC4      JSR  BCDSUB :NEXT POINT MINUS END POINT
01023 26EF 7D0098      TST  CARRY :CHECK FOR WHICH IS DOMINANT
01024 26F2 261D        BNE  ST27E :BRANCHES IF SCAN IS FINISHED
01025 26F4 7C007A      ST27B2 INC  PROCNT :INCREMENT PROGRAM STATE COUNTER
01026 26F7 967A        LDA A  PROCNT
01027 26F9 8104        CMP A  *04H :IS THIS CALCULATING 5TH POINT
01028 26FB 2611        BNE  ST27D :BRANCHES IF THIS IS TRUE
01029 26FD 7F007A      CLR  PROCNT :IS CALCULATING 3RD POINT
01030 2700 7E20B7      ST27B3 JMP  ST0 :GO TO CONTROL LOOP, EXPECT A RETURN
01031 2703 B631FB      ST27C  LDA A  PLUS :CALCULATES 4TH POINT
01032 2706 9758        STA A  ELKEYS
01033 2708 7C007A      INC  PROCNT :INCREMENTS PROGRAM STATE COUNTER
01034 270B 7E20B7      JMP  ST0 :GO TO CONTROL LOOP, EXPECT A RETURN
01035 270E 7E2641      ST27D  JMP  ST26B3
01036 2711 7F007D      ST27E  CLR  PFLAG :CLEAR PROGRAM FLAG
01037 2714 7E20B7      JMP  ST0 :GO TO CONTROL LOOP, DONT COME BACK
01038
01039
01040
01041
01042
01043
01044 2717 7F007F      ST28   CLR  PROANG :INITIALIZE ANGLE COUNTER
01045 271A 7F0059      CLR  MFLAG
01046 271D 7F0065      CLR  COSINE :INITIALIZE TWO-BYTE VALUES
01047 2720 7F0023      CLR  SINE
01048 2723 9665        LDA A  PROCA :GET ANGLE
01049 2725 D666        LDA B  PROCA+1
01050 2727 54          LSR  B :DIVIDE BY 100
01051 2728 46          ROR  A
01052 2729 54          LSR  B
01053 272A 46          ROR  A
01054 272B 54          LSR  B
01055 272C 46          ROR  A
01056 272D 54          LSR  B
01057 272E 46          ROR  A
01058 272F BD29EB      JSR  BCDBIN :CONVERT THIS BCD VALUE TO BINARY
01059 2732 9781        STA A  BINANG :SAVE TWO-BYTE RESULT
01060 2734 D7E2        STA B  BINANG+1

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01061 2736 D67D          LDA B PFLAG      ;SET PROGRAM FLAG
01062 2738 CE0000        ST28A LDX B #0000H ;CALCULATE POINT NUMBER ONE
01063 273B DF53          STX  AZKEY       ;SEND POSITIONER TO ORIGIN
01064 273D DF55          STX  ELKEY
01065 273F C62B          LDA B #2BH       ;FIX SIGNS FOR PROPER QUADRANT
01066 2741 D757          STA B AZKEYS
01067 2743 D758          STA B ELKEYS
01068 2745 CE274D        LDX B #ST28B
01069 2748 DF7B          STX  STADDR      ;SAVES RETURN ADDRESS
01070 274A 7E20B7        JMP  STO        ;GO TO CONTROL LOOP, EXPECT A RETURN
01071 274D DE7F          ST28B LDX B PROANG ;CALCULATE POINT NUMBER TWO
01072 274F 8C016B        CPX  #0168H     ;COMPARE TO 360 DEGREES
01073 2752 2847          BVC  ST28D      ;BRANCHES IF PATTERN COMPLETED
01074 2754 BD2A2A        JSR  TRIGAD     ;PATTERN NOT FINISHED
01075 2757 DF83          LDX B SINE      ;GET SINE VALUE
01076 2759 8640          LDA A #40H      ;GET AZMAX
01077 275B 5F           CLR B
01078 275C BD296D        JSR  BCDMPY     ;SINE (ANGLE) TIMES AZMAX
01079 275F 9753          STA A AZKEY      ;SET AZINUTH DESTINATION
01080 2761 D754          STA B AZKEY+1
01081 2763 DE85          LDX B COSINE    ;GET COSINE VALUE
01082 2765 8640          LDA A #40H
01083 2767 5F           CLR B
01084 2768 BD296D        JSR  BCDMPY     ;COSINE (ANGLE) TIMES ELMAX
01085 276B 9755          STA A ELKEY      ;SET ELEVATION DESTINATION
01086 276D D75C          STA B ELKEY+1
01087 276F D687          LDA B SSIGN     ;GET SIGN OF SINE VALUE
01088 2771 D757          STA B AZKEYS
01089 2773 D68C          LDA B CSIGN     ;GET SIGN OF COSINE VALUE
01090 2775 D758          STA B ELKEYS
01091 2777 CE277F        LDX B #ST28C
01092 277A DF7B          STX  STADDR      ;STORE RETURN ADDRESS
01093 277C 7E20B7        JMP  STO        ;GO TO CONTROL LOOP, EXPECT A RETURN
01094 277F D657          ST28C LDA B AZKEYS ;CALCULATE POINT NUMBER THREE
01095 2781 53           COM B
01096 2782 D757          STA B AZKEYS
01097 2784 D658          LDA B ELKEYS
01098 2786 53           COM B
01099 2787 D758          STA B ELKEYS
01100 2789 967F          LDA A PROANG
01101 278B D680          LDA B PROANG+1
01102 278D BE82          ADD B BINANG+1
01103 278F D780          STA B PROANG+1 ;UPDATE PROGRAMMED ANGLE
01104 2791 977F          STA A PROANG
01105 2793 CE2738        LDX B #ST28A
01106 2796 DF7B          STX  STADDR      ;SAVE RETURN ADDRESS
01107 2798 7E20B7        JMP  STO        ;GO TO CONTROL LOOP, EXPECT A RETURN
01108 279B 7F007D        ST28D CLR PFLAG  ;SCAN FINISHED, CLEAR PROGRAM FLAG
01109 279E 7E20E7        JMP  STO        ;GO TO CONTROL LOOP, DONT RETURN
01110
01111
01112
01113
:
: BEGIN STATE TWENTY-NINE, PATTEN NUMBER FOUR
: ENTER RADIUS (IN DEGRESS) OF CIRCLE
: PROGRAM WILL GENERATE ONE CIRCLE WITH RADIUS " A "

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01114      ; (MODIFICATION 1.1)
01115      ;
01116      ST29      CLR      PROANG      ; INITIALIZE ANGLE COUNTER
01117      CLR      MELAG
01118      CLR      COSINE
01119      CLR      SINE
01120      LDA B #OFFH
01121      STA B PFLAG
01122      LDX      PROANG
01123      CPX      #360
01124      BVC      ST29B
01125      JSR      TRIGAD
01126      LDX      SINE
01127      LDA A PROCA
01128      LDA B PROCA+1
01129      JSR      BCDMPY
01130      STA A AZKEY
01131      STA B AZKEY+1
01132      LDX      COSINE
01133      LDA A PROCA
01134      LDA B PROCA+1
01135      JSR      BCDMPY
01136      STA B AZKEY+1
01137      LDX      COSINE
01138      LDA A PROCA
01139      LDA B PROCA+1
01140      JSR      BCDMPY
01141      STA A ELKEY
01142      STA B ELKEY+1
01143      LDA B ESIGN
01144      STA B AZKEYS
01145      LDA B CSIGN
01146      STA B ELKEYS
01147      LDX      #ST29A
01148      STX      STADDR
01149      JMP      ST0
01150      CLR      PFLAG
01151      JMP      ST0
01152      ;
01153      ; BEGIN STATE THIRTY, SET NEGATIVE ELEVATION LIMIT
01154      ; (MODIFICATION 1.1)
01155      ;
01156      ST30      LDX      #NSG16
01157      JSR      ASCDIS
01158      LDX      #DISL+6
01159      STX      SAVEX
01160      LDA A NELLIN
01161      LDA B NELLIN+1
01162      JSR      BCDIS
01163      JSR      HOVEN
01164      LDX      #ST30B
01165      STX      STADDR
01166      LDA A KFLAG
01114      ;
01115      ;
01116      ST29      CLR      PROANG      ; INITIALIZE ANGLE COUNTER
01117      CLR      MELAG
01118      CLR      COSINE
01119      CLR      SINE
01120      LDA B #OFFH
01121      STA B PFLAG
01122      LDX      PROANG
01123      CPX      #360
01124      BVC      ST29B
01125      JSR      TRIGAD
01126      LDX      SINE
01127      LDA A PROCA
01128      LDA B PROCA+1
01129      JSR      BCDMPY
01130      STA A AZKEY
01131      STA B AZKEY+1
01132      LDX      COSINE
01133      LDA A PROCA
01134      LDA B PROCA+1
01135      JSR      BCDMPY
01136      STA B AZKEY+1
01137      LDX      COSINE
01138      LDA A PROCA
01139      LDA B PROCA+1
01140      JSR      BCDMPY
01141      STA A ELKEY
01142      STA B ELKEY+1
01143      LDA B ESIGN
01144      STA B AZKEYS
01145      LDA B CSIGN
01146      STA B ELKEYS
01147      LDX      #ST29A
01148      STX      STADDR
01149      JMP      ST0
01150      CLR      PFLAG
01151      JMP      ST0
01152      ;
01153      ; BEGIN STATE THIRTY, SET NEGATIVE ELEVATION LIMIT
01154      ; (MODIFICATION 1.1)
01155      ;
01156      ST30      LDX      #NSG16
01157      JSR      ASCDIS
01158      LDX      #DISL+6
01159      STX      SAVEX
01160      LDA A NELLIN
01161      LDA B NELLIN+1
01162      JSR      BCDIS
01163      JSR      HOVEN
01164      LDX      #ST30B
01165      STX      STADDR
01166      LDA A KFLAG

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01167 2812 2AFC          ST39A          ;WAITS FOR KEYENTRY
01168 2814 7F006B        KFLAG          ;A KEY IS PRESSED; CLEAR KEYENTRY FLAG
01169 2817 964F          LDA A           ;GET KEYENTRY
01170 2819 CE3457        LDX #SP60      ;LOADS INDEX REGISTER WITH STATE 30 POINTER
01171 281C BD2FEB        JSR ADI CAL    ;SUBROUTINE CALCULATES NEXT ADDRESS
01172 281F E500          LDX 0,X
01173 2821 6E00          JMP 0,X        ;JUMPS TO CALCULATED ADDRESS OF NEXT STATE
01174 2823 DE4D          LDX ENTRYA     ;JUST RETURNED FROM ENTERING PELLIN
01175 2825 DF8D          STX NELLIM     ;UPDATE NEGATIVE ELEVATION LIMIT
01176 2827 20E7          BRA ST30A      ;BRANCH TO WAIT ON NEXT KEYENTRY
01177
01178
01179
01180
01181 2829 CE319C          ;
01182 282C BD2C22          ; BEGIN STATE THIRTY-ONE, SET POSITIVE ELEVATION LIMITS
01183 282F CE3910          ; (MODIFICATION 1.1)
01184 2832 DF32          ;
01185 2834 968B          ST31          ;
01186 2836 D68C          LDX #NEG17    ;
01187 2839 ASDDIS         JSR          ;DISPLAYS "POS EL LIMIT"
01188 283C #DISSEL+6      LDX          ;
01189 283E CE2B56          STX SAVEX     ;
01190 2841 DF7B          LDA A PELLIM+1 ;GET POSITIVE ELEVATION LIMIT
01191 2843 966D          LDA B          ;DISPLAYS CURRENT POSITIVE ELEVATION
01192 2845 2AFC          JSR ECDDIS     ;
01193 2847 7F006B        JSR MOVED      ;SAVES RETURN ADDRESS
01194 2849 964F          STX STADDR     ;
01195 284C CE347F          ST31A        ;WAITS FOR KEYENTRY
01196 284F BD3BE3        LDX KFLAG     ;A KEY IS PRESSED, CLEAR KEYENTRY FLAG
01197 2852 EE00          LDX 0,X        ;GET KEYENTRY
01198 2854 6F00          JMP 0,X        ;LOADS INDEX REGISTER WITH STATE 31 POINTER
01199 2856 DE4D          LDX ENTRYA     ;SUBROUTINE CALCULATES NEXT ADDRESS
01200 2858 DF8D          STX PELLIM     ;JUMPS TO CALCULATED ADDRESS OF NEXT STATE
01201 285A 20E7          BRA ST31A      ;JUST RETURNED FROM ENTERING PELLIM
01202
01203
01204
01205
01206 285C CE31B0          ;
01207 285F BD2C22          ; BEGIN STATE THIRTY-TWO, SET NEGATIVE AZIMUTH LIMIT
01208 2862 CE0010          ; (MODIFICATION 1.1)
01209 2865 DF32          ;
01210 2867 9691          ST32          ;
01211 2869 D693          LDX #NEG18    ;
01212 286C BD2DE2        JSR          ;DISPLAYS "NEG AZ LIMIT"
01213 286E BD2943        LDX          ;
01214 2871 CE2B29        STX SAVEX     ;SAVES DISPLAY TRACKING POINTER
01215 2874 DF7D          LDA A NAZLIM   ;GET POSITIVE ELEVATION LIMIT
01216 2876 966B          LDA B NAZLIM+1 ;DISPLAY CURRENT NEGATIVE AZIMUTH LIMIT
01217 2878 2AFC          JSR ECDDIS     ;
01218 287A 7F006B        STX SPA99R     ;SAVES RETURN ADDRESS
01219 287D 964F          LDA A KFLAG     ;WAITS FOR KEYENTRY
01220 287F CE3457        LDX #SP60      ;A KEY IS PRESSED, CLEAR KEYENTRY
01221 2881 BD2FEB        JSR ADI CAL    ;GET KEYENTRY

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01220 287F CE34A7 LDX #SP32 ;LOADS INDEX REGISTER WITH STATE 32 POINTER
01221 28E2 BD2BEB JSR ASBCAL ;SUBROUTINE CALCULATES NEXT ADDRESS
01222 2835 E300 LDM O,X
01223 28B7 6700 JMP O,X
01224 2859 DE4D ST32B ;JUMPS TO CALCULATED ADDRESS OF NEXT STATE
01225 28B3 DF91 STX ENTRYA ;JUST RETURNED FROM ENTERING PAZLIN
01226 283D 20E7 BRA ST32A ;UPDATE NEGATIVE AZIMUTH LIMIT
01227 ;BRANCH TO WAIT ON NEXT KEYENTRY
01228 ;
01229 ; BEGIN STATE THIRTY-THREE, SET POSITIVE AZIMUTH LIMIT
01230 ; (MODIFICATION 1.1)
01231 288F CE31C4 LDX #NEG19
01232 2892 BD2C22 JSR ASCDIS ;DISPLAYS "POS AZ LIMIT"
01233 2895 CF0010 LDX #DISL+6
01234 2893 DF32 STX SAVEX ;SAVES DISPLAY TRACKING POINTER
01235 289A 966F LDA A PAZLIN ;GET POSITIVE ELEVATION LIMIT
01236 289C D690 LDA B PAZLIN+1
01237 289E BD2D2F JSR RUDDIS ;DIS"LAY CURRENT POSITIVE AZIMUTH LIMIT
01238 28A1 BD2943 JSR MOVED
01239 28A4 CE28BC LDX #ST33B
01240 28A7 DF7B STX STADDR ;SAVES RETURN ADDRESS
01241 28A9 966B LDA A KFLAG
01242 28AB 2AFC BPL ST33A ;WAITS FOR KEYENTRY
01243 28AD 7F066B CLR KFLAG ;A KEY IS PRESSED, CLEAR KEYENTRY
01244 28B0 964F LDA A KEYENT ;GET KEYENTRY
01245 28B2 CE34CF LDX #SP33 ;LOADS INDEX REGISTER
01246 28B5 BD2BEB JSR ASBCAL ;SUBROUTINE CALCULATES NEXT ADDRESS
01247 28B8 EE00 LDX O,X
01248 28BA 6E00 JMP O,X
01249 28BC DF4D LDX ENTRYA ;JUMPS TO CALCULATED ADDRESS OF NEXT STATE
01250 28BE DF8F STX PAZLIN ;JUST RETURNED FROM ENTERING PAZLIN
01251 28C0 20E7 BRA ST33A ;UPDATE POSITIVE AZIMUTH LIMIT
01252 ;BRANCH TO WAIT ON NEXT KEYENTRY
01253 ;
01254 ; BEGIN STATE THIRTY-FOUR, INPUT NUMBERS FOR SETTING LIMITS--1ST
01255 ; (MODIFICATION 1.1)
01256 28C2 44 LSR A
01257 28C3 16 TAB
01258 28C4 BD2A9E JSR PACK
01259 28C7 CB30 ADD B #30H ;PACKS BCD INPUT INTO PACKED BCD FORM
01260 28C9 FE32 LDX SAVEX ;CONVERTS BCD INPUT INTO ASCII CODE
01261 28CB E700 STA B O,X ;GETS DISPLAY TRACKING POINTER
01262 28CD 0B INX
01263 28CE DF32 STX SAVEX ;INCREMENTS TRACKING POINTER
01264 28D0 966B LDA A KFLAG ;SAVES INCREMENTED POINTER
01265 28D2 2AFC BPL ST34A ;WAITS FOR NEXT BCD INPUT FROM KEYBOARD
01266 28D4 7F006B CLR KFLAG ;KEY IS PRESSED CLEAR KEYENTRY FLAG
01267 28D7 964F LDA A KEYENT ;GET KEYENTRY
01268 28D9 CE34F7 LDX #SP34 ;LOAD INDEX REGISTER WITH STATE 34 POINTER
01269 28DC BD2BEB JSR ASBCAL ;SUBROUTINE CALCULATES NEXT ADDRESS
01270 28DE FE00 LDM O,X
01271 28E1 6F00 JMP O,X ;JUMPS TO CALCULATED ADDRESS OF NEXT STATE
01272 ;

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01273      ;
01274      ;
01275      ;
01276      ST35      LSR A
01277      TAB
01278      JSR PACK
01279      ADD B #COH
01280      LDY SAVEX
01281      STA B 0,X
01282      INX
01283      STX SAVEX
01284      LDA A KFLAG
01285      BPL ST35A
01286      CLR KFLAG
01287      LDA A KEYENT
01288      LAR #SP35
01289      JSR ADDCAL
01290      LDY 0,X
01291      JMP 0,X
01292      ;
01293      ;
01294      ;
01295      ;
01296      ST36      LDA B #2EH
01297      LDY SAVEX
01298      STA B 0,X
01299      INX
01300      STX SAVEX
01301      LDA A KFLAG
01302      BPL ST36A
01303      CLR KFLAG
01304      LDA A KEYENT
01305      LAR #SP36
01306      JSR ADDCAL
01307      LDY 0,X
01308      JMP 0,X
01309      ;
01310      ;
01311      ;
01312      ;
01313      ST37      LSR A
01314      TAB
01315      JSR PACK
01316      ADD B #COH
01317      LDY SAVEX
01318      STA B 0,X
01319      LDA A ENTRYA
01320      LDA B ENTRYB
01321      JSR TSTANG
01322      LDY STADDR
01323      JMP 0,X
01324      ;
01325      ;

```

; BEGIN STATE THIRTY-FIVE, INPUT BCD CHARACTER NUMBER TWO
 (MODIFICATION 1.1)
 ; 2ND INPUT, CONVERT KEYCODE TO BCD CODE
 ; SAVE THIS BCD INPUT
 ; PACKS BCD INPUT INTO PACKED BCD FORM
 ; GETS DISPLAY TRACKING POINTER
 ; ECHOS KEYENTRY
 ; INCREMENTS TRACKING POINTER
 ; SAVES INCREMENTED POINTER
 ; WAITS FOR NEXT BCD INPUT FROM KEYBOARD
 ; A KEY IS PRESSED, CLEAR KEYENTRY FLAG
 ; GET KEYENTRY
 ; LOAD INDEX REGISTER WITH STATE 35 POINTER
 ; SUBROUTINE CALCULATES NEXT ADDRESS
 ; JUMPS TO CALCULATED ADDRESS OF NEXT STATE
 ;

; BEGIN STATE THIRTY-SIX, INPUT DECIMAL POINT
 (MODIFICATION 1.1)
 ; 3RD INPUT, CONVERT INPUT TO BCD CODE
 ; GETS TRACKING POINTER
 ; ECHOS KEYENTRY
 ; INCREMENTS TRACKING POINTER
 ; WAITS FOR LAST BCD CHARACTER
 ; KEY IS PRESSED, CLEAR KEYENTRY FLAG
 ; GET KEYENTRY
 ; LOAD INDEX REGISTER WITH STATE 36 POINTER
 ; SUBROUTINE CALCULATES NEXT ADDRESS
 ; JUMPS TO CALCULATED ADDRESS OF NEXT STATE
 ;

; BEGIN STATE THIRTY-SEVEN, INPUT LAST BCD CHARACTER
 (MODIFICATION 1.1)
 ; LAST INPUT, CONVERT INPUT TO BCD CODE
 ; SAVE THIS BCD INPUT
 ; PACKS BCD INPUT INTO ASCII CODE
 ; ECHOS KEYENTRY
 ; GET BCD ANGLE
 ; TEST ANGLE FOR LIMIT CONDITION
 ; GET RETURN ADDRESS
 ; GO BACK TO THAT STATE
 ;

; "RSTO" SUBROUTINE
 ;

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01326 ; THIS SUBROUTINE RETURNS THE KEYBOARD TO AN INITIALIZED STATE
01327 ; SO THAT ANY KEY PRESS WILL GENERATE AN INTERRUPT.
01328 ;
01329 RESTO LDA A #OFFH
01330 STA A DORA
01331 LDA A DORA
01332 LDA A #OFFH
01333 STA A TFLAG
01334 RTS
01335 ;
01336 MOVED LDA A DISEL+8
01337 LDA B #LPH
01338 STA B DISEL+8
01339 STA A DISEL+0
01340 RTS
01341 ;
01342 ; "CPFLAG" ROUTINE
01343 ; MODIFICATION 1.1)
01344 ; THIS ROUTINE IS REACHED ONLY AFTER POSITIONER HAS STOPPED
01345 ; CHECKS PROGRAM FLAG (PFLAG) TO SEE IF IT IS CURRENTLY IN
01346 ; A PROGRAMMED SEQUENCE.
01347 CPFLAG LDA A SFLAG
01348 CMP A #OFFH
01349 BNE CP1
01350 TST PFLAG
01351 BEQ CP1
01352 LDZ STADR
01353 JNZ OX
01354 JNZ STG
01355 ;
01356 ; "TSTANG" SUBROUTINE
01357 ; COMPARES THE TWO ACCXS WITH THE CONTENTS OF THE
01358 ; INDEX REGISTER. RETURNS FROM SUB. IF CONTENTS
01359 ; OF INDEX REGISTER ARE LARGER THAN THE CONTENTS
01360 ; OF THE ACCXS. BRANCHES TO EROR 6 IF NOT.
01361 TSTANG LDZ #LIMIT
01362 JSR BDSUB
01363 TST CARRY
01364 BND NOPE
01365 JNZ STG
01366 RTS
01367 ;
01368 ; "BCDMPY" SUBROUTINE
01369 ; REVISION 2.1
01370 ; MULTIPLIES TWO PACKED BCD (16-BIT) VALUES
01371 ; BY-ENTRY CODE (USING 7 BYTES ON STACK)
01372 ; ACCA, ACCB TIMES (X), (X+1)
01373 ; RESULT IN ACCA, ACCB
01374 ; MODIFICATION 1.1)
01375 ;
01376 BCDMPY PSN B
01377 PSN A
01378 ; PUSH MULTIPLIER ONTO STACK

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01432 20 04      DFS
01433 20A2 39     TST
01434 20A3 3501   LDA A #1
01435 20A5 6D01   TST
01436 20A7 3F0B   BHI BCD153
01437 20A9 4C     BCD151 INC A
01438 20AA 6E02   ASL 2,X
01439 20AC 6901   ROL 1,X
01440 20AE 2B04   BHI BCD153
01441 20B0 8111   CMP A #17
01442 20B2 26F5   BNE BCD151
01443 20B4 A700   STA A 0,X
01444 20B5 A503   LDA A 3,X
01445 20B8 F604   LDA B 4,X
01446 20BA 6F03   CLR 3,X
01447 20BC 6F04   CLP 4,X
01448           ; STACK LOOKS LIKE:
01449           ; +0 COUNT
01450           ; +1 MS BYTE OF DIVISOR
01451           ; +2 LS BYTE OF DIVISOR
01452           ; +3 MS BYTE OF DIVISOR
01453           ; +4 LS BYTE OF DIVISOR
01454           ; +5 MS BYTE OF RETURN ADDRESS
01455           ; +6 LS BYTE OF RETURN ADDRESS
01456 20BE DF32   BCD163 STX SAVX
01457 20C0 EE01   LDX 1,X
01458 20C2 D2AC4  JSR BCD163
01459 20C5 7D009B TEST CALLY
01460 20C8 270E   DEQ BCD165
01461 20CA 9736   STA A TEMP
01462 20CC 17     TBA
01463 20CD AB02   ADD A 2,X
01464 20CF 19     DAA
01465 20D0 16     TAB
01466 20D1 9636   LDA A TEMP
01467 20D3 A901   ADC A 1,X
01468 20D5 0C     CLC
01469 20D6 2001   BRA BCD167
01470 20D8 0D     ECD165 SEC
01471 20D9 6904   ROL 3,X
01472 20DB 690C   ROL 3,X
01473 20DD 6401   LSR 1,X
01474 20DF 6602   ROR 2,X
01475 20E1 6A01   DEC 1,X
01476 20E3 25D9   BNE BCD163
01477           ; CLEAN UP STACK
01478 20E5 31     LFS
01479 20E6 31     LFS
01480 20E7 31     LFS
01481 20E8 32     PUL A
01482 20E9 33     PUL B
01483 20EA 39     RTS
01484

```

; POINTER IN INDEX REGISTER TO STACKED DATA
 ; COUNT NUMBER OF TIMES DIVISOR IS SHIFTED LEFT
 ; SHIFTS DIVISOR LEFT ONE BIT
 ; BRANCHES IF DIVISOR HAS BEEN SHIFTED LEFT 16 TIMES
 ; CHECK FOR DIVISOR EQUAL TO ZERO
 ; BRANCHES IF DIVISOR NOT LEFT JUSTIFIED
 ; SAVES SHIFT COUNT ON STACK
 ; GET DIVIDEND FROM STACK
 ; INITIALIZE DIVIDEND TO BECOME QUOTIENT
 ; SAVE POINTER TO STACK
 ; GET DIVISOR
 ; DIVIDED MINUS DIVISOR
 ; CARRY = 0, SUBTRACTION OVERFLOW
 ; BRANCHES IF DIVISOR STILL OKAY
 ; BEGIN RESTORE, SAVE VALUE IN ACCA
 ; BEGIN BCD MATH
 ; PUT BCD VALUE BACK IN ACCB
 ; GET ACCA THAT WAS SAVED
 ; FINISH BCD MATH
 ; CLEAR CARRY BIT, SHIFT IN ZERO
 ; BRANCHES TO SHIFT IN ZERO TO QUOTIENT
 ; SET CARRY BIT, SHIFT IN ONE (1)
 ; SHIFTS IN CARRY BIT INTO LS3 OF QUOTIENT
 ; SHIFTS DIVISOR RIGHT WITH ZERO FILL
 ; DECREMENT COUNT
 ; BRANCHES IF COUNT EQUAL TO ZERO (0)
 ; PULLS CORRECTED BCD VALUE FROM STACK
 ; DESTROYS REMAINDER

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01403      :      "BCDBIN" SUBROUTINE
01486      :      CONVERTS FOUR BINARY CODED DECIMAL DIGITS
01487      :      TO A BINARY EQUIVALENT.  THE BCD DIGITS ARE
01488      :      PACKED TWO PER BYTE.  THE BINARY RESULT
01489      :      OCCUPIES TWO BYTES.  THE BCD DIGITS ARE LOADED
01490      :      INTO THE ACCA AND ACCB (MSD TO ACCA) AND THE
01491      :      BCDBIN SUBROUTINE IS CALLED.  THE ROUTINE EXITS
01492      :      WITH THE BINARY RESULT IN ACCA AND ACCB.
01493      :      (MODIFICATION 1.1)
01494      :
01495 29EB 9789      BCDBIN STA A   SAVE1      ;SAVE 2 MS BCD VALUES
01496 29ED 7F008A    CLR      BINUPR
01497 29F0 17       TBA
01498 29F1 C40F     AND B   #0FH      ;SAVE ONLY LS BCD VALUE
01499 29F3 44       LSR A           ;MOVE TENS BCD VALUE OF ACCA
01500 29F4 44       LSR A
01501 29F5 44       LSR A
01502 29F6 44       LSR A
01503 29F7 2705     TENLP BEQ     DOHUND   ;GO DO HUN WHEN TEN IS ZERO
01504 29F9 CB0A     ADD B   #10        ;ADD TEN TO BINARY TOTAL
01505 29FB 4A       DEC A           ;DECREMENT TENS DIGIT AND
01506 29FC 20F9     BRA      TENLP      ;REPEAT UNTIL ZERO
01507 29FE 0C       DOHUND CLC      ;RESET CARRY
01508 29FF 9689     LDA A   SAVE1      ;GET HUN AND THOU DIGIT
01509 2A01 840F     AND A   #0FH      ;SAVE ONLY HUN DIGIT
01510 2A03 270A     HUNLP BEQ     DOTHOU   ;GO DO THOU IF HUN IS ZERO
01511 2A05 CB64     ADD B   #100       ;ADD 100 TO BINARY VALUE
01512 2A07 2403     BCC     HUN00
01513 2A09 7C008A   INC      BINUPR    ;ADD 256 TO BIN UPPER VALUE
01514 2A0C 4A       HUN00 DEC A       ;DECREMENT HUN DIGIT OND
01515 2A0D 20F4     BRA      HUNLP      ;REPEAT UNTIL ZERO
01516 2A0F 9689     DOTHOU LDA A   SAVE1 ;GET THOU DIGIT
01517 2A11 44       LSR A           ;MOVE THOU BCD VALUE TO
01518 2A12 44       LSR A           ;LOWER FOUR BITS OF ACCA.
01519 2A13 44       LSR A
01520 2A14 44       LSR A
01521 2A15 9789     STA A   SAVE1      ;SAVE THOU DIGIT
01522 2A17 2504     BNE     THOU00     ;BRANCH IF THOU DIGIT IS ZERO
01523 2A19 968A     LDA A   BINUPR     ;GET BINARY UPPER VALUE
01524 2A1B 200C     BRA      XITBIN
01525 2A1D 968A     THOU00 LDA A   BINUPR ;GET BINARY UPPER VALUE
01526 2A1F 0C       THOULP CLC      ;RESET CARRY
01527 2A20 CEEB     ADD B   #232      ;ADD 232 TO BINARY LOWER
01528 2A22 8903     ADC A   #02H      ;ADD 768 TO BINARY UPPER
01529 2A24 7A0089   DEC      SAVE1    ;DECREMENT THOU DIGIT
01530 2A27 26F6     DNE     THOULP    ;REPEAT UNTIL THOU DIGIT ZERO
01531 2A29 39       XITBIN RTS
01532      :
01533      :      "TRIGAD" SUBROUTINE
01534      :      SCALES ANGLE TO BETWEEN 0 AND 90 DEGREES
01535      :      FINDS SINE AND COSINE OF ANGLE
01536      :      RETURNS WITH RESULT IN ACCA (SINE) AND ACCB (COSINE)
01537      :      (MODIFICATION 1.1)

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01533 01533 2A2A DF36      TRIGAD STX      TENPA
01539 01539 2A2C BC010F   CPX          #010EH
01540 01540 2A2C 2916     BVS          TRIGCA
01541 01541 2A2C 2916     LDA A      #01H
01542 01542 2A31 8601     LDA L      #601
01543 01543 2A33 C66B     SUB B      TEMPB
01544 01544 2A35 D037     SBC A      TENPA
01545 01545 2A37 9236     STA B      TEMPB
01546 01546 2A39 D737     STA A      TENPA
01547 01547 2A3D 9736     LDA B      #2BH
01548 01548 2A3D C62B     STA B      SSIGN
01549 01549 2A3F D7B7     LDA B      #2BH
01550 01550 2A41 C62D     STA B      CSIGN
01551 01551 2A43 D7B8     BRA          CSIGN
01552 01552 2A45 203A     BRA          CSIGN
01553 01553 2A47 3C00B4    CPX          #0034H
01554 01554 2A4A 2914     BVS          TRIGB
01555 01555 2A4C 8601     LDA A      #01H
01556 01556 2A4E C60E     SUB B      TEMPB
01557 01557 2A50 D037     SBC A      TENPA
01558 01558 2A52 9236     STA B      TEMPB
01559 01559 2A54 D737     STA A      TENPA
01560 01560 2A56 9736     LDA B      #2BH
01561 01561 2A58 C62D     STA B      SSIGN
01562 01562 2A5A D7B7     STA B      CSIGN
01563 01563 2A5C D7B8     BRA          CSIGN
01564 01564 2A5E 2021     BRA          CSIGN
01565 01565 2A60 6C005A    CPX          #005AH
01566 01566 2A63 2916     BVS          TRIGC
01567 01567 2A65 8600     LDA A      #00H
01568 01568 2A67 C6B4     SUB B      TEMPB
01569 01569 2A69 D037     SBC A      TENPA
01570 01570 2A6B 9236     STA B      TEMPB
01571 01571 2A6D D736     STA A      TENPA
01572 01572 2A6F 9736     LDA B      #2BH
01573 01573 2A71 C62D     STA B      CSIGN
01574 01574 2A73 D7B8     LDA B      #2BH
01575 01575 2A75 C62D     STA B      CSIGN
01576 01576 2A77 D7B7     BRA          CSIGN
01577 01577 2A79 2006     BRA          CSIGN
01578 01578 2A7B C62B     LDA B      #2BH
01579 01579 2A7D D7B7     STA B      SSIGN
01580 01580 2A7F D7B8     STA B      CSIGN
01581 01581 2A81 9636     LDA A      TENPA
01582 01582 2A83 B637     ADD B      TEMPB
01583 01583 2A85 BB37     ADD B      TEMPB
01584 01584 2A87 9936     ADC A      TENPA
01585 01585 2A89 FB2FA7    ADD B      TRIGTB+1; ADD TO BEGIN ADDRESS OF TABLE
01586 01586 2A8C B2FA6    ADC A      TRIGTB
01587 01587 2A8F 9736     STA A      TENPA
01588 01588 2A91 D737     STA B      TEMPB
01589 01589 2A93 DC36     LDX      TEMPB
01590 01590 2A95 A600     LDA A      0.X

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; SAVED UPDATED ANGLE
 ; COMPARES ANGLE TO 270 DEGREES
 ; BRANCHES IF ANGLE LESS THAN 270 DEGREES
 ; ANGLE IN 2ND QUADRANT
 ; GET 360 DEGREES
 ; 360 DEGREES MINUS (270 TO 359 DEGREES)
 ; DIFFERENCE BETWEEN 0 AND 90 DEGREES
 ; SAVE DIFFERENCE
 ; FIX PROPER SIGNS FOR CURRENT QUADRANT
 ; GO TO FIND SINE AND COSINE
 ; COMPARES ANGLE TO 180 DEGREES
 ; BRANCHES IF ANGLE LESS THAN 180 DEGREES
 ; ANGLE IN 3RD QUADRANT
 ; GET 270 DEGREES
 ; 270 DEGREES MINUS (180 TO 269 DEGREES)
 ; DIFFERENCE BETWEEN 0 AND 90 DEGREES
 ; SAVE DIFFERENCE
 ; FIX PROPER SIGNS FOR CURRENT QUADRANT
 ; GO TO FIND SINE AND COSINE
 ; COMPARES ANGLE TO 90 DEGREES
 ; BRANCHES IF ANGLE LESS THAN 90 DEGREES
 ; ANGLE IN 4TH QUADRANT
 ; GET 180 DEGREES
 ; 180 DEGREES MINUS (90 TO 179 DEGREES)
 ; DIFFERENCE BETWEEN 0 AND 90 DEGREES
 ; SAVE DIFFERENCE
 ; FIX PROPER SIGNS FOR CURRENT QUADRANT
 ; GO TO FIND SINE AND COSINE
 ; ANGLE ALREADY BETWEEN 0 AND 90 DEGREES
 ; FIX PROPER SIGNS FOR CURRENT QUADRANT
 ; GET PROCESSED ANGLE
 ; DOUBLE ANGLE
 ; ADD TO BEGIN ADDRESS OF TABLE
 ; STORE RESULT
 ; LOAD RESULT INTO INDEX REGISTER
 ; GET SINE


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01644 2AC7 A100      CMP A 0,X
01645 2AC9 2210      BHI SUBT
01646 2ACB 2604      BNE SWAP
01647 2ACD E101      CMP B 1,X
01648 2ACF 220A      BHI SUBT
01649 2AD1 37        SWAP PSH B
01650 2AD2 36        PSH A
01651 2AD3 7A0098     DEC CARRY
01652 2AD6 A600      LDA A 0,X
01653 2AD8 E601      LDA B 1,X
01654 2ADA 30        TSX
01655 2ADB 9736      SUBT STA A TEMPA
01656 2ADD D737      STA B TEMPB
01657 2ADF 8699      LDA A #99H
01658 2AE1 16        TAB
01659 2AE2 A901      SUB A 1,X
01660 2AE4 E090      SUB B 0,X
01661 2AE6 0D        SEC
01662 2AE7 9937      ADC A TEMPB
01663 2AE9 19        DAA
01664 2AEA 36        PSH A
01665 2AEB 17        TBA
01666 2AEC 9936      ADC A TEMPA
01667 2AEE 19        DAA
01668 2AEF 33        PUL B
01669 2AF0 7D0098     TST CARRY
01670 2AF3 2702      BEQ BACK
01671 2AF5 31        INS
01672 2AF6 31        INS
01673 2AF7 39        BACK RTS
01674
01675 : "SHAENC" SUBROUTINE
01676 : ROUTINE THAT TAKES CARE OF READING SHAFT ANGLE ENCODERS
01677 :
01678 2AF8 B68E01      SHAENC LDA A MSBSAZ ;READS AZIMUTH ANGLE
01679 2AFB F68E00      LDA B LSBSAZ
01680 2AFF 973C      STA A MSBENC ;STORES ANGLE IN TEMPORARY LOCATION
01681 2B00 D739      STA B LSBENC
01682 2B02 58        ASL B ;SCALE DAC OUTPUT BY A FACTOR OF 2
01683 2B03 49        ROL A
01684 2B04 B78-04     STA A DDBA2 ;OUTPUT MS 4 BITS OF AZ TO DAC
01685 2B07 F78406     STA B DDBB2 ;OUTPUT LS 8 BITS OF AZ TO DAC
01686 2B0A 9638      LDA A MSBENC ;GET OLD A AND B
01687 2B0C D639      LDA B LSBENC
01688 2B0E CE31F8     LDX #DIVISO
01689 2B11 BD2CAE      JSR DIVIDE ;DIVIDES ANGLE BY THE CONSTANT 14.912
01690 2B14 CE0045     LDX #AZBCD
01691 2B17 BD2C3D      JSR BINBCD ;RETURNS WITH A PACKED BCD NUMBER
01692 2B1A 36        PSH A
01693 2B1B 37        PSH B
01694
01695 :
01696 : ADDITION TO "SHAENC" SUBROUTINE
01697 : CHECKS BOTH POS AND NEG AZIMUTH LIMITS

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01697      ;
01698      ;
01699      2B1C D737      STA B TEMPB      ; SAVES ACCB TEMP
01700      2B1E D642      LDA B SIGN      ; START LIMIT CHECK
01701      2B20 F131FB    CMP B PLUS
01702      2B23 271C      DEQ P.L.
01703      2B25 D637      LDA B TEMPB      ; BRANCHES IF AZIMUTH COORDINATES ARE POSITIVE
01704      2B27 CE0091    LDX #IAZLIM      ; AZIMUTH COORDINATES ARE NEGATIVE
01705      2B2A D22AC4    JSR R2SUB      ; GET NEGATIVE AZIMUTH LIMIT
01706      2B2D 9698      LDA A CARRY      ; ACCX MINUS HAZLIM
01707      2B2F 261C      BNE SH22      ; BRANCHES IF THE ACCXS ARE LARGER THAN HAZLIM
01708      2B31 C6FF      LDA B #0FFH      ; POSITIONER HAS EXCEEDED THE LIMIT
01709      2B33 D794      STA B LFLAGA      ; SET AZIMUTH LIMIT FLAG
01710      2B35 CE3174    LDX #RSG15
01711      2B38 E2C22      JSR ASCDIS      ; DISPLAYS "ANGLE LIMIT EXCEEDED"
01712      2B3B D22ADB    JSR ALSTOP      ; BRANCHES TO STOP BOTH MOTORS
01713      2B3E 7E20B2    JET MSGB      ; RETURNS TO CONTROL LOOP AFTER 1 SEC. WAIT
01714      2B41 D637      LDA B TEMPB      ; CHECKING FOR POSITIVE AZIMUTH LIMIT
01715      2B43 CE008F    LDX #PAZLIM      ; GETTING POSITIVE AZIMUTH LIMIT
01716      2B45 D22AC4    JSR R2SUB      ; ACCXS MINUS PAZLIM
01717      2B49 9698      LDA A CARRY
01718      2B4B 27F4      DEQ PAL1
01719      2B4D 9642      LDA A SIGN
01720      2B4F 9743      STA A ASSIGN
01721      2B51 8641      LDA A #041H
01722      2B53 973A      STA A LETA
01723      2B55 C65A      LDA A #05AH
01724      2B57 973E      STA A LETB
01725      2B59 33      PUL B
01726      2B5A 32      PUL A
01727      2B5D CEC03F    LDX #ANGLE
01728      2B5E D22DLF    JSR BODDIS
01729      2B61 CE0090    LDX #013AZ
01730      2B64 ED2159    JSR ANC2
01731      ;
01732      2B67 F68E03      LDA A MSSEL
01733      2B6A F68E02      LDA B LSESEL
01734      2B6D 9738      STA A PBERC
01735      2B6F D739      STA B LBERC
01736      2B71 58      ASL B
01737      2B72 49      ROL A
01738      2B73 D73B69      STA A DPA3
01739      2B76 F73902      STA B DORB3
01740      2B79 9639      LDA A LBERC
01741      2B7B F639      LDA B LBERC
01742      2B7D CE31F3      LDX #DIVISO
01743      2B79 D22CAE      JSR DIVIDE
01744      2B83 CE0047      LDX #LEBCO
01745      2B86 D9203D      JSR DINEED
01746      2B89 35      PSH A
01747      2B8A 37      PSH B
01748      2B8B D737      STA B TEMPB
01749      2B8D 9642      LDA B SIGN

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01750 2B0F F131FB      CMP B PLUS
01751 2B92 2605      BNE SHA3
01752 2B94 F631FA      LDA B MINUS
01753 2B97 2003      BRA SHA4
01754 2B99 F631FB      LDA B PLUS
01755 2B9C 3742      STA E SIGN
01756
01757
01758
01759
01760
01761 2B9E D642      LDA B SIGN
01762 2BA0 F131FB      CMP B PLUS
01763 2BA3 D637      LDA B TEMPB
01764 2BA5 271A      BEQ PEL
01765 2BA7 CE008D      LDY #NELLIM
01766 2BA9 D02AC4      JSR BCDSUB
01767 2BAD 9693      LDA A CARRY
01768 2BAF 261C      BNE SHA1
01769 2BB1 C6FF      LDA B #OFFH
01770 2BB3 D793      STA B IPLACE
01771 2BB5 CE3174      LDY #MSG15
01772 2BB8 BD2C22      JSR ASCDIS
01773 2BBB BD2ABB      JSR ALSTOP
01774 2BBE 7E2082      JNP NSCB
01775 2BC0 (CL)*D637      PEL
01776 2BC3 CE008D      LDY #NELLIM
01777 2BC6 D02AC4      JSR BCDSUB
01778 2BC9 9698      LDA A CARRY
01779 2BCB 27E4      BEQ SHA
01780 2BCD 9642      LDA A SIGN
01781 2CCF 9744      STA A ELSIGN
01782 2BD1 8645      LDA A #045H
01783 2BD3 973A      STA A IETA
01784 2BD5 864C      LDA A #04CH
01785 2BD7 973B      STA A LETB
01786 2BD9 33      PUL B
01787 2BDA 32      PUL A
01788 2BDB CE003F      LDY #ANGLE
01789 2BDE ED2E2F      JSR DCDDIS
01790 2BE1 CE3C0A      LDY #DISCL
01791 2BE4 ED2D59      JSR ASC2
01792 2BE7 39      RTS
01793
01794
01795
01796
01797
01798
01799
01800 2BF8 9736      ADDCAL STA A TEMPB
01801 2BEA DF29      STX TEMPX
01802 2BEC 5F      CL" B

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ADDITION TO "SHAENC" SUBROUTINE.
 CHECKS BOTH POS AND NEG ELEVATION LIMITS
 (MODIFICATION 1.1)
 ; START LIMIT CHECK
 ; BRANCHES IF ELEVATION COORDINATE IS NEGATIVE
 ; GET NEGATIVE ELEVATION LIMIT
 ; ACCXS MINUS NELLIM
 ; BRANCHES IF THE ACCXS ARE LARGER THAN NELLIM
 ; POSITIONER HAS EXCEEDED THE LIMIT
 ; SET ELEVATION LIMIT FLAG
 ; DISPLAY "ANGLE LIMIT EXCEEDED"
 ; BRANCHES TO STOP BOTH MOTORS
 ; RETURN TO CONTROL LOOP AFTER 1 SEC. WAIT
 ; CHECKING POSITIVE ELEVATION LIMIT
 ; GETTING POSITIVE ELEVATION LIMIT
 ; ACCXS MINUS PELLIM
 ; UNPACKS BCD ANGLE
 ; DISPLAYS PACKED BCD ON PANEL
 ; "ADDCAL" SUBROUTINE
 ROUTINE THAT CALCULATES ADDRESSES FOR NEXT STATE
 ACCA CONTAINS VARIABLE INDEX.
 INDEX REG. CONTAINS CURRENT STATE TABLE
 ADDRESS FOR REFERENCING TEXT STATE.

```

01803 2DED 9E2A      ADD A  TEMPX+1
01804 2BEF D929      ADC B  TEMPX      ; ADDS KEYCODE TO INDEX REGISTER
01805 2BF1 D729      STA B  TEMPX
01806 2BF3 972A      STA A  TEMPX+1
01807 2BF5 DE29      LDX   TEMPX      ; UPDATES INDEX REGISTER
01808 2BF7 9636      LDA A  TEMPX
01809 2BF9 39        RTS
01810
01811      :
01812      : "UP" ROUTINE
01813      : INSTRUCTS EL. MOTOR TO GO UP (CCW)
01814 2BFA 965C      UP   LDA A  SPEEDE
01815 2BFC C600      LDA B  #0001
01816 2BFE BD2DE2    JSR   MOTEL
01817 2C01 7E20B7    JMP   STO
01818
01819      :
01820      : "DOWN" ROUTINE
01821      : INSTRUCTS EL. MOTOR TO GO DOWN (CW)
01822 2C04 965C      DOWN LDA A  SPEEDE
01823 2C06 C6FF      LDA B  #0FFF
01824 2C08 BD2DE2    JSR   MOTEL
01825 2C0B 7E20B7    JMP   STO
01826
01827      :
01828      : "LEFT" ROUTINE
01829      : INSTRUCTS AZ. MOTOR TO GO LEFT (CCW)
01830 2C0E 965B      LEFT LDA A  SPEEDA
01831 2C10 C600      LDA B  #000H
01832 2C12 DD2D36    JSR   MOTAZ
01833 2C15 7E2158    JMP   STOE
01834
01835      :
01836      : "RIGHT" ROUTINE
01837      : INSTRUCTS AZ. MOTOR TO GO RIGHT (CW)
01838 2C18 965B      RIGHT LDA A  SPEEDA
01839 2C1A C6FF      LDA B  #0FFF
01840 2C1C DD2D36    JSR   MOTAZ
01841 2C1F 7E2158    JMP   STOE
01842
01843      :
01844      : "ASCDIS" SUBROUTINE
01845      : DISPLAYS ASCII MSG. ON DISPLAY PANEL
01846      : INDEX REG. HAS STARTING ADDRESS OF MSG.
01847 2C22 DF49      ASCDIS STX   TEMPX1
01848 2C24 CFC000    LDX   #00000H
01849 2C27 DF4B      STX   TEMPX2
01850 2C29 DF49      OVER  LDX   TEMPX1
01851 2C2B A600      LDA A  0.0
01852 2C2D 08        INX
01853 2C2E DF49      STX   TEMPX1
01854 2C30 DF4B      LDX   TEMPX2
01855 2C32 A706      STA A  0.0

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01856	2C34 6C	LDX			
01857	2C35 F24B	STX	TEMP2		
01858	2C37 8C0014	CPX	#2014H		
01859	2C3A 265D	LDX	CPT1		
01860	2C3C 39	RTE			
01861					
01862					
01863					
01864					
01865					
01866					
01867					
01868					
01869					
01870					
01871					
01872					
01873					
01874					
01875	2C3D D532	BINBCD STX	SAVEX		; SAVE DATA POINTER
01876	2C3F 9736	STA A	TEMPA		
01877	2C41 D737	STA B	TEMPB		; SAVE ACCA AND ACB TEMPORARILY
01878	2C43 9638	LDA A	ISBENC		
01879	2C45 D639	LDA B	ISBENC		; SAVE THE 16-BIT SHAFT ANGLE CODE
01880	2C47 C09C	SUB B	#000H		
01881	2C49 8210	SBC A	#010H		
01882	2C4B 2B11	BMI	FNS		; BRANCH IF 16-BIT VALUE IS POSITIVE
01883	2C4D 863C	LDA A	#00CH		; 16-BIT VALUE MUST BE NEGATIVE
01884	2C4F C697	LDA B	#09FH		
01885	2C51 D037	SUB B	TEMPB		; AFTER SUBTRACT ACB WILL CONTAIN CORRECT VALUE
01886	2C53 9236	SBC A	TEMPA		; SUBTRACT 16-31T VALUE FROM 360 DEGREES
01887	2C55 9736	STA A	TEMPA		
01888	2C57 B631FA	LDA A	MINUS		
01889	2C5A 9742	STA A	SIGN		; SAVE ASCII VALUE OF MINUS SIGN
01890	2C5C 2007	BRA	POSN		
01891	2C5E B631FB	LDA A	PLUS		
01892	2C61 9742	STA A	SIGN		; SAVE ASCII VALUE OF PLUS SIGN
01893	2C63 B637	LDA B	TEMPB		; RESTORE ACB TO PROPER VALUE
01894	2C65 9636	LDA A	TEMPA		; RESTORE ACCA TO PROPER VALUE
01895	2C67 C631EC	LDY	#010K		; INITIALIZES INDEX REG. FOR FIRST BCD CONVERSION CONSTANT
01896	2C6A 7F0031	CVDEC1 CLR	SAVEA		; CLEAR BCD CONVERSION COUNTER
01897	2C6D E001	CVDEC2 SUB	B 1 X		
01898	2C6F A200	SEC	A 0 X		
01899	2C71 2505	BCS	CVDEC5		; BRANCH IF SUBTRACTION PRODUCES OVERFLOW
01900	2C73 7C0031	INC	SAVEA		; DECIMAL CHARACTER BEING BUILT, INCREMENT SAVEA
01901	2C76 20F5	BRA	CVDEC2		
01902	2C78 EL01	CVDEC5 ADD	B 1 X		
01903	2C7A A900	ADC	A 0 X		; RESTORES PARTIAL RESULT UPON OVERFLOW
01904	2C7C 36	PSH	A		; SAVES ACCA
01905	2C7D 7B003D	ASL	BCDB		; 16-BIT SHIFTS LEFT WITH ZERO FILL
01906	2C80 77003C	ROL	BCDA		
01907	2C83 7E003D	ASL	BCDB		; SO, NO NEED TO CLEAR EITHER REGISTER
01908	2C86 79003C	ROL	BCDA		

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01909 2C89 73003D ASL BCDB
01910 2C8C 73003C ROL BCDA
01911 2C8F 73003D ASL BCDB
01912 2C92 73003C ROL BCDA
01913 2C95 963D LDA A BCDB
01914 2C97 9B31 ADD A SAVEA
01915 2C99 973D STA A BCDB
01916 2C9B 24 PUL A
01917 2C9C 38 INX
01918 2C9D 08 INX
01919 2C9E 8C31F6 CPX *K10%+10 ; INCREMENTS INDEX REGISTER TO NEXT CONSTANT
01920 2CA1 26C7 BNE CVDCE1 ; TESTS TO SEE LAST CONSTANT HAS BEEN USED
01921 2CA3 963C LDA A BCDA ; BRANCHES IF LAST CHARACTER HAS NOT BEEN REACHED YET
01922 2CA5 963D LDA B BCDB
01923 2CA7 BE22 LDX SAVEX
01924 2CA9 A700 STA A 0.X
01925 2CAB E701 STA B 1.X ; SAVES 16-BIT PACKED BCD NUMBER
01926 2CAD 39 RTS
01927
01928 ; "DIVIDE" SUBROUTINE
01929 ; 15-BIT INTEGER DIVIDE ROUTINE
01930 ; REVISION 1.1
01931 ; LOAD ACCA, ACBB WITH 16-BIT DIVIDEND.
01932 ; LOAD INDEX REGISTER WITH 16-BIT DIVISOR.
01933 ; RETURNS WITH 16-BIT QUOTIENT IN ACCA, ACBB.
01934 ; THIS IS AN ASSUMED DIVIDE ROUTINE.
01935
01936 2CAE 9736 DIVIDE STA A TEMP A ; SAVES ACCA TEMPORARILY
01937 2CB0 8680 LDA A #000H
01938 2CB2 36 PSH A
01939 2CB3 36 PSH A
01940 2CB4 36 PSH A
01941 2CB5 36 PSH A
01942 2CB6 9636 LDA A TEMP A
01943 2CB8 37 PSH B
01944 2CB9 36 PSH A
01945 2CBA A500 LDA A 0.X
01946 2CBC E601 LDA B 1.X
01947 2CCE 37 PSH B
01948 2CBF 36 PSH A
01949 2CC0 2600 LDA A #000H
01950 2CC2 36 PSH A
01951 2CC3 36 PSH A
01952 2CC4 24 DES
01953 2CC5 30 TSK
01954 2CC6 2601 LDA A #1
01955 2CC8 6001 TST 1.X
01956 2CCA 210E BML DIV153
01957 2CCC 2C DIV151 INC A
01958 2CCD 6804 AGL 4.X
01959 2CCE 6903 ROL 3.X
01960 2CCE 6902 ROL 2.X
01961 2CD3 6901 ROL 1.X ; SHIFTS DIVISOR LEFT ONE BIT

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01963 2C05 2B04	BNI	DIV153	
01964 2C07 8121	CMR A		
01965 2C09 2B01	ENE	DIV151	: BRANCHES IF DIVISOR HAS BEEN SHIFTED LEFT 32 TIMES
01966 2C0B A700	DIV153 STA A 3,X		: SAVES SHIFT COUNT ON STACK
01967	: STACK LOGS LIKE THIS		
01968	: +0 3X COUNT		
01969	: +1 00 13 BYTE OF DIVISOR		
01970	: +2 00		
01971	: +3 3X		
01972	: +4 3X	LS BYTE OF DIVISOR	
01973	: +5 3X	MS BYTE OF DIVISOR	
01974	: +6 3X		
01975	: +7 00		
01976	: +8 00	LS BYTE OF DIVISOR	
01977	: +9 00	MS BYTE OF QUOTIENT	
01978	: +10 00	LS BYTE OF QUOTIENT	
01979	: +11 3X	MS BYTE OF RETURN ADDR.	
01980 2CDD A607	: +12 3X	LS BYTE OF RETURN ADDR.	
01981 2CDF E603	DIV163 LDA A 7,X		: BEGIN TO FORM NEW REMAINDER FROM OLD DIVISOR
01982 2CE1 E004	LDA B 8,X		
01983 2CE3 A203	SUB B 4,X		
01984 2CE5 A707	SBC A 3,X		
01985 2CE7 E703	STA A 7,X		
01986 2CE9 A605	STA B 8,X		
01987 2CEB E606	LDA A 5,X		
01988 2CEB E202	LDA B 6,X		
01989 2CEB A201	SBC B 2,X		
01990 2CF1 A705	SBC A 1,X		
01991 2CF3 E706	STA A 5,X		
01992 2CF5 C410	STA B 6,X		
01993 2CF7 A607	BCC DIV165		
01994 2CF9 E600	LDA A 7,X		
01995 2CFB E0A04	LDA B 8,X		
01996 2CFD A903	ADG B 4,X		
01997 2CFF A707	ADC A 3,X		
01998 2D01 E708	STA A 7,X		
01999 2D03 A605	STA B 8,X		
02000 2D05 E306	LDA A 5,X		
02001 2D07 E902	LDA B 6,X		
02002 2D09 A901	ADC B 2,X		
02003 2D0B A705	ADC A 1,X		
02004 2D0D E706	STA A 5,X		
02005 2D0F 07	STA B 6,X		
02006 2D10 2001	CLC		
02007 2D12 0D	LDA	DIV167	
02008 2D13 090A	SEC		
02009 2D15 0907	DIV167 ROL	10,X	
02010 2D17 6501	RCL	9,X	
02011 2D19 6602	LSR	1,X	
02012 2D1B 6603	ROR	2,X	
02013 2D1D 6604	ROR	3,X	
02014 2D1F 6A00	DEC	4,X	
		0,X	

: SUBTRACTS DIVISOR FROM DIVISOR

: BRANCHES IF NO BORROW FROM SUBTRACT

: BEGINS TO RESTORE REMAINDER TO PREVIOUS DIVISOR

: RESTORES LAST SUBTRACT OPERATION IN CASE OF BORROW

: SETS, ASSUMES BINARY 1 FOR THIS PART OF THE DIVIDE

: SHIFTS BINARY 1 OR 0 INTO LSB OF QUOTIENT

: SHIFTS DIVISOR RIGHT WITH ZERO FILL

: DECREMENT COUNT

```

02015 2021 25BA      BNE      DIV163      ; BRANCHES IF COUNT = 0
02016 2022 31      ILS
02017 2023 31      INS
02018 2024 31      INS
02019 2025 31      INS
02020 2026 31      INS
02021 2027 31      INS
02022 2028 31      INS
02023 2029 31      INS
02024 202A 31      INS
02025 202B 31      PUL A
02026 202C 32      PUL B
02027 202D 33      RTS
02028 202E 39
02029
02030
02031
02032
02033
02034
02035
02036
02037 202F 973C      BCDDIS STA A BCD A
02038 2031 8603      LDA A #3
02039 2033 973E      STA A SAVDEC
02040 2035 963C      LDA A BCD A
02041 2037 44      LSR A
02042 2038 56      ROR B
02043 2039 44      LSR A
02044 203A 56      ROR B
02045 203B 44      LSR A
02046 203C 56      ROR B
02047 203D 44      LSR A
02048 203E 56      ROR B
02049 203F 640F      AND A #00FH
02050 2041 8E30      ADD A #039H
02051 2043 47C0      STA A 0 X
02052 2045 7A902E      DEC SAVDEC
02053 2047 7B063E      TST SAVDEC
02054 204B 270B      BEV ASC3
02055 204D 58      ASL B
02056 204F 40      ROL A
02057 2051 F3      ASL B
02058 2053 43      ROL A
02059 2055 53      ASL B
02060 2057 49      ROL A
02061 2059 50      ASL B
02062 205B 40      ROL A
02063 205D 03      INC INZ
02064 205F 0E7      BRA ASC1
02065 2061 33      ASC3
02066
02067

```

; "BCD915" SUBROUTINE
 ; REVISION 1.1
 ; CONVERTS PACKED BCD ANGLES TO UNPACKED ASCII VALUES
 ; TO BE DISPLAYED IN AZ, EL FORMAT. INDEX REGISTER SHOULD
 ; CONTAIN STARTING ADDRESS OF WHERE INFORMATION SHOULD BE
 ; SAVALD. ROUTINE DESTROYS INITIAL ACCA, ACCB VALUES.
 ; (MODIFICATION 1.1)

; BCD915 SUBROUTINE
 ; STA A BCD A
 ; LDA A #3
 ; STA A SAVDEC
 ; LDA A BCD A
 ; LSR A
 ; ROR B
 ; LSR A
 ; ROR B
 ; LSR A
 ; ROR B
 ; LSR A
 ; ROR B
 ; AND A #00FH
 ; ADD A #039H
 ; STA A 0 X
 ; DEC SAVDEC
 ; TST SAVDEC
 ; BEV ASC3
 ; ASL B
 ; ROL A
 ; ASL B
 ; ROL A
 ; ASL B
 ; ROL A
 ; ASL B
 ; ROL A
 ; INC INZ
 ; BRA ASC1
 ; ASC3
 ; RTS

; "ASC2" SUBROUTINE
 ; STA A BCD A
 ; LDA A #3
 ; STA A SAVDEC
 ; LDA A BCD A
 ; LSR A
 ; ROR B
 ; LSR A
 ; ROR B
 ; LSR A
 ; ROR B
 ; AND A #00FH
 ; ADD A #039H
 ; STA A 0 X
 ; DEC SAVDEC
 ; TST SAVDEC
 ; BEV ASC3
 ; ASL B
 ; ROL A
 ; ASL B
 ; ROL A
 ; ASL B
 ; ROL A
 ; ASL B
 ; ROL A
 ; INC INZ
 ; BRA ASC1
 ; ASC3
 ; RTS

; SHIFTS PACKED BCD ANGLE RIGHT ONE BCD VALUE
 ; LOSING SECOND DECIMAL PLACE ACCURACY
 ; MASKS OFF BCD VALUE
 ; CONVERTS THIS VALUE TO ASCII
 ; DISPLAYS THAT BCD VALUE
 ; DECREMENTS UNPACKING COUNT
 ; BRANCHES IF PACKED BCD NUMBER IS COMPLETELY UNPACKED

; SHIFTS PACKED BCD NUMBER LEFT ONE BCD VALUE
 ; INCREMENTS TO NEXT DISPLAY LOCATION


```

02170 0E2A C601 LDA B #1
02175 2E2E D02E2E JSR B
0217C 2E2F C601 LDA B #001H
02177 2E31 F79E93 STA B #BSEL
0217D 2E33 F600 LDA B #000H
02179 2E36 F76D STA B #000H
02180 2E33 B78E92 SAME
02181 2E3B 976F STA A #000H
02182 2E3D 39 RTS
02183
02184
02185
02186
02187
02188
02189 2E3E CE4074 VAITE LDX #04074H
02190 2E41 00 VAITE1 BDX
02191 2E42 C6FD BNE VAITE1
02192 2E44 5A DEC B
02193 2E46 26F7 BNE VAITE
02194 2E47 39 RTS
02195
02196
02197
02198
02199 2E4C 36FF KEYBD LDA A #0FFH
02200 2E4A B78400 STA A D0RA
02201 2E4D B68400 LDA A D0RA
02202 2E50 8670 COLUMN LDA A #070H
02203 2E52 16 COLUMN TAB
02204 2E53 B78400 COLUMN STA A D0RA
02205 2E56 B68401 LDA A C0RA
02206 2E59 43 ASL A
02207 2E5A 2B11 BHI DECODE
02208 2E5C 330C BCS ROW
02209 2E5E C1E0 CMP B #0E0H
02210 2E60 C723 BEQ KI
02211 2E62 37 ASR B
02212 2E63 CAC0 ORA B #0B0H
02213 2E65 C4F0 AND B #0F0H
02214 2E67 17 TBA
02215 2E68 C0E9 BRA
02216 2E6A F68400 ROW LDA B D0RA
02217 2E6D CE2F6A DECODE LDX #KTABLE
02218 2E70 A600 DECODE1 LDA A 00K
02219 2E72 11 CBA
02220 2E73 270E BEQ
02221 2E76 3C2F7D CPX #TABLE5+19
02222 2E78 270E BEQ KI
02223 2E7A 09 INC
02224 2E7E 23E3 BRA
02225 2E7F A614 GTCHAR LDA A 20.X
02226 2E81 C6FF LDA B #0FFH

```

; WAITS .1 SECOND FOR DIRECTION HULAY TO CHANGE
 ; TURNS POWER ON, ORIENTED IN CCW (UP)
 ; REMEMBERS DIRECTION CHANGE BY SETTING DIRECTION FLAG
 ; CHANGES SPEED OF ELEVATION MOTOR
 ; UPDATE RECORD OF EL MOTOR SPEED
 ; "WAITE" SUBROUTINE
 ; DELAY IS IN HUNDREDS OF MILLISECONDS
 ; PLACE DESIRED DELAY IN ACCD
 ; THEN JUMP TO SUBROUTINE "WAITE"
 ;
 ; KEYBOARD SERVICE ROUTINE
 ; SERVICED ON INTERRUPT BASIS ONLY
 ;
 ; MAKE ALL FOUR ROWS OF KEYBOARD INOPERABLE
 ; NOW, CLEAR PIA FLAGS WITH MPU READ
 ; TURN ON ROW #1 OF KEYBD
 ; READ CONTROL REGISTER OF PIA #1
 ; BRANCH IF KEY IN FIFTH COLUMN IS SET
 ; BRANCH IF KEY IN COLUMNS 1-4 IS SET
 ; BRANCH IF NO KEY PRESSED, RESET PIA, RETURN FROM INTERRUPT
 ; PREPARES ACC3 FOR NEXT ROW READ
 ; BRANCH TO READ NEXT ROW
 ; READS D0RA IF KEY IN COLUMNS 1-4 WAS PRESSED
 ; BEGIN COMPARING KEYTABLE WITH KEY THAT WAS PRESSED
 ; FOUND MATCH BETWEEN KEYREAD AND KEYTABLE
 ; BRANCH IF NO MATCH IS FOUND
 ; BRANCH TO KEEP LOOKING FOR MATCH

```

02227 2E91 D76B STA B KFLAG ;SET FLAG TO KNOW WHEN KEY WAS PRESSED
02228 2E93 974F STA A KEYENT ;STORE THE KEYCODE OF THE KEY THAT WAS PRESSED
02229 2E95 860F LDA A #000H ;RESTORE KEYBOARD PIA
02230 2E97 B78400 STA A PDRA ;CLEAR PIA FLAG BY MPU READ
02231 2E9A 668400 LDA A DDBL
02232 2E9D 3D RTI
02233
;
; DISPLAY SERVICE ROUTINE
; ( INTERRUPT BASIS ONLY )
;
02234
02235
02236
02237 2E9E B68402 DISPL LDA A DDBB ;CLEAR PIA FLAG BY MPU READ
02238 2E91 7E70 LDX TEMPD
02239 2E93 8C0014 CPM #014H
02240 2E96 2709 B20 START ;BRANCH IF FIRST CHARACTER OF DISPLAY NEEDED
02241 2E98 4500 LDA A G.N
02242 2E9A B78402 STA A DDBB ;SUPPLY CHARACTER TO DISPLAY
02243 2E9D 08 INX ;INCREMENT CHARACTER COUNTER FOR DISPLAY
02244 2E9E DF70 STX TEMPD
02245 2EAO CB RTI
02246 2EAF CE0000 START LDX #000H
02247 2EAF 4600 LDA A G.N
02248 2EAF B78402 STA A DDBB
02249 2EAF 00 INX
02250 2EAA DF70 STX TEMPD
02251 2EAC B655 LDX A #005H
02252 2EAF B78403 STA A CRB ;MAKE PIA RESET BIT GO LOW TO RESET THE DISPLAY
02253 2EB1 8601 LDA A #1 ;WAIT ONE MILLISECOND
02254 2EB3 3D60 BSR ;
02255 2EB5 863D LDA A #03DH
02256 2EB7 B78403 STA A CRB ;MAKE PIA RESET BIT GO HIGH TO FINISH NEEDED RESET TO DISPLAY
02257 2EB8 3B WAIT LDA B #0A5H
02258 2EBB 6A5 BEC B
02259 2EBD 5A WAIT1 BNE WAIT1
02260 2EBE C6FD DEC A
02261 2EC0 4A BNE WAIT
02262 2EC1 C6F0 DEC A
02263 2EC3 39 RTS
02264
;
; "RCVR" SUBROUTINE
; ACLA RECEIVER HANDLER
; OCCURS ONLY AFTER RCVR INTERRUPT
; ( MODIFICATION 1.1 )
;
02265
02266
02267
02268
02269
02270 2EC4 B58409 RCVR LDA A ACLA ;GET CHARACTER
02271 2EC7 CE2F40 RCVDEC LDX CHARB ;LOAD POINTER TO COMMAND TABLE
02272 2ECA 5F CLR B
02273 2ECB A100 RCVRX CMP A 0.0
02274 2ECD 2600 BNE ;COMPARE WITH VALID COMMAND
02275 2ECF B72F STA B KEYENT ;NO MATCH. TRY ANOTHER ONE
02276 2ED1 86FF LDA A #0FFH ;LOAD KEYBOARD COMMAND
02277 2ED3 976D STA A KFLAG ;SET KEYENTRY FLAG
02278 2ED5 2607 BNE ;RETURN FROM SUBROUTINE
02279 2ED7 00 ;MAKE NEXT COMPARISON AVAILABLE
02280 2ED7 00

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02230 2ED3 5C      INC B      ; HAVE NEXT CODE
02231 2ED3 5C      INC B      ; HAVE NEXT CODE
02232 2ED3 6120    CIP B      ; TABLE END ?
02233 2ED3 26ED    BNE ROUTEX ; NO
02234 2ED3 39      REWIND R7   ; RETURN FROM SUBROUTINE, DONT GO INTO PCOMND
02285             ;
02286             ; "PCOMND" SUBROUTINE
02287             ; TRANSFERS DISPLAY CONTENTS TO SERIAL INTERFACE BUFFER
02288             ; TO BE SENT OUT.
02289             ; (MODIFICATION 1.1)
02290             ;
PCOMND LDX #SUBR ; INITIALIZE VARIABLE WITH BEGINNING
STX CHART ; ADDRESS OF SERIAL INTERFACE BUFFER
STX SAVEZ2 ;
CLR TEMP1 ; INITIALIZE VARIABLE TO BEGINNING ADDRESS OF DISPLAY BUFFER
CLR TEMP2 ;
LDX A 0,X ; GET NEXT ADDRESS OF DISPLAY BUFFER
LDX A 0,X ; FETCH ONE BYTE CONSTANT
INX ; INCREMENT DISPLAY BUFFER ADDRESS
STX TEMP1 ; SAVE ADDRESS OF NEXT BYTE
LDX SAVEZ2 ; GET NEXT ADDRESS OF SERIAL INTERFACE BUFFER
STA A 0,X ; PUT BYTE INTO BUFFER
INX ; INCREMENT SERIAL INTERFACE BUFFER ADDRESS
STX SAVEZ2 ; SAVE ADDRESS OF NEXT BYTE
CPX #SUBR+20 ; SAVE ADDRESS OF NEXT BYTE
BNE NCOM1 ; NO
LDX #SUBR ;
JSR SEND
RTS

;
; "SEND" SUBROUTINE
; MESSAGE INITIATOR FOR INTERRUPT
; DRIVER ACIA TRANSMIT ROUTINE
; X POINTS TO MESSAGE. B=NO. OF BYTE
; (MODIFICATION 1.1)
;
SEND STX CHART ; UPDATE CHARACTER POINTER
STA B ; CHART ; SET BYTE COUNT
LDA A #0FFH ;
STA A MSGFLG ; SET MESSAGE FLAG
LDA A #0A1H ;
STA A ACIAS ; TURN ON TXHT INTERRUPT
CLR CURRUM ;
RTS

;
; "TXHT" SUBROUTINE
; INTERRUPT DRIVER ACIA TRANSMITTER
; (MODIFICATION 1.1)
;
TXHT LDA B CHART ; GET NUMBER OF CHARACTERS TO BE TRANSMITTED
LDX CHART ; GET CHARACTER LENGTH
CIP B C'CURRUM ;

```

```

02330 2F1F 270D      BEQ      MSGDON      ;CHRNUM = CHARCT
02331 2F21 A600      LDA      A 0,N
02332 2F23 273409     STA      A ACIAD      ; INSERT ONE BYTE INTO ACIA DATA REGISTER
02333 2F25 69        INZ
02337 2F27 DF2C      STX      CHAAPT      ;SAVE UPDATED VALUE
02338 2F29 7C0630     INC      CHRNUM      ;UPDATE CURRENT # OF HOW MANY BYTES HAVE BEEN SENT OUT
02339 2F2C 2003      BRA      TXEND      ;RETURN FROM SUBROUTINE
02340 2F2E BB2E0F     MSGDON JSR      MSGDON      ;RESTART MESSAGE
02341 2F31 59        TXEND RTS
02342
02343      ;
02344      ; INTERRUPT SERVICING ROUTINE
02345      ; (MODIFICATION 1.1)
02346      ;
02347      ; INT
02348      ; LDA A CRA
02349      ; BPL A DBR2
02350      ; BHI INT1
02351      ; LDA A ACIAD
02352      ; STA A ACIAS
02353      ; JMP KEYBD
02354      ; LDA A DBR2
02355      ; LDA A ACIAS
02356      ; BPL INT3
02357      ; LDA D DBR2
02358      ; BPL INT3
02359      ; ASR A
02360      ; BCC INT2
02361      ; JSR RCVR
02362      ; LDA A ACIAS
02363      ; ASR A
02364      ; BCC INT3
02365      ; BCC TXMIT
02366      ; JSR TXMIT
02367      ; BRA INT4
02368      ; LDA A ACIAD
02369      ; RTI
02370      ;
02371      ; BEGIN TABLE FOR KEYBOARD
02372      ;
02373      ; KTABLE BYTE 077H,07DH,07EH,07FH,0B7H,0BBH,0BDH,0BEH,0B0H
02374      ; 097H,09BH,09DH,09EH,0B7H,0B9H,0BDH,0BEH,0E0H
02375      ; 0147H,016H,00EH,010H,012H,016H,01AH,00EH,00AH,00CH
02376      ; 01CH,01EH,002H,004H,006H,020H,022H,000H,024H,026H
02377      ;
02378      ; 777B7D7E
02379      ; 70E7BDD
02380      ; 7F72
02381      ; 70E7BDD
02382      ; 7F72
02383      ; 70E7BDD
02384      ; 7F72
02385      ; 70E7BDD
02386      ; 7F72
02387      ; 70E7BDD
02388      ; 7F72
02389      ; 70E7BDD
02390      ; 7F72
02391      ; 70E7BDD
02392      ; 7F72
02393      ; 70E7BDD
02394      ; 7F72
02395      ; 70E7BDD
02396      ; 7F72
02397      ; 70E7BDD
02398      ; 7F72
02399      ; 70E7BDD
02400      ; 7F72
02401      ; 70E7BDD
02402      ; 7F72
02403      ; 70E7BDD
02404      ; 7F72
02405      ; 70E7BDD
02406      ; 7F72
02407      ; 70E7BDD
02408      ; 7F72
02409      ; 70E7BDD
02410      ; 7F72
02411      ; 70E7BDD
02412      ; 7F72
02413      ; 70E7BDD
02414      ; 7F72
02415      ; 70E7BDD
02416      ; 7F72
02417      ; 70E7BDD
02418      ; 7F72
02419      ; 70E7BDD
02420      ; 7F72
02421      ; 70E7BDD
02422      ; 7F72
02423      ; 70E7BDD
02424      ; 7F72
02425      ; 70E7BDD
02426      ; 7F72
02427      ; 70E7BDD
02428      ; 7F72
02429      ; 70E7BDD
02430      ; 7F72
02431      ; 70E7BDD
02432      ; 7F72
02433      ; 70E7BDD
02434      ; 7F72
02435      ; 70E7BDD
02436      ; 7F72
02437      ; 70E7BDD
02438      ; 7F72
02439      ; 70E7BDD
02440      ; 7F72
02441      ; 70E7BDD
02442      ; 7F72
02443      ; 70E7BDD
02444      ; 7F72
02445      ; 70E7BDD
02446      ; 7F72
02447      ; 70E7BDD
02448      ; 7F72
02449      ; 70E7BDD
02450      ; 7F72
02451      ; 70E7BDD
02452      ; 7F72
02453      ; 70E7BDD
02454      ; 7F72
02455      ; 70E7BDD
02456      ; 7F72
02457      ; 70E7BDD
02458      ; 7F72
02459      ; 70E7BDD
02460      ; 7F72
02461      ; 70E7BDD
02462      ; 7F72
02463      ; 70E7BDD
02464      ; 7F72
02465      ; 70E7BDD
02466      ; 7F72
02467      ; 70E7BDD
02468      ; 7F72
02469      ; 70E7BDD
02470      ; 7F72
02471      ; 70E7BDD
02472      ; 7F72
02473      ; 70E7BDD
02474      ; 7F72
02475      ; 70E7BDD
02476      ; 7F72
02477      ; 70E7BDD
02478      ; 7F72
02479      ; 70E7BDD
02480      ; 7F72
02481      ; 70E7BDD
02482      ; 7F72
02483      ; 70E7BDD
02484      ; 7F72
02485      ; 70E7BDD
02486      ; 7F72
02487      ; 70E7BDD
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03000      ; 7F72

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02378      :      ASCII COMMAND TABLE
02379      :
02380 2F92 30312233 CHARTB ASCII  "0123456789"
02380 2F96 34353637
02380 2F9A 3839
02381 2F9C 44354C52      ASCII  "DUT.RAEPs.-"
02381 2FA0 41455053
02381 2FA4 2E2D
02382      :
02383      :      BEGIN TRIG. TABLE FOR SINE AND COSINE VALUES
02384      :      THESE VALUES ARE BETWEEN 0-90 DEGREES.
02385      :      (MODIFICATION 1.1)
02386      :
02387 2FA6 00990199 TRIGTB BYTE  00H,99H, 01H,99H, 03H,99H, 05H,99H, 07H,99H
02387 2FAA 02990599
02387 2FAE 0799
02388 2FB0 08991099      BYTE  08H,99H, 10H,99H, 12H,99H, 13H,99H, 15H,98H
02388 2FB4 12991399
02388 2FB8 1599
02389 2FBA 17981998      BYTE  17H,98H, 19H,98H, 20H,97H, 22H,97H, 24H,97H
02389 2FBE 20972297
02389 2FC2 2497
02390 2FC4 25962796      BYTE  25H,96H, 27H,96H, 29H,95H, 30H,95H, 32H,94H
02390 2FC8 29953095
02390 2FCC 3294
02391 2FCE 34943593      BYTE  34H,94H, 35H,93H, 37H,92H, 39H,92H, 40H,91H
02391 2FD2 37923992
02391 2FD6 4091
02392 2FD8 42904389      BYTE  42H,90H, 43H,89H, 45H,89H, 46H,88H, 48H,87H
02392 2FDC 45894688
02392 2FE0 4887
02393 2FE2 50865185      BYTE  50H,86H, 51H,85H, 53H,84H, 54H,83H, 55H,82H
02393 2FE6 53845483
02393 2FEA 5582
02394 2FEC 57815880      BYTE  57H,81H, 58H,80H, 60H,79H, 61H,78H, 62H,77H
02394 2FF0 60796178
02394 2FF4 6277
02395 2FF6 64766575      BYTE  64H,76H, 65H,75H, 66H,74H, 68H,73H, 69H,71H
02395 2FFA 66746773
02395 2FFE 6971
02396 3000 70707160      BYTE  70H,70H, 71H,69H, 73H,68H, 74H,66H, 75H,65H
02396 3004 73687466
02396 3008 7565
02397 300A 76647762      BYTE  76H,64H, 77H,62H, 78H,61H, 79H,60H, 30H,58H
02397 300E 78617960
02397 3012 8058
02398 3014 81578255      BYTE  81H,57H, 82H,55H, 83H,54H, 84H,53H, 85H,51H
02398 3018 82548353
02398 301C 8551
02399 301E 86508748      BYTE  86H,50H, 87H,48H, 88H,46H, 89H,45H, 59H,43H
02399 3022 88468945
02399 3026 8943
02400 3028 90429140      BYTE  90H,42H, 91H,40H, 92H,39H, 92H,37H, 93H,35H

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02400	302C	92399237		
02400	3030	9335		
02401	3032	94349432	BYTE	94H,34H, 94H,32H, 95H,30H, 95H,29H, 96H,27H
02401	3036	95309529		
02401	303A	9627		
02402	303C	96259724	BYTE	96H,25H, 97H,24H, 97H,22H, 97H,20H, 98H,19H
02402	3040	97229720		
02402	3044	9819		
02403	3046	98179815	BYTE	98H,17H, 98H,15H, 99H,13H, 99H,12H, 99H,10H
02403	304A	99139912		
02403	304E	9910		
02404	3050	99089907	BYTE	99H,08H, 99H,07H, 99H,05H, 99H,03H, 99H,01H
02404	3054	99059903		
02404	3058	9901		
02405	305A	9900	BYTE	99H,00H
02406				
02407				
02408				
02409	305C	454E5452	MSG1	ASCII "ENTR ELEVATION ANGLE"
02409	3060	20454C45		
02409	3064	56415449		
02409	3068	4F4E2041		
02409	306C	4E474C45		
02410	3070	454E5445	MSG2	ASCII "ENTER AZIMUTH ANGLE-"
02410	3074	5220415A		
02410	3078	494D5554		
02410	307C	4820414E		
02410	3080	474C452D		
02411	3084	20202020	MSG3	ASCII "
02411	3088	20202020		
02411	308C	20202020		
02411	3090	20202020		
02411	3094	20202020		
02412	3098	4552524F	MSG4	ASCII "ERROR..INVALID ENTRY"
02412	309C	522E2E49		
02412	30A0	4E56414C		
02412	30A4	49442045		
02412	30A8	4E545259		
02413	30AC	5241444F	MSG5	ASCII "RADOME POS. READY..."
02413	30B0	4D452050		
02413	30B4	4F532E20		
02413	30B8	52454144		
02413	30BC	592E2E2E		
02414	30C0	415A494D	MSG6	ASCII "AZIMUTH "
02414	30C4	55544620		
02414	30C8	20202020		
02414	30CC	20202020		
02414	30D0	20202020		
02415	30D4	454C4556	MSG7	ASCII "ELEVATION "
02415	30D8	4154494F		
02415	30DC	4E202020		
02415	30E0	20202020		
02415	30E4	20202020		

02416	30E8	414E474C	MSG8	ASCII	"ANGLE TOO LARGE....."
02416	30EC	4520544F			
02416	30F0	4F204C41			
02416	30F4	5247452E			
02416	30F8	2E2E2E2E			
02417	30FC	454E5445	MSG9	ASCII	"ENTER PROGRAM NUMBER"
02417	3100	52205052			
02417	3104	4F475241			
02417	3108	4D204E55			
02417	310C	4D424552			
02418	3110	50524F47	MSG10	ASCII	"PROC @DENTER "
02418	3114	20203A45			
02418	3118	4E544552			
02418	311C	20202020			
02418	3120	20202020			
02419	3124	504F5349	MSG11	ASCII	"POSITIONER HALTED "
02419	3128	54494F4E			
02419	312C	45522048			
02419	3130	414C5445			
02419	3134	44202020			
02420	3138	54484520	MSG12	ASCII	"THE GA. TECH-RFSS "
02420	313C	47412E20			
02420	3140	54454348			
02420	3144	2D524653			
02420	3148	53202020			
02421	314C	5241444F	MSG13	ASCII	"RADOME POSITIONER "
02421	3150	4D452050			
02421	3154	4F534954			
02421	3158	494F4E45			
02421	315C	52202020			
02422	3160	20202020	MSG14	ASCII	" VERSION 1.1 "
02422	3164	20564552			
02422	3168	53494F4E			
02422	316C	20312E31			
02422	3170	20202020			
02423	3174	414E474C	MSG15	ASCII	"ANGLE LIMIT EXCEEDED"
02423	3178	45204C49			
02423	317C	4D495420			
02423	3180	45584345			
02423	3184	45444544			
02424	3188	4E454720	MSG16	ASCII	"NEG EL LIMIT "
02424	318C	454C204C			
02424	3190	494D4954			
02424	3194	20202020			
02424	3198	20202020			
02425	319C	504F5320	MSG17	ASCII	"POS EL LIMIT "
02425	31A0	454C204C			
02425	31A4	494D4954			
02425	31A8	20202020			
02425	31AC	20202020			
02426	31B0	4E454720	MSG18	ASCII	"NEG AZ LIMIT "
02426	31B4	415A204C			
02426	31B8	494D4954			

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02426 31BC 20202020
02426 31C0 20202020
02427 31C4 504F5320 MSG19 ASCII "POS AZ LIMIT "
02427 31CB 415A204C
02427 31CC 494D4954
02427 31D0 20202020
02427 31D4 20202020
02428 31D8 56414C49 MSG20 ASCII "VALID COMMAND RCVD "
02428 31DC 4420434F
02428 31E0 4D4D414E
02428 31E4 44205C43
02428 31E8 56454420
02429 ;
02430 ; BEGIN ROM CONSTANTS
02431 ;
02432 31EC 2710 K10K WORD 10000
02433 31EE 03E8 WORD 1000
02434 31F0 0064 WORD 100
02435 31F2 000A WORD 10
02436 31F4 0001 WORD 1
02437 31F6 4010 LIMIT WORD 04010H
02438 31F8 3A40 DIVISO WORD 03A40H
02439 31FA 2D MINUS BYTE 02DE
02440 31FB 2B PLUS BYTE 02BH
02441 31FC 20 BLANK BYTE 020H
02442 31FD 27 DEGMR BYTE 027H
02443 31FE 2E POINT BYTE 02EH
02444 ;
02445 ; BEGIN STATE TABLE ADDRESSES
02446 ;
02447 31FF 2282 SP0 WORD ST5 ;KEY 0
02448 3201 2282 WORD ST5 ;KEY 1
02449 3203 2282 WORD ST5 ;KEY 2
02450 3205 2282 WORD ST5 ;KEY 3
02451 3207 2282 WORD ST5 ;KEY 4
02452 3209 2282 WORD ST5 ;KEY 5
02453 320B 2282 WORD ST5 ;KEY 6
02454 320D 2282 WORD ST5 ;KEY 7
02455 320F 2282 WORD ST5 ;KEY 8
02456 3211 2282 WORD ST5 ;KEY 9
02457 3213 21D6 WORD ST1 ;KEY DOWN
02458 3215 2201 WORD ST2 ;KEY UP
02459 3217 222C WORD ST3 ;KEY LEFT
02460 3219 2257 WORD ST4 ;KEY RIGHT
02461 321B 22A2 WORD ST10 ;KEY SET AZ
02462 321D 22CE WORD ST11 ;KEY SET EL
02463 321F 243F WORD ST20 ;KEY PRCG
02464 3221 23F9 WORD ST19 ;KEY START/STOP
02465 3223 2282 WORD ST5 ;KEY DECIMAL POINT
02466 3225 2282 WORD ST5 ;KEY MINUS SIGN
02467 3227 22FA SP10 WORD ST12 :0
02468 3229 22FA WORD ST12 :1
02469 322B 22FA WORD ST12 :2

```

02470	322D	22FA	WORD	ST12	:3
02471	322F	22FA	WORD	ST12	:4
02472	3231	22FA	WORD	ST12	:5
02473	3233	22FA	WORD	ST12	:6
02474	3235	22FA	WORD	ST12	:7
02475	3237	22FA	WORD	ST12	:8
02476	3239	22FA	WORD	ST12	:9
02477	323B	2262	WORD	ST5	:DOWN
02478	323D	2282	WORD	ST5	:UP
02479	323F	225C	WORD	ST32	:LEFT
02480	3241	22EF	WORD	ST33	:RIGHT
02481	3243	22A2	WORD	ST10	:SET AZ
02482	3245	22CE	WORD	ST11	:SET EL
02483	3247	243F	WORD	ST20	:PROC
02484	3249	20B7	WORD	ST0	:START/STOP
02485	324B	2382	WORD	ST16	:DECIMAL POINT
02486	324D	2322	WORD	ST13	:MINUS SIGN
02487	324F	22FA	SP11 WORD	ST12	:0
02488	3251	22FA	WORD	ST12	:1
02489	3253	22FA	WORD	ST12	:2
02490	3255	22FA	WORD	ST12	:3
02491	3257	22FA	WORD	ST12	:4
02492	3259	22FA	WORD	ST12	:5
02493	325B	22FA	WORD	ST12	:6
02494	325D	22FA	WORD	ST12	:7
02495	325F	22FA	WORD	ST12	:8
02496	3261	22FA	WORD	ST12	:9
02497	3263	27F6	WORD	ST30	:DOWN
02498	3265	2829	WORD	ST31	:UP
02499	3267	2282	WORD	ST5	:LEFT
02500	3269	2282	WORD	ST5	:RIGHT
02501	326B	22A2	WORD	ST10	:SET AZ
02502	326D	22CE	WORD	ST11	:SET EL
02503	326F	243F	WORD	ST20	:PROC
02504	3271	20B7	WORD	ST0	:START/STOP
02505	3273	2382	WORD	ST16	:DECIMAL POINT
02506	3275	2322	WORD	ST13	:MINUS SIGN
02507	3277	2361	SP12 WORD	ST15	:0
02508	3279	2361	WORD	ST15	:1
02509	327B	2361	WORD	ST15	:2
02510	327D	2361	WORD	ST15	:3
02511	327F	2361	WORD	ST15	:4
02512	3281	2361	WORD	ST15	:5
02513	3283	2361	WORD	ST15	:6
02514	3285	2361	WORD	ST15	:7
02515	3287	2361	WORD	ST15	:8
02516	3289	2361	WORD	ST15	:9
02517	328B	2282	WORD	ST5	:DOWN
02518	328D	2282	WORD	ST5	:UP
02519	328F	2282	WORD	ST5	:LEFT
02520	3291	2282	WORD	ST5	:RIGHT
02521	3293	22A2	WORD	ST10	:SET AZ
02522	3295	22CE	WORD	ST11	:SET EL

AD-A166 821

**RADOME POSITIONER FOR THE RFSS (RADIO FREQUENCY
SIMULATION SYSTEM)(U) GEORGIA INST OF TECH ATLANTA
ENGINEERING EXPERIMENT STATION D O GALLENTINE ET AL.
27 FEB 78 DAAK40-77-C-0047 F/G 17/9**

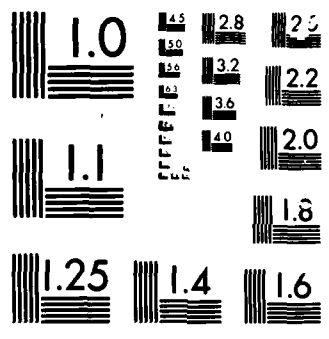
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UNCLASSIFIED

F/G 17/9

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[illegible]



MICROCOPY

CHART

02523	3297	243F	WORD	ST20	:PROG
02524	3299	20B7	WORD	ST0	:START/STOP
02525	329B	2382	WORD	ST16	:DECIMAL POINT
02526	329D	2282	WORD	ST5	:MINUS SIGN
02527	329F	2340	SP13 WORD	ST14	:0
02528	32A1	2340	WORD	ST14	:1
02529	32A3	2340	WORD	ST14	:2
02530	32A5	2340	WORD	ST14	:3
02531	32A7	2340	WORD	ST14	:4
02532	32A9	2340	WORD	ST14	:5
02533	32AB	2340	WORD	ST14	:6
02534	32AD	2340	WORD	ST14	:7
02535	32AF	2340	WORD	ST14	:8
02536	32B1	2340	WORD	ST14	:9
02537	32B3	2282	WORD	ST5	:DOWN
02538	32B5	2282	WORD	ST5	:UP
02539	32B7	2282	WORD	ST5	:LEFT
02540	32B9	2282	WORD	ST5	:RIGHT
02541	32BB	22A2	WORD	ST10	:SET AZ
02542	32BD	22CE	WORD	ST11	:SET EL
02543	32BF	243F	WORD	ST20	:PROG
02544	32C1	20B7	WORD	ST0	:START/STOP
02545	32C3	2382	WORD	ST16	:DECIMAL POINT
02546	32C5	2282	WORD	ST5	:MINUS SIGN
02547	32C7	2361	SP14 WORD	ST15	:0
02548	32C9	2361	WORD	ST15	:1
02549	32CB	2361	WORD	ST15	:2
02550	32CD	2361	WORD	ST15	:3
02551	32CF	2361	WORD	ST15	:4
02552	32D1	2361	WORD	ST15	:5
02553	32D3	2361	WORD	ST15	:6
02554	32D5	2361	WORD	ST15	:7
02555	32D7	2361	WORD	ST15	:8
02556	32D9	2361	WORD	ST15	:9
02557	32DB	2282	WORD	ST5	:DOWN
02558	32DD	2282	WORD	ST5	:UP
02559	32DF	2282	WORD	ST5	:LEFT
02560	32E1	2282	WORD	ST5	:RIGHT
02561	32E3	22A2	WORD	ST10	:SET AZ
02562	32E5	22CE	WORD	ST11	:SET EL
02563	32E7	243F	WORD	ST20	:PROG
02564	32E9	20B7	WORD	ST0	:START/STOP
02565	32EB	2382	WORD	ST16	:DECIMAL POINT
02566	32ED	2282	WORD	ST5	:MINUS SIGN
02567	32EF	2290	SP15 WORD	ST6	:0
02568	32F1	2290	WORD	ST6	:1
02569	32F3	2290	WORD	ST6	:2
02570	32F5	2290	WORD	ST6	:3
02571	32F7	2290	WORD	ST6	:4
02572	32F9	2290	WORD	ST6	:5
02573	32FB	2290	WORD	ST6	:6
02574	32FD	2290	WORD	ST6	:7
02575	32FF	2290	WORD	ST6	:8

02576	3301	2290	WORD	ST6	: 9
02577	3303	2282	WORD	ST3	: DOWN
02578	3305	2282	WORD	ST3	: UP
02579	3307	2282	WORD	ST3	: LEFT
02580	3309	2282	WORD	ST3	: RIGHT
02581	330B	22A2	WORD	ST10	: SET AZ
02582	330D	22CE	WORD	ST11	: SET EL
02583	330F	243F	WORD	ST20	: PROC
02584	3311	20B7	WORD	ST0	: START/STOP
02585	3313	2382	WORD	ST16	: DECIMAL POINT
02586	3315	2282	WORD	ST3	: MINUS SIGN
02587	3317	239E	SP16 WORD	ST17	: 0
02588	3319	239E	WORD	ST17	: 1
02589	331B	239E	WORD	ST17	: 2
02590	331D	239E	WORD	ST17	: 3
02591	331F	239E	WORD	ST17	: 4
02592	3321	239E	WORD	ST17	: 5
02593	3323	239E	WORD	ST17	: 6
02594	3325	239E	WORD	ST17	: 7
02595	3327	239E	WORD	ST17	: 8
02596	3329	239E	WORD	ST17	: 9
02597	332B	2282	WORD	ST5	: DOWN
02598	332D	2282	WORD	ST5	: UP
02599	332F	2282	WORD	ST5	: LEFT
02600	3331	2282	WORD	ST5	: RIGHT
02601	3333	22A2	WORD	ST10	: SET AZ
02602	3335	22CE	WORD	ST11	: SET EL
02603	3337	243F	WORD	ST20	: PROC
02604	3339	20B7	WORD	ST0	: START/STOP
02605	333B	2282	WORD	ST5	: DECIMAL POINT
02606	333D	2282	WORD	ST5	: MINUS SIGN
02607	333F	2282	SP17 WORD	ST5	: 0
02608	3341	2282	WORD	ST5	: 1
02609	3343	2282	WORD	ST5	: 2
02610	3345	2282	WORD	ST5	: 3
02611	3347	2282	WORD	ST5	: 4
02612	3349	2282	WORD	ST5	: 5
02613	334B	2282	WORD	ST5	: 6
02614	334D	2282	WORD	ST5	: 7
02615	334F	2282	WORD	ST5	: 8
02616	3351	2282	WORD	ST5	: 9
02617	3353	2282	WORD	ST3	: DOWN
02618	3355	2282	WORD	ST3	: UP
02619	3357	2282	WORD	ST3	: LEFT
02620	3359	2282	WORD	ST3	: RIGHT
02621	335B	22A2	WORD	ST10	: SET AZ
02622	335D	22CE	WORD	ST11	: SET EL
02623	335F	243F	WORD	ST20	: PROC
02624	3361	23ED	WORD	ST13	: START/STOP
02625	3363	2282	WORD	ST5	: DECIMAL POINT
02626	3365	2282	WORD	ST5	: MINUS SIGN
02627	3367	2282	SP20 WORD	ST5	: 0
02628	3369	2469	WORD	ST21	: 1

02629	336B	2469	WORD	ST21	:2
02630	336D	2469	WORD	ST21	:3
02631	336F	2469	WORD	ST21	:4
02632	3371	2282	WORD	ST5	:5
02633	3373	2282	WORD	ST5	:6
02634	3375	2282	WORD	ST5	:7
02635	3377	2282	WORD	ST5	:8
02636	3379	2282	WORD	ST5	:9
02637	337B	2282	WORD	ST5	:DOWN
02638	337D	2282	WORD	ST5	:UP
02639	337F	2282	WORD	ST5	:LEFT
02640	3381	2282	WORD	ST5	:RIGHT
02641	3383	22A2	WORD	ST10	:SET AZ
02642	3385	22CE	WORD	ST11	:SET EL
02643	3387	243F	WORD	ST20	:PROC
02644	3389	20B7	WORD	ST0	:START/STOP
02645	338B	2282	WORD	ST5	:DECIMAL POINT
02646	338D	2282	WORD	ST5	:MINUS SIGN
02647	338F	2489	SP21 WORD	ST22	:0
02648	3391	2489	WORD	ST22	:1
02649	3393	2489	WORD	ST22	:2
02650	3395	2489	WORD	ST22	:3
02651	3397	24C9	WORD	ST22	:4
02652	3399	2489	WORD	ST22	:5
02653	339B	2489	WORD	ST22	:6
02654	339D	2489	WORD	ST22	:7
02655	339F	2489	WORD	ST22	:8
02656	33A1	2489	WORD	ST22	:9
02657	33A3	2282	WORD	ST5	:DOWN
02658	33A5	2282	WORD	ST5	:UP
02659	33A7	2282	WORD	ST5	:LEFT
02660	33A9	2282	WORD	ST5	:RIGHT
02661	33AB	22A2	WORD	ST10	:SET AZ
02662	33AD	22CE	WORD	ST11	:SET EL
02663	33AF	243F	WORD	ST20	:PROC
02664	33B1	20B7	WORD	ST0	:START/STOP
02665	33B3	24CB	WORD	ST24	:DECIMAL POINT
02666	33B5	2282	WORD	ST5	:MINUS SIGN
02667	33B7	24AA	SP22 WORD	ST23	:0
02668	33B9	24AA	WORD	ST23	:1
02669	33BB	24AA	WORD	ST23	:2
02670	33BD	24AA	WORD	ST23	:3
02671	33BF	24AA	WORD	ST23	:4
02672	33C1	24AA	WORD	ST23	:5
02673	33C3	24AA	WORD	ST23	:6
02674	33C5	24AA	WORD	ST23	:7
02675	33C7	24AA	WORD	ST23	:8
02676	33C9	24AA	WORD	ST23	:9
02677	33CB	2282	WORD	ST5	:DOWN
02678	33CD	2282	WORD	ST5	:UP
02679	33CF	2282	WORD	ST5	:LEFT
02680	33D1	2282	WORD	ST5	:RIGHT
02681	33D3	22A2	WORD	ST10	:SET AZ

02682	33D5	22CE		WORD	ST11	:SET EL
02683	33D7	243F		WORD	ST20	:PROC
02684	33D9	20B7		WORD	ST0	:START/STOP
02685	33DB	24CB		WORD	ST24	:DECIMAL POINT
02686	33DD	2282		WORD	ST5	:MINUS SIGN
02687	33DF	2290	SP23	WORD	ST6	:0
02688	33E1	2290		WORD	ST6	:1
02689	33E3	2290		WORD	ST6	:2
02690	33E5	2290		WORD	ST6	:3
02691	33E7	2290		WORD	ST6	:4
02692	33E9	2290		WORD	ST6	:5
02693	33EB	2290		WORD	ST6	:6
02694	33ED	2290		WORD	ST6	:7
02695	33EF	2290		WORD	ST6	:8
02696	33F1	2290		WORD	ST6	:9
02697	33F3	2282		WORD	ST5	:DOWN
02698	33F5	2282		WORD	ST5	:UP
02699	33F7	2282		WORD	ST5	:LEFT
02700	33F9	2282		WORD	ST5	:RIGHT
02701	33FB	22A2		WORD	ST10	:SET AZ
02702	33FD	22CE		WORD	ST11	:SET EL
02703	33FF	243F		WORD	ST20	:PROC
02704	3401	20B7		WORD	ST0	:START/STOP
02705	3403	24CB		WORD	ST24	:DECIMAL POINT
02706	3405	2282		WORD	ST5	:MINUS SIGN
02707	3407	24E7	SP24	WORD	ST25	:0
02708	3409	24E7		WORD	ST25	:1
02709	340B	24E7		WORD	ST25	:2
02710	340D	24E7		WORD	ST25	:3
02711	340F	24E7		WORD	ST25	:4
02712	3411	24E7		WORD	ST25	:5
02713	3413	24E7		WORD	ST25	:6
02714	3415	24E7		WORD	ST25	:7
02715	3417	24E7		WORD	ST25	:8
02716	3419	24E7		WORD	ST25	:9
02717	341B	2282		WORD	ST5	:DOWN
02718	341D	2282		WORD	ST5	:UP
02719	341F	2282		WORD	ST5	:LEFT
02720	3421	2282		WORD	ST5	:RIGHT
02721	3423	22A2		WORD	ST10	:SET AZ
02722	3425	22CE		WORD	ST11	:SET EL
02723	3427	243F		WORD	ST20	:PROC
02724	3429	20B7		WORD	ST0	:START/STOP
02725	342B	2282		WORD	ST5	:DECIMAL POINT
02726	342D	2282		WORD	ST5	:MINUS SIGN
02727	342F	2282	SP25	WORD	ST5	:0
02728	3431	2282		WORD	ST5	:1
02729	3433	2282		WORD	ST5	:2
02730	3435	2282		WORD	ST5	:3
02731	3437	2282		WORD	ST5	:4
02732	3439	2282		WORD	ST5	:5
02733	343B	2282		WORD	ST5	:6
02734	343D	2282		WORD	ST5	:7

02735	343F	2282	WORD	ST3	:8
02736	3441	2282	WORD	ST3	:9
02737	3443	2282	WORD	ST3	:DOWN
02738	3445	2282	WORD	ST3	:UP
02739	3447	2282	WORD	ST3	:LEFT
02740	3449	2282	WORD	ST3	:RIGHT
02741	344B	22A2	WORD	ST10	:SET AZ
02742	344D	22CE	WORD	ST11	:SET EL
02743	344F	243F	WORD	ST20	:PROG
02744	3451	2578	WORD	ST00	:START/STOP
02745	3453	2282	WORD	ST5	:DECIMAL POINT
02746	3455	2282	WORD	ST5	:MINUS SIGN
02747	3457	28C2	SP30 WORD	ST34	:0
02748	3459	28C2	WORD	ST34	:1
02749	345B	28C2	WORD	ST34	:2
02750	345D	28C2	WORD	ST34	:3
02751	345F	28C2	WORD	ST34	:4
02752	3461	28C2	WORD	ST34	:5
02753	3463	28C2	WORD	ST34	:6
02754	3465	28C2	WORD	ST34	:7
02755	3467	28C2	WORD	ST34	:8
02756	3469	28C2	WORD	ST34	:9
02757	346B	27F6	WORD	ST30	:DOWN
02758	346D	2829	WORD	ST31	:UP
02759	346F	285C	WORD	ST32	:LEFT
02760	3471	288F	WORD	ST33	:RIGHT
02761	3473	22A2	WORD	ST10	:SET AZ
02762	3475	22CE	WORD	ST11	:SET EL
02763	3477	243F	WORD	ST20	:PROG
02764	3479	20B7	WORD	ST0	:START/STOP
02765	347B	2904	WORD	ST36	:DECIMAL POINT
02766	347D	2282	WORD	ST5	:MINUS SIGN
02767	347F	28C2	SP31 WORD	ST34	:0
02768	3481	28C2	WORD	ST34	:1
02769	3483	28C2	WORD	ST34	:2
02770	3485	28C2	WORD	ST34	:3
02771	3487	28C2	WORD	ST34	:4
02772	3489	28C2	WORD	ST34	:5
02773	348B	28C2	WORD	ST34	:6
02774	348D	28C2	WORD	ST34	:7
02775	348F	28C2	WORD	ST34	:8
02776	3491	28C2	WORD	ST34	:9
02777	3493	27F6	WORD	ST30	:DOWN
02778	3495	2829	WORD	ST31	:UP
02779	3497	285C	WORD	ST32	:LEFT
02780	3499	288F	WORD	ST33	:RIGHT
02781	349B	22A2	WORD	ST10	:SET AZ
02782	349D	22CE	WORD	ST11	:SET EL
02783	349F	243F	WORD	ST20	:PROG
02784	34A1	20B7	WORD	ST0	:START/STOP
02785	34A3	2904	WORD	ST36	:DECIMAL POINT
02786	34A5	2282	WORD	ST5	:MINUS SIGN
02787	34A7	28C2	SP32 WORD	ST34	:0

02788	34A9	28C2	WORD	ST34	:1
02789	34AB	28C2	WORD	ST34	:2
02790	34AD	28C2	WORD	ST34	:3
02791	34AF	28C2	WORD	ST34	:4
02792	34D1	28C2	WORD	ST34	:5
02793	34B3	28C2	WORD	ST34	:6
02794	34B5	28C2	WORD	ST34	:7
02795	34B7	28C2	WORD	ST34	:8
02796	34B9	28C2	WORD	ST34	:9
02797	34BB	27F6	WORD	ST30	:DOWN
02798	34BD	2829	WORD	ST31	:UP
02799	34BF	285C	WORD	ST32	:LEFT
02800	34C1	283F	WORD	ST33	:RIGHT
02801	34C3	22A2	WORD	ST10	:SET AZ
02802	34C5	22CE	WORD	ST11	:SET EL
02803	34C7	243F	WORD	ST20	:PROC
02804	34C9	20D7	WORD	ST0	:START/STOP
02805	34CB	2904	WORD	ST36	:DECIMAL
02806	34CD	2232	WORD	ST5	:MINUS SIGN
02807	34CF	28C2	SP33 WORD	ST34	:0
02808	34D1	28C2	WORD	ST34	:1
02809	34DC	28C2	WORD	ST34	:2
02810	34DE	28C2	WORD	ST34	:3
02811	34D7	28C2	WORD	ST34	:4
02812	34D9	28C2	WORD	ST34	:5
02813	34DB	28C2	WORD	ST34	:6
02814	34DD	28C2	WORD	ST34	:7
02815	34DF	28C2	WORD	ST34	:8
02816	34E1	28C2	WORD	ST34	:9
02817	34E3	27F6	WORD	ST30	:DOWN
02818	34E5	2829	WORD	ST31	:UP
02819	34E7	285C	WORD	ST32	:LEFT
02820	34E9	288F	WORD	ST33	:RIGHT
02821	34EB	22A2	WORD	ST10	:SET AZ
02822	34ED	22CE	WORD	ST11	:SET EL
02823	34EF	243F	WORD	ST20	:PROC
02824	34F1	20E7	WORD	ST0	:START/STOP
02825	34F3	2904	WORD	ST36	:DECIMAL POINT
02826	34F5	2282	WORD	ST5	:MINUS SIGN
02827	34F7	28E3	SP34 WORD	ST35	:0
02828	34F9	28E3	WORD	ST35	:1
02829	34FB	28E3	WORD	ST35	:2
02830	34FD	28E3	WORD	ST35	:3
02831	34FF	28E3	WORD	ST35	:4
02832	3501	28E3	WORD	ST35	:5
02833	3503	28E3	WORD	ST35	:6
02834	3505	28E3	WORD	ST35	:7
02835	3507	28E3	WORD	ST35	:8
02836	3509	28E3	WORD	ST35	:9
02837	350B	2282	WORD	ST5	:DOWN
02838	350D	2282	WORD	ST5	:UP
02839	350F	2282	WORD	ST5	:LEFT
02840	3511	2282	WORD	ST5	:RIGHT

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02841 3513 22A2      WORD    ST10    ;SET AZ
02842 3515 22CE      WORD    ST11    ;SET EL
02843 3517 243F      WORD    ST20    ;PROC
02844 3519 20B7      WORD    ST0     ;START/STOP
02845 351B 2904      WORD    ST36    ;DECIMAL POINT
02846 351D 2282      WORD    ST5     ;MINUS SIGN
02847 351F 2290      SP35  WORD    ST6     ;0
02848 3521 2290      WORD    ST6     ;1
02849 3523 2290      WORD    ST6     ;2
02850 3525 2290      WORD    ST6     ;3
02851 3527 2290      WORD    ST6     ;4
02852 3529 2290      WORD    ST6     ;5
02853 352B 2290      WORD    ST6     ;6
02854 352D 2290      WORD    ST6     ;7
02855 352F 2290      WORD    ST6     ;8
02856 3531 2290      WORD    ST6     ;9
02857 3533 2282      WORD    ST5     ;DOWN
02858 3535 2282      WORD    ST5     ;UP
02859 3537 2282      WORD    ST5     ;LEFT
02860 3539 2282      WORD    ST5     ;RIGHT
02861 353B 22A2      WORD    ST10    ;SET AZ
02862 353D 22CE      WORD    ST11    ;SET EL
02863 353F 243F      WORD    ST20    ;PROC
02864 3541 20B7      WORD    ST0     ;START/STOP
02865 3543 2904      WORD    ST36    ;DECIMAL POINT
02866 3545 2282      WORD    ST5     ;MINUS SIGN
02867 3547 2920      SP36  WORD    ST37    ;0
02868 3549 2920      WORD    ST37    ;1
02869 354B 2920      WORD    ST37    ;2
02870 354D 2920      WORD    ST37    ;3
02871 354F 2920      WORD    ST37    ;4
02872 3551 2920      WORD    ST37    ;5
02873 3553 2920      WORD    ST37    ;6
02874 3555 2920      WORD    ST37    ;7
02875 3557 2920      WORD    ST37    ;8
02876 3559 2920      WORD    ST37    ;9
02877 355B 2282      WORD    ST5     ;DOWN
02878 355D 2282      WORD    ST5     ;UP
02879 355F 2282      WORD    ST5     ;LEFT
02880 3561 2282      WORD    ST5     ;RIGHT
02881 3563 22A2      WORD    ST10    ;SET AZ
02882 3565 22CE      WORD    ST11    ;SET EL
02883 3567 243F      WORD    ST20    ;PROC
02884 3569 20B7      WORD    ST0     ;START/STOP
02885 356B 2282      WORD    ST5     ;DECIMAL POINT
02886 356D 2282      WORD    ST5     ;MINUS SIGN
02887
02888
02889
02890      FFF8
02891 FFF8 2F32      ORG      0FFFFH
02892 FFFA 2000      WORD    INT      ;IRQ VECTOR
02893 FFFC 2E8E      WORD    G0E     ;SWI VECTOR JUST IN CASE
                     WORD    DISPL   ;NMI VECTOR JUST IN CASE
:
: BEGIN RESET INTERRUPT VECTORS
:

```

TEKTRONIX

M6800 ASM V2.2

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02894 FFFE 2000

***** P

02895

WORD

GOE

;RESET VECTOR

END

ACIAD	8409	ACIAS	8408	ADDCAL	2B2B	ALSTOP	2AB8	ANGLE	003F
ASC1	2D3F	ASC2	2D59	ASC	2D58	ASCDIS	2C22	AZPCD	0045
AZEL	0061	AZKEY	0053	AZKEYS	0057	AZMAG	005D	AZSIGN	0043
B2	213B	B3	214A	B4	2153	B5	21BC	B6	21C9
B7	21D3	B8	21D0	BACK	2AF7	BCD151	29A9	BCD153	29B4
BCD163	29BE	BCD165	29DB	BCD167	29D9	BCDA	003C	BCDB	003D
BCDBIN	29EB	BCDDIS	2D2F	BCDDIV	2999	BCDMPY	296D	BCDSUB	2AC4
BCDVSR	0072	BINANG	0081	BINSCD	2C3D	BINUPR	008A	BLANK	31FC
CARRY	009B	CHARDF	003B	CHARCT	003E	CHARPT	002C	CHARTB	2F92
CHINUM	0039	COLUM1	2553	COLUMN	2E59	COSINE	0085	CP1	295B
CPFLAG	294C	CRA	8401	CRA2	8405	CRA3	8001	CRB	8403
CRB2	8407	CRB3	83C3	CSIGN	0088	CVDEC1	2C6A	CVDEC2	2C6D
CVDEC3	2C78	DDRA	8400	DDRA2	8404	DDRA3	8000	DDRB	8402
DDRB2	8405	DDRB3	8B02	DECOD1	2E70	DECODE	2E6D	DECJAR	31FD
DFLAGA	00GC	DFLAGE	006D	DIFF	2DE6	DIFF1	2D8A	DIFFAZ	2134
DIFFEL	21B6	DISAZ	0000	DISBUF	0000	DISEL	009A	DISPL	2EBE
DIV151	2C0C	DIV153	3CDD	DIV163	2CDD	DIV165	2D12	DIV167	2D13
DIVIDE	2CAE	DIVISO	31F8	DOHUND	297E	DOHOU	2A0F	DOWN	2304
ELRCD	0047	ELKEY	0053	ELKEYS	0078	ELMAG	005F	ELSIGN	0044
ENTRYA	004D	ENTRYB	004E	ETHSPD	00F0	FIN	25EF	FPTAZ	0076
FPTAZS	0079	FPTEL	0074	FPTELS	007B	GOE	2000	GTCHAR	2E7D
HAFSPD	00D0	HUNLP	2A03	HUN00	2A0C	INT	2F32	INT1	2F47
INT2	2F5A	INT3	2F66	INT4	2F69	K1	2E35	K10K	31FC
KEYRD	2F4B	KEYC	0052	KEYENT	004F	KFLAG	006B	KTABLE	2F6A
LEFT	2C0E	LETA	003A	LETB	003B	LFLAGA	0094	LFLAG	0093
LIMIT	31F6	LSBENG	0039	LSBSAZ	8E00	LSBSEL	8E02	MC0M1	2EEC
MC0MND	2EDF	MFLAG	0059	MINUEN	005A	MINUS	31FA	MOTAZ	2D86
MC0MND	2EDF	MOVED	2943	MPY163	297B	MPY167	298F	MSBENC	0038
MSBSAZ	8E01	MSBSEL	3E03	MSG1	305C	MSG10	3110	MSG11	3124
MSG12	3138	MSG13	314C	MSG14	3160	MSG15	3174	MSG16	3188
MSG17	319C	MSG18	31B0	MSG19	31C4	MSG2	3070	MSG20	31D8
MSG3	3034	MSG4	309B	MSG5	30AC	MSG6	30C0	MSG7	30D4
MSG8	30E3	MSG9	30FC	MSCA	2096	MSCB	20B2	MSGDON	2F2E
MSGFLG	0093	NAZLIM	0091	NEGS	23ED	NELLIM	008D	NEXTC	2035
NMATCH	2ED7	NOAZ	2142	NOEL	21C2	NOPE	296C	O2	2DC4
O3	2DC6	O4	2E30	O5	2E32	ONE	2E12	ONE1	2DB6
OVER	2C29	PACK	2A9E	PAL	2B41	PAL1	2B31	PAZLIM	008F
PEL	2BC1	PELLIM	008B	PFLAG	007D	PLUS	31FB	POINT	31FE
POS	2C5E	POSN	2C65	PROANG	007F	PROCNT	007A	PROCA	0063
PROGB	0067	PROGC	0069	PROGL	0064	PROGN	0063	QUASPD	0920
RCVDEC	2EC7	RCVEND	2EDE	RCVNEX	2ECB	RCVR	2EC4	RESET	2EAC
RESTO	2936	RIGHT	2C18	ROW	2E6A	SAME	2E38	SAVE1	2DDC
SAMEAZ	213E	SAMEEL	21BE	SAVDEC	003E	SAVE1	0089	SAVEA	0031
SAVEX	0032	SAVER1	0034	SAVEN2	0096	SEND	2F08	SFLAGA	006E
SFLAGE	006F	SHA	2BB1	SHA1	2DCD	SHA2	2B4D	SHA3	2B99
SHA4	2B9C	SHAENC	2AFB	SIBUF	0014	SIGN	0042	SINE	0063
SP0	31FF	SP10	3227	SP11	324F	SP12	3277	SP13	329F
SP14	32C7	SP15	32EF	SP16	3317	SP17	333F	SP20	3367
SP21	3387	SP22	3337	SP23	33D7	SP24	3407	SP25	342F
SP20	3457	SP31	347F	SP32	34A7	SP33	34C7	SP34	3477
SP25	351F	SP36	3547	SPEEDA	005B	SPEEDE	005C	SSIGN	0037
ST0	30B7	ST00	2578	ST001	25B9	ST002	258C	ST003	25BF
ST0A	207A	ST0B	211C	ST0C	2126	ST0D	212E	ST0E	2138

ST0F --- 219E	ST0G --- 21AB	ST0H --- 21B0	ST0X --- 20EF	ST0X1 --- 210E
ST0X2 --- 20FD	ST0Y --- 2170	ST0Y1 --- 217E	ST0Z --- 2190	ST1 --- 2126
ST10 --- 22A2	ST10A --- 22AF	ST11 --- 22CE	ST11A --- 22DB	ST12 --- 23FA
ST12A --- 230F	ST13 --- 2322	ST13A --- 232D	ST14 --- 2340	ST14A --- 234E
ST15 --- 2361	ST15A --- 236F	ST16 --- 2382	ST16A --- 238B	ST17 --- 239E
ST17A --- 23C9	ST17C --- 23DA	ST18 --- 23ED	ST19 --- 23F9	ST19A --- 241B
ST19B --- 240C	ST17C --- 23DA	ST1B --- 21F1	ST2 --- 2201	ST20 --- 243F
ST20A --- 244A	ST21 --- 2469	ST21A --- 2476	ST22 --- 2489	ST22A --- 2497
ST23 --- 24AA	ST23A --- 24BB	ST24 --- 24CB	ST24A --- 24D4	ST25 --- 24F7
ST25A --- 2565	ST25B --- 2537	ST25C --- 255D	ST26 --- 2592	ST26A --- 2504
ST26A1 --- 25D9	ST26B --- 25F7	ST26B1 --- 261B	ST26E2 --- 2635	ST26B3 --- 2641
ST26C --- 2644	ST26E --- 264F	ST27 --- 2653	ST27A --- 2687	ST27A1 --- 269D
ST27B --- 26B6	ST27B1 --- 26D7	ST27B2 --- 26F4	ST27B3 --- 2700	ST27C --- 2703
ST27D --- 270E	ST27E --- 2711	ST28 --- 2717	ST28A --- 2738	ST28B --- 274D
ST28C --- 277F	ST28D --- 279B	ST29 --- 27A1	ST29A --- 27B1	ST29B --- 27F0
ST2A --- 220B	ST2B --- 221C	ST3 --- 222C	ST30 --- 27F6	ST30A --- 2810
ST30B --- 2823	ST31 --- 2829	ST31A --- 2843	ST31D --- 2856	ST32 --- 285C
ST32A --- 2876	ST32B --- 2883	ST33 --- 288F	ST33A --- 28A9	ST33B --- 28DC
ST34 --- 28C2	ST34A --- 28D0	ST35 --- 28E3	ST35A --- 28F1	ST36 --- 2904
ST36A --- 290D	ST37 --- 2920	ST37A --- 292D	ST3A --- 2233	ST3B --- 2247
ST4 --- 2257	ST4A --- 225E	ST4B --- 2272	ST5 --- 2282	ST6 --- 2290
ST7 --- 2299	STADDER --- 067B	START --- 2EA1	SUBT --- 2ADB	SWAP --- 2AD1
TEMPA --- 0036	TEMPA1 --- 0050	TEMPB --- 0037	TEMPB1 --- 0051	TEMPD --- 0070
TEMPS --- 0062	TEMPX --- 0029	TEMPX1 --- 0049	TEMPX2 --- 004B	TEMPL --- 29F7
THOULP --- 2A1F	THOU00 --- 2A1D	TRIGA --- 2A47	TRIGAD --- 2A2A	TRIGB --- 2A60
TRIGC --- 2A7B	TRIGD --- 2AB1	TRIGTB --- 2FA6	TSTANG --- 295E	TQEND --- 2F31
TXCHT --- 2F19	UP --- 2BFA	WAIT --- 2EBB	WAIT1 --- 2EBD	WAITE --- 2E3E
WAITE1 --- 2E41	XITBIN --- 2A29	YCSAZ --- 214D	YSEL --- 21CB	Z2 --- 2D9C
Z3 --- 2D9E	Z4 --- 2DF8	Z5 --- 2DFA	ZERO --- 2DEA	ZERO1 --- 2D8E

2895 SOURCE LINES 1 ERROR

APPENDIX C

COMPONENT OPERATING MANUALS AND DATA SHEETS



Measurement Systems Division
Christina Street
Newton, Mass. 02161

OPERATION AND MAINTENANCE MANUAL
DIGISEC® RA __/23C SERIES ENCODERS

MANUAL NO. 2802
REV. E, JANUARY 1976

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1. INTRODUCTION

1.1 SCOPE

This manual is to be used with the DIGISEC[®] RA __/23C series of absolute shaft position encoders. The manual covers installation, operation, theory of operation, and field maintenance. The discussion has general application inasmuch as design, operation, and maintenance features are similar for all encoders in this series. Refer to Section 6 for identifying nomenclature applicable to all models in this series. Differences in models are also tabulated in Section 6. Maintenance or repair beyond that covered in this manual must be performed by the manufacturer.

1.2 GENERAL DESCRIPTION

Encoders of the DIGISEC RA __/23C series are medium resolution, absolute shaft position encoders of the photoelectric, non-contacting type, which are designed for use wherever shaft position information is required in digital form. Typical applications include digital servos, stable platforms, navigation systems, theodolites, tracking radars, laser tracking systems, and numerical control systems.

An outline drawing applicable to all RA __/23C series encoders is contained in Section 6. All RA __/23C series encoders have a standard Size 23 synchro mount (2.25 inch diameter mounting flange) with 2-inch pilot diameters on both sides of the flange, as shown in the outline drawing. Thus, the encoder can be mounted with the flange located on either side of the mounting surface. The notch in the synchro flange mates with a standard zeroing ring (not supplied) which can be used to precisely align the encoder to the drive shaft zero reference.* RA --/23C series encoders are provided with either a plain or a standard splined 0.25 inch shaft. The drive shaft to be monitored is coupled to the plain shaft through a high accuracy flexible coupling, and to the splined shaft through a standard gear fastened to the latter. The choice of flexible coupling or gear hardware is left to the user.

RA __/23C series encoders are designed to operate from a +5V source (+6V optional). Except for this external source, the encoder is functionally self-contained. Within its cylindrical case are contained a shaft-mounted glass code disc, illuminating lamps, photodetectors, and signal processing solid state circuits, which provide a digital output word representing the instantaneous absolute angular position of the encoder shaft. The output word is in natural binary code and is provided in parallel format, with one bit per output channel. One pigtail cable supplies power to the encoder, brings out the parallel outputs, and provides a test point for the illuminating lamps. One cable lead (HOLD) is also used to apply an external HOLD

*Refer to MIL-HDBK-214A (Synchros) for information on applicable zeroing hardware (zeroing rings, pinion wrenches, etc.)

pulse when reading out "on the fly". To eliminate any possible ambiguity in the parallel readout, an inherent characteristic of the natural binary code, DIGISEC encoders utilize anti-ambiguity logic, which requires a finite amount of settling time for the signal to propagate from the least significant bit to the most significant bit. Application of the HOLD pulse freezes the state of the least significant bit and enables non-ambiguous parallel readout, subsequent to the settling period, for the remainder of the HOLD pulse duration.

All RA __/23C series encoders have field replaceable illuminating lamps^{1/} and signal processing electronics to facilitate maintenance.

1.3 SPECIFICATIONS

General specifications applicable to all encoders of the RA __/23C series are contained in Table 1-1. Additional detailed specifications showing differences between various models are contained in Section 6. These differences include resolution, power supply voltage, direction of rotation for increasing count, shaft style, and temperature range. Output stages on all encoder channels are either 5404 or 7404 TTL (transistor-transistor logic) elements. 5404 elements are used in encoders with a "military" temperature range. 7404 elements are used in encoders with a "commercial" temperature range. Performance characteristics are similar for both types. Figure 1-1 provides output/load interface information.

1.4 DESIGN FEATURES

The DIGISEC RA __/23C series has been designed to meet the requirements of the most demanding military and industrial applications with emphasis on ruggedness, long life, and reliability. All electronic circuits are solid state and of conservative design with components substantially derated. Noteworthy design features are the following:

- a. Standard Size 23 synchro mount.
- b. Optional shaft style (plain/splined).
- c. One power supply voltage (+5V, +6V optional).
- d. Optional temperature ranges (military/commercial).
- e. Sealed bearings, field lubrication not required.
- f. Hard-chrome-on-glass code disc.

^{1/} See Section 4.3.1

Table 1-1 General Specifications for DIGISEC RA ___/23C Series Encoders*

Electrical

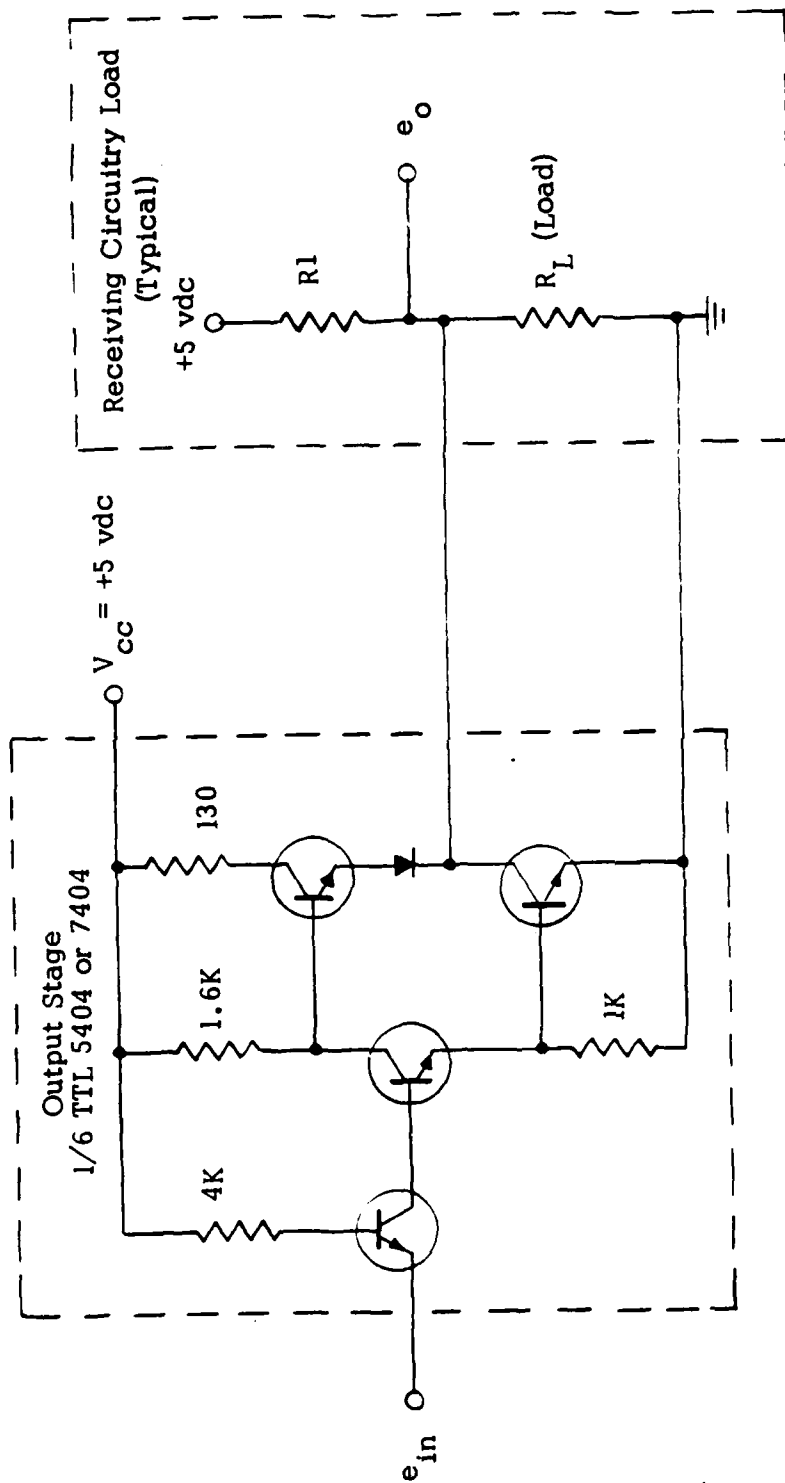
Resolution	Refer to Section 6
Accuracy	1/3 Bit RMS, excluding quantization
Output Signals (Fig. 1-1)	
Data format	Parallel, one output channel per bit
Logic levels	ONE: +3.5 to +5.5 vdc ZERO: ± 0.5 vdc
Rise and fall times	0.5 microseconds, maximum, with 3900-ohm load shunted by 1000 picofarads, or 10 TTL loads
Output stages	Fanout of ten 5404 or 7404 TTL elements
Settling time	3 microseconds, maximum
Note: Readout can be initiated 3 microseconds after application of external HOLD pulse	
Input HOLD pulse	
Pulse levels	OFF (normal output): 0 to +0.5 vdc ON (frozen output): +3.5 to +5.5 vdc
Pulse width	Refer to Section 2.5
Sink current	7 milliamperes, maximum
Power requirements	
Voltage	Either: +5 vdc $\pm 2\%$, 1% max. peak to peak ripple Or: +6 vdc $\pm 2\%$, 1% max. peak to peak ripple (Refer to Section 6 for applicable voltage)
Current	600 milliamperes for 5V option 650 milliamperes for 6 V option

Mechanical

Outline dimensions	Refer to Section 6
Shaft	0.25-inch diameter, plain or splined
Weight	16 ounces
Rotation direction for increasing count	Refer to Section 6
Rotation rate	
Operating	360 rpm maximum
Slew	3600 rpm maximum
Rotor moment of inertia	0.4 oz.-in. ² maximum
Breakaway torque	0.5 oz.-in. maximum
Running torque	0.4 oz.-in. maximum
Shaft loading	
Axial	5 lbs. maximum
Radial	2 lbs. maximum at shaft end

Table 1-1 General Specifications for DIGISEC RA ___/23C Series Encoders (Cont.)

<u>Environmental</u>		
Temperature	<u>Military</u>	<u>Commercial</u>
Operating	-40°C to +85°C	0 to +70°C
Non-Operating	-62°C to +90°C	-62°C to +90°C
Humidity	MIL-STD-202, Method 103, Condition B, (0-95%) operating. Will withstand 100% humidity with condensation non-operating.	
Shock	MIL-STD-202, Method 213, Test Condition A (50g peak, half sine wave, 11 ms duration, 3 shocks each direction each axis, 18 shocks total)	
Vibration	MIL-STD-202, Method 204, Condition D, except that vibration amplitude is .075 (total excursion) or 25g (peak) whichever is less. (swept sine, 10 hz to 2000 hz).	
Thermal shock	MIL-STD-202, Method 107C, Test Condition A-1 (25 cycles) except minimum temperature to be -62°C	
Salt atmosphere	MIL-STD-202, Method 101, Condition B, 5% salt solution	
Inclination	MIL-E-16400 Paragraph 4.5.14.2	
<u>Rated Life</u>		
Mechanical, operating	10 ⁹ revolutions minimum	
MTBF	50,000 hours minimum calculated per MIL-HDBK-217A ground factors. 30,000 hours minimum calculated per MIL-HDBK-217A shipboard factors.	



For $e_{in} = 0$ vdc, e_o High (One State)

$$e_o = \frac{5R_L}{R_L + R_1 \times 130} - 0.6$$

For $e_{in} = +5$ vdc, e_o Low (Zero State)

$$e_o = \frac{5}{R_1 + \frac{R_L \times 5}{R_L + 5}}$$

Figure 1-1. Encoder Output and Load Interface Characteristics.

- g. Small encoder diameter achieved by using integrated circuit modules.
- h. Stainless steel case.
- i. Low torque.
- j. Field replaceable lamp assembly (long-life incandescent lamps) 1/
- k. Field replaceable signal-processing integrated circuit modules requiring no field adjustment.
- l. The use of anti-ambiguity logic which synchronizes all coarser data to the fine code track and thereby permits all but the fine track to be of relatively low accuracy.
- m. Capability for readout on the fly at any speed up to the maximum rated operating speed. To allow for non-ambiguous readout on the fly, the encoders are designed to accept an external HOLD pulse which freezes the parallel outputs during readout.

1/ See Section 4.3.1

2. INSTALLATION AND OPERATION

2.1 HANDLING

DIGISEC RA __/23C series encoders are precision instruments and should be handled with care. Avoid shock to the encoder, particularly to the encoder shaft which is mounted on bearings to extremely fine tolerances. The plastic covering and the protective cap should remain in place during shipment or storage and should be removed only at the time that the encoder is installed in its operating location.

2.2 MECHANICAL ALIGNMENT

RA __/23C series encoders are supplied in standard Size 23 synchro mount configuration (see Fig. 2-1 and the outline drawing contained in Section 6). All encoders have a 1/4-inch OD shaft, either plain or splined.

CAUTION

No alterations may be made to the encoder shaft or body except by the manufacturer, or warranty will be voided. Drilling or machining of the shaft will cause serious damage to the code disc, readout optics, or bearings.

CAUTION

Do not use a rigid coupling between the encoder shaft and the drive shaft. A flexible coupling of high angular accuracy (Kinnemotive Corporation, Kinneflex series, or equivalent) must be used, unless the encoder is to be gear driven.

All splined shafts have a standard 22 teeth/96 pitch configuration with 1/4-28 outside thread, and are designed to accept a gear secured to the shaft by means of an MS 17186-4 or -8 drive washer and an MS 17178-3 drive nut.

The encoder may be installed in any attitude. However, the encoder shaft must be precisely aligned with the drive shaft because misalignment will degrade readout accuracy and shorten encoder life through excess loading of its bearings. The mounting hole must be bored to a diameter that is 0.001 inch (nominal) larger than the pilot diameter of the encoder.

CAUTION

All misalignments between the encoder mounting surface and the drive shaft must be such that the radial and axial loading on the encoder shaft (through either the flexible coupling or drive gear) do not exceed the limits specified in Table 1-1.

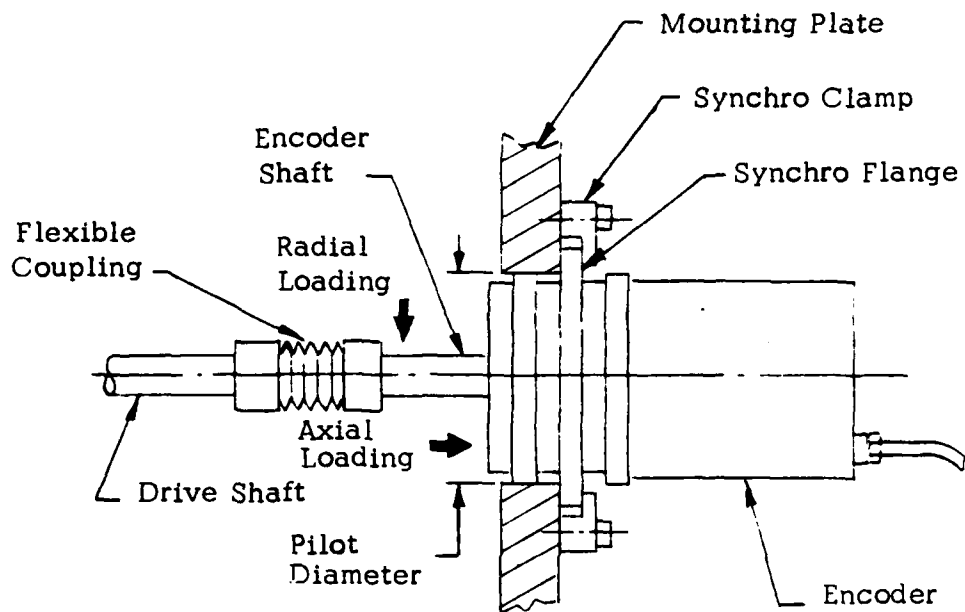


Figure 2-1 Installation of typical RA__/23C encoder with plain shaft

Note that the encoder has zero reference marks at the base of the shaft and on the case. These marks, when coincident, set the shaft angular position to a coarse zero count. The encoder must be oriented on its mounting surface so that its zero approximately coincides with that of the drive shaft. A standard Size 23 zeroing ring, to be driven by a pinion gear, may be inserted between the synchro flange and the mounting surface to facilitate precise zeroing after installation (see Section 2.4). Refer to MIL-HDBK-214A (Synchros) for information on applicable zeroing rings and associated components.

2.3 ELECTRICAL CONNECTIONS

2.3.1 Encoder Cable Wire Functions

All input/output electrical connections for the encoder cable are identified in the outline drawing contained in Section 6. The Lamp Test connection is used for troubleshooting (Section 4).

2.3.2 Grounding

Power and signal common are tied together within the encoder and are isolated from case ground since many applications require independent electrical and case grounds. In order to minimize noise problems, the noise level between the electrical and case grounds should be kept as low as possible. It is recommended that case ground be connected to electrical ground at only one point in the user's system, at a location to be determined experimentally for the particular installation.

2.3.3 Power Supply Considerations

RA __/23C series encoders are designed to operate from either +6vdc or +5vdc. The voltage applicable to a particular encoder can be found in Section 6.

NOTE

The external power supply must be set to provide +5V (or +6V), $\pm 2\%$, 1% maximum peak to peak ripple, at the encoder cable end in order to avoid possible erroneous readings caused by interconnection losses.

2.3.4 HOLD Pulse Line Driver Protection

The encoder HOLD pulse input is normally customer energized from a circuit that is powered from the same supply that operates the encoder, thus ensuring simultaneous application of power to all circuits of the encoder. In the event that the encoder proper and external HOLD driver circuits are energized from separate, non-interlocked supplies, this could result in a high state (5V) HOLD signal applied to an unenergized encoder, which could damage the encoder. Operation in this latter condition is allowed as long as a series protection diode is connected between the encoder HOLD line and the user's equipment. Any small signal diode with a PIV rating 50V or larger may be used. The anode of the diode should connect to the encoder HOLD line. The diode is considered part of the user's drive circuitry which should be capable of meeting the limits of para. 2.5 (Page 10) at the input of the encoder.

2.4 ZERO ALIGNMENT

1. Check that encoder is properly installed and that coarse zero has been set in accordance with instructions contained in Section 2.2.
2. Connect encoder to power supply and to output receiving circuitry.
3. Turn on power supply and receiving circuitry.
4. Slightly loosen the synchro clamps securing the encoder synchro flange to the mounting surface.
5. Set drive shaft to zero reference position.
6. While monitoring the encoder output with the receiving circuitry, carefully rotate the encoder case (either directly or through a gear-driven zeroing ring) until the zero is set to the desired tolerance.
7. Carefully tighten the synchro clamps. The encoder is now ready for operation.

2.5 OPERATION

After the encoder has been properly installed and connected to a power source and suitable receiving circuitry, operation involves only the application of the external HOLD pulse, as described below, for non-ambiguous readout on the fly. No adjustments or preventive maintenance are required aside from normal external cleaning procedures.

The encoder parallel outputs are always present as dc levels once external power is applied to the encoder. However, the anti-ambiguity logic within the encoder (Section 3.3) requires a certain amount of settling time (3 microseconds, maximum) which could cause improper readings if these were taken on the fly during a "settling cycle". To assure correct readout on the fly, DIGISEC encoders are designed to accept an external HOLD pulse. The net function of this pulse is to guarantee reliable readout if sampling is initiated 3 microseconds (or more) after the leading edge of the pulse and is terminated with the trailing edge. The HOLD pulse requirements are as follows:

OFF: ± 0.5 vdc, 7 ma Sink
ON: $+3.5$ to $+5.5$ vdc, 100 μ a Source
Maximum Width: See below

The maximum width of the HOLD pulse can be determined from the following equation:

$$T_H = \frac{13.2 \times K \times R}{S}$$

Where T_H = Maximum width of HOLD pulse in microseconds

S = Shaft rotation speed in rpm

R = Encoder resolution in seconds of arc

K = A constant determined by the encoder type, as follows:

RA ___/23C	<u>K</u>
10	1
11	1
12	1
13	2

If the HOLD pulse is applied for longer than T_H , the readout may show incorrect count. The maximum time, T_R , allowable for correct readout is therefore

$$T_R = (T_H - 3) \text{ microseconds}$$

3. THEORY OF OPERATION

A general functional block diagram applicable to all RA __/23C series encoders is contained in Fig. 3-1. The encoder consists of an optical subassembly, trim board A1, logic and hold board A2, and logic board A3. Field replaceable assemblies are the lamp assembly (which is part of the optical subassembly) and boards A2 and A3.

3.1 OPTICAL SUBASSEMBLY

The optical subassembly consists of a shaft-mounted glass code disc, a lamp assembly, and a slit and photodetector assembly. The code disc contains a series of concentric annular code tracks, each consisting of alternating transparent and opaque segments describing equal arcs along the circumference. The number of code cycles (one transparent segment followed by one opaque segment) varies by a factor of two from track to track, starting with one cycle on the inner track. The transparent and opaque states of all tracks thus represent the ONE and ZERO states of a multi-digit natural binary word, with one track per digit. The state of each track is sensed by illuminating the code disc and detecting the modulated light behind each track (as the disc is rotated) with a precisely registered slit/photodetector assembly. Each photodetector's output is essentially a square wave, with one cycle corresponding to a code cycle. The frequency of each detector's output is therefore a function of shaft rotation speed. When the shaft is stationary, the output of any detector is simply a dc level corresponding to either a ONE or ZERO state.

3.2 TRIM BOARD A1

Trim board A1 contains several trimming components which are factory set to provide the required parallel signal levels as they enter boards A2 and A3. The trim board components are precisely set for the detector outputs of its particular optical subassembly. Consequently, board A1 is not field replaceable.

3.3 LOGIC AND HOLD BOARD A2

Logic and hold board A2 performs two basic functions. It processes the parallel photodetector outputs corresponding to the three finer tracks on the code disc to provide the least significant digit (LSD) for all encoders as well as a few more significant digits for the higher resolution encoders (see Fig. 3-1). A2 also initiates anti-ambiguity control for the entire encoder and receives the input HOLD pulse enabling unambiguous readout on the fly.

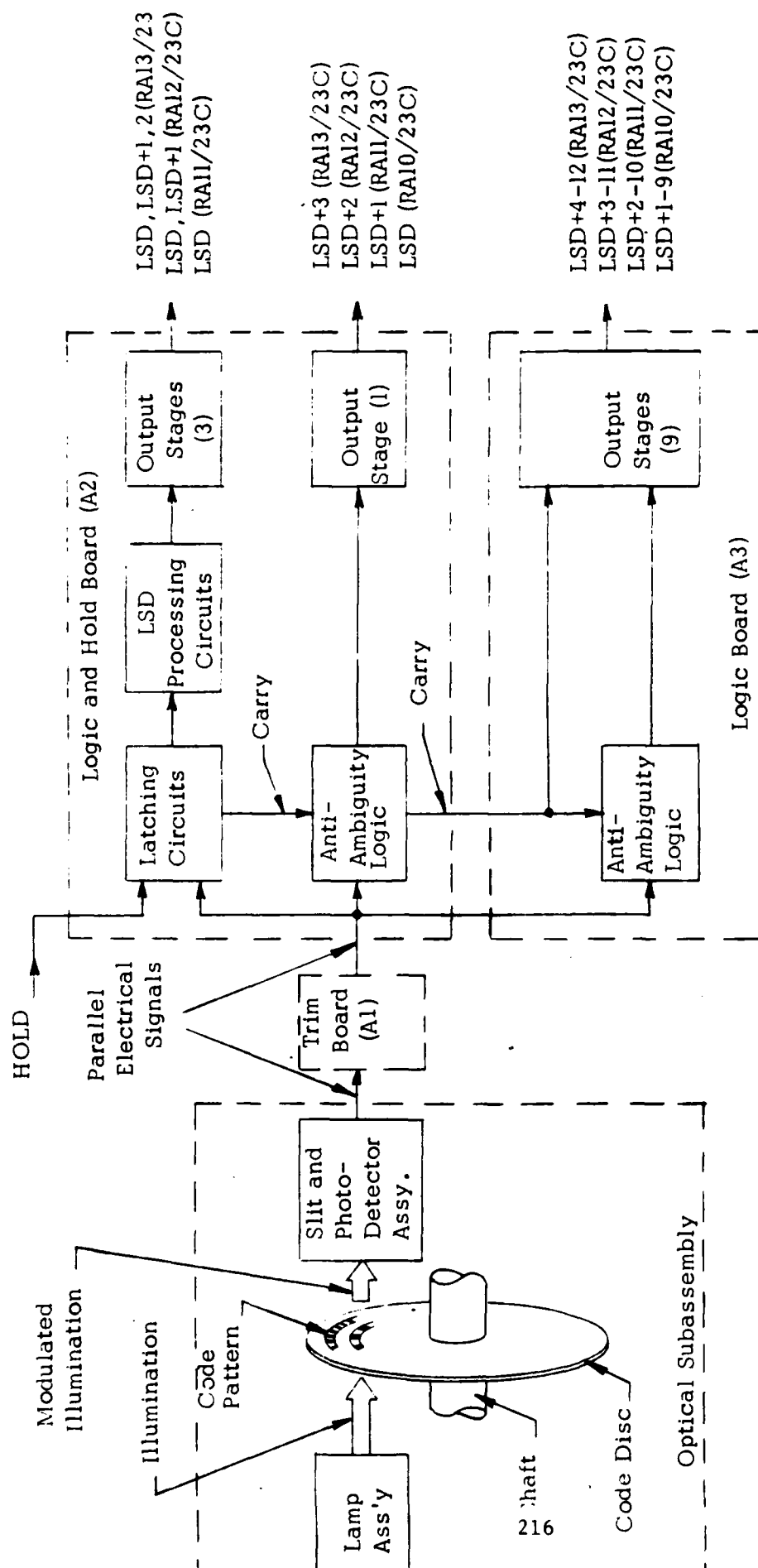


Figure 3-1 Encoder General Functional Block Diagram

The fine track circuit consists of the latching circuits, LSD processing circuits, and output stages shown in line in Fig. 3-1. This circuit generates one or more bits, depending on the encoder, from the fine track on the code disc. The CARRY signal represents the state of the fine track, which is used to synchronize the output transitions of all more significant bits. The CARRY cycle requires a maximum three microseconds of settling time after each fine track transition. Application of the HOLD pulse freezes the states of all bits through the latching circuits and through the nature of the CARRY logic. Reliable readout can then be initiated three microseconds after the leading edge of the HOLD pulse. The maximum duration of the HOLD pulse for reliable readout is dependent on the encoder resolution and shaft speed, as defined in Section 2.5. The output stages, which function as buffer amplifiers are either 5404 or 7404 TTL elements (refer to Section 1.3).

The two remaining tracks whose signals are processed by A2 each provide one of the parallel output bits. The CARRY from the fine track to the anti-ambiguity logic synchronizes the transitions of these two bits with those of the fine track. The more significant bit of the two, which is also the first CARRY for board A3, has its output stage on A3.

3.4 LOGIC BOARD A3

Logic board A3 processes the photodetector outputs of the remaining tracks to provide the remaining more significant bits. Each bit becomes the CARRY for the anti-ambiguity logic of the next more significant bit.

3.5 LAMP TEST CIRCUIT

The field replaceable lamp assembly ^{1/} contains several precisely aligned and potted lamps, all electrically connected in parallel. All RA 13/23C encoders contain four lamps. All remaining encoders (RA 12/23C, RA 11/23C, and RA 10/23C) contain three lamps. The LAMP TEST wire is connected to the less positive side of the parallel combination in each case. A voltmeter connected across the LAMP TEST wire and common will read the total current drain of all lamps through a series resistor. The normal readings can be found in Section 4. Failure of any lamp is indicated by a decrease in the current through the series resistor.

^{1/} See Section 4.3.1

4. MAINTENANCE

1.1 SCOPE

The optical subassembly of RA __/23C series encoders is factory aligned to extremely high precision. Therefore, field maintenance of encoders in this series is restricted to repair by replacement of the following three potted subassemblies: the lamp assembly, logic and hold board A2, and logic board A3. Refer to Section 6 for part numbers of replaceable assemblies applicable to any encoder. Trim board A1 is factory set for each encoder and is not field replaceable. It is partially hard-wired to the encoder.

The troubleshooting instructions which follow should help in isolating failure to either the external equipment, the three replaceable assemblies, or the rest of the encoder. Replace field replaceable assemblies in accordance with the instructions contained in Section 4.3. If failure is diagnosed in the non-replaceable portion of the encoder, no attempt should be made to correct the malfunction by opening the optical subassembly or forcing rotation of the encoder shaft. A detailed description of failure symptoms, suspected malfunctions, and operating conditions should be made. The encoder should then be carefully decoupled and removed from its mount, securely packed with its protective cap, plastic covering, and failure description, and returned to the manufacturer for repair.

If failure is diagnosed in the encoder cable, do not unsolder or solder wires where they connect to the encoder circuitry. Repair broken or shorted wires by splicing. If splicing does not correct the malfunction, replace the encoder.

RA __/23C series encoders have sealed bearings and no field lubrication is necessary.

CAUTION

Do not open any portion of the encoder beyond providing access to the three field replaceable assemblies or warranty will be void. Repair of the optical subassembly beyond replacing the lamp assembly must be performed by the manufacturer.

1.2 TROUBLESHOOTING

Troubleshooting the encoder involves first checking each of the parallel outputs for proper waveform amplitude and frequency as specified in Section 4.2.1. If the parallel output waveforms do not conform to the performance standards, the

malfunction must be isolated either to the equipment external to the encoder (Section 4.2.2) or to the encoder itself (Section 4.2.3). Follow all steps in the order given. A voltmeter and a dual-trace oscilloscope equivalent to Tektronix Model 502A are required. Refer to the outline drawing contained in Section 6 for the encoder cable connections.

4.2.1 Encoder Output Test

Perform the output test as follows, using oscilloscope:

1. Shut off encoder power supply.
2. Disconnect encoder parallel outputs from receiving circuitry.
3. Turn on encoder power supply.
4. Rotate encoder shaft smoothly at maximum rated operating speed.
5. Connect oscilloscope (internal trigger) to parallel output in pairs, starting with LSD and LSD+1, then LSD+1 and LSD+2, (etc.) and check that all channel waveforms conform to the following standards:
 - a. Each channel's output is a square wave with logic levels as follows:

ONE: +3.5 to +5.5 vdc
ZERO: 0.0 to +0.5 vdc
 - b. Each channel's square wave has one half the frequency of the next less significant channel.
6. If any performance standard is not met, proceed with Sections 4.2.2 and 4.2.3 as judged necessary.

4.2.2 Troubleshooting External Equipment

If any performance standards are not met in Section 4.2.1, proceed with the following steps to check out the external equipment.

1. Check that encoder power supply voltage is within proper tolerance.

NOTE

Ensure that external power supply is set to +5V* (or +6V*), $\pm 2\%$, 1% maximum peak-to-peak ripple at the end of the encoder cable, to avoid possible erroneous readings caused by interconnection losses.

*Voltage depends on particular encoder (Section 6)

2. Check that output wires and receiving circuitry are free of shorts.
3. Check that encoder shaft is not binding and that coupling is not loose. If shaft is binding, check that encoder is installed in accordance with the requirements of Section 2.2. Encoder must be replaced if it is properly aligned mechanically but the shaft still binds.

4.2.3 Troubleshooting Encoder

If any performance standards are not met in Section 4.2.1, proceed with the following steps to check out the encoder itself.

1. Turn on encoder power supply.
2. Check encoder lamps ^{1/} by connecting voltmeter across LAMP TEST wire (+) and common.

<u>Encoder Type</u>	<u>Performance Standard</u>
RA 10/23C	0.35 vdc Minimum
RA 11/23C	0.35 vdc Minimum
RA 12/23C	0.35 vdc Minimum
RA 13/23C	0.4 vdc Minimum

If performance standard is not met, replace lamp assembly (refer to Section 4.3). * If in doubt, replace lamp assembly.

3. Check boards A2 and A3, in that order, by monitoring the following output channels on oscilloscope and checking for output waveform standards indicated in Section 4.2.1, Step 5.

<u>Encoder Type</u>	<u>Board A2</u>	<u>Board A3</u>
RA 10/23C	LSD	LSD+1 thru LSD+9
RA 11/23C	LSD, LSD+1	LSD+2 thru LSD+10
RA 12/23C	LSD, LSD+1, LSD+2	LSD+3 thru LSD+11
RA 13/23C	LSD, LSD+1 thru LSD+3	LSD+4 thru LSD+12

If any performance standard is not met, replace boards A2 and/or A3, in that order (refer to Section 4.3). Note that the anti-ambiguity control (CARRY) for the entire encoder is initiated on A2. If replacement of A2 and/or A3 does not correct the malfunction, failure resides in non-field-replaceable portions of the encoder.

* To test a lamp assembly outside the encoder, apply 3.5 to 4.0V to lamp block pins, and observe that all bulbs light. Bulbs also wear out due to gradual blackening, so that this test is not always conclusive. If in doubt, replace lamp assembly.

4.3 PARTS REPLACEMENT

CAUTION

Shut off input power before removing or replacing components.

4.3.1 Removal/Replacement of Lamp Assembly (Figure 4-1)

NOTE

Replacement lamps are made up on a custom basis for specific encoders. Make sure the serial number on the replacement lamp matches the encoder serial number. Do not interchange lamps among encoders. The following three steps of this paragraph apply only to those encoders for which replacement lamps have been supplied.

Removal

1. CAREFULLY BRUSH AWAY ALL DIRT FROM THE FRONT OF THE ENCODER. Loosen two captive screws securing lamp assembly to encoder. Do not remove the screws from the lamp assembly.
2. Note the electrical contact pins, the alignment pins, and the sealing lip shown in Fig. 4-1.
3. Carefully remove the lamp assembly by pulling alternately on the two captive screws to overcome the friction from the sealing lip.

Replacement

Reverse removal procedures, taking care not to bend the electrical contact pins. Be careful not to get finger marks on the polished lamp reflectors. (See Page 19)

4.3.2 Removal/Replacement of Boards A2 and A3

Removal

- 1 (a) Older Models - Pinch grommet at junction of encoder case and cable and push grommet and cable into case sufficiently to free cable.
- 1 (b) New Models - Unscrew cable clamp packing nut and slide back nut and "O" ring.
2. Loosen two screws securing case to encoder on cable end of case. Remove screws.
3. Pull case back along cable to expose A2 and A3.
4. Carefully pull A2 and/or A3 back from its connector.

Replacement

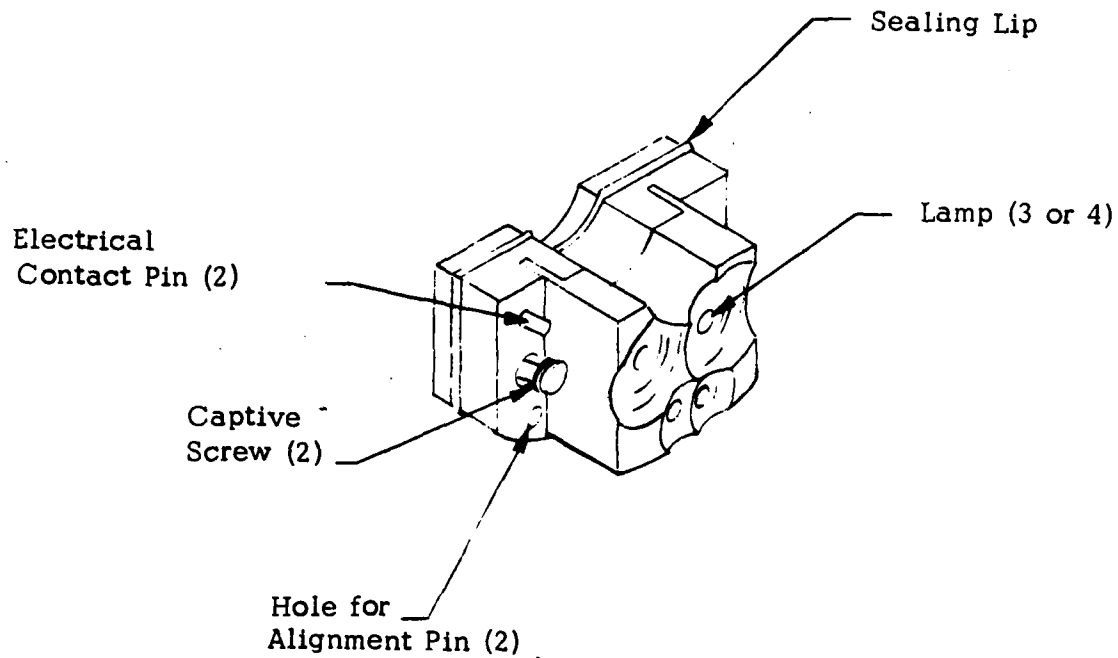
Reverse removal procedures.

CAUTION

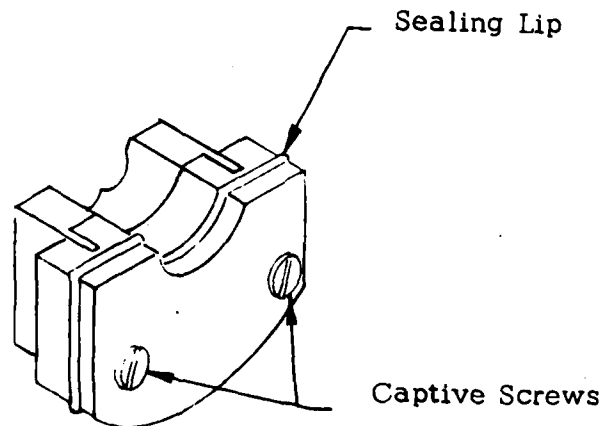
Plug-in boards are keyed to their proper sockets. Do not force a board into an improper socket or in reverse orientation.

NOTE

If cleaning of dirt or finger marks is required, use a cotton swab ("Q tip") and isopropyl alcohol. Swab gently and allow to dry. Do not use harsh or abrasive cleaning agents.



(a) Rear 3/4 View



(b) Front 3/4 View

5. REPLACEMENT PARTS

Replacement parts applicable to any encoder of the DIGISEC __/23C series are listed in Table 5-1. These parts are the lamp assembly, logic and hold board A2, and logic board A3.

Table 5-1 Replacement Parts

Encoder Part Number (2785-__)	Replacement Part and Part Number		
	Lamp Assy. ^{1/} 2757-16G__	Logic and Hold Board (A2) 2757-33G__	Logic Board (A3) 2757-36G__
1, 33	1	6	2
2, 34	↓	3	1
3, 35		6	2
4, 36		3	1
5, 37		6	2
6, 38		3	1
7, 39	↓	6	2
8, 40		3	1
9, 41	2	5	2
10, 42	↓	2	1
11, 43		5	2
12, 44		2	1
13, 45		5	2
14, 46		2	1
15, 47		5	2
16, 48		2	1
17, 49		4	2
18, 50		1	1
19, 51		4	2
20, 52		1	1
21, 53		4	2
22, 54		1	1
23, 55		4	2
24, 56		1	1
25, 57		4	2
26, 58		1	1
27, 59		4	2
28, 60		1	1
29, 61		4	2
30, 62		1	1
31, 63		4	2
32, 64	↓	1	1

^{1/} See Section 4.3.1

6. DIFFERENCES IN MODELS

This section contains detailed specifications for all DIGISEC RA __/23C series encoders in addition to those listed in Table 1-1. These detailed specifications are listed in Table 6-1. Also contained in this section is an outline drawing (C 2000-583) that shows pertinent dimensions of all encoders, as well as optional shaft details. The drawing also identifies the electrical connections to the encoder.

All RA __/23C series encoders are identified by type number and part number. The type number gives the major (but not all) encoder characteristics as follows:

RA(a)/23C(b)X

Where R = rotary

A = absolute

(a) = resolution (Table 6-1, Column 1)

23 = standard Size 23 synchro configuration

C = contained electronics

(b) = temperature range (M - Military; C-Commercial)

X = modification of catalog unit; see supplement in front of manual for details.

The part number completely specifies the encoder.

Example: RA 12/23C(M), P/N 2757-47

Table 6-1 shows that this encoder has the following characteristics:

Resolution: 2^{12} transitions/revolution

Input voltage: +6VDC

Shaft style: Splined

Temperature range: Military

Direction of rotation for increasing count: CCW

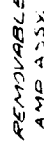
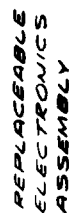
Table 6-1 Detailed specifications for DIGISEC RA __/23C series encoders

DIGISEC Type Number (RA __/23C)	Part Number (2785-__)	Angular Resolution (minutes)	Transitions per Revolution	Input Voltage (+ vdc)	Shaft (Note 5)	Temperature Range (Note 6)
13	1, 33	2.6	2^{13}	5	P	M
	2, 34				P	C
	3, 35				S	M
	4, 36				S	C
	5, 37			6	P	M
	6, 38				P	C
	7, 39				S	M
	8, 40				S	C
12	9, 41	5.3	2^{12}	5	P	M
	10, 42				P	C
	11, 43				S	M
	12, 44				S	C
	13, 45			6	P	M
	14, 46				P	C
	15, 47				S	M
	16, 48				S	C
11	17, 49	10.5	2^{11}	5	P	M
	18, 50				P	C
	19, 51				S	M
	20, 52				S	C
	21, 53			6	P	M
	22, 54				P	C
	23, 55				S	M
	24, 56				S	C
10	25, 57	21.1	2^{10}	5	P	M
	26, 58				P	C
	27, 59				S	M
	28, 60				S	C
	29, 61			6	P	M
	30, 62				P	C
	31, 63				S	M
	32, 64				S	C

Notes

- (1) Outline dimensions shown on drawing C 2000-583
- (2) Electrical connections listed on drawing C 2000-583
- (3) Rotation for increasing count, defined looking at shaft end of encoder:
 - (a) Part numbers 2757G1 through G32, clockwise
 - (b) Part numbers 2757G33 through G64, counterclockwise
- (4) Other specifications listed in Table 1-1
- (5) P = plain, S = splined (see drawing C 2000-583)
- (6) M = military, C = commercial (refer to Table 1-1)

Ⓢ 7



COLOR	LG B/L	PS	UL	MP	B/L	B/L
Black	Black	OMIT	OMIT	PS	RE	RE
Brown	Brown	OMIT	OMIT	PS	RE	RE
Red	Red	OMIT	OMIT	PS	RE	RE
Orange	Orange	OMIT	OMIT	PS	RE	RE
Yellow	Yellow	OMIT	OMIT	PS	RE	RE
Green	Green	OMIT	OMIT	PS	RE	RE
Blue	Blue	OMIT	OMIT	PS	RE	RE
Violet	Violet	OMIT	OMIT	PS	RE	RE
Gray	Gray	OMIT	OMIT	PS	RE	RE
White	White	OMIT	OMIT	PS	RE	RE
Black	Black	OMIT	OMIT	PS	RE	RE
White	White	OMIT	OMIT	PS	RE	RE
Brown	Brown	OMIT	OMIT	PS	RE	RE
Red	Red	OMIT	OMIT	PS	RE	RE
Orange	Orange	OMIT	OMIT	PS	RE	RE
Yellow	Yellow	OMIT	OMIT	PS	RE	RE
Green	Green	OMIT	OMIT	PS	RE	RE
Blue	Blue	OMIT	OMIT	PS	RE	RE
Violet	Violet	OMIT	OMIT	PS	RE	RE
Gray	Gray	OMIT	OMIT	PS	RE	RE
White	White	OMIT	OMIT	PS	RE	RE

MILITARY UNIT TO BE AS SHOWN.
COMMERCIAL UNIT TO BE 2.25 1.010

NOTES:

G/ QTY		ITEM NO	PART NO	DESCRIPTION	MATERIAL	SPECIFICATION	CODE IDENT
				LIST OF MATERIALS			
				UNITS, OTHER AIN SPECIFIED	DWN	U2D	DATE
				1. 1/2" DIA. 1/4" THICK	CHKR	A L	6-26-70
				2. 1/2" DIA. 1/4" THICK	ENGR	1. 1. 1	6-26-70
				3. 1/2" DIA. 1/4" THICK	QA	1/4" DIA. 1/4" THICK	6-26-70
				4. 1/2" DIA. 1/4" THICK	APVD	1/4" DIA. 1/4" THICK	6-26-70
				5. 1/2" DIA. 1/4" THICK			
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SELF-SCAN PANEL DISPLAY

1920-Character Display Consisting of 24 Rows of 80 Characters Each

Single-Line, Intermediate Size, 20-Character-Wide, Alpha-Numeric Display

Model SII0120-0030



The model SII0120-0030 SELF-SCAN II panel display is a single-line, intermediate size, 20-character-wide, alpha-numeric display that is ideal where readability and visibility are primary considerations. The display presents a bright, flicker-free, soft neon-orange glow that is characteristic of gas plasma technology. An additional feature of the panel is its buttability, which permits it to be assembled into multi-panel large displays. For example, a 1920-character display consisting of 24 rows of 80 characters each can be mounted in an enclosure 4 feet by 5 feet by 5 inches.

The panel display operates in a multiplexed scanning mode, with scanning being performed from left to right. Because of the internal panel address feature, only 14 external connections are required to control all of the functions of the panel. The internal address feature also substantially reduces the drive electronics required in comparison to a standard X-Y address matrix display.

The light output is generated by a neon glow discharge between transparent anodes on the front glass plate (for the horizontal rows) and the cathodes (corresponding to the columns) on the rear glass.

The cathodes are bussed in a six-phase arrangement so that 01 cathodes are columns 1, 7, 13, etc. While the common 01 cathodes are all driven low simultaneously during clock periods 1, 7, 13, etc., a glow occurs only under one cathode column due to the internal panel characteristics. This glow is under the anodes addressed by the character generator or auxiliary data inputs. This matrix address results in only those display cells needed in that one vertical column being on at a given moment of time.

This display can be directly interfaced to computer/micro-processor based systems because all logic level inputs/outputs are TTL compatible. The display is ideal for applications where information must be presented to an operator.

ENVIRONMENTAL AND MECHANICAL CHARACTERISTICS

Operating Temperature	0° to 50°C
Storage Temperature	-40° to +85°C
Relative Humidity	90% max. (no condensation)
Weight	14 ounces
Size	14" x 2" x 1 1/2"
Shock	20 g, 1/2 sine wave, 11 ms in Y axis
Vibration	
Constant	2 g acceleration, 50-100 Hz, 10 min each axis
Sinusoid	0.018" double amplitude, 5-50 Hz
Operating Altitude	10,000 ft. max.
Storage Altitude	30,000 ft. max.

OPTICAL CHARACTERISTICS

Character Height	0.65 inch
Character Width	0.55 inch
Dot Size	0.05 inch square
Dot Center-to-Center Spacing	0.10 inch
Luminous Intensity	230 microcandelas
Light Output	60 ft-Lamberts (Note 1)
Contrast Ratio	5 to 1 at 300 ft.-L
Horizontal Viewing Angle	150°
Vertical Viewing Angle	50°
Color	Neon Orange

IN20 SELF

CHARACTER FORMAT (Actual Size)

as in a POS terminal. Each character is displayed in a 5 x 7 dot matrix, and formed of 0.050-inch square cells. Characters are defined by a positive logic six-bit ASCII code. Used in conjunction with the count logic, a character is formed by turning the display dot cells on and off as required at approximately 70 Hz.

The appropriate six-bit ASCII code for each desired character must be present for a minimum of five clock periods of each character position. After the 20th character is displayed, a reset pulse must be supplied to start a new scan. The character displayed in the extreme left location corresponds to the ASCII code present at the data input lines just after the reset pulse. The subsequent characters are displayed sequentially to the right according to the ASCII code provided to the display.

While the panel display is provided with a character generator capable of displaying a 64-character ASCII subset repertoire, seven auxiliary data input lines permit the character generator to be bypassed so that additional symbols or characters can be displayed. Each auxiliary data line controls one horizontal row of dot cells. A logic 0 at an auxiliary data input line turns on a cell; a logic 1 keeps the cell off.

When the auxiliary data inputs are used in conjunction with the character generator, either a logic 1 level must be

applied to pin 1 (display disable) or a blanking code must be present at all the data input lines. In addition, a logic 1 level must also be present at all auxiliary data inputs during the entire reset period, during the last two columns of each character position, and for 14 us (min) after each high-to-low transition of the clock.

An external clock signal of 100 to 120 us provides the basic system timing. For complete scan cycle of the panel, 139 clock pulses are required: 138 clock pulses for the six-phase drive, and one pulse for scan reset. The screen of the panel can also be blanked by applying logic 0 level signal at the display disable input, provided all auxiliary data inputs are at logic 1 level.

The drive circuitry board is mounted with component side accessible to the user. This permits the character generator to be field-replaceable without dismantling the panel/driver board assembly.

For additional information or applications assistance on this panel, write to Burroughs Corporation, Electronic Components Division, P. O. Box 1226, Plainfield, New Jersey 07061; or call our special sales/applications number, (201) 757-3400 in New Jersey, or (714) 835-7335 in California.

NOTES:

1. ALL UNTOLERANCED DIMENSIONS ARE REFERENCE.
2. OPTIONAL PANEL SUPPORT CLIPS ARE SUGGESTED FOR ENVIRONMENTAL CONDITIONS WHERE EXTREME SHOCK AND VIBRATION IS ANTICIPATED.
3. SUGGESTED ALTERNATE MOUNTING PATTERN, HARDWARE KIT WILL SUPPLY (4) FOUR MOUNTING BRACKETS WHEN REQUESTED.
4. PRINTED WIRING BOARD INTERFACE CONSISTS OF 26 PINS .025 SQUARE .318 HIGH AND LOCATED (2) TWO ROWS ON .100 x .100 SPACING.

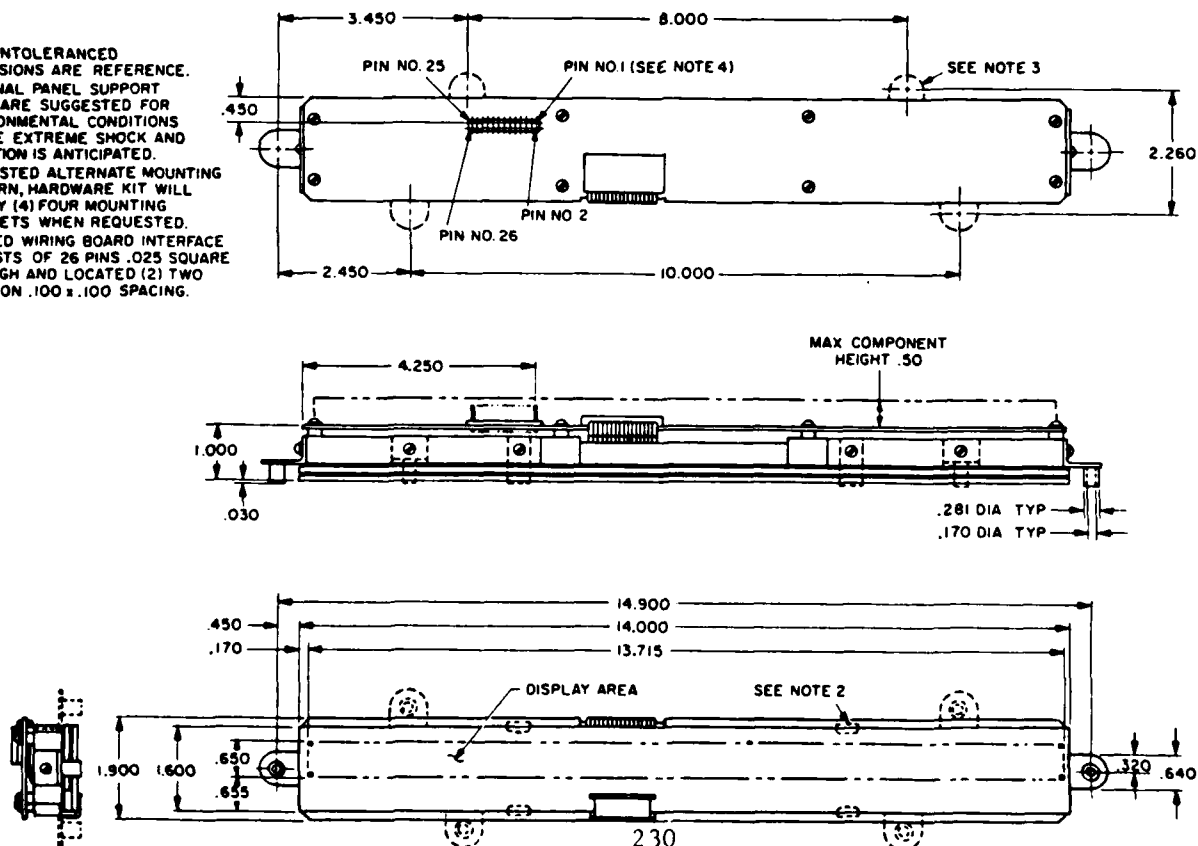


Figure 1. OUTLINE DRAWING

SCAN PANEL

ELECTRICAL CHARACTERISTICS (Note 4)

Power Required

Positive Logic Supply	4.75 to 5.25V @ 350 mA max.
Negative Logic Supply	-11.4 to -12.6V @ -50 mA max.
Display Supply	-237.5 to -262.5V @ -110 mA max.

Clock Input Signal (See Figure 1)

Logic 1 Level	2.0 to 5.25V @ 40 uA
Logic 0 Level	0 to 0.8V @ -7 mA
Clock Period	100 to 120 us
Logic 0 Voltage Duration	20 us to Clock Period -20 us

Data Input Signals

Logic 1 Level	3.75 to 5.25V @ 10 uA max.
Logic 0 Level	-7.0 to 0.6V @ 10 uA max.
Duration (Note 2)	5 Clock Periods

Auxiliary Data Input Signals (Note 3)

Logic 1 Level	4.35 to 5.55V @ 20 uA max.
Logic 0 Level	0 to 0.4V @ -4 mA max.
Logic 1 Duration	14 us min. to 1 Clock Period max.

Reset Input

Logic 1 Level	2.0 to 5.25V @ 40 uA
Logic 0 Level	0 to 0.8V @ -7 mA
Duration	2 to 4 us
Reset Input Delay	0 to 1 us

Display Disable Input (Blanking Control)

Logic 1 Level	2.0 to 5.25V @ 40 uA
Logic 0 Level	0 to 0.8V @ -7 mA

Data Update Output (Pulse Indicating End of Character)

Logic 1 Level	2.0 to 5.25V @ -2 mA
Logic 0 Level	0 to 0.4V @ 10 mA

Table 2. TRUTH TABLE

BINARY INPUT	CHAR.	BINARY INPUT	CHAR.	BINARY INPUT	CHAR.
0	@	22	V	43	+
1	A	23	W	44	.
2	B	24	X	45	-
3	C	25	Y	46	.
4	D	26	Z	47	/
5	E	27	[	48	0
6	F	28	~	49	1
7	G	29	]	50	2
8	H	30	{	51	3
9	I	31	}	52	4
10	J	32	BLANK	53	5
11	K	33	!	54	6
12	L	34	"	55	7
13	M	35	#	56	8
14	N	36	\$	57	9
15	O	37	%	58	:
16	P	38	&	59	;
17	Q	39	/	60	<
18	R	40	(	61	=
19	S	41	)	62	>
20	T	42	*	63	?
21	U				

Table 1. PIN CONNECTIONS

1	Display Disable In	14	Aux. Data 6 In
2	Data Update Out	15	Binary 2 In
3	Clock In	16	Aux. Data 7 In
4	Not Used	17	Binary 4 In
5	Not Used	18	Aux. Data 5 In
6	-250V	19	Binary 8 In
7	Reset In	20	Aux. Data 3 In
8	Not Used	21	Not Used
9	Ground	22	Aux. Data 1 In
10	Aux. Data 2 In	23	Binary 16 In
11	Not Used (Leave Open)	24	-12V
12	Aux. Data 4 In	25	Binary 32 In
13	Binary 3 In	26	+5V

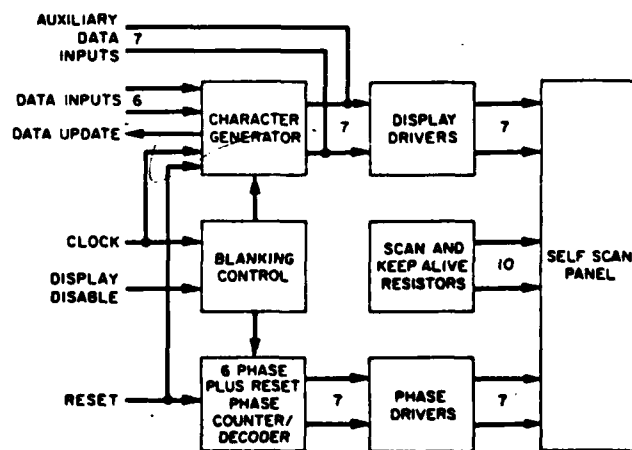


Figure 2. BLOCK DIAGRAM

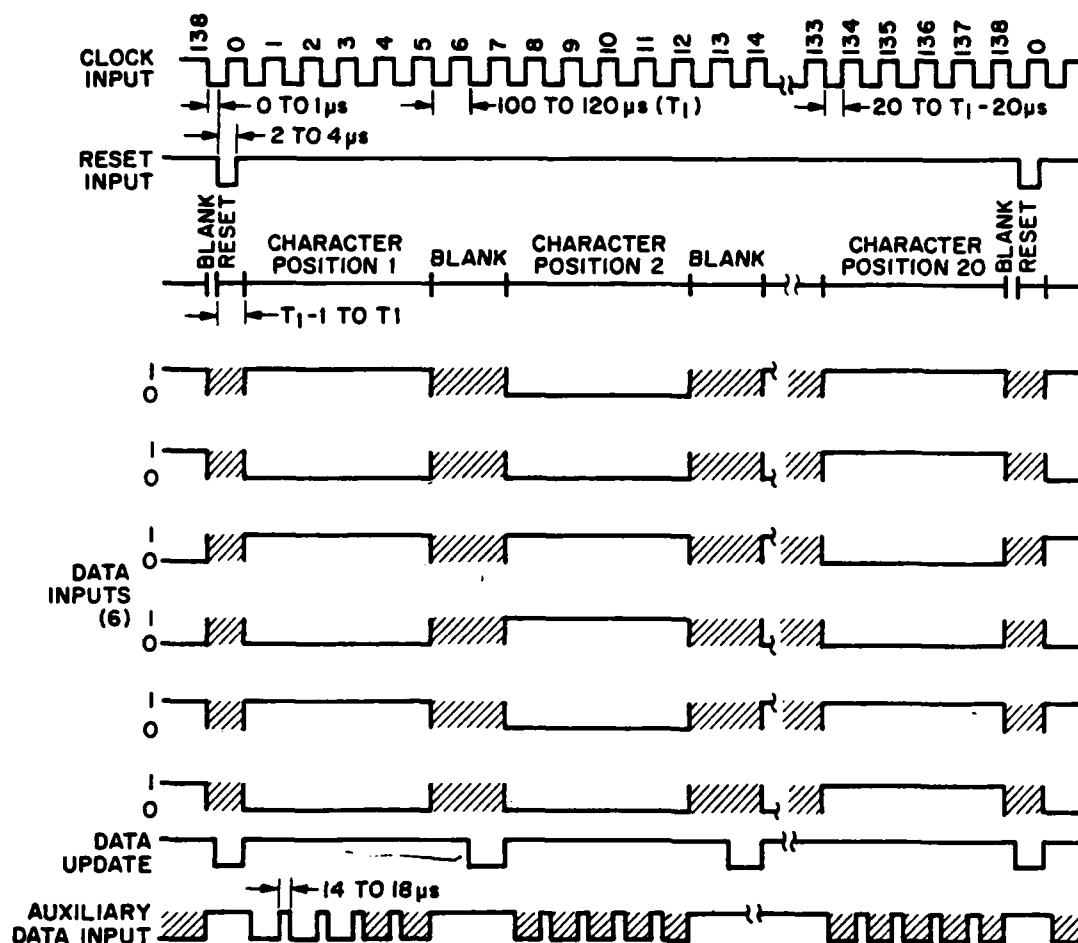


Figure 3. SYSTEM TIMING DIAGRAM

NOTES

1. This value is a typical time-averaged luminous intensity per dot at a current of 10 mA. The intensity may vary slightly with individual panels; but within any panel, all cells will have a constant luminous intensity.
2. Data input must remain constant for the first five clock periods of each character position. A logic 1 level is "true" data.
3. These inputs may be left open-circuited when not used. These inputs must be pulled up to positive logic supply voltage level when used. They must be in logic 1 state for at least 14 μ s after every negative clock transition and during the entire reset period.
4. Absolute ratings beyond which life and performance will be impaired.

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This data sheet is subject to change without notice.

APPENDIX D

EXTERNAL SERIAL INTERFACE

External Serial Interface

The serial interface on the microprocessor allows remote operation of the radome positioner. This interface is based on the RS-232-C interface standard*. ASCII commands are entered from a remote device which invokes the same responses as keyboard entries. A list of valid commands for the serial interface are given in Table D-1. A continuous display of current positioner status is sent to the external device. This device may at anytime send a valid command back through the interface to the microprocessor. Any invalid command received by the microprocessor will invoke an error message. The display on the radome positioner will echo any valid command just as it does for a keyboard entry. A switch, located at the front panel of the computer, will determine the mode of operation of the RFSS Radome Positioner. The two modes of operation are "Local" and "Remote". The local mode will allow only keyboard access and the remote mode will deny keyboard access and allow remote entry of valid commands. Note, however, that the arrow commands can only be used in setting their respective azimuth and elevation limits. Also, a valid command must be typed in to start the continuous display from the serial interface.

Access to the serial interface is by way of a EIA standard 25-pin connector located on the back panel of the microcomputer chassis. This connector, labeled "RS-232-C", is attached to connector P3 on the micro-module 1A board by way of solid wire ribbon cable as indicated on drawing #65. Pin identification using this standard is given in Table D-2.

The low data rates used in this system require no handshaking through the serial interface, therefore, a jumper from pin 15 to pin 14 of P3 (Drawing 65) has been used to constantly enable the I/O port of the microprocessor. For a software listing of the serial interface routine, please refer to Appendix B.

*EIA STANDARD NO. RS-232-C, "Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange", August, 1969, Electronics Industries Association, Engineering Department, 2001 Eye Street N. W., Washington, D.C.

TABLE D-1

Valid Serial Interface Commands

S $\equiv$ Start/Stop

E $\equiv$ Set Elevation

A $\equiv$ Set Azimuth

P $\equiv$ Program

. $\equiv$ Decimal Point

- $\equiv$ Minus Sign

↓ $\equiv$ DOWN

↑ $\equiv$ UP

← $\equiv$ LEFT

→ $\equiv$ RIGHT

NOT ACCESSIBLE
with in REMOTE

Manual positioning

1 E, 20.0, S

2 E, 20.0, A, 10.0, S

To ADJUST LIMITS

{E}, [↓, ↑, ←, →] this is the

current limit: change it by the

TO SET LIMIT OK S.

To run programs

P

Enter {E} see Table D-1

it will ask for parameters (again see Table D-1) then S

TABLE D-2

Pin Description for Serial Interface Connector

Pin Number (25 Pin Connector)	P3-Edge Connector (20 Pin Connector) (Drawing 65)	Description	Abbreviation
1	1	Protective Ground	GND
2	3	Transmitted Data	Tx DATA
3	5	Received Data	Rx DATA
4	7	Request to Send	RTS
5	9	Clear to Send	CTS
6	11	Data Set Ready	DSR
7	13	Signal Ground	GND
8	15	Received Line Signal Detector	SIG DET
9	17	Ground	GND
10	19	Ground	GND
11 - 19	x,x,x,2,4,6,8,10,12	Not Used	—
20	14	Data Terminal Ready	DTR
21 - 25	16,18,20,x,x,	Not Used	—

APPENDIX E

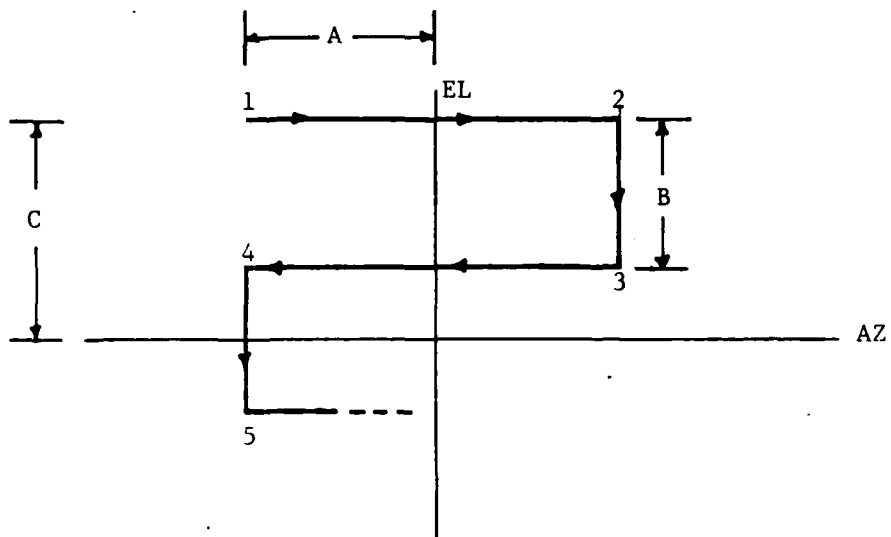
PRESTORED RASTER SCAN PATTERNS

Raster Scan Patterns

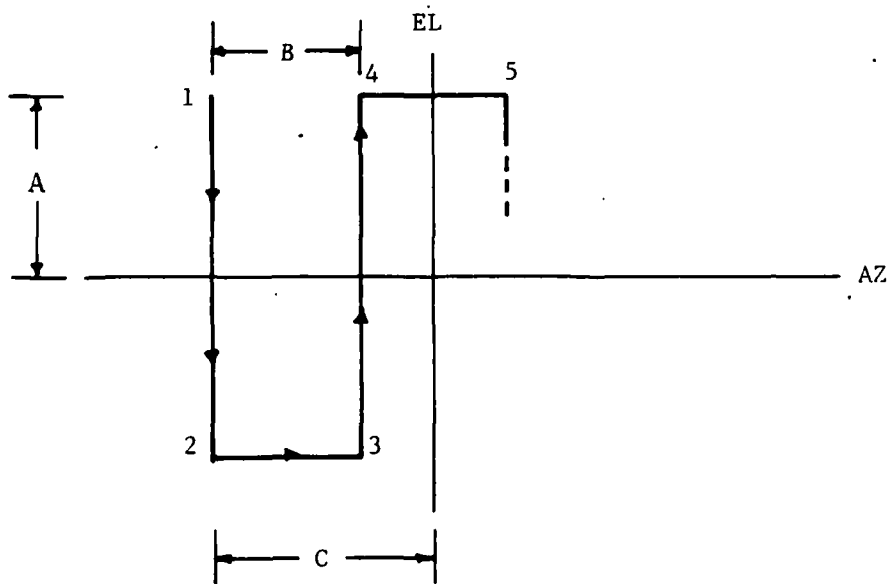
The patterns are generated from keyboard entries made by the user. The entries are variable parameters that determine how each pattern is generated. The display is used to prompt user access through either the keyboard or external serial interface by the use of these variable parameters: A, B, and C. Currently, there are four user programmable patterns that are invoked by activation of the "PROG" key on the keyboard. The display will then ask the user to enter a programmed pattern number from 1-4. The user will then be prompted by the display to enter the required parameters upon which the processor will then wait for a "START" key to be pressed before the desired program will start.

Patterns 1, 2 and their associated variables are defined in Figure E-1. The microcomputer, using the entered values of "A" and "C", computes point 1 and promptly moves the positioner to that point. The positioner will briefly stop and then move to the next calculated position, point 2. Point 3 is computed by the entered parameter "B". The positioner is moved to point 4 taking advantage of the change in coordinate signs and then finishes one period of the scan after arriving at point 5. The remainder of the raster positions are calculated in a similar manner. Pattern 2 is generated in a similar manner, the only difference being a 90 degree shift of the AZ/EL axes.

Patterns 3 and 4, shown in Figure E-2, access stored trigonometric values which are used to generate the desired patterns. These stored values can be found in the software listing of Appendix B. Activation of pattern 3 will initialize the positioner at the origin of the coordinate system. This position is referred to in the figure as point 1. The positioner will then move up in elevation until it reaches point 2. One leg of the star has now been generated. It will then move down in elevation and stop when point 3 is reached. The positioner will move back up to the origin (point 1). The positioner moves in a similar manner to complete the star raster. The legs of the star are separated by the entered angle

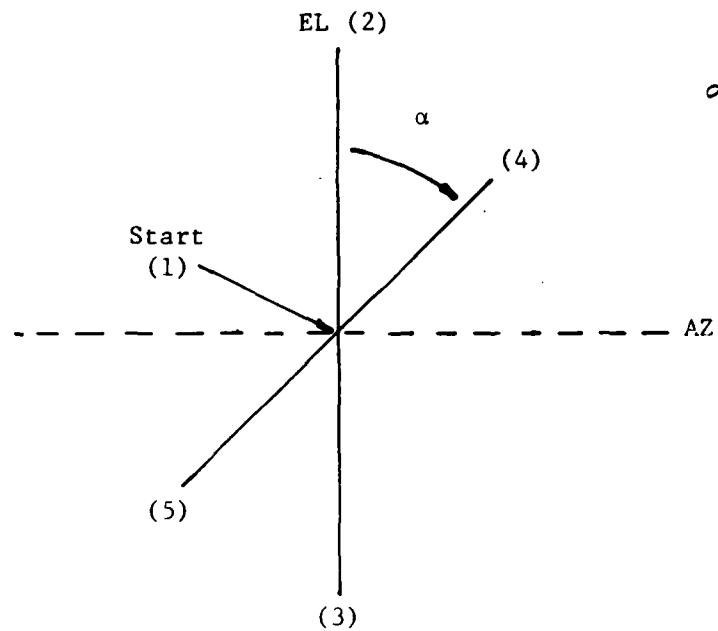


a) Pattern #1

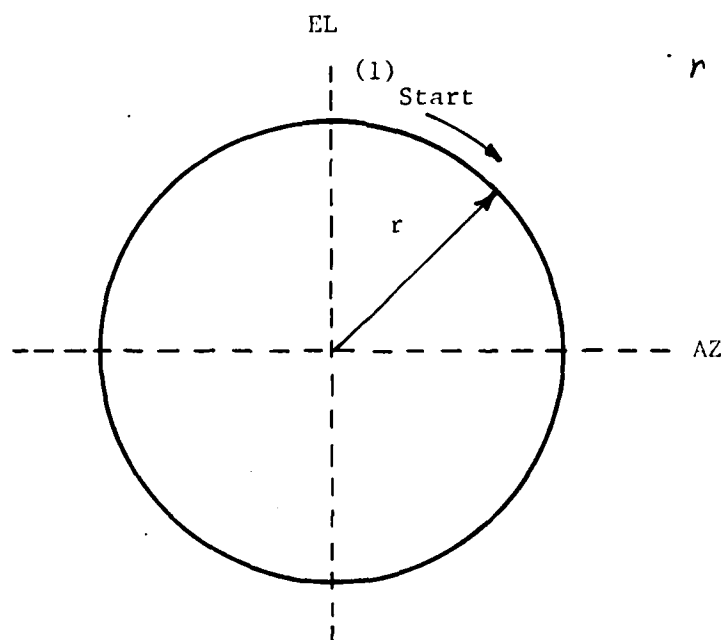


b) Pattern #2

Figure E-1. Linear Raster Patterns



a) Pattern #3 (Star)



b) Pattern #4 (Circle)

Figure E-2. Star and Circle Raster Patterns

α and all the end points of the legs are computed using analytical geometry. These points are defined as points on a circle with a maintained radius. Pattern 4 is a circle of which the radius is a variable through an entered parameter r . The circle is begun at point 1 on the elevation axis and moves in a clockwise direction with a constant increment of one degree. This angular resolution cannot be changed by the user and always completes a cycle of 360 degrees. The software listing of all four patterns can be found in Appendix B.

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