TECHNICAL MANUAL

OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL

RADAR SET AN/SPS-64(V) 5
(NSN 5840-01-034-3946)
TRUE MOTION/ANTI-COLLISION

HEADQUARTERS, DEPARTMENT OF THE ARMY

30 NOVEMBER 1981

HIGH VOLTAGE WARNING

Do not open any of the units when the radar is on; high voltages, which could be fatal to anyone coming in contact with them, are present within the indicator, MTR, and antenna pedestal.

Disconnect ship's power from the indicator and the MTR before attempting any maintenance; otherwise, ship's power will be present at terminals inside the MTR, indicator, and antenna pedestal.

WARNINGS

Microwave receiver protector tube V3 in the receiver-transmitter contains radioactive material, Tritium (H-3).

As long as the tube is unbroken it does not emit any harmful radiation and is safe to handle. If the tube is broken, avoid skin contact and notify the local Radiological Protection Officer (RPO) for assistance. If skin contact is made with any area suspected of being contaminated with Tritium, immediately clean the skin with lukewarm water and a nonabrasive soap and call the local RPO for further decontamination procedures. Disposal of radioactive microwave receiver protector tubes not in equipment, damaged or broken shall be handled as radioactive waste in accordance with AR 755-15.

The statements below are a brief summary of the safety warnings. Full warning precautions appear throughout the test before any procedure which involves dangerous voltages.

RADIATION HAZARD

Be extremely careful to avoid possible harmful effects (particularly to the eyes) of radiation from radar transmissions.

To avoid harmful radiation, the indicator POWER switch should be turned to the ST BY or OFF position when working on the antenna. Never look directly into the antenna from a distance of less than 6 feet when the radar is operational.

EXTREMELY DANGEROUS VOLTAGES EXIST IN THE FOLLOWING UNITS: BEFORE TOUCHING ANY PARTS, DISCHARGE ANY STORED HIGH VOLTAGE USING A WELL-INSULATED GROUNDING LEAD.

Receiver-transmitter	**9,000 and 12,000 volts**
Indicator	**17,000 volts**

Many power supplies use a floating common bus which operates at voltages between -75 and -175 v with respect to chassis. Be extremely careful.

WARRANTY
RADAR SYSTEM SPS-64(V)

Raytheon warrants each new radar to be free of defects in material and workmanship and will exchange any parts proven to be defective, at no charge, for a period of one year from the date of original installation, except for specialized electron power tubes, provided the radar has been properly installed and operated. The warranty is contingent upon receipt of an installation report and warranty certificate completed by the installing firm.

Specialized electron power tubes (Magnetron, Modulator, CRT, and T/R Limiter) will be replaced, if proven to be defective, at no charge for a period of six months or 1000 hours of use, whichever comes first, after the date of original installation.

If, upon inspection of Raytheon or one of its authorized representatives, the radar proves to be defective and has not been damaged by accident, abuse or misuse, it will be repaired during normal working hours by an authorized Raytheon Service Station at no charge for a period of six months after the date of original installation. Travel cost of Raytheon's authorized radar service station representative up to a total of 50 highway miles will be borne by Raytheon.

Raytheon equipment, or parts thereof, which have been repaired or altered outside of its plant except by authorized Raytheon Service Stations, are not warranted in any respect.*

Raytheon shall not be liable for special or consequential damages of any nature with respect to any merchandise or services sold, rendered or delivered. This certificate is the only warranty expressed or implied by Raytheon, except as to title. Raytheon reserves the right to make changes or improvements on previously sold equipments.

This warranty is effective only with respect to the original purchaser from Raytheon Marine Company or an authorized Raytheon Commercial Dealer.

* EXCEPTION

U.S. Government personnel who have successfully completed a Raytheon Marine Company approved training course are authorized to perform the following operations without voiding the warranty.

1. Certify installations of equipment on which factory training was received.
2. Replace any component furnished as shipboard spares, and make necessary adjustments on such equipment.

The material in this manual was furnished by Raytheon Marine Company

TECHNICAL MANUAL
No. 11-5840-360-14-2

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *30 November 1981*

OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL

RADAR SET AN/SPS-64(V) 5
(NSN 5840-01-034-3946)
TRUE MOTION/ANTI-COLLISION

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in back of this manual, direct to: Commander, US Army Communications and Electronics Materiel Readiness Command, ATTN: DRSEL-ME-MQ, Fort Monmouth, NJ 07703.

In either case a reply will be furnished to you.

TABLE OF CONTENTS

A complete set of Technical Manuals for the AN/SPS-64(V) 5 consists of 3 volumes: TM-11-5840-360-14-1-1, Relative Motion, Chapters 0-5; TM 11-5840-360-14-1-2, Relative Motion, Chapter 6; and TM-11-5840-360-14-2, True Motion/Anti-Collision.

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SECTION 0

INTRODUCTION

0.1 SCOPE OF MANUAL

0.1.1 This manual contains instructions for the installation, operation, maintenance, and repair of the True Motion/Anti-Collision (TM/AC) option, portion of the radar set. This option, when added to the basic relative motion radar set, constitutes Radar Set AN/SPS-64(V) 5.

0.1.2 This manual must be used with TM 11-5840-360-14-1-1 and TM 11-5840-360-14-1-2 to provide complete coverage for Radar Set AN/SPS-64(V) 5.

0.1.3 When operating the AN,/SPS-64(V) 5, use this manual for normal operation in both the relative and true motion modes.

0.1.4 *Emergency Operation.* in case of failure in the TM/AC unit, it is possible to bypass the TM/AC and use the set as a relative motion radar (para 3.4).

0.2 INDEXES OF PUBLICATIONS

Refer to the latest issue of DA PAM 310-4 to determine whether there are new editions, changes, additional publications or modification work orders pertaining to the equipment.

0.3 MAINTENANCE FORMS, RECORDS, AND REPORTS

0.3.1 *Reports of Maintenance and Unsatisfactory Equipment.* Department of the Army forms and procedures used for equipment maintenance will be those prescribed by TM 38-750, The Army Maintenance Management System.

0.3.2 *Report of Packaging and Handling Deficiencies.* Fill out and forward DD Form 6 (Packaging Improvement Report) as prescribed in AR 700-58/NAVSUPINST 4030.29/AFR 71-13/MCO P4030.29A, and DLAR 4145.8.

0.3.3 *Discrepancy in Shipment Report (DISREP) (SF 361).* Fill out and forward Discrepancy in Shipment Report (DISREP) (SR 361) as prescribed in AR 55-38/NAVSUPINST 4610.33B/AFR 75-18/ MCO P4610.19C and DLAR 4500.15.

0.4 ADMINISTRATIVE STORAGE

Refer to TM 11-5840-360-14-1-1 as the Headset is an integral component of Radar Set AN/SPS-64(V) 5.

0.5 DESTRUCTION OF ARMY ELECTRONICS MATERIEL

Refer to TM 11-5840-360-14-1-1 as the Headset is an integral component of Radar Set AN/SPS-64(V) 5.

0.6 REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR's)

If your AN/SPS-64(V) 5 needs improvement, let us know. Send us an EIR. You, the user, are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design. Tell us why a procedure is hard to perform. Put it on an SF 368 (Quality Deficiency Report). Mail it to Commander, US Army Communications and Electronics Materiel Readiness Command, ATTN: DRSEL-ME-MQ, Fort Monmouth, NJ 07703. We'll send you a reply.

SECTION 1

GENERAL INFORMATION

1.1 INTRODUCTION

1.1.1 Purpose of Manual

This manual presents instructions for the installation, operation and maintenance of the Raytheon TM/EP Unit.

1.1.2 Features of the TM/EP Unit

The TM/EP can be added to any of the Raytheon Mariner's Pathfinder Radar series that use either a 12-inch or a 16-inch PPI screen. The Raytheon TM/EP provides tile radar in which it is installed with the capability of presenting to the observer a true picture of the surrounding area. Stationary objects (land, buoys, etc.) remain stationary on the screen while "own ship" (the vessel itself) moves across the screen on its true course and at its true speed. It also provides the capability to plot and track up to eight separate targets.

The true motion display feature, by itself, would provide a distinct advantage over relative motion presentations in that the direction of the "echo tails" (caused by the afterglow of the successive paints of an echo) of targets is not affected by own ship's motion.

The Raytheon TM/EP enhances this capability by providing the display of the target's position at the time of plot (true mark), elapsed time since the plot, and an electronic bearing line (EBL) which originates at the point of the original plot (EBL true). This capability permits very rapid calculation of the true course and speed of the target as well as own ship's true course and speed. The TM/EP also calculates and displays the position of the original plot displaced by own ship's movement (REL mark) and an EBL which originates from this point (EBL relative).

This last feature, when combined with the elapsed time display, permits rapid calculation of the closest point of approach (CPA) and the time to the closest point of approach (TCPA). Up to eight targets can be plotted and simultaneously tracked.

A trial maneuver feature permits visual display and rapid calculation of CPAs and TCPAs that would result from any change in own ship's course and/or speed without actually performing the maneuver.

1.2 PHYSICAL DESCRIPTION

The TM/EP unit is shown installed on an indicator in Figure 1-1 and the individual TM/EP components are shown in Figure 1-2. The TM/EP consists of six assemblies: the TM/EP headset, the digital card cage, the low voltage power supply, the joystick assembly, the Sin/Cos (heading) potentiometer assembly and the EBL assembly. The TM/EP is connected to the indicator

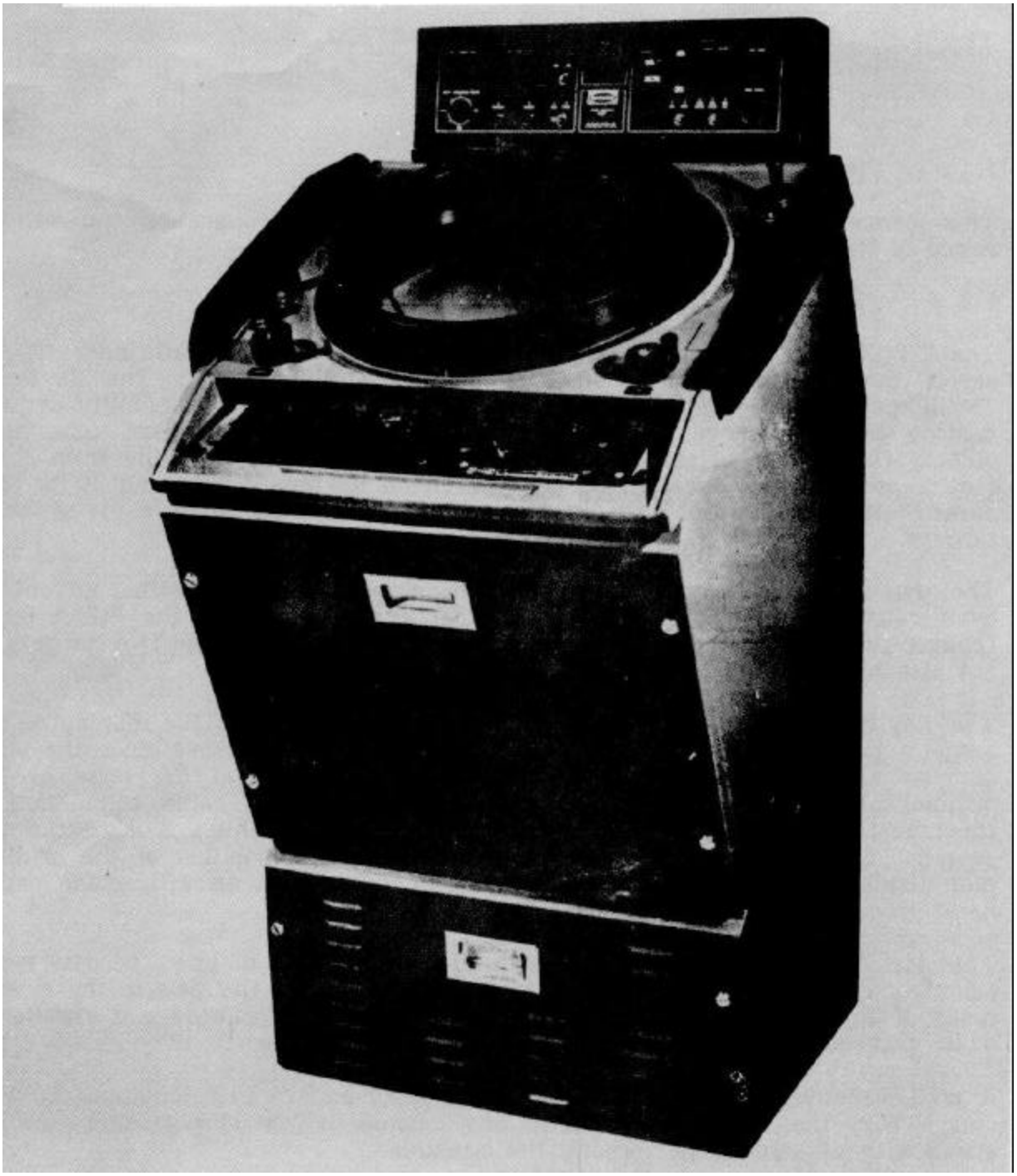


Figure 1-1. Radar Indicator with TM/EP Installed

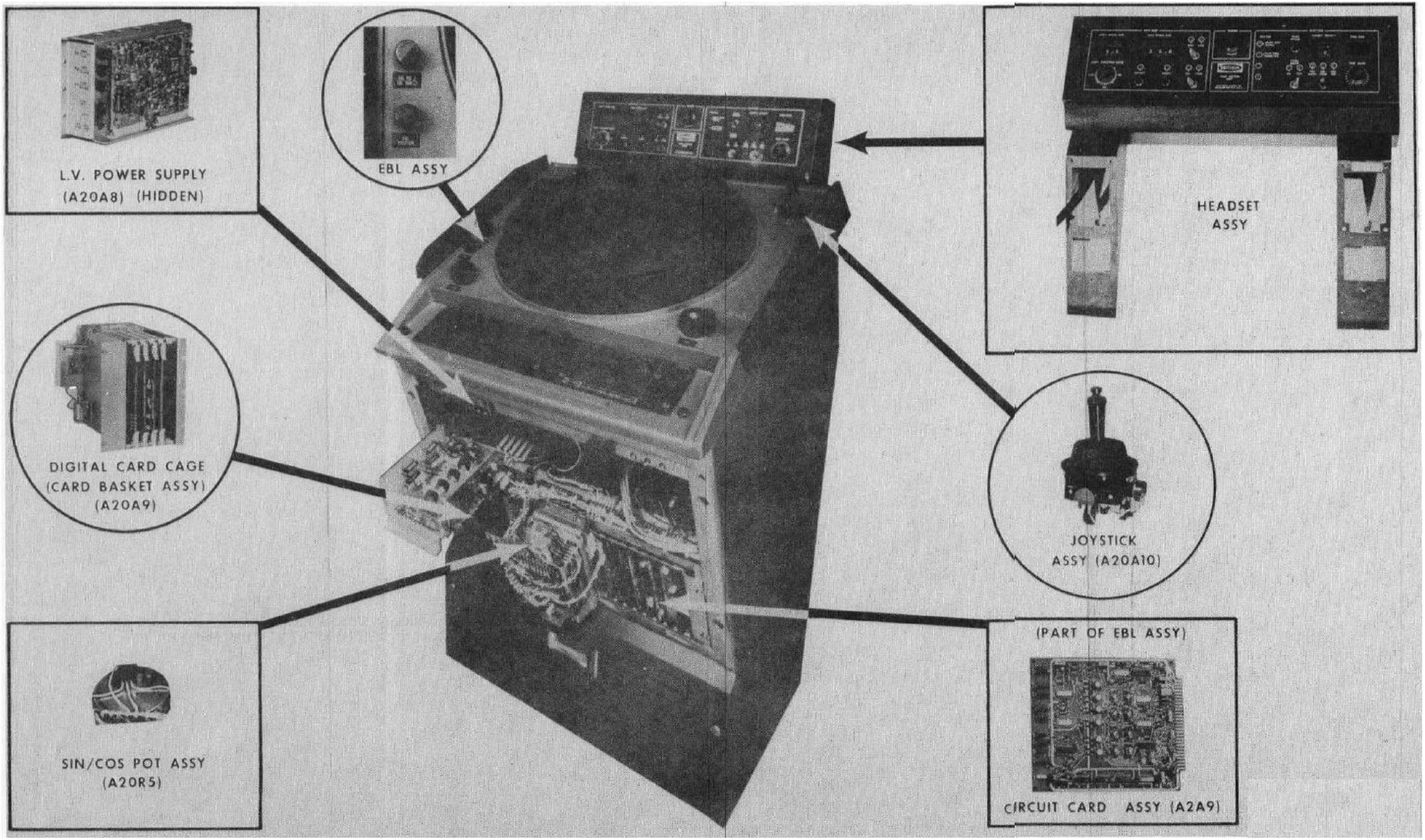


Figure 1-2. TM/EP Assemblies

through a wiring harness. AC power input to the TM/EP is from the indicator on which it is installed.

1.2.1 TM/EP Headset

The TM/EP headset, which contains the TM/EP time and status indicators, is mounted on the rear of the radar indicator. The headset houses the PCB assemblies which interface the control panel switches and indicators with the processor circuitry. All of the controls for the TM/EP, except the joystick and EBL dials, are mounted on the control panel of the headset.

1.2.2 TM/EP Digital Card Cage

The digital card cage mounts the four PCB assemblies which comprise the Digital Processor circuit. The card cage is connected to the Headset, the Power Supply and the indicator through the TM/EP wiring harness attached to the TM/EP headset.

1.2.3 Low Voltage Power Supply

The low voltage power supply is an enclosed assembly that mounts inside the indicator. It supplies all of the dc voltages required by the TM/EP circuitry.

1.2.4 Joystick Assembly

The joystick assembly, which is mounted on the indicator bezel, is used by the operator to position target marks, enter trial maneuver data and, in the offset mode, to position the sweep origin to the desired position on the CRT. Joystick operations are performed by depressing the joystick pushbutton switch, steering the moving mark by movement of the joystick in the desired direction, and releasing the switch when the mark is in position.

1.2.5 Sin/Cos (Heading) Potentiometer Assembly

The Sin/Cos potentiometer (Pot.) assembly, which is mounted on the north stabilization kit (NSK) assembly, provides ships heading information to the TM/EP circuitry.

1.2.6 EBL Assembly

The EBL assembly consists basically of two component items: two potentiometer controls and associated switch (EBL RD/EBL DIM and EBL POSITION) mounted on the left side of the indicator bezel and an EBL (switching) circuit card assembly (A2A9) located inside the indicator digital card cage assembly. These controls, in conjunction with the circuit card assemblies, allow the operator to set the origin of EBL to the CRT center to enable reading from the bearing scale and permit (angular) rotation of the EBL about its origin in either a clockwise or counterclockwise direction.

1.3 EQUIPMENT SUPPLIED

The TM/EP option is installed at the factory as shown in Figure 1-1, and the equipment supplied is illustrated in Figure 1-2. An instruction manual is supplied with the modified indicator.

1.4 FUNCTIONAL DESCRIPTION

Figure 1-3 is a simplified block diagram which shows the basic functions of the various components of the TM/EP. Refer to Section 4 for the detailed circuit description of the TM/EP unit. Information representing ship's heading, drift angle, joystick position, and time mark spacing is fed to the processor in the digital card cage from the TM/EP assemblies and from the indicator circuitry in analog form (varying voltage level). The voltage levels are separately converted to binary numbers by the processor. Digital inputs in the form of binary numbers or logic levels are also fed to the processor from the headset controls. A programmed set of instructions causes the processor to manipulate the numbers and internally stored data in accordance with the inputs from the operator controls.

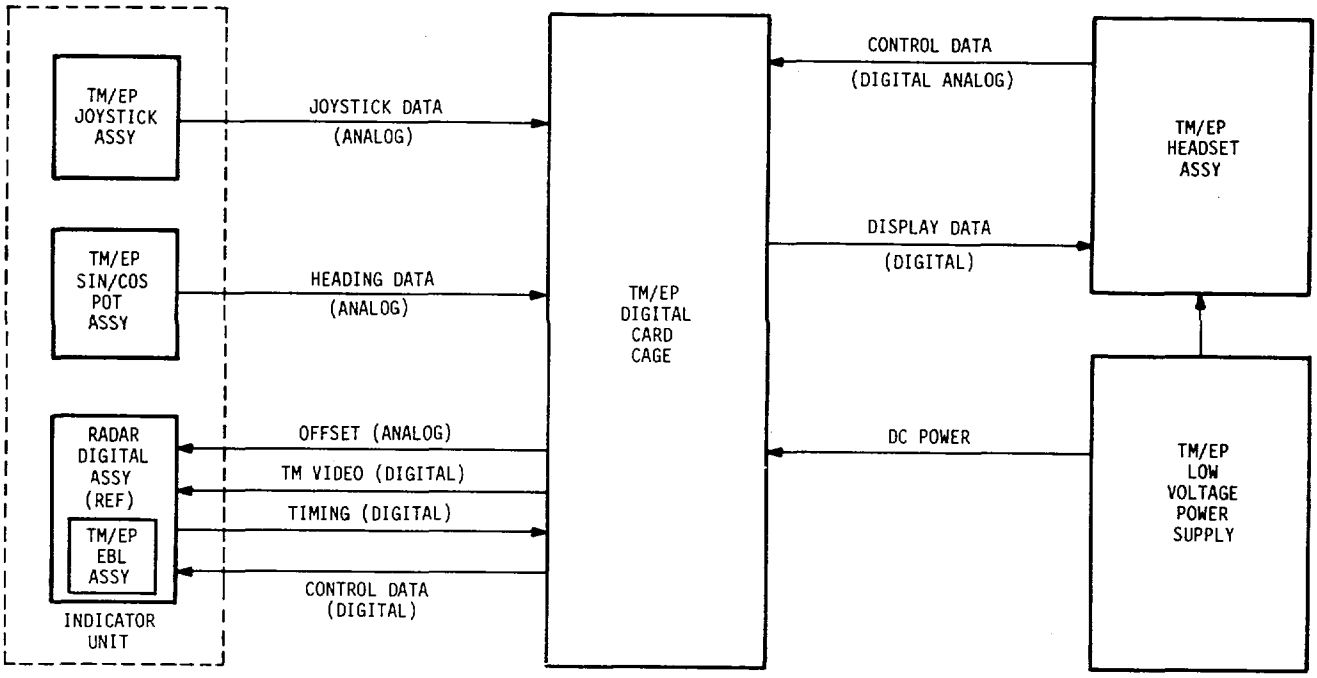


Figure 1-3 TM/EP Functional Block Diagram

The result of this data manipulation is used to control the TIME (MIN) display and STATUS indicators on the control panel of the TM/EP headset directly. For control of the sweep origin on the CRT, the resultant processor data is converted to analog form and sent to the indicator circuits as a variable voltage, along with digital control information.

The low voltage power supply provides +5 Vdc for operation of the logic circuitry of both the digital card cage and the TM/EP headset. It also provides ±15 Vdc for operation of the linear IC circuits in the digital card cage.

1.5 SPECIFICATIONS

Performance characteristics for the TM/EP option when integrated with the radar indicator are listed in Table 1-1.

1.6 PCB AND COMPONENT SPARES

Table 1-2 lists the contents of the TM/EP minimum special spares kit (Product Code, M27524). The recommended TM/EP shipboard full complement spares kit (Product Code, M27522) is listed in Table 1-3.

Table 1-1 TM/EP Unit/Indicator Performance Characteristics

Parameter	Description											
Range Scale (miles)	0.25	0.5	0.75	1.5	3	3(*)	6	12	24	48	64	12RT
Maximum Offset Display (miles)	0.42	0.85	1.28	2.55	5.1	5.1	10.2	20.4	40.8	N/A	N/A	20.4
Maximum Offset Display (usec)	189	189	189	189	189	285	295	295	378	N/A	N/A	285
Normal Display Sweep (usec)	111	111	111	111	111	166.5	166.5	166.5	222	222	222	166.5
True Motion Display	no	no	yes	yes	yes	yes	yes	yes	yes	no	no	no
Range Ring Interval (miles)	125	25	25	25	5	5	1	2	4	8	16	2
Display Rep Rate (kHz)	3.6	3.6	3.6	3.6	3.6	1.8**	1.8**	1.8**	0.9	0.9	0.9	1.8
Speed Input	0. to 59 knots											

Table 1-1 TM/EP Unit/Indicator Performance Characteristics (cont'd)

Parameter	Description		
Speed Input Resolution	0.1 knots		
Drift Speed Input	0 to 9.9 knots		
Drift Speed Resolution	0.1 knots		
Plotting Time	78 minutes maximum		
Plotting Time Resolution	0.1 minutes		
Targets Plotted	8 maximum		
Offset Direction	Operator variable - 0 to 360 degrees		
Range Ring Accuracy	10 yards or ± 0.25% (whichever is greater)		
Range Resolution	0.25, 0.5, 0.75NM 20 yards	1.5NM 25 yards	3.0NM 43 yards
Bearing Accuracy	± 1.0 degree		
Bearing Resolution VRM	1.25 degrees at 1/3 radius		
VRM Accuracy	10 yards or 1.0% (whichever is greater)		
VRM Resolution	5.062 yards or 0.25% (whichever is greater)		
Ambient Tempera-ture Range	0° to +55°C		

Table 1-1 TM/EP Unit/Indicator Performance Characteristics (cont'd)

Parameter	Description		
Relative Humidity (at 55°C)	95%		
Shock (all planes)	15G		
Vibration (16" Indicator)	1G at 5-50Hz		
Vibration (12" Indicator)	5 to 12.5 Hz 125" disp. (sine)	12.5 to 25 Hz 031" disp. (sine)	25 to 50 Hz 008" disp. (sine)

(*) with POWER BOOST function
(**) optional 0.9kHz

Table 1-2 TM/EP Minimum Special Spares Kit (P/N 980084-1)

Qty.	Description	Part Number
1	Digital PCB Assy (A20A9A4)	166999-1
1	Analog PCB Assy (A20A9A1)	167003-1
1	Processor PCB Assy (A20A9A2)	167006-1
1	Memory PCB Assy (A20A9A3)	167009-2
1	Switch and Lamp Buffer PCB Assy (A20A3)	168588-1
2	LED Display, Lighted	166346-2
2	LED Display, Lighted	166346-3
5	Fuse, F, AGC1.5, 250V	226-7176P41
5	Fuse, Glass Tube, MDL1/2	226-7177P20

Table 1-3 TM/EP Shipboard Spares Kit (P/N 169475-1)

Qty.	Description	Part Number
1	Digital PCB Assy (A20A9A4)	166999-1
1	Analog PCB Assy (A20A9A1)	167003-1
1	Processor PCB Assy (A20A9A2)	167006-1
1	Memory PCB Assy (A20A9A3)	167009-2
1	Control PCB Assy	982220-1
1	Time Display PCB Assy (A20A1)	589465-1
1	TMU Time Display DVR PCB Assy (A20A2)	168601-1
1	Switch & Lamp Buffer PCB Assy (A20A3)	168588-1
1	TM Power Supply Assy (A20A8)	982221-1
1	EBL PCB Assy (Circuit Card Assy) (A2A9)	589468-2
1	NSK Rslvr Dr. PCB Assy (Al)	167688-2
1	Switch, Pushbutton	168547-1
1	Sw Toggle	168806-6

Table 1-3 TM/EP Shipboard Spares Kit (P/N 169475-1) (cont'd)

Qty.	Description	Part Number
1	Switch	169442-1
2	Transistor	585748-1
2	Xstr SIL 2N3902 BLU	18-212-2
2	LED Display, Lighted	166346-2
2	LED Display, Lighted	166346-3
5	Fuse, F, AGC1.5, 250V	226-7176P41
5	Fuse, Glass Tube, MDL 1/2	226-7177P20

SECTION 2

INSTALLATION

2.1 GENERAL

As presently configured, the TM/EP option is not considered to be a field installation. The TM/EP components are mounted in the radar indicator at the factory and the complete true motion indicator is aligned and tested before shipment.

Field installation consists of installation of the indicator unit itself. Procedures for installation of the indicator are included in the basic radar manual. The only added installation procedure resulting from the addition of the TM/EP option to the indicator is the connection of the ship's speed log to the indicator.

2.2 TM/EP INDICATOR INSTALLATION

2.2.1 Basic Indicator Installation

1. Install the indicator in accordance with the procedures given in Chapter 2, Section 2 of the basic radar manual.

NOTE

Installation drawings for the 12-inch (Figure 2-1) and the 16-inch (Figure 2-2) radar indicators are included in this section for reference.

2.2.2 Speed Log Connections

1. Route the cable from the ship's speed log through the entry plate on the bottom of the indicator and up the right side to TB4. The speed log is generally three twisted pairs.

2. Connect the SPEED LOG (F/A) to TB4-7.

3. Connect the SPEED LOG P/S SENSE to TB4-8.

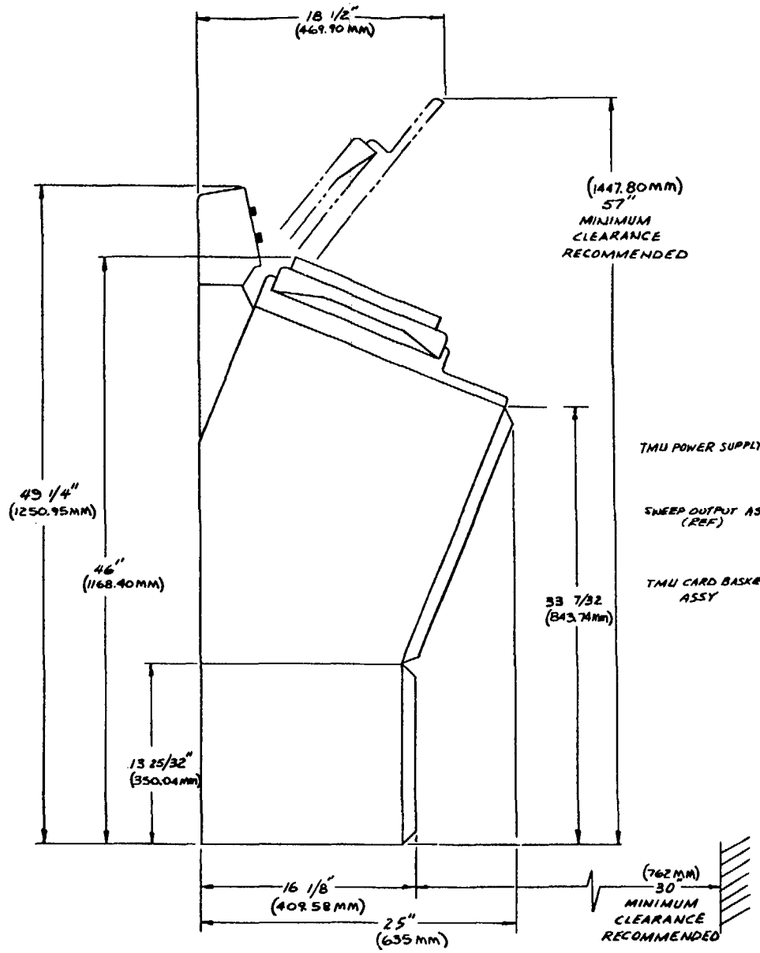
4. Connect the SPEED LOG (P/S) to TB4-9.

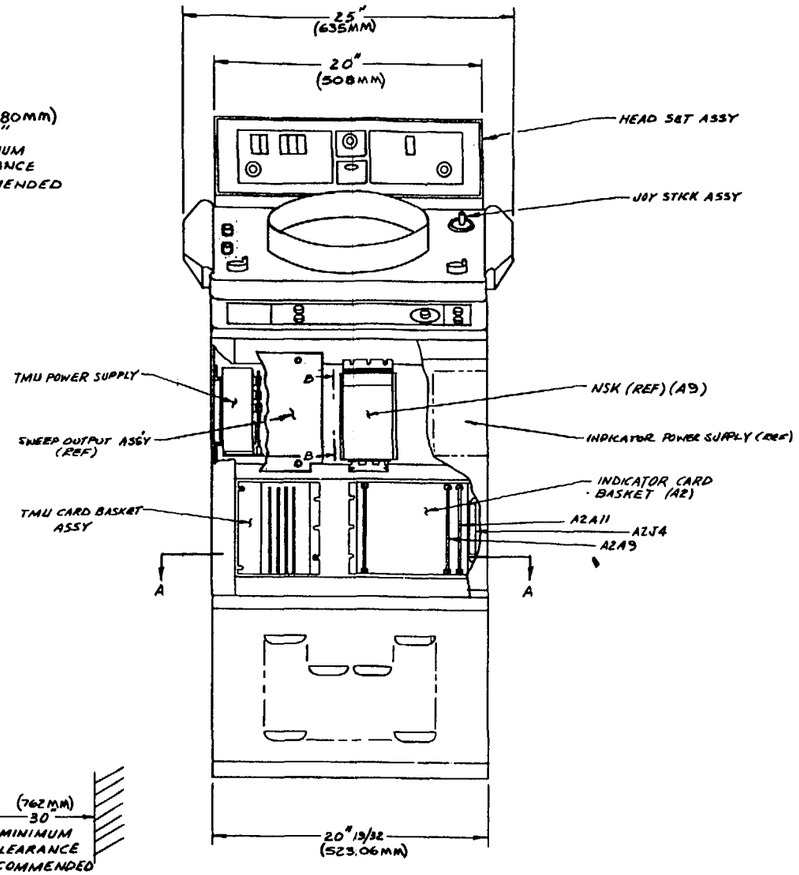
5. Connect all three returns to Eli on the indicator chassis. Refer to Figure 2-1 for location.

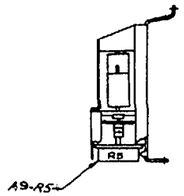
6. Secure cable end so as to prevent strain on the connections.

2.3 SYSTEM CHECKOUT

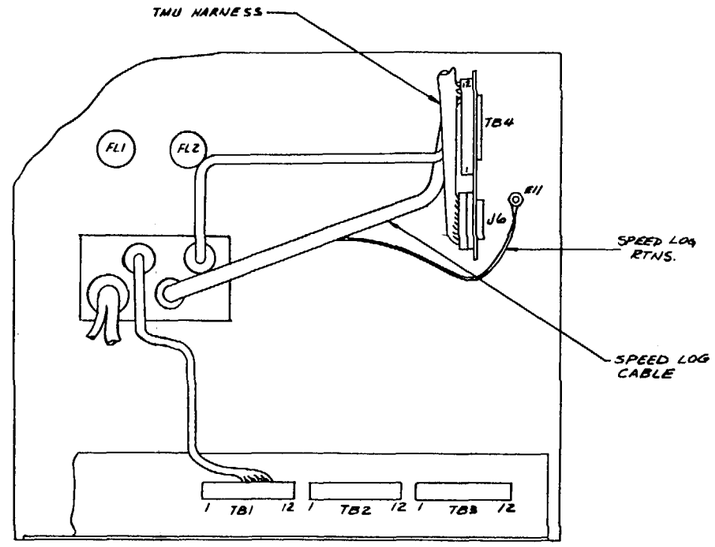
After the TM/EP indicator installation and connections have been completed, perform the checkout procedures covered in paragraph 5.6 of this manual to assure that the TM/EP radar system is operationally ready.







VIEW B-B
SCALE: NONE

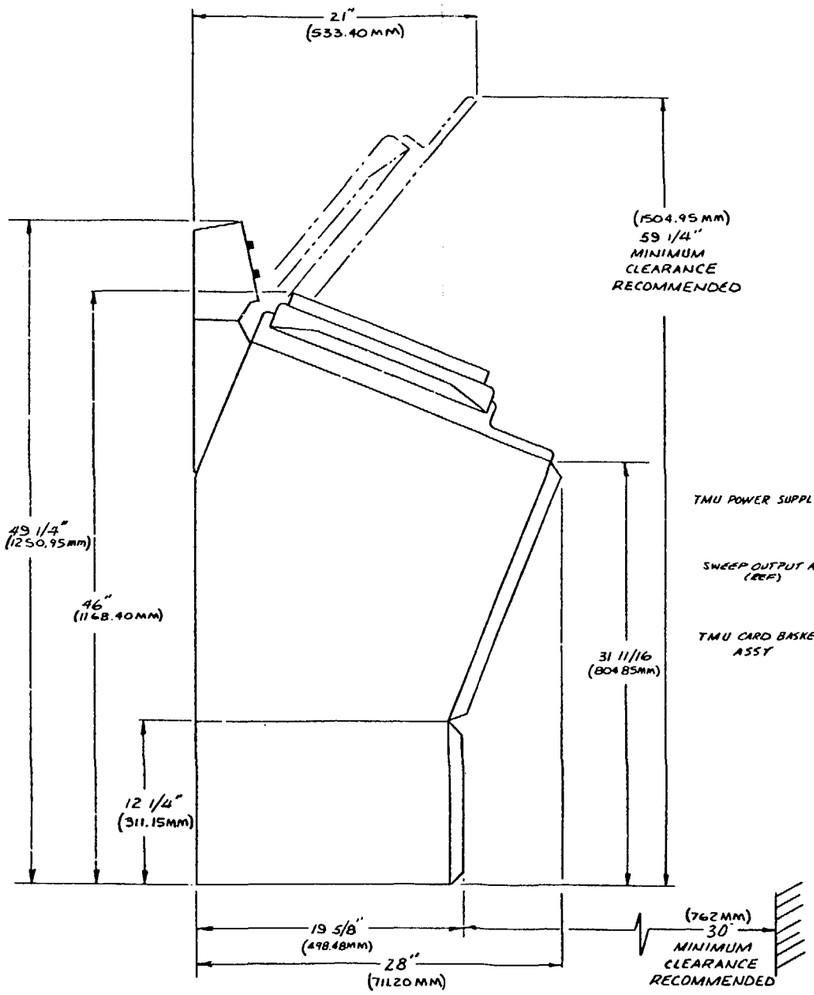


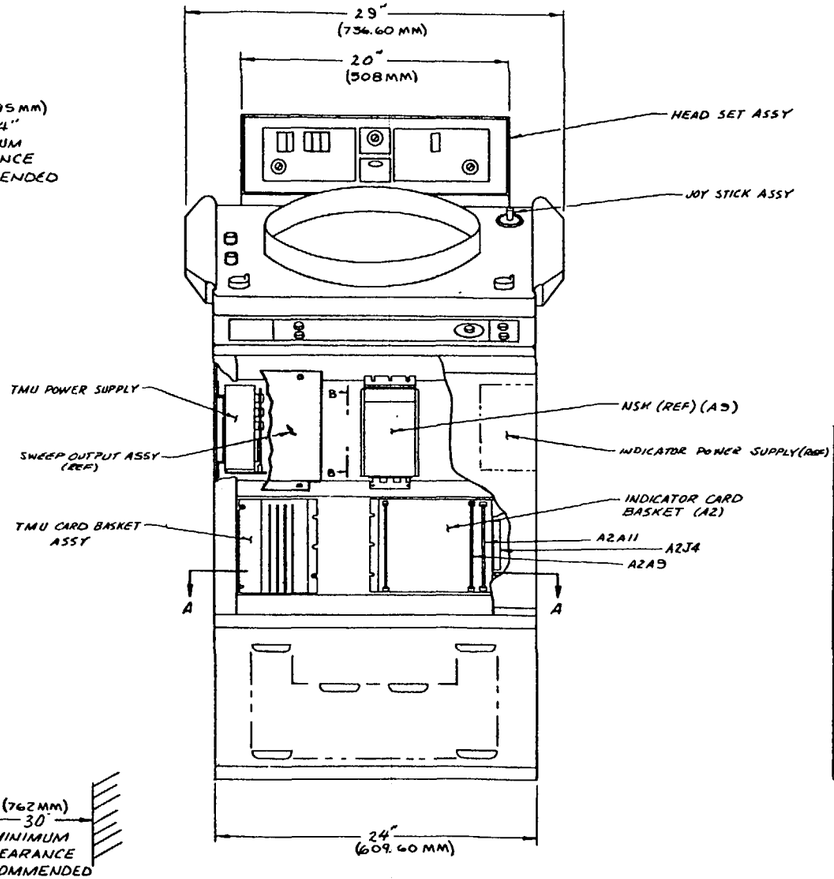
SECT A-A
SCALE: NONE

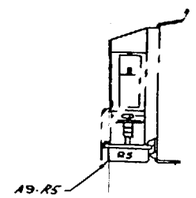
NOTE: AFTER INSTALLATION OF THE TM/EP RADAR INDICATOR AND BEFORE APPLICATION OF POWER, REMOVE THE EBL CIRCUIT CARD ASSEMBLY (A2A9) AND CHECK THAT THE WIRE LINKS (SHORTING WIRES) ARE CONNECTED AS FOLLOWS:

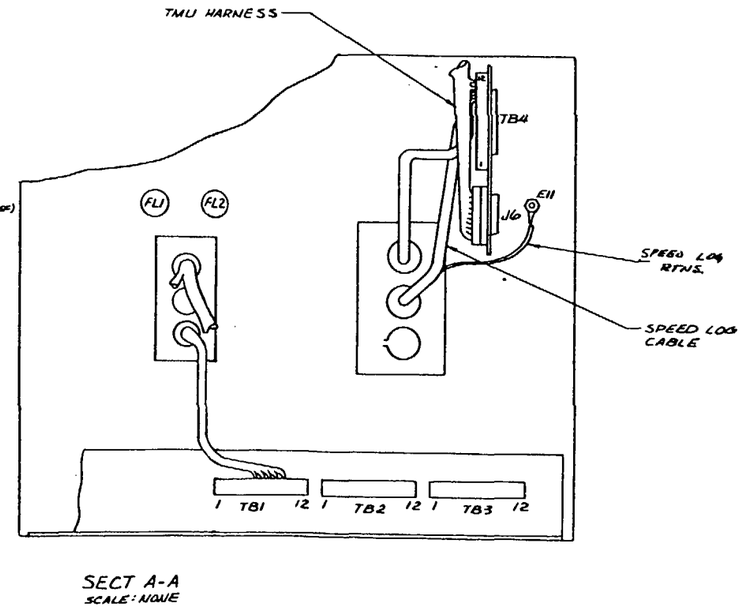
1. LINK E2 TO E4
2. LINK E8 TO E10
3. LINK E14 TO E15
4. LINK E18 TO E19
5. LINK E16 TO E17

Figure 2-1 True Motion Installation Drawing - 12" Indicator E169273 Rev B









NOTE: AFTER INSTALLATION OF THE TM/EP RADAR INDICATOR AND BEFORE APPLICATION OF POWER, REMOVE THE EBL CIRCUIT CARD ASSEMBLY (A2A9) AND CHECK THAT THE WIRE LINKS (SHORTING WIRES) ARE CONNECTED AS FOLLOWS:

1. LINK E2 TO E4
2. LINK E8 TO E10
3. LINK E14 TO E15
4. LINK E18 TO E19
5. LINK E16 TO E17

Figure 2-2 True Motion Installation Drawing - 16" Indicator E169272 Rev B

SECTION 3

OPERATION

3.1 OPERATING CONTROLS AND INDICATORS

Figure 3-1 shows those indicator controls which are used in TM/EP operation as well as the TM/EP controls located on the radar indicator bezel and the TM/EP headset. A brief description of the control functions is also given in Figure 3-1. Included are resolution, time and range limits for the controls on the TM/EP headset unit.

Normal TM/EP system operation is covered in paragraph 3.2 while detailed operating procedures (above and beyond the normal radar operation) are given in paragraph 3.3.

3.2 SYSTEM OPERATION

Prior to operation of the TM/EP option function, the basic radar indicator controls must first be adjusted for optimum radar performance. The following paragraphs detail procedures for preliminary adjustments of the radar indicator controls, initial radar turn-on from the indicator, true motion operation, turn-off, and emergency operation in that order. Refer to Figure 3-1 for location of radar indicator and TM/EP controls.

3.2.1 Initial Radar Indicator Setup

On the radar indicator control panel, make the following settings:

Control	Setting
RANGE SELECT	24 MILES
CONTRAST	CCW
BRILLIANCE	CCW
RANGE RINGS	CCW
ANTI-CLUTTER/RAIN	CCW
ANTI-CLUTTER/SEA	CCW
POWER	STBY (from OFF) (Allow 3 minutes for warmup)

In the STBY position the associated red light flashes slowly. After three minutes the radar is warmed up and ready for transmitting. The STBY position maintains the radar in a constant state of readiness at minimum power consumption.

3.2.2 Turn-on Procedure

1. Set POWER switch to TX ON. When the flashing red light becomes steady (after 3 minutes), the radar is ready for use and is transmitting.

2. Turn BRILLIANCE control clockwise until sweep is just barely visible on the scope.

3. Turn CONTRAST control to 3 o'clock position or suitable picture brightness for day/night viewing.

4. Turn GAIN control clockwise until strong signals appear and a light speckle of noise is visible.

5. Adjust TUNE control for the brightest display of small targets, sea clutter, and distance targets.

6. Set RANGE SELECT switch to 0.75 MILE.

7. Adjust ANTI-CLUTTER SEA control to reduce (but not eliminate) sea clutter.

8. Adjust CURSOR handwheel to 0° on bearing ring scale.

9. Rotate VRM handwheel one full turn clockwise.

10. Adjust VRM/READOUT intensity controls, RANGE RINGS/ BRILLIANCE intensity controls, and EBL DIM control to a comfortable viewing level.

3.2.2.1 Inclement Weather Operation (Rain)

1. If rain echo return obscures targets, reduce GAIN control to see whether rain clutter disappears with targets still visible. If not, adjust GAIN to optimum setting.

2. Turn ANTI-CLUTTER/RAIN switch to ON and adjust to eliminate rain, but not targets for best viewing.

NOTE

Reduced GAIN settings will, in effect, limit the maximum range of the radar. Restore to normal GAIN after the rain passes the target.

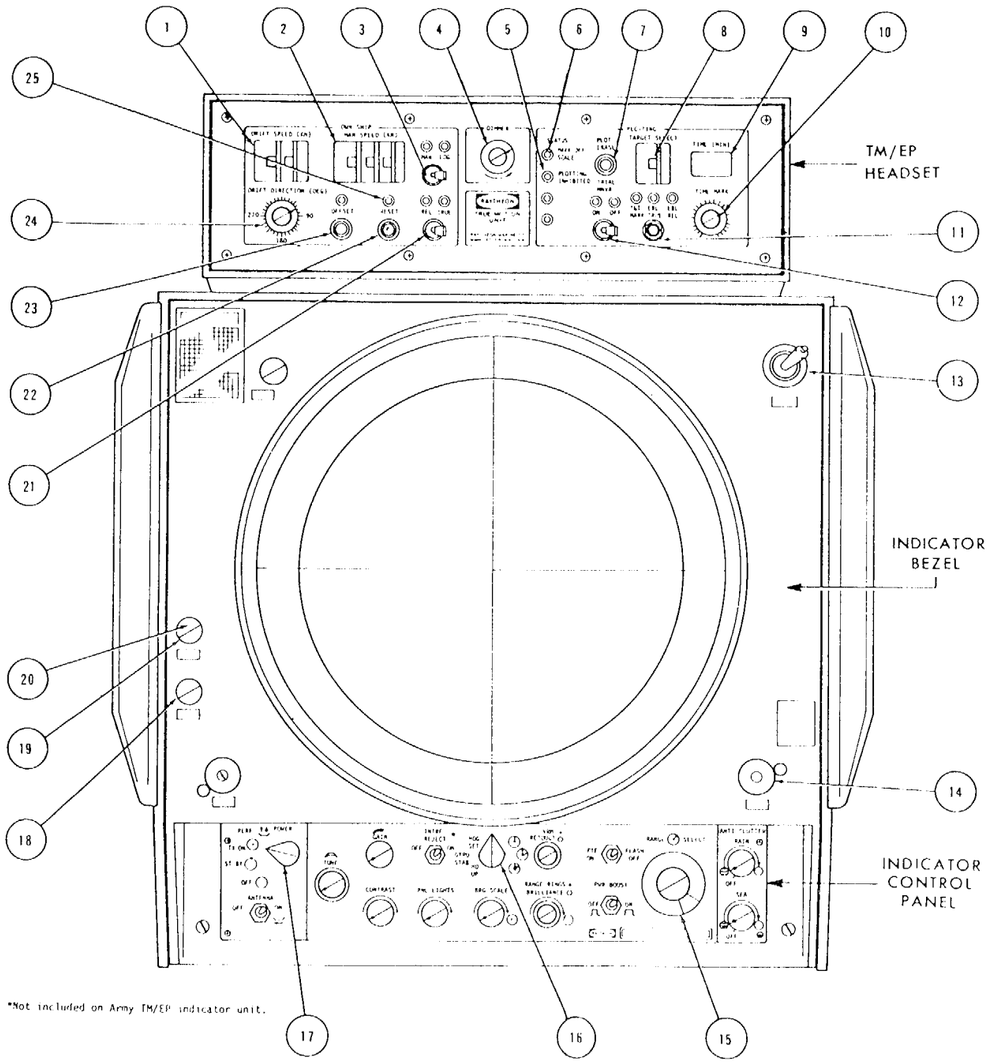
3.2.3 Initiating True Motion Operation

1. Set REL/TRUE switch to TRUE.

2. Set RANGE SELECT switch to one of the TM/EP operational ranges (.75, 1.5, 3, 6, 12, or 24 MILES).

3. If ship's speed LOG input is available, set MAN/LOG switch to LOG, if not set to MAN.

4. Set MAN SPEED (KN) control to the known ship's speed.



Controls and Indicators

Item	Panel Name	Control Type	Function
1	DRIFT SPEED (KN)	Two- Ganged Thumbwheel Switch (A20S7)	Used for manual insertion of drift speed from 0.0 to 9.9 in 0.1 knot steps.
2	MAN SPEED) (KN)	Three-Ganged Thumbwheel Switch (A2055)	Used for manual Insertion of ship's own speed from 00.0 to 59.9 in 00.1 knot steps.
3	MAN/LOG	Toggle Switch (A20S6)	Selects manual or speed log inputs. MAN SPEED (KN) thumbwheel switch effective in MAN position only.
4	DIMMER	Potentiometer Control (A20R1)	Varies background panel lighting of TM/ EP headset control panel and intensity of TIME: (MIN) display.
5	STATUS/ PLOTTING INHIBITED	LED Indicator (A20DS1)	Indicates that targets cannot be plotted or displayed. Illuminates when an illegal range or mode is selected.
6	STATUS/ MARK OFF SCALE	LED Indicator (A20DS2)	Indicates that one target is off CRT viewing scale when flashing, more than one target off scale when on steady.
7	PLOT ERASE	Pushbutton Switch (A20S1)	When depressed, deletes single target if TARGET SELECT thumbwheel switch is at 1 through 8. Deletes all targets if TARGET SELECT is set to zero (0).
8	TARGET SELECT	Thumbwheel Switch (A20S8)	Selects one of eight targets (1 through 8) separately for display or displays all eight targets simultaneously when zero (0) is selected.
9	TIME (MIN)	Three-Place LED Readout Display (A20A1)	Displays elapsed time from start of plot. Maximum range is from 00.0 to 78.0 minutes in 00.1 minute steps.
10	TIME MARK	Potentiometer Control (A20R3)	Adjusts spacing of time marks for TCPA calculation. Also sets the time mark spacing intervals along the displayed EBL.
11	TGT MARK/ EBL TRUE/	Toggle Switch (A20S9)	Selects three joystick functions for: initiating and updating target plotting, determining true course and speed, and determining selected CPAs and TCPAs.
12	TRIAL MNVR	Toggle Switch (A20S10)	Selects normal (OFF) or trial maneuver (ON) mode of operation. When ON, allows displacement of REL mark by joystick. Audio alarm sounds.
13	TGT MARK EBL ORIGIN	Joystick Pushbutton Switch and Control (A20A10)	Sets position of sweep origin, EBL origin, target mark, or trial maneuver REL mark depending on settings of other controls. Joystick function is enabled by joystick pushbutton.
14	VRM	VRM Handwheel Control (Radar Indicator)	Sets range of VRM marker on the EBL and VRM range ring.
15	RANGE SELECT	Selector Switch (Radar Indicator)	Selects range of sweep on CRT. TM/EP functions available at settings of 3/4, 1 1/2, 3, 6, 12, and 24 MILES.
16	HDG SET/ GYRO STAB/ HD UP	Three-Position Selector Switch (Radar Indicator)	Selects direction of heading flash (HDG SET), true north at top of screen (GYRO STAB), or ship's heading at top of screen (HD UP). (True motion available in GYRO STAB only.)
17	POWER (OFF/ STBY/TX ON/PERF)	Four-Position Selector Switch (Radar Indicator)	Turns power off to radar and TM/EP unit (OFF), supplies power to radar system and TM/EP except radar modulator circuits (STBY), applies full power to radar system (TX ON) or selects performance monitor option, if Installed (PERF). LED indicator flashes when in STBY, on steady in TX ON (or PERF) and extinguishes in OFF.
18	EBL POSITION	Potentiometer Control (A20R14)	Sets angular position of electronic bearing line (EBL) through 360°.
19	EBL RD/	Combined	Push-to-activate switch (EBL RD) sets
20	EBL DIM	Switch and Potentiometer Control	origin of EBL to CRT center so that bearing can be read from scale. EBL DIM control sets brightness of EBL (A20S8, A20R13) TM/EP video on CRT.
21	REL/TRUE	Toggle Switch (A20S3)	Selects relative or true motion display on CRT. LED illuminates with mode selection.
22	RESET	Pushbutton Switch (A20S4)	Resets sweep origin to 0.7 CRT radius on the counter heading.
23	OFFSET	Pushbutton Switch (A20S2)	Enables the sweep offset function. Joystick pushbutton will initiate new sweep position and cancel offset operation. Associated LED illuminates during offset function.
24	DRIFT DIRECTION (DEG)	Potentiometer Control (A20R2)	Operator sets for calculated drift direction. Variable throughout 360°.
25	RESET	LED Indicator (A20DS8)	Illuminates when RESET pushbutton is depressed as well as for automatic reset operation (12 sec). Extinguishes at completion of reset action.

Figure 3-1 Controls and Indicators for TM/EP Operation

5. Set NSK function switch (HDG SET/GYRO STAB/HD UP) to GYRO STAB, and use HDG SET to align the heading flash to the gyro course (inner fixed bearing dial). This alignment must be made with the sweep origin centered.

6. Depress RESET pushbutton switch, and sweep origin will offset to 0.7 CRT radius point, and start moving across the CRT at own ships speed and course presenting a true motion display. (RESET action may be initiated at any time by pressing the RESET switch.)

7. Set DRIFT SPEED (KN) and DRIFT DIRECTION (DEG) to compensate for drift so that fixed targets, land, buoys, etc, remain stationary.

8. The sweep origin may be offset in any direction out to a maximum of 0.7 radii as follows:

   a. Depress the OFFSET switch.

   b. Depress and hold the pushbutton on the joystick control (TGT MARK EBL ORIGIN) while maneuvering the mark on the CRT by moving the joystick control.

   c. Release the pushbutton on the joystick control when the mark is at the point where the sweep is to originate.

The display will blank, then reform with the sweep origin at the point designated by the mark.

3.2.3.1 Target Plotting

NOTE

The TRIAL MNVR switch must be in the OFF position to obtain correct plotting results.

1. Select a target address (1 through 8) by setting the TARGET SELECT switch to a desired number.

2. Set TGT MARK/EBL TRUE/EBL REL switch to TGT MARK.

3. Depress the joystick pushbutton control and position the mark appearing at the center of the PPI over the selected target by moving the joystick. Release the pushbutton when the mark is superimposed on the target.

4. Select a new target address and repeat steps 2 and 3 for up to eight targets.

NOTE

Allow sufficient target motion to occur.

5. To measure CPA and TCPA, select the appropriate target number and set TGT MARK/EBL TRUE/EBL REL switch to EBL REL position:

a. Rotate EBL to intersect target using EBL POSITION control.

b. Adjust VRM handwheel control until VRM ring touches the EBL.

c. Read CPA on VRM readout.

d. Adjust TIME MARK control to place the first time mark (blank spot) on the EBL on the target.

e. Count the number of EBL segments from the target where the VRM touches the EBL. Multiply the count by the reading of the TIME (MIN) display to obtain TCPA.

6. To measure true course and speed, set TGT MARK/EBL TRUE/EBL REL switch to the EBL TRUE position:

a. Rotate EBL to intersect target using EBL POSITION control.

b. Depress EBL RD control and read target's true course on the fixed bearing scale.

c. Adjust VRM handwheel control until VRM dot on EBL is on the target.

d. Refer to speed table on label at upper left hand corner of radar indicator bezel to obtain targets true speed.

7. To take a quick check on the "true" or "relative" course of all targets under plot, set TARGET SELECT switch to 0. Then set TGT MARK/EBL TRUE/EBL REL switch to EBL TRUE to show the "true" course of the targets, or to EBL REL to show the "relative" course of the targets.

3.2.4 Turn-off Procedure

To turn off the TM/EP and radar system, simply set the POWER switch on the radar indicator control panel to OFF.

3.2.5 Emergency Operation

In the event that a malfunction in the TM/EP circuitry occurs that cannot be cleared at sea and it causes the radar indicator to be unusable (blanked CRT, etc.), the following procedure will provide radar operation.

1. With the indicator POWER switch OFF, remove the upper front access cover of the radar indicator and the indicator digital card cage (see paragraph 5.8.3).

2. Disconnect the plugs from J6 on the indicator chassis and from A2J4 on the digital card cage. See Figures 2-1 or 2-2.

CAUTION

When removing or installing the indicator digital card cage, use extreme care not to place too much strain on cables or damage cables or the pins on the backplane.

3. Stow the cables so that they cannot cause short circuits. Replace the digital card cage and upper front access cover.

4. The radar can now be operated as before installation of the TM/EP unit, except that the offset function will not be available.

Without the TM/EP function, the CRT origin and bearing line may be shifted from the center. Also, under this condition, disregard all panel indications on the TM/EP headset unit.

3.3 DETAILED FUNCTIONS OF CONTROLS

3.3.1 REL/TRUE Switch

This switch selects relative motion or true motion display. When REL (relative) position is selected, own ship's position (sweep origin) remains fixed on the CRT and the display shows the relative motion between own ship and all radar targets. Stationary objects (land masses, buoys, etc.) appear to move across the display in accordance with own ship's motion; a moving target, such as another vessel, appears to move as a function of both own ship's motion and target's motion. When HD UP condition or .25, .5, 48, 64 or 12RT mile range scales are selected, the display is automatically switched to relative even though the REL/TRUE switch may be in the TRUE position.

True motion display is available only when the GYRO STAB condition and a range scale between .75 and 24 miles (inclusive) are selected. When these conditions exist and the REL/TRUE switch is set to TRUE, own ship's position (sweep origin) moves across the CRT in accordance with own ship's heading and speed input data. If own ship's heading and speed input data are correct and the drift controls (direction and speed) are properly set, land masses and other stationary objects appear fixed on the CRT, resulting in a display similar to a geographical map of the vicinity. This display shows, in true perspective, the position and motion of own ship with respect to other vessels, land masses and other stationary objects. The display offset and automatic reset features are operational with both relative and true motion displays.

3.3.2 OFFSET Switch

This pushbutton switch allows the operator to locate the sweep origin (own ship's position) at any point on the CRT display. It is operational for all range scales except 48 and 64 miles in both HD UP and GYRO STAB conditions. When

the OFFSET switch is depressed, the OFFSET lamp illuminates, indicating that the operator can offset the display using the joystick. The display origin should not be offset more than seven tenths of a CRT radius; if greater offset is established, the automatic reset feature is activated (see RESET Indicator) and portions (wedges) of the display will be blanked until the automatic reset occurs. The offset feature is not available on the 48 or 64-mile range scale. If offset is attempted when 48 or 64 mile range scale is selected, the display will blank for one second, then reform about the center of the CRT. (See paragraph 3.3.17, Joystick Control.)

3.3.3 RESET Switch

The RESET pushbutton switch allow the operator to relocate the sweep origin (own ship's position) seven tenths of a CRT radius along own ship's counter heading. This unique offset feature is operational for all range scales except 48 and 64 miles in both HD UP and GYRO STAB conditions. When the RESET switch is depressed, the display is blanked; one second after the switch is released, the display reforms at seven tenths CRT radius on the counter heading. Following a RESET operation, the heading flash should pass through the center of the CRT even though own ship's motion may not be along the heading line because of drift.

3.3.4 RESET Indicator

When illuminated, the RESET indicator warns the operator that the display is about to be automatically reset. Own ship's position on the CRT display is continuously monitored; when it exceeds seven tenths CRT radius, the RESET indicator illuminates and a twelve second delay is initiated. Upon expiration of the twelve second delay, the RESET indicator extinguishes and the display blanks for one second, then reforms at 0.7 radius on the counter heading. Depressing the RESET pushbutton or performing an offset operation during the twelve second warning period cancels the automatic reset.

3.3.5 MAN/LOG Switch

When the MAN position is selected, the velocity shown on the MAN SPEED (KN) thumbwheel switches is used as own ship's heading velocity. When LOG position is selected, velocity data from ship's speed log is used to move own ship's position on the CRT display.

3.3.6 MAN SPEED (KN) Thumbwheel Switches

These three thumbwheels allow the operator to manually enter heading velocities from 0.0 knots to 59.9 knots. The heading used with the manually entered velocity is automatically derived from the gyrocompass input. The velocity entered via the thumbwheels is used only when the MAN/LOG switch is at MAN position.

3.3.7 DRIFT SPEED (KN) Switches and DRIFT DIRECTION (DEG) Control

These controls allow the operator to enter drift velocity and direction data into the true motion display so that the movement of own ship's position reflects only ship's course and heading velocity parameters. When proper drift

data has been entered, the effects of drift on own ship's movement are cancelled so that own ship's position moves across the true motion display in a straight line along ship's true course. The DRIFT SPEED (KN) thumbwheel switches permit drift velocities from 0.0 (zero) to 9.9 knots to be entered in 0.1 knot increments. The DRIFT DIRECTION (DEG) control allows selection through 360 degrees. Drift speed and direction data can be obtained from navigational charts or measured per paragraph 3.4.5.

3.3.8 DIMMER Control

This knob controls the brightness of the back-lighting on the TM/EP headset control panel and the intensity of the TIME (MIN) readout display.

3.3.9 PLOTTING Control Group

The operating controls contained in the PLOTTING section of the TM/EP headset control panel (except the TIME MARK control) are operational only when the following indicator switches are set as specified.

1. The HDG SET/GYRO STAB/HD UP switch is set to GYRO STAB.

2. The RANGE SELECT switch is set to .75, 1.5, 3, 6, 12, or 24 MILES. Operation of the TIME MARK control is independent of these switch settings.

3.3.10 TGT MARK/EBL TRUE/EBL REL Switch

This switch must be operated in conjunction with the TARGET SELECT thumbwheel switch. When a target (1 through 8) is selected at the TARGET SELECT switch (i.e., for any thumbwheel switch setting other than target zero), the TGT MARK/EBL TRUE/EBL REL switch provides the functions described in paragraph 3.3.10.1 through 3.3.10.3 as follows:

3.3.10.1 TGT MARK (Target 1 through 8) - This position is used to initiate and update target plotting; eight separate targets can be plotted simultaneously. When the joystick push button is depressed and held, a bright spot appears at the center of the CRT; the spot is moved to target position by steering it with the joystick. Releasing the joystick push button initiates plotting for the selected target and causes two initially superimposed marks (spots) to be displayed. The true mark and relative mark appear initially as one spot; as time progresses they separate. If true motion display is selected (see REL/TRUE switch) the true mark remains fixed while the relative mark moves away from initial target position in accordance with own ship's motion. When relative motion display is selected, the relative mark remains fixed while the true mark moves away. The target plotting time display on the TIME (MIN) indicator begins when the joystick pushbutton is released. The true mark, relative mark and plotting time are displayed as long as the TGT MARK position remains selected and the target has not timed out or been cancelled. Actuating the joystick pushbutton initiates a new plotting operation for the selected target and will cancel previously selected target.

3.3.10.2 EBL TRUE (Target 1 through 8) - This position is used for determining the true course and true speed of the selected target. The CRT display shows the relative mark and an EBL (electronic bearing line) whose origin (axis of

rotation and zero range point) is at the position of the true mark. Target's true course is determined by rotating the EBL until it lies through target's present position, depressing the EBL RD control knob and reading target's true course on the inner bearing scale.

NOTE

EBL RD control is a "turn to actuate" control on earlier units.

Target's true speed is determined by rotating the EBL through target's present position, placing the variable range marker (VRM) spot over the target and dividing the VRM readout by the TIME (MIN) readout.

Own ship's true course and true speed can be determined by substituting the relative mark for target position in the procedure described above.

3.3.10.3 EBL REL (Target 1 through 8) - This position is used for determining the selected target's closest point of approach (CPA) and time until CPA (TCPA). The CRT display shows the true mark and an EBL whose origin is at the position of the relative mark.

NOTE

Unless a trial maneuver has been set up and is under assessment, the TRIAL MNVR switch must be OFF when CPA and TCPA measurements are being performed.

CPA is measured by rotating the EBL until it lies through target's present position, then rotating the VRM handwheel control until the VRM range ring is tangent to the EBL. Target's CPA can then be read directly from the VRM readout. To determine TCPA, first adjust the EBL and VRM to measure CPA, then adjust the TIME MARK control to place the first hole in the EBL over the target and count the number of EBL holes between target's present position and the point of VRM/EBL tangency; TCPA is this number of EBL holes times the TIME (MIN) readout.

When target zero is selected on the TARGET SELECT thumbwheel, the TGT MARK/EBL TRUE/EBL REL switch provides the functions described in paragraphs 3.3.10.4 through 3.3.10.6 which follow.

3.3.10.4 TGT MARK (Target Zero) - The CRT display shows the true marks for all targets for which plotting has been initiated; the joystick serves no useful purpose in this condition.

3.3.10.5 EBL TRUE (Target Zero) - The CRT display shows the true marks for all targets for which plotting has been initiated. The joystick controls the origin position of a free-floating EBL; this EBL is useful for determining range and bearing between displayed targets.

3.3.10.6 EBL REL (Target Zero) - The CRT display shows the relative marks for all targets for which plotting has been initiated. The EBL originates at own ship (sweep origin), providing for quick assessment of potential

collisions between own ship and each target being plotted. This is accomplished by rotating the EBL through each of the relative marks in turn and observing each target's present position with respect to the EBL; any target whose present position lies on or near the EBL between own ship and the relative mark represents a collision threat.

3.3.11 TARGET SELECT Thumbwheel

This switch is used in conjunction with the TGT MARK/EBL TRUE/EBL REL switch to initiate target plotting or display the current plotting data for one of eight targets. Target plotting data is always superimposed on the current radar display. When a target (1 through 8) is selected for display, the CRT shows plotting data for that target only; the data displayed (true and relative marks or either of these marks with an EBL) is determined by the setting of the TGT MARK/EBL TRUE/EBL REL switch. When the TARGET SELECT thumbwheel is set to zero, marks for all targets for which plotting has been initiated are displayed.

3.3.12 TIME (MIN) Indicator

This three-element readout shows time of plotting for the selected target in tenths of minutes. The readout intensity is controlled by the DIMMER knob. The time readout is used in determining target's (or own ship's) true speed and time to closest point of approach (TCPA) ; for either, the readout must be divided by 60 to convert it to hours. The TIME (MIN) indicator is blanked when any of the following conditions exist:

1. The TARGET SELECT thumbwheel is set at zero.
2. The RANGE SELECT switch is set at .25, .5, 48, 64 or 12RT.
3. The HD UP/GYRO STAB/HDG SET switch is not set at GYRO STAB.
4. The selected target has been cancelled (see PLOT ERASE switch).
5. The selected target has timed-out (plotted through 78 minutes).

3.3.13 TIME MARK Control

This knob sets the interval (distance) between holes along the displayed EBL. It is used in conjunction with the TIME (MIN) readout for determining time to closest point of approach.

3.3.14 PLOT ERASE Switch

This pushbutton switch allows the operator to cancel plotting for any or all targets. When the TARGET SELECT thumbwheel is set for display of plotting data for a particular target (1 through 8), actuation of the PLOT ERASE pushbutton cancels the plot of the selected target only. When target zero is selected, depressing the PLOT ERASE pushbutton cancels plotting for all targets. When a target has been cancelled, both true and relative target marks and the associated EBL disappear from the display. Automatic cancellation of target plotting occurs when plotting time for that target exceeds 78 minutes.

3.3.15 STATUS Indicators

Two STATUS indicators are enclosed in the PLOTTING section of the TM/EP headset control panel.

3.3.15.1 MARK OFF SCALE Indicator - This indicator flashes if either the true or relative mark-for the selected target is too far from the sweep origin to be displayed on the CRT (off scale). If both marks for a selected target are off scale, the indicator is lit constantly. When the TARGET SELECT switch is set to zero, all targets being plotted are displayed; if one or more of the target marks is off scale, the indicator flashes. The off-scale condition may be eliminated by switching to a higher range scale or performing an offset operation.

3.3.15.2 PLOTTING INHIBITED Indicator - This indicator is illuminated when either or both of the following conditions exist:

a. The RANGE SELECT switch is set at .25, 5, 48, 64 or 12RT.

b. The HD UP/GYRO STAB/HDG SET switch is not set at GYRO STAB.

When the PLOTTING INHIBITED indicator is illuminated relative motion display is automatically selected and target plotting cannot be initiated. If targets were being plotted prior to selection at the inhibiting switch setting, the plotting data for those targets continues to be updated, but cannot be displayed.

3.3.16 TRIAL MNVR Switch

This toggle switch allows the operator to set up a trial maneuver and assess the resulting CPA's and TCPA's for that maneuver. The trial maneuver parameters are established by substituting a trial maneuver relative mark for the target's relative mark and positioning the trial mark in accordance with the proposed speed and course changes. The trial maneuver relative mark is then used to determine the CPA's and TCPA's which will result if the proposed speed and course changes are implemented. It should be noted that neither the time used to evaluate the trial maneuver nor the time required to accomplish the course change are reflected in the trial maneuver display.

NOTE

An audible warning signal is sounded when the TRIAL MNVR switch is set to ON.

3.3.17 Joystick Control (TGT MARK EBL ORIGIN)

The joystick control is located in the upper right-hand corner of the indicator front panel. It allows the operator to position plotting marks on the CRT display, to initiate target plotting and to offset the position of own ship on the display. In general, the joystick is operated in three steps: 1) the pushbutton at the top of the stick is depressed to enable joystick operation and cause a joystick mark (spot or EBL) to appear on the display, 2) the joystick is moved left-right and up-down

to steer the mark to the desired location on the display, and 3) the pushbutton is released to initiate (or update) plotting from the location of the mark. The joystick is used to accomplish the following display and plotting control functions:

3.3.17.1 Offset - When the OFFSET pushbutton has been depressed (OFFSET indicator is illuminated) the joystick controls the position of own ship (sweep origin) on the display (see OFFSET switch, paragraph 3.3.2).

3.3.17.2 Target Marking - When one of the eight targets is selected and the TGT MARK/EBL TRUE/EBL REL switch is at TGT MARK, the joystick is used to mark the target's initial (true) position on the CRT display. Releasing the joystick pushbutton initiates the automatic plotting program for the selected target (see TGT MARK/EBL TRUE/EBL REL switch, paragraph 3.3.10).

3.3.17.3 Floating EBL - When the TARGET SELECT switch is at zero and the TGT MARK/EBL TRUE/EBL REL switch is at EBL TRUE, the joystick controls the origin location of an independently positionable EBL on the display. The EBL origin can be positioned anywhere on the display; this facilitates making range and bearing measurements between targets and allows the EBL to be used as a navigation line.

3.3.17.4 Trial Maneuver - During the trial maneuver operation, the joystick is used to position the trial maneuver relative mark in accordance with the proposed course and speed changes.

3.4 TRUE MOTION OPERATING PROCEDURES

The following procedures provide instructions for performing the various operations and measurements applicable to a true motion Pathfinder Radar.

NOTE

The operator must wait until 10 to 15 seconds after the transmitter is operating before the reset and motion generation functions will operate properly.

3.4.1 Head-Up Operation

When the HDG SET/GYRO STAB/HD UP switch is set to HD UP, the operating instructions given in the instruction manual for the basic Pathfinder Radar with 12/16 inch indicators apply except as follows.

NOTE

When HD UP operation is selected, the TRIAL MNVR switch on the TM/EP headset control panel should be set to OFF.

3.4.1.1 Display Offset - The OFFSET switch normally shown adjacent to the CRT on the indicator is not installed on true motion radars and is replaced with a cover plate. The sweep origin can be positioned anywhere on the CRT display by means of the OFFSET pushbutton on the TM/EP headset control panel and the joystick. Also, except when 48 or 64 miles range is selected, depressing the RESET pushbutton on the TM/EP headset control panel offsets the sweep origin

0.7 CRT radius along the counter heading. After offsetting the display by means of the RESET switch, the sweep origin can be returned to CRT center by: (1) performing an offset operation using the joystick, (2) momentarily setting the RANGE SELECT switch to 48 or 64 MILES, or (3) momentarily switching to GYRO STAB then back to HD UP.

3.4.1.2 EBL Display - During HD UP operation, setting the TGT MARK/EBL TRUE/EBL REL switch on the TM/EP headset control panel to EBL REL provides EBL display and operation as described in the basic manual. When EBL TRUE is selected (provided that the TRIAL MNVR switch is OFF), the EBL origin can be positioned anywhere on the display using the joystick. This feature facilitates making range and bearing measurements between targets.

3.4.1.3 Display Switching - If the radar is operated for a time in GYRO STAB condition and is then switched to HD UP condition, the plotting data for targets which were being plotted during GYRO STAB operation continues to be updated (but cannot be displayed) during HD UP operation. If the HDG SET/GYRO STAB/HD UP switch is set back to GYRO STAB before the targets have timed-out, the plotting data is displayed accurately with respect to the total plotting time. The display may be switched between range scales without loss or alteration of the plotting data.

3.4.2 GYRO Stabilized Operation

When the HD UP/GYRO STAB/HDG SET switch is set to GYRO STAB, and the RANGE SELECT is set to any position except .25, .5, 12RT, 48 or 64 MILES, the true motion functions of the radar are operational. The following paragraphs give step-by-step procedure for performing true motion operations and measurements.

3.4.2.1 Preliminary Set-Up

1. Set controls as follows:

    a. HDG SET/GYRO STAB/HD UP switch to GYRO STAB.

    b. TGT MARK/EBL TRUE/EBL REL switch to EBL REL.

    c. TRIAL MNVR switch to OFF.

2. Perform the steps for energizing the radar and true motion operation given in paragraphs 3.2.1 through 3.2.3.

NOTE

When operating a 16-inch indicator in GYRO STAB condition, the outer (compass) bearing scale must NOT be used to take bearing measurements.

3. Set RANGE SELECT switch to .75, 1.5, 3, 6, 12 or 24 MILES as appropriate for the operating locale. Verify that PLOTTING INHIBITED indicator on TM/EP headset control panel is not illuminated.

4. Select relative or true motion display at REL/TRUE switch as desired and check that the associated light is illuminated.

    a. REL - Own ship (sweep origin) remains stationary while land masses move across display in accordance with own ship's motion.

    b. TRUE - Land and other fixed objects (buoys, bridges, lighthouses, etc.) remain stationary while own ship moves across the display in accordance with course and speed inputs.

5. Select own ship's speed input at MAN/LOG switch:

    a. If ship's speed log input is available, select LOG and disregard step 6; proceed to step 7.

    b. If speed log input is not available, select MAN and perform step 6.

6. Set MAN SPEED (KN) thumbwheels to ship's speed.

7. Set DRIFT SPEED (KN) thumbwheels and DRIFT DIRECTION (DEG) control per:

    a. Navigational chart data, or

    b. Drift measurement procedure given in paragraph 3.4.5.

8. Establish own ship's position (sweep origin) on the display either by performing an offset or reset function:

    a. Offset Depress OFFSET pushbutton switch, then depress and hold joystick pushbutton. Steer CRT spot to desired sweep origin location using joystick and release joystick pushbutton, or

    b. Reset Depress and release RESET pushbutton switch to position sweep origin at 0.7 CRT radius on counter heading. Verify heading flash passes through center of CRT display.

3.4.2.2 Range and Bearing Measurements From Own Ship (Figure 3-2)

1. Set TARGET SELECT thumbwheel to 0.

2. Set TGT MARK/EBL TRUE/EBL REL switch to EBL REL.

3. Turn EBL POSITION control to pass the displayed EBL through target under consideration.

4. Depress EBL DIM/EBL RD switch and read target true bearing from EBL and inner bearing scale.

NOTE

EBL RD switch may be a "rotate" control on some indicators.

5. Adjust VRM handwheel control to position the VRM spot on the EBL over the target under consideration; read target range from VRM readout at top of CRT.

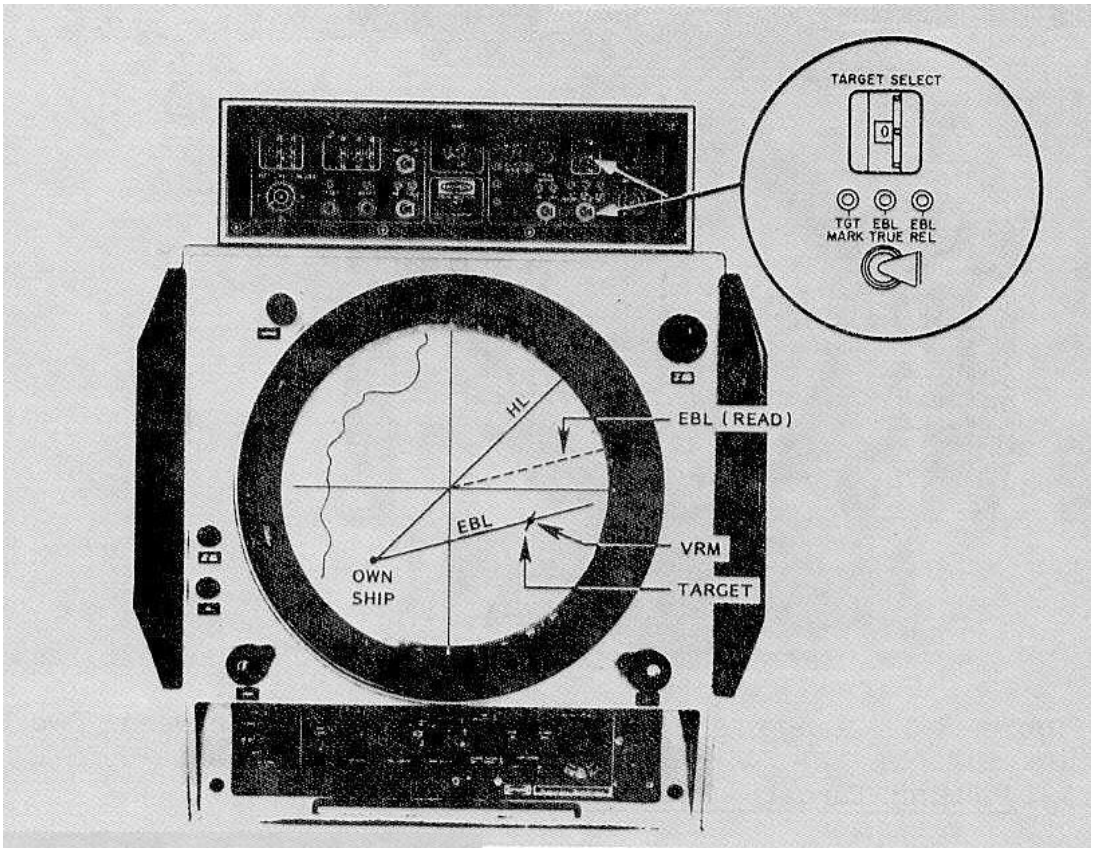


Figure 3-2 Range and Bearing Measurements from Own Ship

3.4.2.3 Range and Bearing Measurements Between Targets (Figure 3-3)

1. Set TARGET SELECT thumbwheel to 0.

2. Set TGT MARK/EBL TRUE/EBL REL switch to EBL TRUE. Insure TRIAL MNVR switch is set to OFF.

3. Depress joystick pushbutton and position EBL origin over one of the targets using the joystick, then release pushbutton.

4. Turn EBL POSITION control to make displayed EBL pass through the second target.

5. Depress EBL DIM/EBL RD control and read true bearing of the second target with respect to the first on the inner bearing scale.

6. Rotate VRM handwheel control to position the VRM spot on the EBL over the second target; read the distance between the targets on the VRM readout at the top of the CRT.

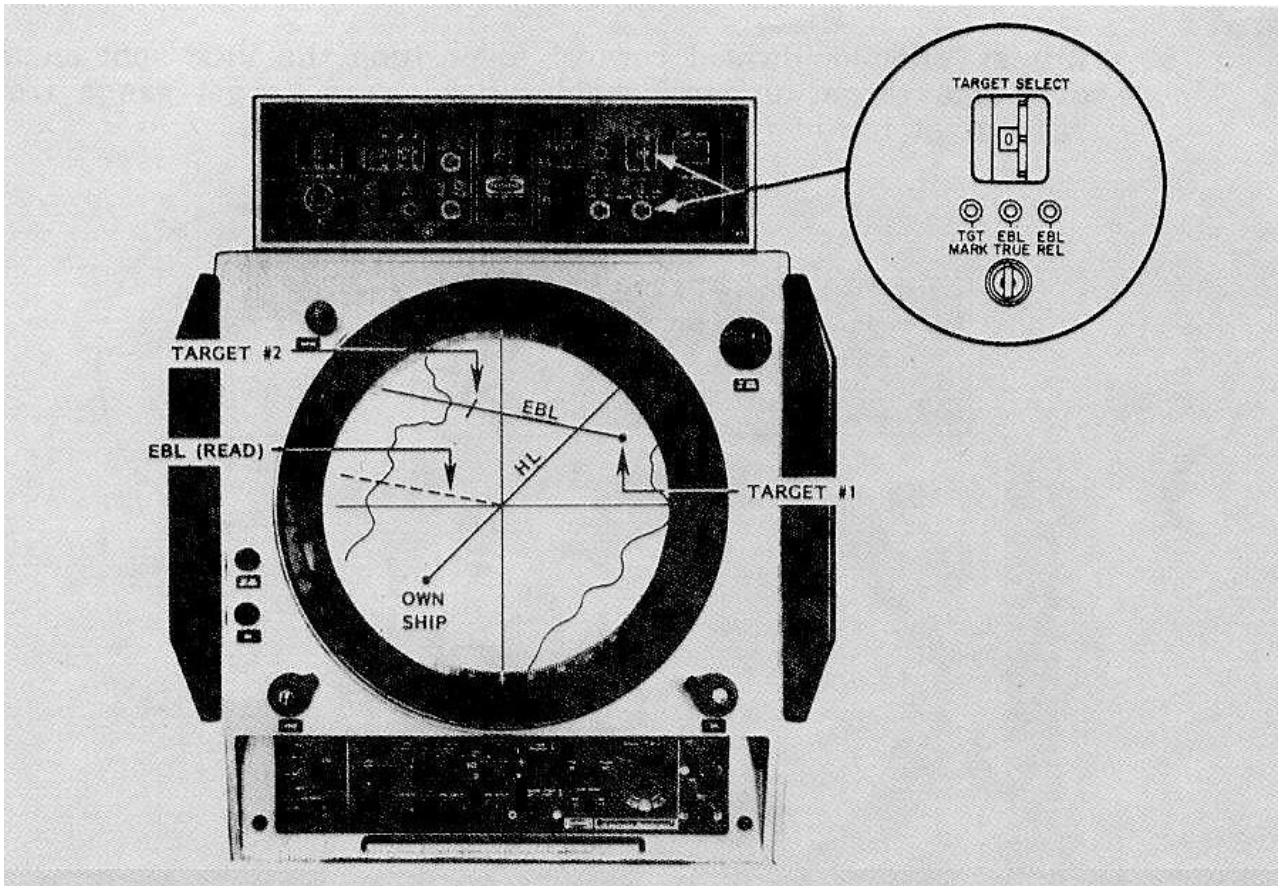


Figure 3-3 Range and Bearing Measurements Between Two Targets

3.4.2.4 Plotting Target: True Course and Speed

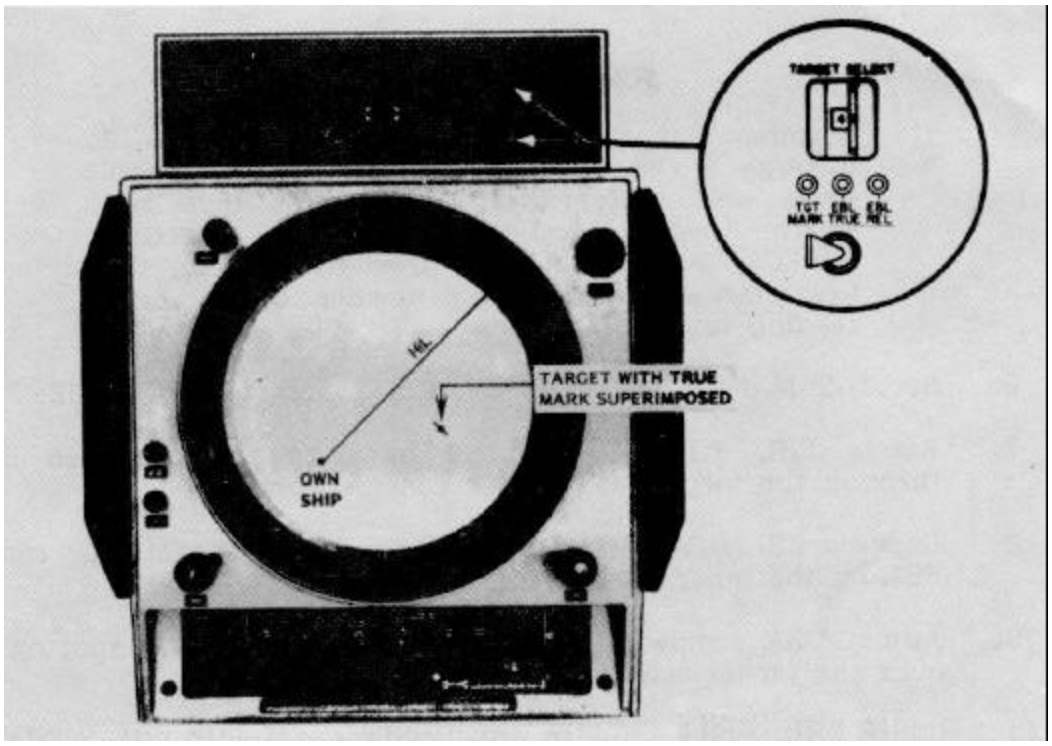
1. Perform preliminary set-up procedure of paragraph 3.4.2.1.

2. Set TARGET SELECT thumbwheel to appropriate target designation number (1 for first target to be plotted, etc.).

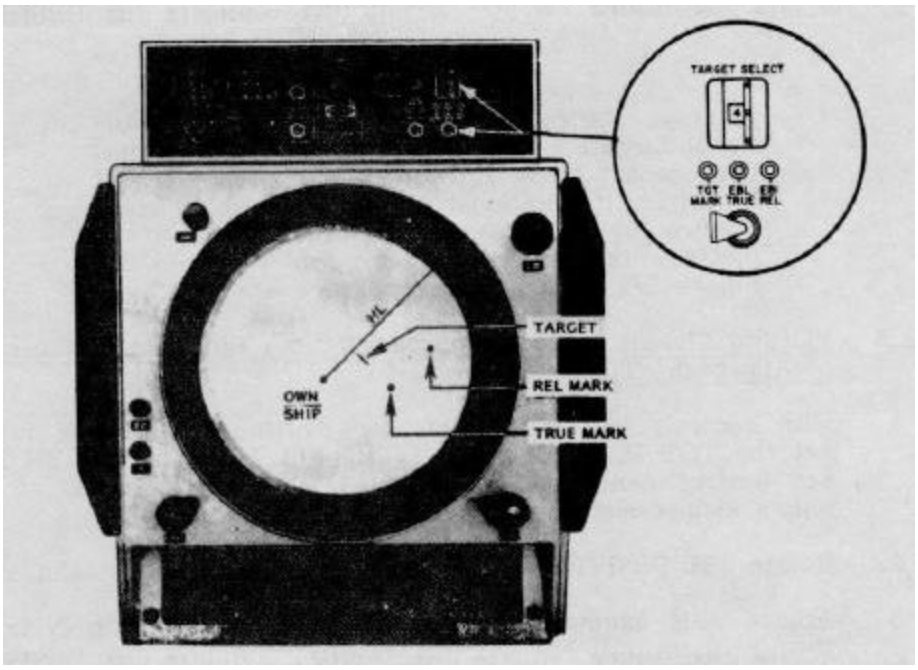
3. Set TGT MARK/EBL TRUE/EBL REL switch to TGT MARK.

4. Depress joystick pushbutton and steer the target mark spot to the target position using the joystick; center the spot on the target echo and release the pushbutton (Figure 3-4A).

5. Allow time for own ship's motion to cause separation of the true and relative target marks. This separation defines the relative vector line of the navigation triangle and will require approximately three to eight minutes to form depending on own ship's speed (Figure 3-4B).



A. DISPLAY AT TIME OF ZERO PLOT (T_O)



B. DISPLAY AT T_O + 3 MINUTES

NOTE
Displacement of sweep origin and REL mark are equal and parallel.

Figure 3-4 Target Mark Displacement with Time

NOTE

If other targets are to be plotted, steps 2 through 5 can be performed for those targets while waiting for the first target's true and relative marks to separate. The TARGET SELECT thumbwheel must then be reset to the first target's designating number before proceeding to step 6.

6. Set TGT MARK/EBL TRUE/EBL REL switch to EBL TRUE.

7. Rotate EBL POSITION control to make the displayed EBL pass through the target echo under consideration.

8. Depress EBL DIM/EBL RD controls and read target true course from EBL on the inner bearing scale.

9. Adjust VRM handwheel control to position the VRM spot on the EBL over the target echo.

10. Calculate target's true speed as follows:

$$\text{SPEED(KN)} = \text{VRM Readout} \times \frac{60}{\text{TIME (MIN) Readout}}$$

NOTE

If steps 2 through 5 were performed for additional targets, set TARGET SELECT thumbwheel then repeat steps 7 through 10 for each target in turn. If additional targets (for which steps 2 through 5 were not performed) are to be plotted, repeat steps 2 through 10 for each. Figure 3-5 illustrates the measurement.

3.4.2.5 Plotting Closest Point of Approach (CPA) and Time to Closest Point of Approach (TCPA) (Figure 3-6)

1. With controls and markers as for plotting true course and speed, set the TGT MARK/EBL TRUE/EBL REL switch on the TM/EP headset control panel to EBL REL. (EBL now originates at the own ship's displacement marker (REL mark).

2. Rotate EBL POSITION control to intersect the target echo.

3. Adjust VRM handwheel control so that the VRM ring is tangent to the EBL.

4. Read VRM digital readout for the distance at CPA.

5. Adjust TIME MARK control on the TM/EP headset control panel so that the first time mark (space in EBL) after the origin falls on the target.

6. Count the number of time marks between the target and the VRM tangent point on the EBL.

7. Calculate the TCPA by the following formula: TCPA (minutes) = TIME (minutes) x NUMBER OF SEGMENTS (step 6).

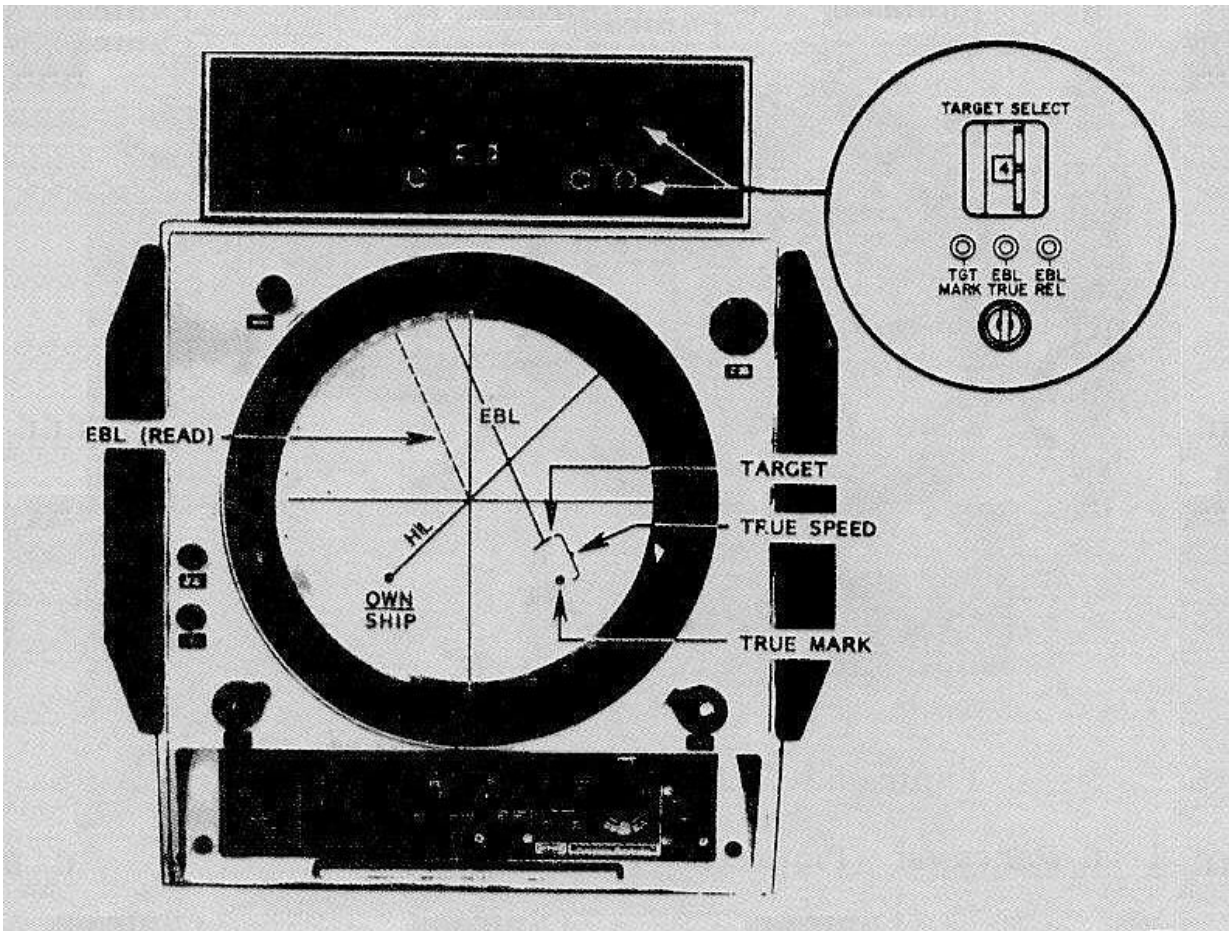


Figure 3-5 True Course and Speed Measurement

NOTE

After completion of plotting sequence for one or more targets, return to most dangerous target, (least CPA and shortest TCPA), and place TGT MARK/EBL TRUE/EBL REL switch in position EBL REL. Rotate EBL, now emanating from the REL-marker, to intersect target. (CPA may be low, but acceptable, provided target does not change course and/or speed). As the EBL now continuously is showing the predicted relative trace, the predicted CPA will be true, if target remains on EBL. If the target departs from the EBL, a new CPA must be measured immediately to determine whether evasive maneuvers are necessary.

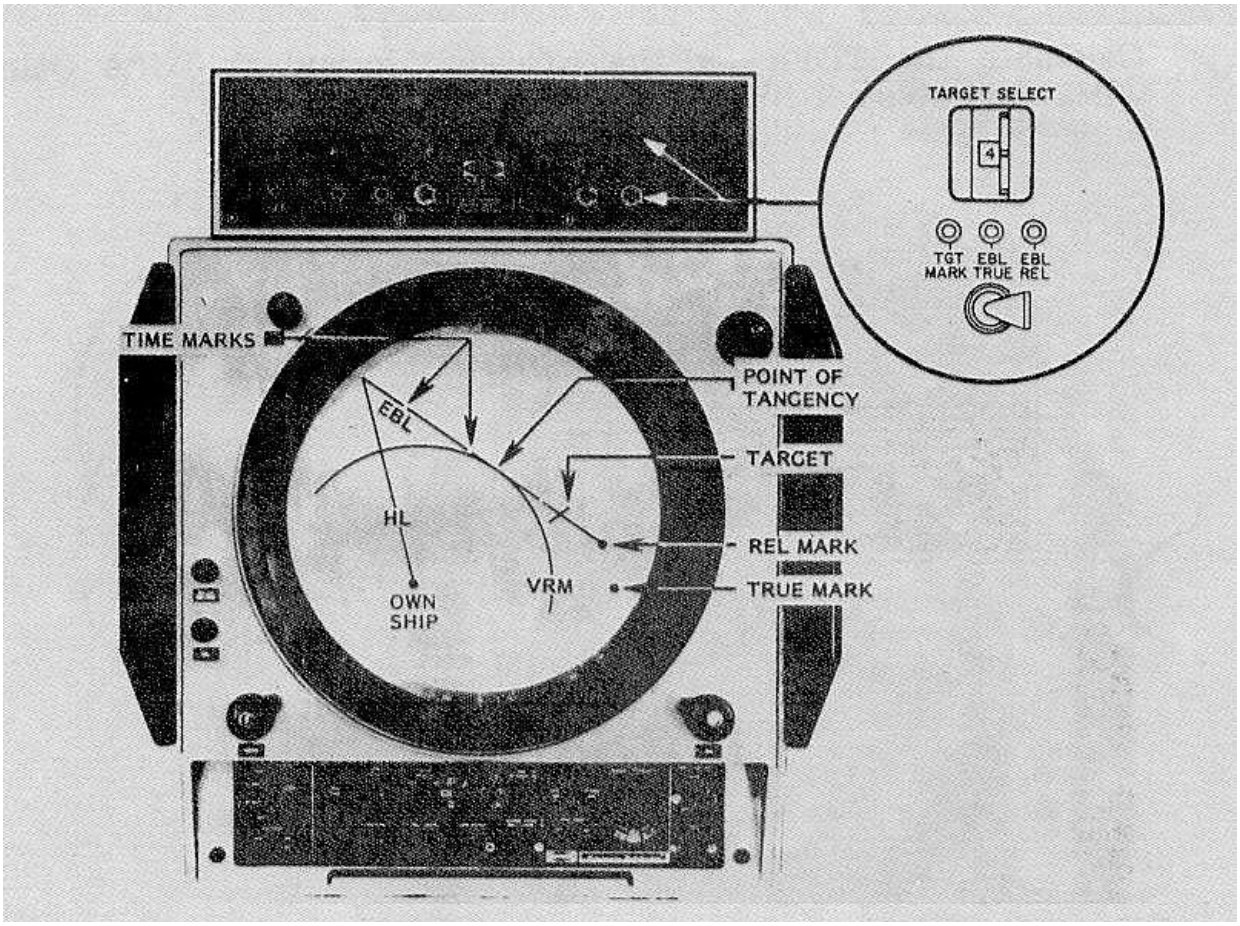


Figure 3-6 Measuring CPA and TCPA

3.4.3 Trial Maneuver (Figure 3-7)

To find out what effect a change in course or speed may give for the increase of CPA (closest point of approach), the operator may make a trial maneuver.

To do this, the operator will have to change the position of the electronic marker, giving relative information, on the PPI:

For a "course change" to a new position on a circle with its center on the true marker.

For a "speed change", own ship's displacement vector (position of REL mark) will have to be increased or decreased.

The operational procedure for a "course change" and a "speed change" is outlined in paragraphs 3.4.3.1 and 3.4.3.2 as follows:

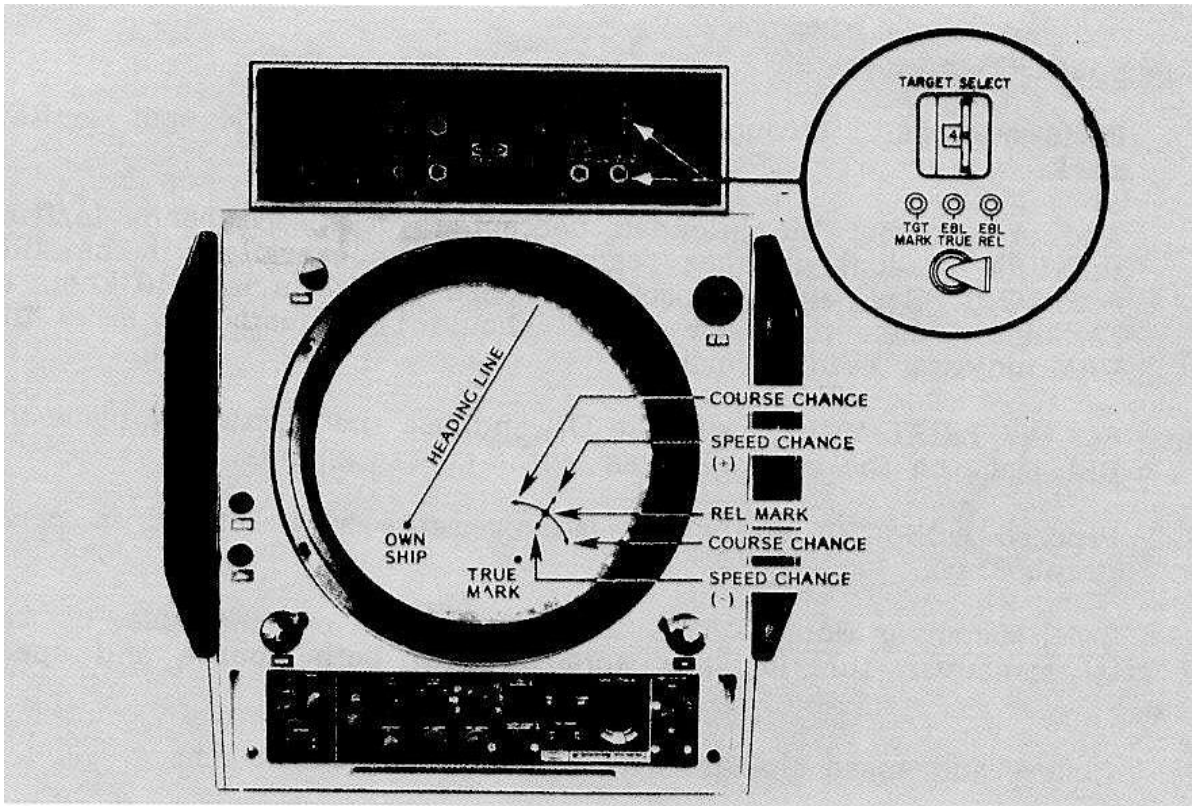


Figure 3-7 Trial Maneuver Variables

3.4.3.1 Course Change

1. Set TGT MARK/EBL TRUE/EBL REL switch to EBL/TRUE. This will cause the EBL to emanate from true marker.

2. Rotate EBL POSITION control to intersect the REL marker.

3. Place the VRM spot on the REL marker with VRM handwheel.

4. Activate EBL RD. EBL will emanate from the center of the PPI. Present course can be read on inner bearing scale.

5. Rotate EBL POSITION control to new trial course.

6. Release EBL RD. EBL will jump back to and emanate from true marker, pointing in the direction of trial course.

7. Set TRIAL MNVR switch to ON. This will put the REL marker under joystick control and inform the microprocessor that a trial maneuver is being performed. An intermittent buzzer will warn the operator of this switch position so that incorrect CPAs and TCPAs will not be measured accidentally.

8. Activate joystick pushbutton and put REL marker on top of VRM spot and release.

9. Measurement of the revised CPA and TCPA can now be made using the procedures described in paragraph 3.4.2.

3.4.3.2 Speed Change

1. Perform steps 1 through 3 of 3.4.3.1 to place VRM spot on REL mark.

2. Add or subtract the intended percentage of speed change to/from the VRM readout distance reading. (As an example: if the VRM reads 2.0 miles, and the proposed speed change is from 10 knots to 12 knots; then the VRM control should be adjusted to make the VRM indicator read 2.4 miles.)

3. Set the TRIAL MNVR switch to ON and use the joystick to place the REL mark on the VRM spot, as in the course change.

4. Proceed with CPA and TCPA measurements as described in paragraph 3.4.2.

3.4.3.3 Trial Maneuver Notes - The following notes on the use of the TM/EP trial maneuver function are applicable to both course and speed changes:

1. Course and speed changes may be made at the same time.

2. The change in position of the REL mark for one target is applied to all targets being plotted, i.e., CPAs and TCPAs for all targets may be measured by merely changing the TARGET SELECT thumbwheel. It is not necessary to enter the information for each target separately.

3. Setting the TRIAL MNVR switch to OFF will immediately reset the REL mark to its correct position.

4. For as long as own ship (vessel itself) remains on its present course at its present speed, trial maneuver data, once entered, will be continuously updated by the TM/EP, i.e., a new CPA and TCPA may be measured (for the original trial change) at any time after it is entered.

5. An intermittent audio tone which occurs for as long as the TRIAL MNVR switch is ON, warns the operator that the REL marks do not represent real conditions.

NOTE

The revised CPAs and TCPAs measured in the trial maneuver mode assume instantaneous speed and/or course changes. The time required for the vessel to perform a particular maneuver should be taken into consideration.

3.4.4 Plotting in Relative Mode

All target plotting functions, including measurement of CPA and TCPA, can be made with the system in the relative motion mode of operation. The procedures of paragraphs 3.4.2.2 through 3.4.3.3 can be used.

3.4.5 Drift Measurement (Figure 3-8)

1. Check that DRIFT SPEED (KN) and DRIFT DIRECTION (DEG) controls are set to zero.
2. Select a fixed target (buoy or point of land).
3. Select a target number on TARGET SELECT switch (1-8).
4. Set TGT MARK/EBL TRUE/EBL REL switch to TGT MARK position.
5. Place a target mark over a fixed echo with the joystick.
6. Allow sufficient time to elapse for target to move/drift away from marker.
7. Set TGT MARK/EBL TRUE/EBL REL switch to EBL TRUE position and rotate EBL POSITION control to intersect target.
8. Run out VRM spot (with VRM handwheel) to target.
9. Depress EBL RD. EBL will now jump to center of PPI. Course of drift can be accurately read off the inner fixed bearing dial and is to be inserted as drift direction.
10. Drift speed to be inserted is given by following formula:

$$\text{Drift speed} = \frac{\text{VRM-readout value} \times 60}{\text{Elapsed time read from timer}}$$

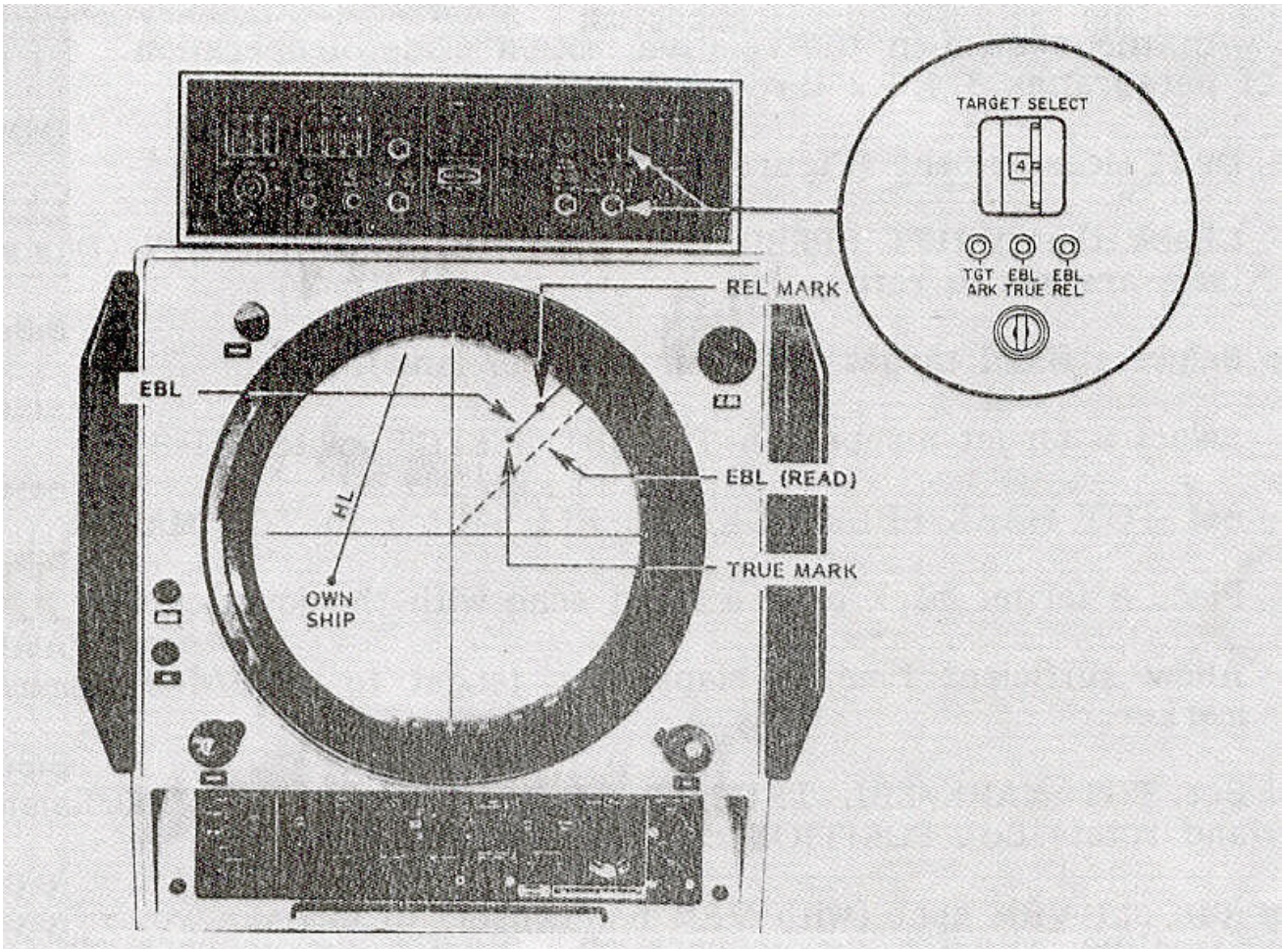


Figure 3-8 Drift Measurement

NOTE

When using speed log inputs, an aft movement of the vessel can cause a plotting or sweep origin error. All targets being tracked should be erased and reacquired following an aft movement of the vessel.

SECTION 4

THEORY OF OPERATION

4.1 GENERAL

The true motion/electronic plotting (TM/EP) unit theory of operation is presented in the form of a functional block diagram description and detailed circuit descriptions. The first part of this section contains the overall functional block diagram description of the TM/EP unit followed by a detailed circuit description of each electronic subassembly comprising the TM/EP unit. Illustrations are included in this section to aid in understanding unique or intricate circuits along with references to schematic diagrams in Section 6.

4.2 FUNCTIONAL BLOCK DIAGRAM DESCRIPTION

Functionally the TM/EP unit consists basically of three major assemblies, namely, the TM/EP headset (control panel), the TM/EP digital card cage and the TM/EP low voltage power supply (LVPS). Major signal flow between these main assembly units is shown in Figure 4-1.

4.2.1 TM/EP Headset

The TM/EP headset, which is mounted at the rear and above the indicator CRT, contains most of the TM/EP operating controls and indicators. TM/EP headset outputs are switch position data on discrete lines and multiplexed thumbwheel position information on the processor data bus. Headset inputs are constant logic levels for indicator operation and multiplexed binary coded decimal (BCD) data for generation of the TIME (MIN) display. Inputs and outputs of the headset are to and from the TM/EP digital card cage. The headset receives its operating power (+5 Vdc) from the low voltage power supply.

4.2.1.1 Time Display - The time display circuitry consists of two separate printed circuit board (PCB) assemblies: the time display readout (Al), and the time display driver (A2). The time display readout (Al) contains three LED seven segment digital readouts interconnected on a PCB. The display driver (A2) is a PCB assembly containing the circuits which convert the BCD data from the processor to the seven segment format required by the time display readout (Al). The board also contains the drive circuits which provide the current necessary to illuminate the individual digits of the TIME (MIN) panel display and activate the trial maneuver buzzer circuitry.

4.2.1.2 TM/EP Status Indicators - Two status LED indicators (MARK OFF SCALE and PLOTTING INHIBITED) are located in the PLOTTING section of the TM/EP headset control panel. These LEDs are initiated by the digital processor via the output flag control over the indicator control lines. The MARK OFF SCALE (DS1) is illuminated (by flashing) whenever one or more plot markers are off scale. Illumination of PLOTTING INHIBITED (DS2) occurs when new targets cannot be marked or displayed.

4.2.1.3 Panel Control Switches - The panel control switches perform the following functions:

Switch	Function
S1	PLOT ERASE
S2	OFFSET
S3	REL/TRUE
S4	RESET
S6	MAN/LOG
S9	TGT MARK/EBL TRUE/EBL REL
S10	TRIAL MNVR

Each of the TM/EP headset switch functions can be executed manually by the operator. When a particular switch function is desired and executed, the output of the switch is placed on its respective switch position data line where it enters an input flag select circuit. This circuit multiplexes the switch output onto a single control line as an ANALOG FLAG signal. The ANALOG FLAG is used to control the clock and strobe generator and hence, the processor operation. The output of each switch is placed on the ANALOG FLAG line when the switch is addressed by the program.

4.2.1.4 Thumbwheel Switches and Range/Lamp Buffer - The thumbwheel switches and range/lamp buffer (A3) circuits provide the switching functions that allow the data representing the settings of the TM/EP headset MAN SPEED (KN), DRIFT SPEED (KN) and TARGET SELECT thumbwheel switches along with that of the indicator RANGE SELECT switch to be placed on the processor data bus in the proper time sequence. This circuit also provides the additional task of limiting the current to the various light emitting diode (LED) indicators on the TM/EP headset control panel.

4.2.2 TM/EP Digital Card Cage

The digital card cage assembly consists of four PCB assemblies which contain the digital processor and the peripheral circuits necessary to interface it to the headset and the indicator. A fifth PCB location is included in the card cage to accommodate a test card for troubleshooting purposes.

4.2.2.1 Digital Processor - The heart of the TM/EP is the digital processor, a miniature digital computer which is dedicated to the TM/EP tasks. Under program control, the processor converts analog inputs from the indicator and TM/EP controls to their binary number equivalents, manipulates the numbers as necessary, and converts the results to analog signals for control of the indicator displays.

The processor can perform a number of specific operations, such as: place a number (digital word) in memory, add two numbers, add 1 to a number, read a number from memory, find the difference between two numbers, output a logic level, input the binary equivalent of an analog voltage, etc. The specific operation to be performed depends on the system address word.

The address word, an 8-bit binary word, is simultaneously applied to the control terminals of all the decoder and data manipulating devices in the system simultaneously by the address bus. The digital word on the address bus is decoded by the address block decoder into six functional areas: signal output and register enable, signal input enable, store data, read stored data, read permanent data, and perform computation (ALU enable).

Addresses within address decoder block are further decoded by the output and register decoder to select the specific output or register that is to be enabled. The address also specifies whether the input or the output terminals of the selected register will be active. A decoder in the flag select circuit enables individual inputs as addressed within the signal input enable area.

Decoding capability within the selected devices enabled in the store data, read stored data, read permanent data, and perform computation areas determine the specific memory location or X arithmetic logic unit (ALU) function.

From the above, it can be seen that the address word is decoded to select the operation to be performed and the device which supplies the data or the device which is to receive the resultant data. (A transfer register either supplies or receives data in all cases.) A timing strobe pulse (EXECUTE) is generated at all data transfer addresses to prevent errors due to switching transients. The input and/or output terminals of all the data handling devices are connected by the 16-bit data bus. Devices which are not selected are effectively disconnected from the data bus.

The order in which addresses are generated is known as the program. in the true motion unit (TMU), the program is stored in a 2048-word memory and can be changed only by replacing the programmable read-only memory (PROM) ICs. Selection of the specific PROM output (program word) is accomplished by applying an 11-bit binary number, known as the program count (PC), to the PROM address terminals.

The program count is generated by a binary counter which is clocked by the 1.01 MHz PC clock signal. This clock signal is obtained from the indicator, thus assuring that the timing of the TM/EP signals is compatible-with indicator video processor signal timing. PC is generally incremented one step at a time, but when desired, it can be set to an entirely new number (higher or lower) within a single clock period. The incrementing process will continue from the new number.

This ability to "jump" from one portion of the program to another allows the use of the same instruction words (subroutine) to be used at different points in the main program without rewriting the subroutine instructions into the program memory more than once. This results in a large savings in the amount of program memory required. The jump is achieved by placing the new PC on the data bus and then loading the data word into the program counter through its preset terminals.

In the TM/EP processor, a transfer register (T-Reg) is used in every data transfer operation, i.e., data is transferred from the initial location to the T-Reg in one processor cycle and then from the T-Reg to the new location in the second processor cycle. Although this process reduces the total speed of the processor operation; speed is not a problem in the

TM/EP, and the controls that would be necessary for direct transfer would add significantly to the hardware and software requirements of the system.

The arithmetic logic unit (ALU) used in the TM/EP processor is capable of performing any one of 32 arithmetic operations on two 16-bit binary numbers. The specific operation to be performed is determined by the program via the address bus.

4.2.2.2 Processor Peripheral Circuitry - One of the peripheral circuits that is necessary to interface a digital processor with analog (varying voltage levels) input signals is an analog-to-digital converter (ADC). This circuit converts voltage levels to an equivalent binary number.

The ADC used in the TM/EP is a modified version of the "successive approximation" type. in this type of ADC, a digital word is converted to an analog (dc) voltage and the amplitude of this voltage is compared with the amplitude of the input signal voltage in an analog voltage comparator. The result of the comparison, a logic "1" or a logic "0", depends on whether the input level exceeds the level of the stored word or vice versa. If the level generated by the stored word is lower than the input, the word is incremented, and conversely, the stored value is decremented if it is high. The comparison and increment/decrement is repeated until the word is alternately high and low on successive comparisons. At this point, the conversion is deemed complete. The accuracy of the ADC system depends on the sensitivity of the comparator and the number of bits in the digital word, as well as the accuracy of the digital-to-analog converter (DAC) used to generate the comparison voltage.

In the TM/EP, eight inputs (one spare) are applied through separate comparators. The comparator outputs are time multiplexed onto a single line, setting or resetting the flag flip-flop in the clock and strobe generator. The condition of the flip-flop, when addressed, determines ensuing processor action.

A second type of peripheral circuit, the digital-to-analog converter (DAC) is used to convert the digital words of the processor to analog voltage levels. The operation is performed by summing binarily weighed currents at the input of an operational amplifier (Op Amp). The Op Amp converts the sum of the currents to a proportional voltage at its output. A precision voltage source within the DAC is used to supply the currents which are switched by the digital input.

For control of the CRT offset, digital words representing the instantaneous X and Y offset values are latched into registers whose outputs control the offset voltage through 10-bit DACs. The latching registers are necessary because the voltages are required to remain constant during the periods while the processor is performing other tasks. The registers are updated regularly with newly calculated values by the processor. The TM video output does not require the use of a DAC since it is connected to the video amplifier in the indicator.

The processor is programmed to stop its operation at intervals and wait for the sweep gate signal from the indicator. This is done to synchronize the TM video and the X and Y offset information signals with the radar video display, and for internal timing reasons.

Data for controlling the time display (in BCD format) for each individual digit is latched into a register from the data bus. At the same time, a strobe, which is derived from the 1800 Hz signal of the indicator, is applied to the digit driver PCB in the time display to illuminate the correct display digit. The data output of the register is changed by the strobe generating circuit in synchronism with the digit strobe so that the correct data is applied as the digits are illuminated in succession.

Status indicators (LEDs) are also required to be continuously on or off. This function is accomplished by storing the data for each indicator as a single bit of the output flag word. When the output flag (external word) register is addressed by the program, the individual bits are applied to the data terminals of "D" type latches. When the latches are clocked by the EXECUTE signal, the latch output assumes the value of the D-input and holds it until the latch is clocked once again. The E-register provides both memory and drive service to the LEDs. Momentary inputs, such as from the ship's speed log are sampled by the program.

Control switch positions are tested by selecting the addresses for the switches at regular intervals and storing the results of the test (logic 1 or 0) in processor memory.

4.2.3 TM/EP Low Voltage Power Supply (LVPS)

The TM/EP LVPS receives its input (115 Vac) from the ship's power mains via the indicator POWER switch. in this way the indicator control also controls the power input to the TM/EP unit. The supply, which is of the switching regulator type for higher efficiency, provides outputs of +5 Vdc to the digital card cage and to the headset for operation of the logic circuits. It also provides +15 Vdc and -15 Vdc to the digital card cage to power the linear integrated circuits (ICs).

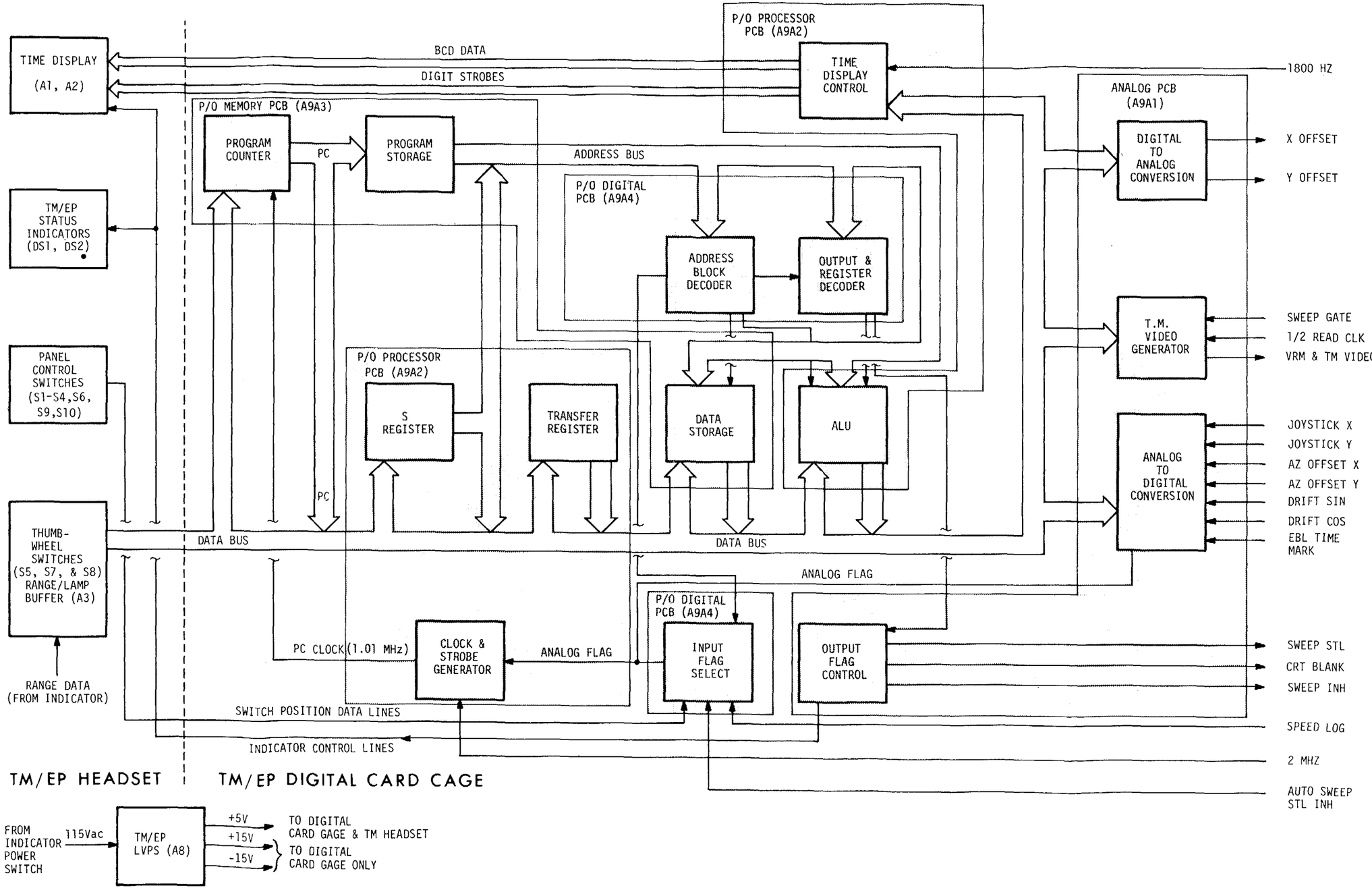


Figure 4-1. TM/EP Unit Functional Block Diagram

4.3 DETAILED CIRCUIT DESCRIPTION

The following paragraphs provide detailed circuit descriptions of the various circuits within the major subassemblies of the TM/EP unit. Figures 4-2 through 4-8 and schematic diagrams in Section 6 are referenced in the appropriate circuit discussions to provide a clearer understanding of the functions of the electrical devices and elements in each circuit.

4.3.1 Time Display PCB (A20A1) (Figure 6-2)

The time display PCB is located in the TM/EP headset unit and consists of three identical seven segment digital readout devices. Each device contains seven LEDs with their anodes connected to a common terminal. The LED cathodes are connected to separate terminals (A through G) see Figure 4-2. The LEDs are positioned within the device in such a way that illumination of any one will illuminate a particular segment of a decimal digit. Illumination of all seven LEDs generates the decimal 8 numeral, and combinations of LEDs can generate any decimal numeral from 0 to 9. See Figure 4-2. An 8th LED is used to form a decimal point (DP) as shown.

The cathodes of the LEDs forming line segments in the three digits of the display are connected in parallel ; the parallel combinations from each segment are connected to the time display driver PCB (A20A2). The anode terminals from each digit are connected to the driver PCB separately. The decimal point terminal (DP) is connected directly to the processor PCB (A20A9A2) in the TM/EP digital card cage.

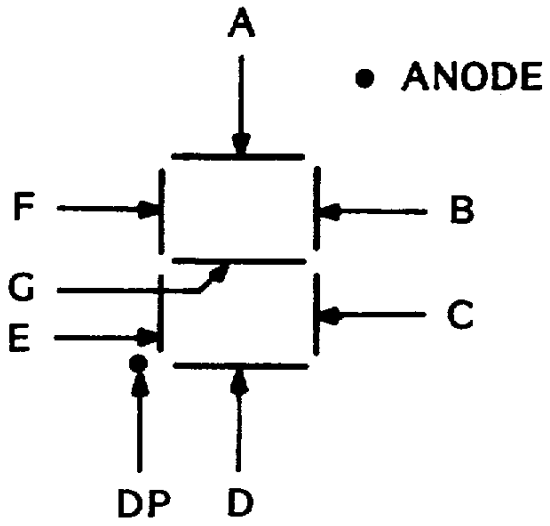


Figure 4-2 Seven Segment Display Connections

4.3.2 Time Display Driver PCB (A20A2) (Figure 6-3)

The circuitry located on the time display driver PCB is divided into two functional areas: time display control, and trial maneuver alarm. The time display driver assembly is contained within the TM/EP headset unit.

4.3.2.1 Time Display Control - The time display control circuitry is composed of the binary coded decimal (BCD) to seven segment encoder, U2, the current limiting resistor network, U3, and the digit driver transistors, Q1, Q2, and Q3.

The encoder, U2, an integrated circuit of medium scale integration (MSI) complexity, determines the number described in BCD format at its four input terminals. Through internal gating, it places the correct combination of logic levels at its output terminals. The seven output terminals (A through G) correspond directly to the LED display segments with the same designation. Signals at the output terminals cause the corresponding segments of the LED display to illuminate, forming a decimal numeral corresponding to the binary number at the encoder input.

Since the TM/EP time display is time-multiplexed (refer to processor PCB theory, paragraph 4.3.6) the current through the LEDs of the display can be higher than for a constant illumination display. The average current is lower due to the off-time for each display digit. The resistors of U3 limit the peak LED current to approximately 35 ma.

Transistors Q1 through Q3 provide the current source for all of the LEDs within a single display digit when switched on (in sequence) by the LSD, 2SD and MSD signals from the processor.

4.3.2.2 Trial Maneuver Alarm - A pulsating audible warning signal is generated by the warning circuitry when the TM/EP is in the trial maneuver mode of operation.

An integrated circuit timer, U5, is connected as an astable multivibrator (see Figure 4-3). The combination of R7, R8 and C6 sets the frequency of oscillation at approximately 1 KHz with a duty cycle of nearly 50%. The square-wave output of the oscillator is filtered by R10, C8 and volume adjustment control, R11.

A second IC timer, U4, is also connected as an astable multivibrator. The period of oscillation is approximately 2 seconds, and the duty cycle is greater than 90%. The output of U4 is inverted by U1 and the off-time (output low) of U4 is converted to a positive going enabling signal for the tone oscillator, U5. U5 is inhibited from operating by the output of U1 for the period that the gating oscillator, U4, is on. The result is a tone burst at 1 KHz for a period of 175 ms which occurs at a rate of 1 burst per 2 seconds.

When the TM/EP is not in the trial maneuver mode, tone burst outputs are inhibited by the low logic level (controlled by the TRIAL MNVR switch) at connector pin H.

4.3.3 Switch and Lamp Buffer PCB (A20A3) (Figure 6-4)

The switch and lamp buffer PCB is situated in the TM/EP headset unit. Twelve bits of BCD data from the 3-digit MAN SPEED (KN) thumbwheel switch are applied to the processor data bus through tri-state buffers (U1, 2). Because the common line of the switch is connected to ground, the data from the switch is in its complementary form. The buffer inverts the signal to

present true (sense) data to the bus so that it will be compatible with the format used in the processor. The tri-state buffer output is used to present a high impedance to the data bus when the buffer is not selected to present its data. The format of the switch data word is shown in the word format Table 4-1.

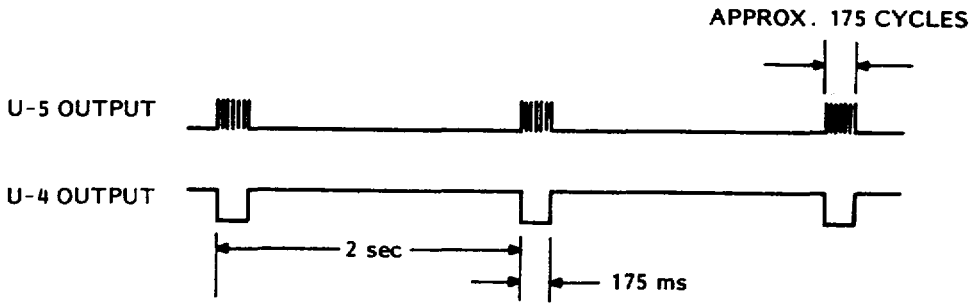


Figure 4-3 Alarm Generator Timing

The outputs of the DRIFT SPEED (KN) thumbwheel switch (2 digits) and the TARGET SELECT thumbwheel (1 digit) are combined and connected to the data bus through inverter/buffers U3 and U4. The format of the combined data word is also shown in Table 4-1. Except for the use of the enabling signal, drift/target word rather than ship speed, operation is the same as described for the MAN SPEED (KN) switch input.

Similarly, the range select word (RSW) (indicating the position of the RANGE SELECT switch in the indicator) is connected to the data bus through U5 and U6 when the RSW address is selected by the processor program. Inputs from the 48 and 64 mile positions of the indicator RANGE SELECT switch are ORed by U7 and sent to the digital processor PCB as the 64/48 signal.

Current limiting resistors, used in illumination of the LED indicators on the TM/EP headset control panel are mounted on this PCB in a dual inline package (DIP) (U10). These resistors limit the LED current to a value that can be supplied by the IC outputs that provide the ON/OFF control function.

Resistor networks U8 and U9 provide pull-ups for the switch terminals. By connecting the IC inputs to the +5V supply in this way, a logic 1 (high) level is assured when the switch is OFF and only 5 ma (of current) is drawn when the switch is ON (terminal connected to ground).

Table 4-1 Word Format Table

DATA BUS LINE SOURCE	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	Y5	D4
SHIP SPEED	80	8	8	40	4	.4	20	2	.2	10	1	.1
DRIFT SPEED	8	.8	-	.4	.4	-	2	.2	-	1	.1	-
TARGET SEL	-	-	8	-	-	4	-	-	2	-	-	1
RANGE WORD	64	48	24	RT	12	6	3PB	3	1 1/2	3/4	1/2	1/4

4.3.4 Low Voltage Power Supply (LVPS) (A20A8) (Figure 6-5)

The LVPS provides the three dc voltages (+5V, +15V and -15V) required for operation of the TM/EP circuits. The supply is of the switching regulator type, with the dc outputs being rectified from the output of a high frequency inverter rather than from the ac input to improve efficiency.

4.3.4.1 Input Circuits. The supply is protected from surges and transients on the ac inputs by E1, a spark gap which operates at voltages greater than 250 volts and by varistor RV1, a voltage variable resistor. Both sides of the input line are fused.

The input voltage is rectified by bridge rectifier, CR1 and filtered by C1. A 1.5 amp fuse in this dc line protects the input circuits against failure of the regulator and inverter. Zener diode, VR1, provides a regulated source of 12.1 Vdc through emitter follower, Q3, for operation of the high frequency oscillator which provides inverter and regulator timing.

The input dc voltage is reduced to +72 Vdc by the chopper regulator, Q1 and filtered by L2 and C2. This voltage is used to power the inverter. The single ended inverter consists of the inverter transformer, T1 and the switching transistor, Q2.

4.3.4.2 Output Circuits - One of the tapped secondaries of T1 is rectified by CR17 and CR18 to provide the +15 and -15 Vdc outputs. The outputs of these halfwave rectifiers are coupled to choke input filters to provide adequate ripple reduction.

Another winding of T1 is rectified and filtered by CR2, CR3, L4 and C4 to provide the +5 Vdc output. A sample of the +5 volt output is connected to the reference amplifier as feedback to be used for controlling the regulator output.

4.3.4.3 Regulator Circuits - The integrated circuit (IC) timer, U2, is connected as an astable multivibrator to generate a 20 kHz square wave. The IC output is applied to current switch, Q10, to provide sufficient drive for transformer T1. The transformer output is: (1) rectified by CR25 to produce +12 Vdc to power the pulse width modulator, reference amplifier and inverter drive ICs; (2) rectified by CR10 and 11 to provide bias for inverter drive transistors, Q5 and 7; (3) rectified by CR8 and 9 to provide bias for regulator drive transistors, Q4 and 8. It also provides a 20 kHz trigger for the pulse width modulator (PWM) U3, and inverter drive, U5.

The PWM, a variable pulsewidth one-shot, is triggered at 20 kHz by the master oscillator; the width of the output pulses is controlled by the differential between the +5 Vdc feedback and the internal reference voltage of the reference amplifier. The duty cycle of the PWM is limited to approximately 85% by VR7. The output of U3 is applied to an IC timer which is connected as a voltage comparator through T4 to provide isolation between the different voltages at which the devices operate. The comparator, U7, drives Q4 and Q8 to switch the chopper, Q1, on for sufficient lengths of time to recharge the inductor, L2. in this way, the +5 Vdc supply is held constant by preregulating the inverter drive voltage.

4.3.4.4 Inverter Drive - One shot multivibrator U5 generates 20 us pulses at the trigger rate. The output of U5 is coupled to inverter drive transistors Q5 and Q7 through T6 to provide the necessary voltage isolation. Q5 and Q7 provide the drive to switch the inverter transistor.

4.3.5 Analog PCB (A20A9A1) (Figure 6-6)

The analog PCB converts varying voltage levels (joystick, heading, drift, offset, EBL time mark) to an equivalent binary number which is then compared and time-multiplexed onto a single line. The signal is used to control the action of the TM/EP digital processor. Timing signals are also generated for synchronizing TM video and X and Y offset signals with the radar video display. A block diagram of the analog PCB is shown in Figure 4-4.

4.3.5.1 TM Video Generation - Of the 11 bits of data latched into the video register, (U4, 16) two, (D0 and D1) are decoded to determine the type of display to be generated, i.e., target mark or EBL time mark. D2 is not used, and the remaining nine bits (D3 through D11) are decoded to determine the number of range cell counts (of the indicator video processor) before the TM/EP mark shall be generated.

When time marks are to be generated, (DO and D1 low), the data stored in the V register (range cell count) is applied to the preset terminals of the binary counter, U1, 2 and 3. The counter is clocked by the read clock signal that times the video display in the indicator signal processor. A count of 512 is decoded by AND gate, U8, allowing the "D" type flip-flop, U10, to be set at the next rising clock edge.

The resulting low level at U10-8, through pins 13 to 12 of active low OR gate U8, is applied to the "load" terminals of the counter. The counter then shifts its output state to that of the preset input (V register) at the following clock. Since the counter is no longer at the 512 count, U10 is clocked into its reset condition and the level at U10-8 goes high.

The negative-going pulse thus generated at U10-8 is inverted by passage through the enabled NAND gate, U9 (pins 13 to 11). The pulse, now positive, is passed through AND gate U8 and finally inverted by U15 to produce a low logic level pulse which is one range cell in length at the TM video output. This pulse produces a darkened spot in the EBL (approximately 1/16 long).

The pulse producing process continues for the length of the EBL sweep,

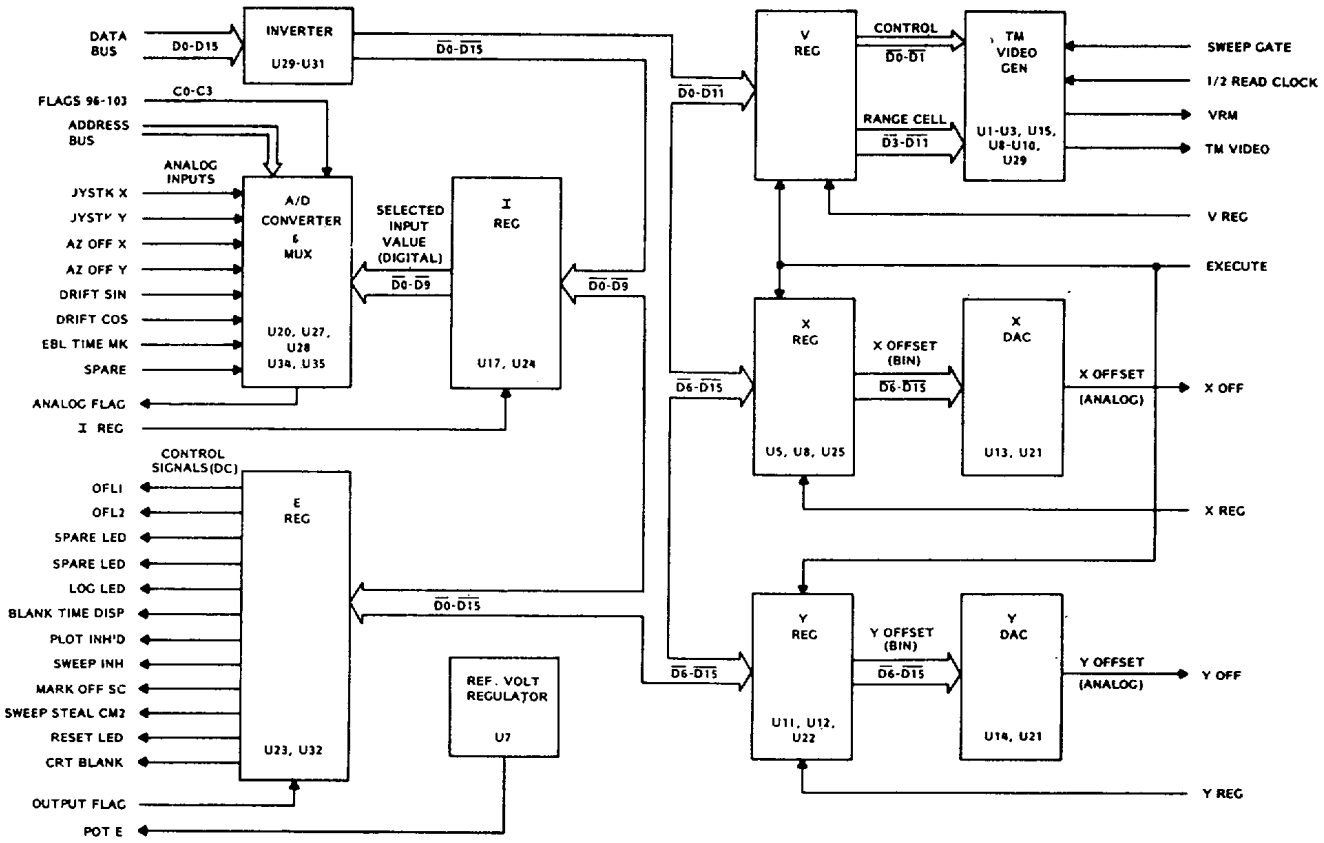


Figure 4-4. TM/EP Analog PCB Block Diagram

producing equally spaced time marks, because the counter is enabled as soon as the preset clock period has been completed (U10-8 high).

All TM video outputs are inhibited between sweeps by the low level at the "clear" terminals of both halves of U10 that occurs when the sweep gate input goes high.

When generation of target marks is selected by the processor (D0 and D1 both high), the path for TM video through U9-13 is inhibited and the TM VIDEO line enabled for the entire sweep by the low at U9-12. The second section of U10, which is clocked by the trailing edge of the pulse at U10-8 produces a low level at the enabled video output via its complementary output, U10-6, which goes low. The low is inverted by U9, and the high at U9-8 causes a low in the TM VIDEO when it is applied through AND gate, U8-9. The low level is maintained until U10 is reset at the end of the sweep, resulting in a bright dot at the start of the sweep only.

4.3.5.2 Output Flags - The output flag signals are essentially steady state switch levels which control various indicators and functions in an On/Off fashion. A low level (less than 0.8 Vdc) activates the function and a high

level (greater than 2.4 Vdc) inhibits the function. The data for each of the twelve Flag outputs is stored in the E-register (U23, 32) by a separate latch. The latch outputs provide the indicator current as well as the data.

Data is stored in the latches of the E-REG by applying the data to the latch inputs simultaneously via the data bus and then clocking the E-REG with a strobe from the digital card. Flag outputs cannot be affected by data at the input terminals unless the strobe signal is applied to the clock inputs.

4.3.5.3 Digital-to-Analog Conversion - Operation of the X and Y digital-to-analog conversion (DAC) circuits is identical and only the Y DAC will be described.

The Y-register (U11, 12, 22) latches and stores the binary number on the data bus when the registers input terminals are enabled by the Y-REG signal and the latches are clocked by the EXECUTE strobe. The data, enabling, and strobe signals are applied by the processor under program control.

The data on the latch output lines comprise the value of the Y OFFSET as a binary number in complementary (inverted) form. This number is continuously applied to the logic (control) terminals of the integrated circuit DAC, U14. This IC converts the binary signals at its input to a binarily weighted current at its output. The current, in turn, is converted to a dc voltage by the operational amplifier (Op Amp), U21.

The feedback resistor used to set the gain of U21 is internal to the DAC to provide better temperature compensation. The inverting input to the Op Amp (DAC output) is clamped to ground by CR5 and CR6 to prevent voltage excursions greater than 0.7V on this line. Voltages on this can cause erratic DAC operation.

The maximum DAC output level (full scale) is set at the factory by the adjustment of R1. The scale input set by VR5 (approximately 6.4V) is used to offset the internal DAC reference so that the output voltage from the Op Amp will swing between -5 Vdc and +5 Vdc. Without the offset, the DAC output would always be positive.

The Y OFF output of the DAC circuit controls the vertical position of the sweep origin on the CRT. The position is changed at a rate corresponding to the North/South component of ship speed by the processor when the system is in true motion mode of operation.

The X OFF output controls the horizontal position of the sweep origin and its rate of change is determined by the East/West component of ships speed.

4.3.5.4 Analog-to-Digital Conversion - Generalized operation of successive approximation analog-to-digital converter (ADC) systems is discussed in paragraph 4.2.2.2.

The particular analog input which is to be digitized is selected by the program by setting the three-bit binary input at the address inputs of digital multiplexer, U34. The multiplexer is enabled by the "flags 96-103" signal at its gate terminal, pin 7. The selected input is gated to the Y (non-inverted) output terminal and is connected to the flag flip-flop on the digital card.

The data storage circuits of the processor act as the successive approximation register of the ADC and the stored binary number is latched into the I-register (U17, 24) by the I-REG signal upon command of the program. The complementary binary number output of the I-Register is applied as the controlling input to the DAC, U20. This IC and the Op Amp, U28 perform the same functions as described in the DAC paragraph. The only difference is that the output voltage is unipolar (0 to +10 Vdc). The voltage generated by the DAC (equivalent to the stored binary word) is applied to the inverting inputs of the eight voltage comparators contained in U27 and U35. The voltage comparators, which are extremely high gain Op Amps, saturate full on or full off with an input voltage differential (between + and inputs) of only a few millivolts. The comparator outputs are controlled to saturate at logic levels. The result is that if the external signal is even slightly higher than the DAC output, the comparator output will be a logic "1". If even slightly lower than the DAC output, the comparator will go to a logic "0". A slight amount of positive feedback is connected from the multiplexer output to the DAC Op Amp input through R24 to prevent oscillation when the two comparator inputs are nearly equal.

The signals on the 16 lines of the data bus are inverted by U29, 30, and 31 as they enter the analog card. This results in complementary state levels at the input terminals of the five latching registers on the card.

4.3.5.5 Voltage Regulator - A precision monolithic voltage regulator, U7, is used to provide a nominal +10 Vdc as reference voltage for the drift direction and joystick controls. R4 is set at the factory to compensate for cable losses so that the controls receive the correct voltage. The IC regulator contains its own voltage reference and with the use of temperature compensating resistor, R23, provides a highly stable voltage source.

4.3.6 Processor PCB (A20A9A2) (Figure 6-7)

The processor PCB contains the arithmetic logic unit (ALU), S-register, transfer register (T REG), and clock & sync control portions of the processor.

The plotting time display control circuitry is also located on this PCB. A block diagram of the processor PCB is shown in Figure 4-5. Processor clock timing is shown in Figure 4-6.

4.3.6.1 Arithmetic Logic Unit - The ALU, which performs all of the arithmetic and logical data manipulations of the processor, consists of the ALU proper, two input registers, a control latch and an output buffer. All of these devices, except the control latch, are made up of multiple ICs to provide the required 16-bit word width.

U1, 2, 4, and 5 are connected so as to form an ALU capable of performing any one of 32 different operations on two 16-bit binary numbers. The specific operation to be performed is internally decoded from the state of the four select (S) inputs and the carry (C_n) input. The instruction word is supplied via the four lowest bits of the address bus and latched into the quad D type driver (U33). The state of the C_n input depends on whether the address was

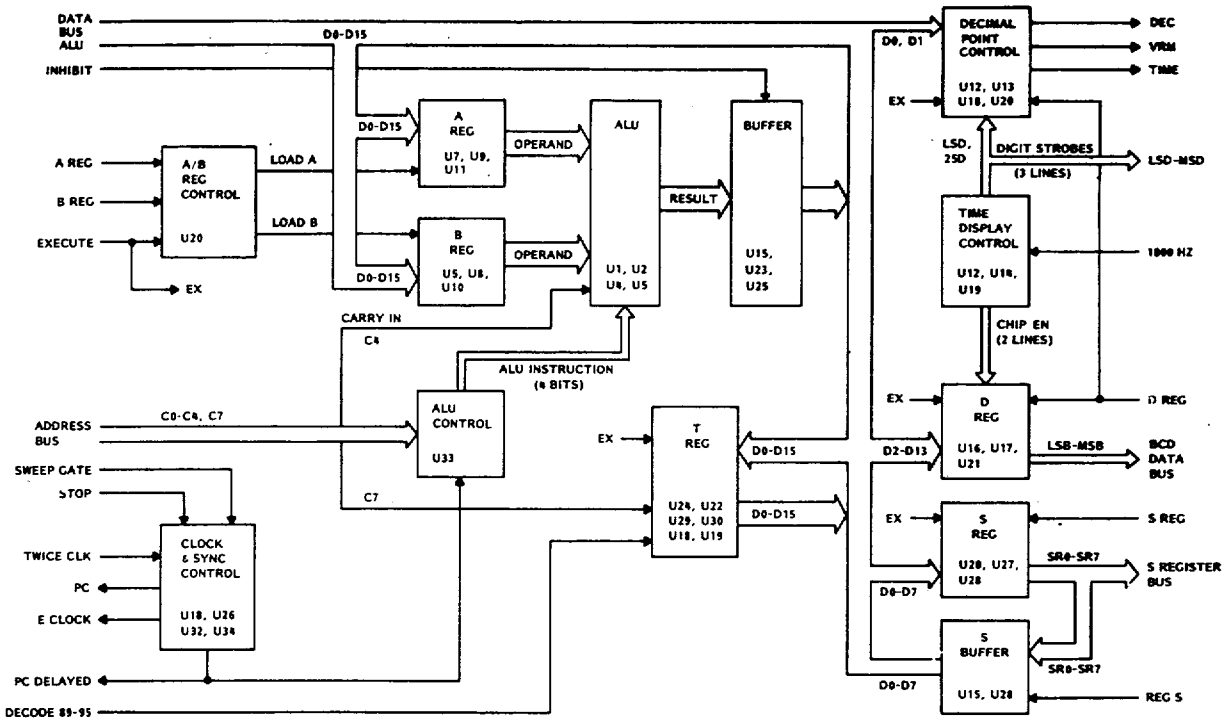


Figure 4-5 TM/EP Processor PCB Block Diagram

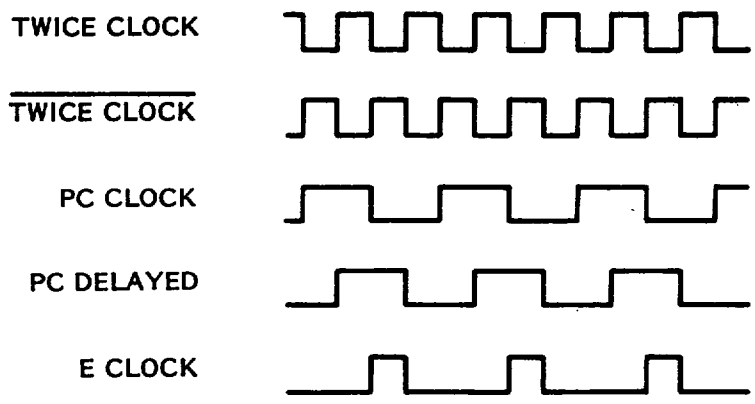


Figure 4-6 Processor Clock Timing

selected from the 16-word field of 192 to 207 or from the field of 208 to 223.

The following describes the generalized steps that would perform a typical ALU task: Find the sum of two numbers stored in RAM and store the result in a third RAM location.

(a) Transfer the first word from its RAM location to the ALU input register, A REG, via the data bus and the T REG.

(b) Transfer the second word from its location in RAM to the second ALU input register, B REG.

(c) Select address 209 to latch the A + B instruction into the ALU control and enable the ALU output buffer, U15, 23, and 25.

The results of the summation are now on the data bus and will be latched into the T REG when the execute strobe occurs.

(d) The sum can now be transferred to a RAM location.

4.3.6.2 Transfer Register - The transfer register (T REG) is used as temporary (usually not more than 1 or 2 clock cycles) storage when transferring data from one location to another within the processor or to and from peripheral circuitry. The register IC, whose input and output terminals are separately controllable, is connected by control circuitry so that enabling of the inputs and outputs is mutually exclusive, i.e., only one set of terminals may be enabled at a time. During operations in which the register is not involved, the input terminals are enabled. This prevents data in the register from affecting the data bus and since the latch is not strobed, data at the input will not affect the register status.

The S-register can be used as a transfer register since its input and output terminals are both connected to the Data Bus. However, the latch, whose S Register outputs can control the address bus (via the multiplexer on the memory PCB) is also used for temporary address control and for storing the program count (PC) at which a jump to subroutine was made. This allows returning to the correct point in the main program when the subroutine is completed.

4.3.6.3 Time Display Control - Twelve bits (three digits) of BCD data are latched into the D-register from D2 through D13 of the data bus to set the value of TIME displayed. The status of the DO bit sets the location of the decimal point in the display. The status of the D1 bit indicates whether the displayed value represents plotting time or variable range marker (VRM) distance. (Note that the VRM display is not connected in present systems.)

The 1800 Hz signal from the indicator is counted and the count decoded to generate three digit strobe pulses of approximately 0.5 ms each by U12, 14, and 19. The strobes are applied to the display driver PCB in the TM/EP headset continuously in a LSD, 2SD, MSD sequence. Synchronously, the control circuit connects the outputs of the D-register to the BCD data bus (four bits at a time), in the same sequence. Thus the display digit representing tenths of a minute is illuminated only while the correct tenths of a minute data

is on the BCD data bus. The same holds true for the units and tens digits. In this time-multiplexed system, the data is connected to all display digits in parallel via the four data lines and the digits are controlled by the three strobe lines. The number of interconnections is thus reduced by nearly 50% from the twelve lines that would be necessary for continuous display illumination and the power consumption is reduced to that required by a single digit.

4.3.6.4 Clock and Sync Control - The 2.02 MHz, twice clock (TC) signal from the indicator is inverted by U18 and used to clock the divide by two sections of U26 at pin 3. The divider output (U26-5), a 1 MHz (nominal) square wave is applied to the processor circuits as the PC CLOCK signal. Refer to the processor clock timing diagram of Figure 4-6.

The TC signal is inverted by another section of U18 (pins 5 to 6) and used to clock the second section of U26. The Q output at U26-9 switches as the clock goes from low to high. The output level depends on the level at its "D" terminal, pin 12, which is controlled by the PC clock. The signal at U26-9, therefore, is also a 1 MHz square wave, but delayed by 1/2 the TC width. Refer to timing diagram below. This output is used by the processor circuits as the PC DELAYED signal.

The PC DELAYED and TC signals are ANDed by U32 with the resultant 1 MHz train of 250 ns pulses being applied to processor circuits as the E CLOCK. The E Clock pulses occur at the center of the PC Clock cycle.

The software controlled flag signal, STOP, sets the flip-flop U34. The output of the flip-flop inhibits the clock generator and all processor operations cease until U34 is reset by the sweep gate (SG) from the indicator, signaling the start of the sweep on the CRT. The clock is again enabled and processor operation continues. The STOP command is timed by the program to occur just prior to the expected reception of the SG signal to reduce processor down time.

4.3.7 Memory PCB (A20A9A3) (Figure 6-8)

Basic timing of the processor system is controlled by the 11-bit binary up counter (program counter) which consists of U15, U16, and U22. The PC clock input causes the counter state to increment at a 1 MHz rate. This clock sets the minimum period of any one counter state (program count) at approximately 1 ms. Figure 4-7 is a block diagram of the memory PCB.

The counter output controls the address of the 8 program storage ICs (PROMs U23-U26, and U30-U33). The lower 8 bits are applied to the PROM address terminals and the upper 3 bits control the chip enable inputs to select pairs of PROMs in sequence. This method of connection and control provides 2048 words 8 bits wide from the 512 X 4 configured ICs.

The 8-bit output of the PROMs (program word) becomes the processor address when it is connected to the address bus through the 2 input multiplexer (U27, U34). The multiplexer acts as an 8-pole, double throw switch connecting the address bus to either the program word or to the output of the S-register.

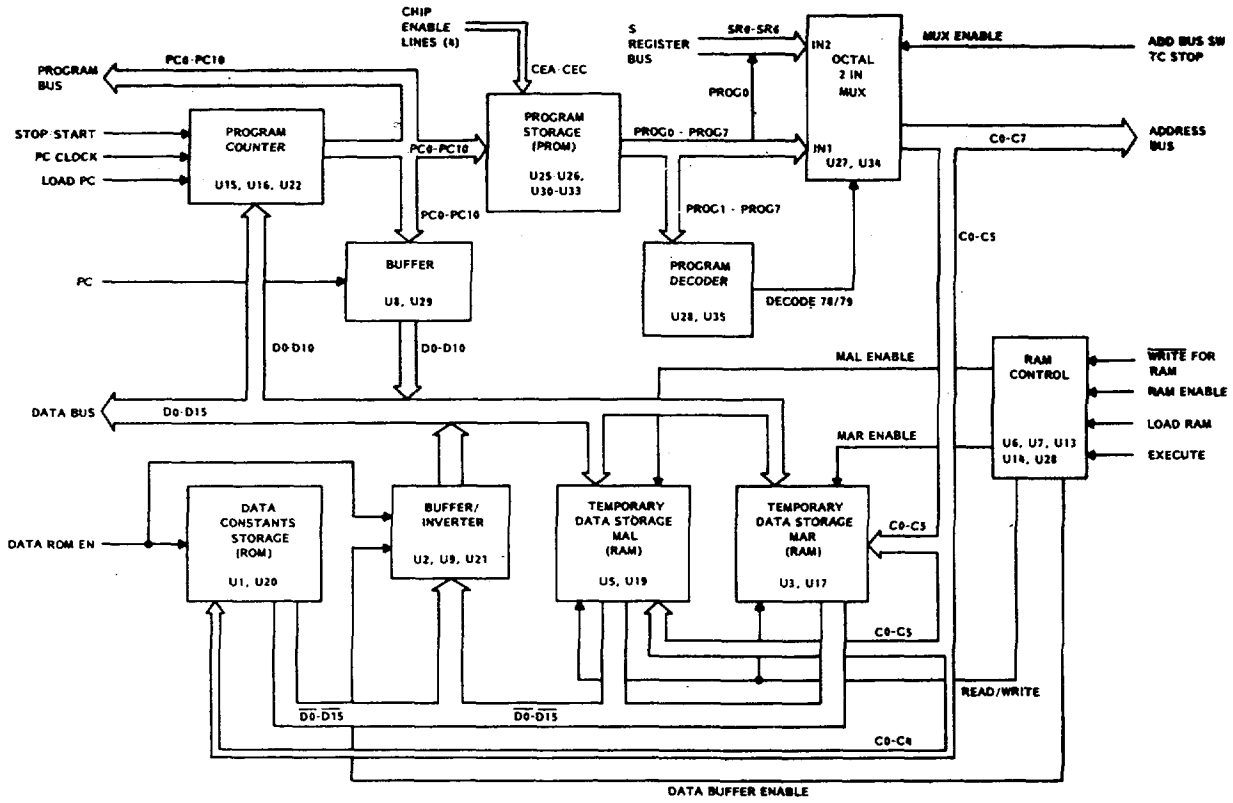


Figure 4-7 TM/EP Memory PCB Block Diagram

The address is supplied to the address controlled devices on the other PCBs via the address bus. It is also used on the memory board to select a specific word, of the 64 available, in the data storage ICs (RAM) for either entry or retrieval of data. Data is stored in 8-bit groups (bytes) in two separate devices of RAM. To enter a 16-bit word into RAM, it is necessary to address a particular word location in RAM with an address between 0 and 63 with the LOAD RAM R line low, thus loading the word into MAL. The LOAD RAM R line must be set high (by the proper addressing sequence) and the original address again selected with the original information on the data bus to enter data into the MAR section of RAM.

A similar procedure is used to read a word from RAM except that the RAM word location is selected from the block of addresses 128 to 191.

Since there is an internal inversion between input and output in the RAM ICs, an inverter/buffer (U2, 9, 21) is used to restore RAM output data to its correct sense before connecting it to the data bus. RAM control circuitry (U6, 7, 13, 14, 28) converts the decoded address to the properly timed signals required to actuate the correct RAM ICs. This same circuitry also enables the output inverter whenever a RAM output is selected.

Thirty-two words of permanently stored data are also available from the

memory board. This data is stored in the two mask programmable ROM ICs (U1, 20). Two IC chips are required to provide the 16-bit word width. This data represents constant values used in the processor computations. The individual words are accessed by addresses in the 224 to 255 block. Each of these addresses places a specific data word on the data bus via the inverter/ buffer. Because of the inversion, data is stored in the ROM in its complementary form.

The program count can be placed directly on the data bus via a buffer, (U8, 29) when the buffer is enabled by the decoded address PC. Conversely, the data on the bus can be used to set the counter to a new number (in' one clock cycle), by setting the address to LOAD PC.

4.3.8 Digital PCB (A20A9A4) (Figure 6-9)

The major portion of the circuitry located on the digital card is involved in the decoding of the address bus to generate the enable signal for the various devices and, functions. Two independent circuits are also mounted on this card. A block diagram of the digital PCB is shown in Figure 4-8.

4.3.8.1 Chip Enable Decoder - One of the independent circuits, the chip enable decoder, decodes the two highest order bits of the program count (PC-9 and PC-10) to obtain the four chip enable signals for selecting the PROM pairs in the proper sequence. The three line to eight line decoder, U30, which is connected so that only the first four outputs are active, generates four active low outputs in sequence as the two inputs are changed in a binary progression.

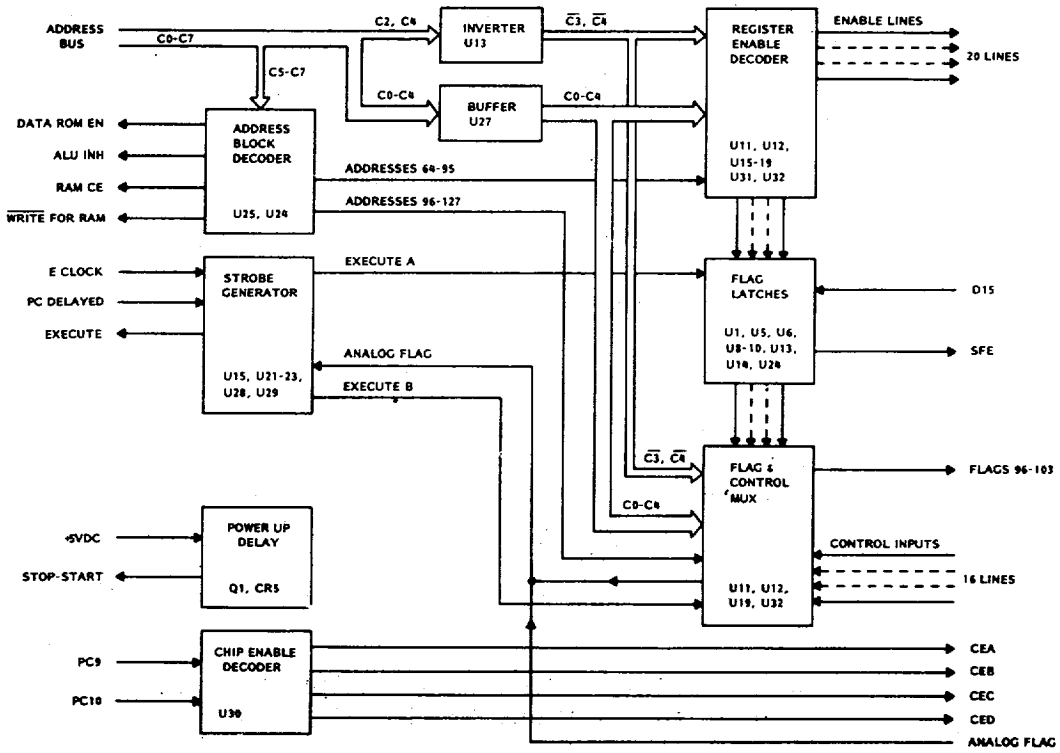


Figure 4-8 TM/EP Digital PCB Block Diagram

4.3.8.2 Power Up Delay - Since the states of the various registers, counters and memory circuits could be set in some random fashion at the application of power, it is necessary to provide a means of setting the processor devices to some known state. This is done in part by the power up delay circuit. A time delay is caused by charging C19 through R11 toward the +5 volt supply level. After approximately 7 ms, sufficient current is flowing through Q1 to turn on the programmable unijunction transistor, CR5. The output pulse from CR5 (STOP-START) is used to set the program counter in the processor to a count of zero. An initializing routine starts at this address which sequentially sets all of the processor devices to a known state, from which the normal programming sequence can take place. Without the power-up Delay and initializing routine, it would be possible for the processor to enter a sequence from which it could not recover or be controlled.

4.3.8.3 Address Block Decoder - A 3-line to 8-line decoder and two OR gates comprise the address block decoder. The three most significant bits of the address bus are decoded by U24 and U25 to form, by enable outputs, two blocks of 64 addresses each and four blocks of 32 addresses each. The decoder divides the total address field of 256 addresses into 8 equal blocks.

The first two (outputs 0 and 1) are combined by the OR gate to provide an enabling signal (WRITE FOR RAM) that allows data to be written into the 64 RAM words. Outputs 4 and 5 are similarly combined to allow retrieval of RAM data (RAM CE). The remaining decoder outputs are used singly to: enable the register enable decoder (output 2), enable the flag and control multiplexer circuit (output 3), enable the ALU (output 6), and enable the data ROM (output 7).

4.3.8.4 Register Enable Decoder - The 32 addresses within the block controlled by this circuit are further decoded to: provide a separate enabling signal for each register within the processor system (T REG, S REG, etc.) ; provide a specific address for each output flag (logic level control signal) ; provide clocking signals for the input latches.

For all outputs except the latch clocks, the signals described above are truly enabling signals. The actual controlling output is the EXECUTE strobe, which is timed to occur after the data and enabling signals have had time to settle. This strobing procedure is necessary to prevent "glitches" (erroneous operation due to the difference in switching time of the various devices).

The latches (U1, 2, 3, 5, 6, 8, 9, 10, 13, 14, 24) are used to hold momentary signals at a constant output are "D" type latches. This means that they sense the logic level applied to their D terminal at the time of a low to high transition of the signal at their clock (C) input. The level at the D terminal is transferred to the Q terminal by the clock. Further changes at the D input will have no effect on the Q output. The latches do have separate set (PR) and reset (CLR) inputs. These are overriding inputs and a low level at either terminal will control the output regardless of the state or operation at the CK and D inputs.

Most of the latches used in this function are controlled by software, i.e., the processor sets the level at the D input via the D15 line of the data bus. In the case of the offset latch (U10) however, the latch can be set directly by a low level at its (PR) terminal from the OFFSET pushbutton switch on the

TM/EP headset control panel. It is reset only via the data bus (after 1 second), and can be set from the data bus (automatic reset) as well as by the OFFSET switch.

4.3.8.5 Flag Control Multiplexing - All of the external signals which control processor operation (either analog or digital in form) are multiplexed onto a single control line (ANALOG FLAG). The signal on this line controls a flip-flop in the strobe generator (described below).

By the selection of addresses within its enabled block, the flag and control multiplexer can be used to test (for a high or low logic level) inputs from each of the control switches on the TM/EP headset control panel and, via the circuitry of the switch and lamp buffer (A20A3), those switches in the indicator which affect TM/EP operation. The output of each switch (or the logic level equivalent of its output) is placed on the analog flag line when the switch is addressed by the program. The outputs of those latches (U1, 2, 3, 5, 6, 8, 9, 10, 13, 14, 24) which were clocked by outputs of the register enable decoder can also be placed on the analog flag line.

The multiplexer (A1U34) in the analog PCB (A20A9A1) is functionally part of this circuit. ADDRESSES 96 to 103 are decoded as a group and the resultant signal sent to the analog PCB to enable U34. The only difference is the use that the processor makes of the flag signal.

4.3.8.6 Strobe Generator - The EXECUTE strobe, which performs all of the actual clocking of the various processor registers, is generated from the 250 ns positive portion of the E CLOCK. This clock pulse occurs once per processor cycle. The E CLOCK is converted to the EXECUTE signal by the use of three sections of AND gate U29. The series connection of the three gates provides buffering action and also delays the EXECUTE output by three gate delays (approximately 25 ns).

The strobe is enabled at U29-2 by the output of the flag flip-flop, U22, applied to U29-1. The enabling signal can only be removed by a high on the ANALOG FLAG line during a flag select address period.

If the ANALOG FLAG line is high when the processor addresses one of the flag circuits, the resultant high level at U22-11 causes the flip-flop to set and the EXECUTE strobe to be inhibited. The following instruction of the processor will not be executed due to the lack of a strobe. The flag flip-flop output also enables the PC control flip-flop, U23, which generates a LOAD PC signal at the next positive transition of the PC DELAYED clock signal.

Resetting of the flag flip-flop is controlled by the condition of the skip continue/skip discontinue latch consisting of the terminals 4, 5, and 6 sections of U15 and U21. The output of the U15 section is set high when the processor is programmed to address the SKIP C line. The U21 output is set high by addressing the SKIP D line or by a low level on the ANALOG FLAG line while the SKIP C section of the latch is high.

It is to be noted that these two signals (SKIP C and SKIP D) do not require the presence of an EXECUTE signal, but are strobed directly by the E CLOCK. If the SKIP D section of the latch is set (had been addressed last),

the high output at U24-11 will cause the flag flip-flop to reset at the next E CLOCK. A single instruction is skipped (not executed).

If the SKIP C section of the latch is set (last addressed), the resultant low at U22-12 will maintain U22 in a set condition regardless of the state of the ANALOG FLAG line at U22-11. A low level at the ANALOG FLAG input will, however, indirectly cause U22 to reset by setting the SKIP D latch through U28. U22 will then reset at the next E CLOCK as explained above.

U22 can also be reset directly by the program if the SKIP D address is encountered before the flag line goes low.

SECTION 5

MAINTENANCE

5.1 PRECAUTIONS

5.1.1 Authorized Service

Radar service and repair should be performed only by qualified personnel.

Raytheon Marine Company Service Centers are listed in the front of this manual. They are equipped and prepared to provide replacement parts and technical assistance to all service stations. Inquiries should include:

1. Model and Serial number.
2. Purchase and installation dates.
3. Nature of trouble.
4. Name of selling dealer.

5.1.2 Safety

Because of the high voltages present within an operating radar indicator, service personnel are cautioned to adhere to the safety notices provided in the front of this manual.

WARNINGS

- **Do not open any of the units while the radar is energized. Although the indicator high voltage is disabled by means of an interlock when the indicator upper front access panel is removed, potentially lethal voltages are present at several points within the unit.**
- **The equipment must be switched off, both at the indicator POWER switch and the ship's line-disconnect switch prior to attempting any maintenance or cleaning procedure.**

5.2 TOOLS, TEST EQUIPMENT, AND ACCESSORIES

No special tools are required for servicing the TM/EP unit. Common shop tools of the standard variety type such as pliers, screwdrivers, wrenches, etc. may be used.

The test equipment recommended for servicing the TM/EP unit is given in Table 5-1.

Table 5-1 Recommended Test Equipment

Test Equipment	Manufacturer or Supplier	Model or Part Number
Multimeter (20K Ohms/V)	Simpson	260
35-MHz Oscilloscope	Tektronix	335
Pulse Generator	Hewlett-Packard	8011A
Extender PCB Assy (used only with PC boards in TM/EP digital card cage A20A9) (Not supplied)	Raytheon Marine Co.	984290-1

Equivalent test equipment may be substituted where necessary provided the electrical characteristics are within the same range and tolerance. The test equipment listed in Table 5-1 are in addition to the tool complement normally carried by service engineers. The extender PCB assembly is required for servicing and testing of TM/EP PCBs in the digital card cage (A20A9). The extender PCB is optionally available at the Raytheon Marine Company upon request.

The accessories used are ordinary clip leads or jumpers and those accessories normally associated with the test equipment.

5.3 PARTS LOCATION

Location of the printed circuit boards and many of the major components, controls, and adjustments will be facilitated by referencing Figure 2-1 or Figure 2-2 and the following illustrations:

Figure 5-1 TM/EP Parts Location (in Radar Indicator)
Figure 5-2 TM/EP Headset Control Panel Parts Location (Rear View)

5.4 PREVENTIVE MAINTENANCE

Preventive maintenance at periodic intervals contributes considerably to electronic systems service life. Minimal inspection, cleaning, and lubrication are required under normal operating conditions.

5.4.1 Condensation Prevention

If the equipment is to be inoperative for periods longer than 24 hours, it should be fully energized for at least one hour each day. This procedure ensures that any condensation, particularly in tropic climates, is dried out and vented.

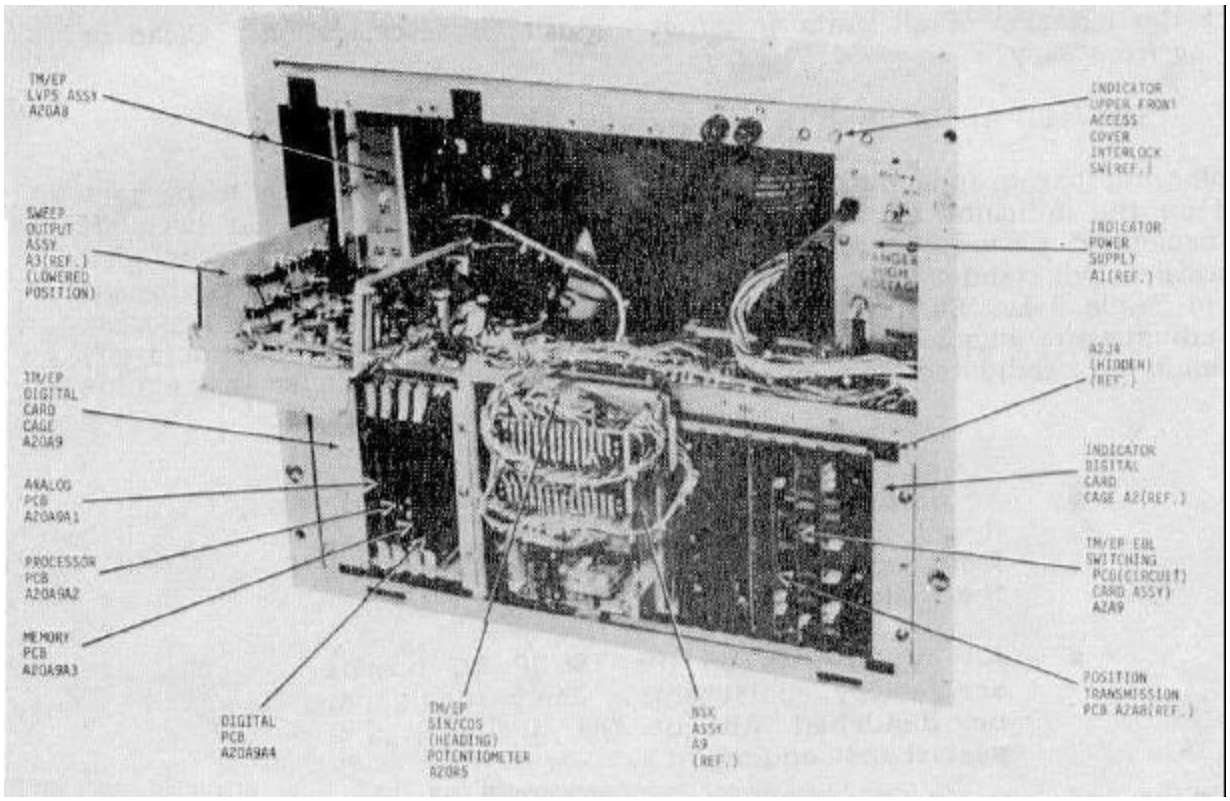


Figure 5-1 TM/EP Parts Location (in Radar Indicator)

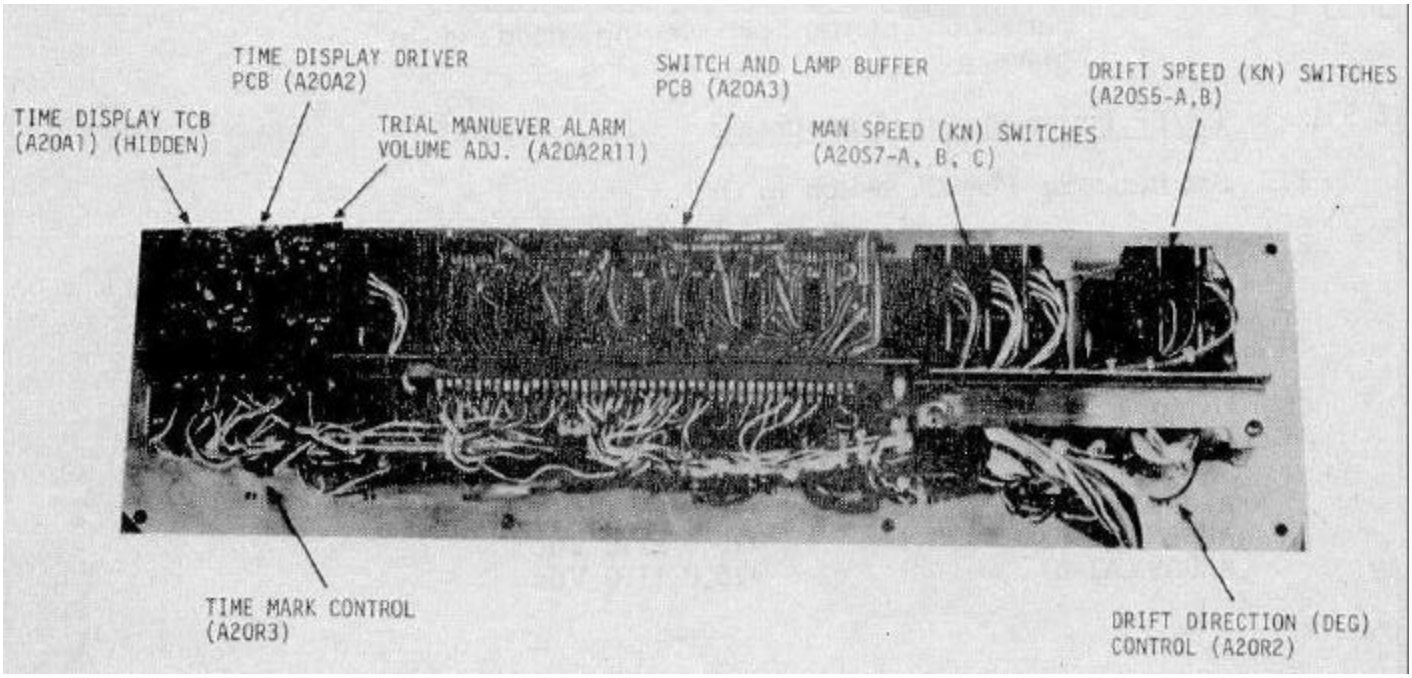


Figure 5-2 TM/EP Headset Control Panel Parts Location (Rear View)

5.4.2 Inspection (Monthly Intervals)

Inspect the exterior of all units for dust and finish deterioration. Clean or repair as necessary.

5.5 SERVICE ADJUSTMENTS

The following paragraphs outline the TM/EP adjustment procedure to be performed on the indicator during initial operation, after the radar has been off for a prolonged period, or following service. Field adjustments are included for normal service and repair; they may be performed with the test equipment listed in Table 5-1. Factory adjustments are listed for information purposes; these adjustments should require only one setting (initially at the factory), and should be readjusted only by qualified personnel with proper test equipment.

NOTE

- **To perform the TM/EP service adjustments, it will be necessary to remove the upper front access cover and stabilizer bar from the indicator.**
- **All adjustments on the TM/EP PC boards are factory adjustments. They should not be disturbed without the availability of special test equipment.**
- **The indicator bezel may require raising for access to circuit wiring of TM/EP related parts. The indicator bezel cannot be raised to its full upright position when the reflection plotter or viewing hood is in place.**

5.5.1 TM/EP Power Supply Adjustments

1. Set indicator POWER switch to OFF.
2. Remove the analog card (Al) from the TM/EP digital card cage (A20A9) and reinstall on an extender card.
3. Set indicator POWER switch to STBY.
4. Using a dc voltmeter, check for the proper voltage between the following points and the chassis:

A20A9XA1-5	+5.00 ±0.10 Vdc
A20A9XA1-63	+15.0 ±1.0 Vdc
A20A9XA1-67	-15.0 ±1.0 Vdc

5. If necessary, adjust R34 (Voltage Set) on the TM/EP low voltage power supply (A20A8) for the correct readings. (Note that the one adjustment affects all three readings and must be set so that all three voltages are within tolerance simultaneously.) Refer to paragraph 5.8.1, steps 1 through 4 for access to LVPS.

NOTE

A20A8R33 is a factory adjustment affecting the regulator range and should not be adjusted.

6. Set indicator POWER switch to OFF, then remove and reinstall A20A9A1 without the extender board.

NOTE

If a complete indicator alignment is to be performed, refer to the basic radar service manual and perform the necessary adjustments for yoke alignment and centering of sweep octagon.

5.5.2 TM/EP Input Alignment

The following steps provide a complete procedure for adjusting TM/EP input circuits and for making the minor readjustments that may be necessary to compensate the indicator for the additional TM/EP circuitry.

CAUTION

Do not remove PC boards while indicator is in STBY. To remove or install PC boards for alignment or troubleshooting, set indicator to STBY and remove power using interlock switch.

---

1. Set the indicator POWER switch to STBY.
2. Remove indicator upper front access cover (interlock switch opens).
3. Remove EBL switching PCB (A2A9) and reinstall on an extender card.
4. Pull indicator front panel interlock switch down and out to defeat interlock.

5. Set the controls on the indicator and TM/EP headset control panels as listed below:

Controls	Setting
POWER	TX ON
RANGE SELECT	48 MILES
HDG SET/GYRO STAB/HD UP	HD UP
MAN/LOG	MAN
REL/TRUE	TRUE
TRIAL MNVR	OFF
TGT MARK/EBL TRUE/EBL REL	EBL REL
TARGET SELECT	0
MAN SPEED (KN)	00.0
DRIFT SPEED (KN)	0.0

6. Adjust indicator for normal display. (Refer to steps 1 through 10 in paragraph 3.2.2.)

7. Set the RANGE SELECT to 24 MILES and turn down gain.

8. Set VRM handwheel to 23 miles. Set the EBL at 0° and adjust R1 on position transmission PCB (A2A8) until the bright spot (EBL range) is placed on the VRM range ring.

9. Set the EBL at 180° and check the bright spot on EBL relative to VRM ring. Adjust R23 on EBL switching PCB (circuit card assembly) (A2A9) to move the EBL bright spot halfway to the VRM range ring.

10. Repeat steps 8 and 9 as required to place the EBL bright spot on the VRM range ring at 0° and 180°.

11. Set the EBL at 90° and adjust R7 on position transmission PCB (A2A8) until the bright spot (EBL range) is placed on the VRM range ring.

12. Set the EBL at 270° and adjust R39 on EBL switching PCB (A2A9) to move the EBL bright spot halfway to the VRM range ring.

13. Repeat steps 11 and 12 as required to place the EBL bright spot on the VRM range ring at 90° and 270°.

14. Rotate EBL POSITION control slowly through 360° and observe the bright spot of EBL. The bright spot of the EBL should be on the VRM range ring when the EBL is set at any position. Three or less range cells are acceptable. (One range cell is approximately 1/16-inch long.)

15. On A2A9, adjust R30 (vertical) and R34 (horizontal) so that the sixth range ring is 1/8-inch from the edge of the CRT.

16. When the previous alignment conditions are met, set HDG SET/ GYRO STAB/HD UP switch to GYRO STAB.

17. Using knob on NSK stepping motor, set heading flash to 0°.

18. Set VRM handwheel to 23 miles and EBL POSITION control to 270° on the inner bearing scale.

19. Adjust R14 on the NSK resolver drive PCB (A9A1) so the VRM spot on the EBL is directly on top of the VRM ring.

20. Rotate heading flash to 90°.

21. Adjust R13 on NSK resolver drive PCB (A9A1) so that VRM spot on the EBL is directly on top of the VRM ring.

22. Rotate heading flash to 0°.

23. Rotate EBL POSITION control so that EBL is at 1800 on the inner bearing scale.

24. Adjust R15 on the NSK resolver drive PCB (A9A1) so that the VRM spot on the EBL is directly on top of the VRM ring.

25. On the indicator, alternately operate the EBL RD switch between its read and normal (spring loaded) positions.

26. While operating the EBL RD switch, adjust A2A9R72 (horizontal) and A2S9R73 (vertical) until there is no displacement of the EBL as the switch is operated.

5.5.3 Joystick Alignment

The following steps assure that the target marks positioned by the joystick control (TGT MARK EBL ORIGIN) will have the correct relationship with the sweep.

1. Remove sweep generator PCB A10 from the indicator digital card cage A2 and reinstall on an extender board.

CAUTION

The indicator bezel cannot be raised to its full upright position with the TM/EP headset installed and the reflection plotter and/or viewing hood in place.

---

2. Set the controls on the indicator and TM/EP headset control panels as follows:

Control	Setting
POWER	TX ON
RANGE SELECT	24 MILES
HDG SET/GYRO STAB/HD UP	GYRO STAB
MAN/LOG	MAN
REL/TRUE	REL
TRIAL MNVR	OFF
TGT MARK/EBL TRUE/EBL REL	TGT MARK
TARGET SELECT	0
MAN SPEED (KN)	00.0
DRIFT SPEED (KN)	0.0

3. Loosen captive screws and raise indicator bezel until it locks in place.

4. Connect a clip lead between terminals E1 and E2 on the joystick assembly (A20A10).

5. With the joystick in its centered position (joystick perpendicular to the bezel), adjust R1 and R2 on the joystick assembly (A20A10) until there is no movement of the target mark on the CRT, i.e., the mark remains centered as the sweep rotates.

6. Use the joystick to move the target mark to the right along the CRT center line.

7. Adjust R64 on the EBL switching PCB (A2A9) so that the mark disappears just as it passes the sixth range ring at 90°.

8. Move the joystick so that the mark moves to the left along the CRT center line.

9. If the mark does not disappear as it passes the sixth range ring at 270°, adjust R31 on the sweep generator PCB (A2A10) until the error has been reduced by 1/2.

10. Readjust A2A9R64 to set the point of disappearance at the sixth range ring at 90°.

11. Repeat steps 6 through 10 until there is no error at the 90° and 270° intersections with the sixth range ring.

12. Use the joystick to move the mark upward along the CRT center line.

13. Adjust R43 on EBL switching PCB (A2A9) so that the mark just disappears at the sixth range ring at 0°.

14. Move the mark downward along the CRT center line.

15. If the mark does not disappear as it passes the sixth range ring at 180°, adjust R11 on the sweep generator PCB until the error has been reduced by 1/2.

16. Readjust A2A9R43 to set the point of disappearance at the sixth range ring at 0°.

17. Repeat steps 12 through 16 until there is no error at the 0° and 180° intersections with the sixth range ring.

18. Remove clip lead from terminals E1 and E2 of the joystick assembly (A20A10).

19. Note the position of the sweep origin relative to the crosshairs on the cursor. The sweep origin should be directly under cursor cross hairs. If this is not the case, adjustment of the sweep origin may be accomplished by the movement of the centering rings on the CRT yoke.

20. Set indicator POWER switch to OFF.

21. Remove and reinstall A2A10 without the extender board.

5.5.4 Ship's Heading Alignment

Alignment of the ship's heading sine/cosine potentiometer (A20R5) is required to generate the correct relative marker on the CRT. This control is located on the NSK assembly (A3) of the indicator. To perform this alignment, it is necessary to remove the screws holding the NSK assembly in its operating position and swing the assembly to its service position.

NOTE

The 10K-ohm potentiometer mounted on the back of A20R5 is a factory adjustment and should not require readjustment.

1. Set the controls on the indicator and TM/EP headset control panels as follows:

Control	Setting
RANGE SELECT	48 MILES
REL/TRUE	REL
TGT MARK/EBL TRUE/EBL REL	TGT MARK
TARGET SELECT	1
TRIAL MNVR	OFF
DRIFT SPEED (KN)	00.0
MAN SPEED (KN)	40.0

2. Set RANGE SELECT switch to 3 MILES.

3. Depress joystick pushbutton and place mark at sweep origin.

4. Release joystick pushbutton.

5. Set TGT MARK/EBL TRUE/EBL REL switch to EBL TRUE.

6. Rotate EBL, using EBL POSITION control, so that it passes through the dot at the sweep origin.

7. Loosen NSK resolver and rotate until the heading flasher is aligned with the EBL. Retighten NSK resolver.

8. Return the NSK assembly (A3) to its operating position and secure with the screws previously removed.

5.5.5 DRIFT DIRECTION (DEG) Control Alignment

1. On the TM/EP headset control panel, make the following control settings:

Control	Setting
TGT MARK/EBL TRUE/EBL REL	TGT MARK
TARGET SWITCH	1
DRIFT DIRECTION (DEG)	90°
DRIFT SPEED (KN)	9.9
MAN SPEED (KN)	00.0

2. On the indicator, set the heading flash to 90°, with the RANGE SELECT switch set at 48 MILES.

3. Set RANGE SELECT switch to 1.5 MILES and depress the RESET pushbutton switch on the TM/EP headset control panel.

4. Using the joystick, place a mark exactly on the heading flash.

5. Check that the second mark follows the heading flash toward 90°.

   If it does not follow the line, make minor adjustments of the DRIFT DIRECTION (DEG) control until the second relative mark is within 1/8-inch of the heading flash as it passes the sixth range ring.

6. If the DRIFT DIRECTION (DEG) control does not read 90 ± 3.0°, loosen the control knob on the shaft and readjust the knob until it reads 90.0°.

7. When all alignments have been completed, replace the stress bar and front access cover of the indicator.

5.6 CHECKOUT PROCEDURE

Successful completion of the tests and checks outlined in the following paragraphs will provide assurance that the TM/EP and those portions of the radar indicator that affect TM/EP operation are performing within specifications. in the event that a malfunction in the TM/EP operation occurs, refer to the troubleshooting section (paragraph 5.7) for fault-isolation and repair of the TM/EP equipment. Once the faulty part causing the malfunction has been corrected and the TM/EP restored to service, the checkout procedures should be repeated to ensure that the equipment is functioning properly.

5.6.1 Initial Control Settings

All controls should remain in the positions listed in the steps below except as directed in specific tests.

1. On the indicator bezel and control panel, make the following control settings:

Control	Setting
(Pre-Operation)	
CONTRAST	CCW
BRILLIANCE	CCW
RANGE RINGS	CCW
ANTI-CLUTTER/RAIN	CCW
ANTI-CLUTTER/SEA	CCW
GAIN	CCW
(Operation)	
POWER	STBY (allow 3-minute warmup)
POWER	TX ON
RANGE SELECT	24 MILES
BRILLIANCE	Barely visible trace
RANGE RINGS	Comfortable viewing level
CONTRAST	3 o'clock
GAIN	Adjust on threshold of snow
TUNE	Adjust to optimum
CURSOR	0°
VRM (handwheel)	Rotate one turn CW
VRM Intensity	VRM (inner dial) to on CRT comfortable viewing level
VRM READOUT Intensity	READOUT (outer dial) to comfortable viewing level of digital readout.
EBL DIM	Comfortable viewing level

2. The remaining indicator controls can be left in any position as they will have no effect on the test results.

3. On the TM/EP headset control panel, make the following control settings:

Control	Setting
DRIFT SPEED (KN)	0.0
DRIFT DIRECTION (DEG)	0°
MAN SPEED (KN)	00.0
MAN/LOG	MAN
REL/TRUE	REL
DIMMER	Fully CW
TRIAL MNVR	OFF
TGT MARK/EBL TRUE/EBL REL	EBL REL
TARGET SELECT	0
TIME MARK	Fully CCW

5.6.2 Relative Motion Checks

The following steps check the operation of the indicator and the added TM/EP functions in the relative motion mode.

1. Set RANGE SELECT switch to 48 MILES.
2. Set VRM handwheel control for a reading of 47.0 miles.
3. Rotate EBL POSITION control slowly throughout 360°.
4. Check that the EBL range mark (bug) remains on the VRM ±2 range cells for the whole 360° rotation.
5. Check that the EBL origin remains stationary as the sweep rotates.
6. On the indicator, set RANGE SELECT switch to 24 MILES, and use HDG SET position of the HDG SET/GYRO STAB/HD UP switch to set the heading flash to 0°. (Refer to Section 3 of the basic radar manual for procedure.)
7. On the TM/EP headset control panel, depress and hold the RESET pushbutton switch.
8. Check that the display (CRT) is blank for as long as the switch is held.
9. Release RESET pushbutton switch and check that the display reforms after 1 second, with the sweep origin offset toward 180° and that the heading flash is directly under the cursor.
10. Using the VRM handwheel control, set the VRM so that it passes under the intersection of the horizontal and vertical cursor lines (CRT center).
11. Check that the VRM digital readout reads 15.3 to 16.3 miles.
12. Depress and release the OFFSET pushbutton switch on the TM/EP headset control panel.
13. The OFFSET indicator on the TM/EP headset control panel should be lit. Perform a normal OFFSET operation as outlined in paragraph 3.3.2
14. Set RANGE SELECT switch to 48 MILES and confirm that the sweep returns to the CRT origin. Return RANGE SELECT switch to 24 MILES.
15. The OFFSET indicator should go out; the display should blank for 1 second, then reform with the sweep origin at the location of the dot (CRT center).
16. Set heading flash to 90° using the HDG SET position of the HDG SET/GYRO STAB/HD UP switch.

NOTE

If the RESET switch is depressed immediately after a large change in heading, it may be necessary to RESET several times until the sweep origin remains stationary. (This is a normal function of the TM/EP operation.)

17. Wait approximately 10 seconds, then repeat steps 7 through 15.

18. Repeat steps 16 and 17 at headings of 180° and 270°.

19. Set RANGE SELECT switch to 48 MILES, then to 1.5 MILES.

20. Adjust heading flash line to 0°.

21. On TM/EP headset control panel, set MAN SPEED (KN) thumbwheel switches to 30.0.

22. Wait at least 1 minute and verify that sweep origin is not moving. With the REL/TRUE switch in REL position, manual speed input will have no effect on the movement of the sweep origin.

5.6.3 True Motion Checks

The following steps check that portion of the circuitry that produces the true motion display.

1. On the TM/EP headset control panel, set controls as follows:

Control	Setting
RANGE SELECT	48 MILES, then to 1.5 MILES
MAN SPEED (KN)	30.0
REL/TRUE	TRUE

2. Verify that the sweep origin moves up the screen.

3. Set RANGE SELECT switch to 48 MILES.

4. Check that the display blanks, then reforms with the sweep origin at the center of the CRT.

5. On the TM/EP headset control panel, set controls as follows:

Control	Setting
MAN SPEED (KN)	00.0
TARGET SELECT	1
TGT MARK/EBL TRUE/EBL REL	EBL TRUE
DRIFT DIRECTION (DEG)	90°
DRIFT SPEED (KN)	9.9

6. On the indicator, rotate the EBL DIM control for a visible display and adjust EBL POSITION control to 90°.

7. Set RANGE SELECT switch to 1.5 MILES, and TGT MARK/EBL TRUE/EBL REL switch to TGT MARK; then depress and hold joystick pushbutton while placing mark (bug) close to the CRT center on the horizontal cursor line, by moving the joystick control.

8. When mark is in position, release joystick pushbutton.

9. Wait several minutes and observe that moving dot is following the EBL (under horizontal cursor).

10. Adjust DRIFT DIRECTION (DEG) control until the moving mark is exactly following the EBL. Check that the DRIFT DIRECTION (DEG) reads 90 ± 3°.

11. Depress and hold EBL RD switch. Note that the EBL originates from the CRT center; then release EBL RD switch.

12. Depress OFFSET switch on the TM/EP headset control panel and with the joystick place the dot slightly less than 0.7 radius from the CRT center in the direction of the heading flash.

13. Set MAN SPEED (KN) to 30.0.

14. Check that after a few moments, the RESET indicator on the TM/EP headset control panel illuminates and remains on for 12 seconds.

15. Check that the RESET indicator then extinguishes, the CRT display blanks for one second and then reforms at 0.7 radius on the counter heading, and the heading flash passes through the CRT center.

16. Repeat steps 12 through 14, except that when the RESET indicator illuminates, verify that the RESET function can be cancelled by performing a normal OFFSET function before the 12 seconds has expired.

17. Observe that the OFFSET and RESET indicators extinguish as soon as the joystick pushbutton is released.

5.6.4 Own Ship Speed and Direction Checks

The following steps check the accuracy of the heading and speed (manual or automatic) related circuitry.

1. Remove indicator upper front access panel to gain access to internal assemblies (refer to paragraph 5.8.1, steps 1 and 2).

2. On TM/EP headset control panel, set controls as follows:

Control	Setting
TGT MARK/EBL TRUE/EBL REL	TGT MARK
TRUE/REL	TRUE
TARGET SELECT	1
MAN SPEED (KN)	24.0
MAN/LOG	MAN

3. On the indicator bezel and control panel, set RANGE SELECT switch to 48 MILES and adjust heading flash to 315° using the HDG SET position of the HDG SET/GYRO STAB/HD UP switch.

4. Set RANGE SELECT switch to 3 MILES, then depress and release RESET pushbutton on the TM/EP headset control panel.

5. Adjust VRM handwheel for 1.60 miles (on VRM digital readout).

6. The sweep origin should now be displaced 0.7 CRT radius toward 135° with the CRT center beyond the VRM.

7. Using the joystick control, place a target mark at the intersection of the VRM and the heading flash. (Depress and hold joystick pushbutton until the target mark is in position, then release pushbutton.)

8. The mark should remain stationary while a second mark should originate from that position and move along the heading flash toward 315°.

9. When the TIME (MIN) display reads 4.0 minutes, the sweep origin should be within 1/8-inch of the original mark.

10. Repeat steps 2 through 9 with RANGE SELECT, heading flash, MAN SPEED (KN) and VRM (digital readout) values listed below:

RANGE SELECT	Heading Flash	MAN SPEED (KN)	VRM	Elapsed Time (Min.)
6 MILES	2250	48.0 Knots	3.2 Miles	4.0
24 MILES	1350	50.0 Knots	3.76 Miles	4.5

NOTE

Steps 11 through 21 are to be performed only if an electronic speed log is installed on the vessel.

11. Set MAN SPEED (KN) thumbwheel switches to 00.0, MAN/LOG switch to MAN, DRIFT SPEED (KN) thumbwheel switches to 0.0, REL/TRUE switch to REL, RANGE SELECT to 48 MILES, and then to 1.5 MILES.

12. At TB4 inside the indicator, remove leads from ship's speed log input on terminals 7, 8 and 9 (if installed). (Refer to paragraph 5.8.3 for access to TB4.)

13. Set the controls of a pulse generator to obtain an output with the following characteristics:

FREQUENCY	1.0 ± 0.1 PPS
PULSE WIDTH	50 ± 10 ms
PULSE AMPLITUDE	TTL Logic Level (3.5 to 4.5V)
PULSE POLARITY	Logic complement (negative-going pulse on a +4.75 to +5.25 base line)

14. Connect pulse generator output to TB4-7 (high) and chassis (gnd).

15. Depress and release RESET pushbutton switch. The display should blank and then reform with the sweep origin displaced 0.7 CRT radius toward 180° with the heading flash passing through the CRT center.

16. Depress and hold joystick pushbutton switch while moving the mark to a point about 1 inch to the left of the CRT center.

17. Simultaneously release joystick pushbutton switch and set MAN/LOG switch on TM/EP headset control panel to LOG.

18. Set TGT MARK/EBL TRUE/EBL REL switch to EBL TRUE.

19. Set EBL to 00 using EBL RD and EBL POSITION controls.

20. Adjust VRM handwheel to 1.0 miles (on VRM digital readout) and note position of bug on EBL.

21. When the TIME (MIN) display reads 3.0 minutes, check that a dot appears on the EBL line and that the EBL origin starts moving down screen. At 3.3 minutes, the dot will intercept the EBL position, ±1/8 inch. (The TM/EP does not display speed log information until after 3 minutes.)

22. Remove the pulse generator connections from TB4-7 and chassis.

23. Reconnect original leads to TB4-7, TB4-8 and TB4-9 and install indicator upper front access cover to original configuration.

5.6.5 Target Plotting Checks

The following steps check the target position computation and time measurement, and display circuits.

1. On TM/EP headset control panel, set controls per paragraph 5.6.1, step 3 except set TGT MARK/EBL TRUE/EBL REL switch to TGT MARK, REL/TRUE switch to TRUE and MAN SPEED (KN) to 30.0 knots.

2. Set RANGE SELECT switch to 6 MILES.

3. Select targets 1 through 8 in turn (using TARGET SELECT thumbwheel switch) ; for each target use the joystick control to position the target at points just within the 0.7 CRT radius of center screen and at approximately 45° intervals.

4. As each target is selected, check that the TIME (MIN) display is blank until the joystick pushbutton switch is released, at which time it illuminates at a reading of 00.0. Check also that the TIME (MIN) display reading increases with time.

5. Select target 0 (zero). Check that all eight marks are displayed.

6. Select target 1. Check that two marks (one stationary and one moving in the heading flash direction) are displayed.

7. Set TGT MARK/EBL TRUE/EBL REL switch to EBL TRUE. Check that only the stationary mark is displayed and that an EBL originates at the point where the moving mark was seen (in TGT MARK mode). (Refer to Figure 3-4B.)

8. Set TGT MARK/EBL TRUE/EBL REL switch to EBL REL. Check that only the moving mark is displayed and that an EBL originates from the location of the stationary mark.

9. Verify EBL read function for each target using EBL RD switch.

10. Rotate TIME MARK control and check that the spaces on the EBL can be varied in length for each target.

11. Select targets 2 through 8 in turn. Check that the TIME (MIN) display reads the approximate time (from original setting) for each target.

12. Select target 1 and set TGT MARK/EBL TRUE/EBL REL switch to TGT MARK.

13. Depress PLOT ERASE pushbutton switch. Check that the two marks disappear from the CRT display and that the TIME (MIN) display is blanked.

14. Select target 0 (zero). Check that seven marks (targets 2 through 8) are displayed.

15. Depress PLOT ERASE pushbutton switch. Check that all target marks disappear from the display.

16. Select targets 1 through 8 in turn. Check that the TIME (MIN) display is blank for all targets.

5.6.6 STATUS Indicator Tests

The following steps check the STATUS indicator circuitry.

1. On the indicator, set heading to 0°.

2. On the TM/EP headset control panel, set REL/TRUE switch to TRUE, TGT MARK/EBL TRUE/EBL REL to TGT MARK and TARGET SELECT thumbwheel switch to 1.

3. Set RANGE SELECT switch to 24 MILES.

4. Using joystick control, place the mark just beyond the fourth range ring near the heading flash.

5. Select target 2 and place it just beyond the first range ring near the heading flash.

6. Set RANGE SELECT switch to 48 MILES.

7. Check that the PLOTTING INHIBITED indicator is illuminated, that the TIME (MIN) display is blanked, and that no marks are displayed on the CRT.

8. Set RANGE SELECT switch to 12 MILES.

9. Set TARGET SELECT thumbwheel switch to 0.

10. Check that the PLOTTING INHIBITED indicator is extinguished and that the STATUS/MARK OFF SCALE indicator is flashing and the TIME (MIN) display is extinguished.

11. Select target 1. The TIME (MIN) display is illuminated and the STATUS/MARK OFF SCALE indicator is on and not flashing.

12. Select target 2. The TIME (MIN) display is illuminated and the STATUS/MARK OFF SCALE indicator is extinguished.

13. Set RANGE SELECT switch to 3 MILES while TARGET SELECT is 0. Check that the STATUS/MARK OFF SCALE indicator is flashing and that the TIME (MIN) display is blanked.

14. Select target 1. The STATUS/MARK OFF SCALE indicator is on steady and the TIME (MIN) display advances.

15. Select target 2. The STATUS/MARK OFF SCALE indicator is illuminated and the TIME (MIN) display advances.

16. Slowly rotate the DIMMER control to its CCW extreme and verify that the intensity of the panel lighting and the TIME (MIN) display can be varied over the range. (Return the control to the desired viewing level at the completion of the check.)

5.6.7 Trial Maneuver Check

The following steps check the circuitry and programming of the trial maneuver function of the TM/EP for proper operation.

1. On the indicator control panel, set RANGE SELECT switch to 1.5 MILES and heading to 0°.

2. On the TM/EP headset control panel, set controls as follows:

Control	Setting
MAN SPEED (KN)	30
REL/TRUE	REL
TARGET SELECT	1
TGT MARK/EBL TRUE/EBL REL	TGT MARK

3. Depress and release the RESET pushbutton switch.

4. After the display has reformed, use the joystick control to place the target mark in the upper center of the screen.

5. Check that a second mark originates from that point and moves down the screen.

6. Set TRIAL MNVR switch to ON. Check that the TRIAL MNVR/ON indicator is illuminated.

7. Depress joystick pushbutton switch and move the mark that is under joystick control to the left at least one inch away from the mark that is moving down the screen.

8. Release joystick pushbutton switch. Check that the mark that was moving down screen continues unchanged.

9. Set TGT MARK/EBL TRUE/EBL REL switch to EBL REL.

10. Rotate EBL POSITION control (on the indicator bezel) so that the EBL passes through the moving mark.

11. Check that both the mark and the EBL origin move and that the mark stays on the EBL.

12. Set TRIAL MNVR switch to OFF. Check that the TRIAL MNVR/OFF indicator is illuminated and the ON indicator is extinguished.

13. Check that the EBL origin is at the location of the original mark in the upper center of the screen.

5.7 TROUBLESHOOTING

Troubleshooting of the TM/EP is provided in the form of a troubleshooting flow chart (Figure 5-3). The troubleshooting flow chart is a compilation of problems which are determined by using the indicator CRT as a troubleshooting device in detecting the symptom associated with the malfunction. If, at any time, a malfunction is discovered or suspected during normal operation, the check procedures outlined in paragraph 5.6 should be performed first in the order given until an unsatisfactory result in the procedure occurs. This will lead to the correct starting point in the flow chart as depicted in Table 5-2.

Table 5-2 Probable Checkout-Related Problems

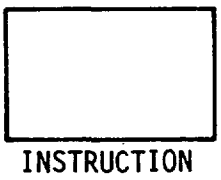
Flow Chart Problem (Fig. 5-3)	Checkout Procedure (para./step reference)
1. CRT Blank	N/A
2. TM/EP Video Absent (Target Mark and/or EBL)	Para. 5.6.2, step 3
3. No Manual Reset	Para. 5.6.2, step 7

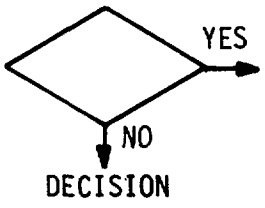
Table 5-2 Probable Checkout-Related Problems (cont'd)

Flow Chart Problem (Fig. 5-3)	Checkout Procedure (para./step reference)
4. Incorrect Manual Reset	Para. 5.6.2, steps 8 thru 11
5. No Offset Operation	Para. 5.6.2, step 12
6. Offset Display Displacement Error	Para. 5.6.2, step 13
7. Speed Inaccuracy in LOG or MAN	Para. 5.6.4
8. No True Motion	Para. 5.6.3, step 2
9. Cannot Plot Any Targets	Para. 5.6.4, step 7
10. Cannot Plot All Eight Targets	Para. 5.6.5, step 3
11. Incorrect Target Mark Placement	Para. 5.6.4, step 10
12. Cannot Erase Target	Para. 5.6.5, step 13
13. EBL Function Does Not Follow EBL Switch Setting	Para. 5.6.5, steps 7 and 8
14. TIME (MIN) Display Blank	Para. 5.6.5
15 Incorrect Time Display	Para. 5.6.5
16. PLOT INHIBITING Illuminates on Active TM/EP Ranges	(Self-evident when plot inhibiting function occurs.)
17. No EBL Time Mark	(Evident by a solid EBL with no time marks.)
18. Drift Speed Error	(Evident by inability to maintain true motion display.)
19. Drift Direction Error	Para. 5.6.3, step 9

5.7.1 Symbols

The following symbols are used in the troubleshooting flow chart of Figure 5-3.





5.7.2 Multiple PC Board Replacement

There are many places in Figure 5-3 where the final instruction states "Replace in turn A20A9A1, A20A9A2, A20A9A3 and A20A9A4 as required". This does not mean to replace all the PC boards at once but instead, replace each PC board one at a time until the faulty condition is removed and normal operation is restored.

5.7.3 Problems Solved by Initial PC Board Replacement

When some problems occur, they can be resolved exclusively by replacing A20A9A1, A20A9A2, A20A9A3 and A20A9A4 one by one until the problem is cleared with no further action required. Because of this, these problems were not included in the flow chart of Figure 5-3. The problems, requiring only replacement of PC boards as a final solution, are as follows:

No Automatic Reset.
Failure of MARK OFF SCALE function
Failure of TRIAL MNVR function.

5.7.4 PC Board Repair

If a PC board malfunction occurs, it is replaced with one that is new and not repaired at this level of maintenance. Repair of the PC board is referred to the next higher category of maintenance.

5.7.5 Troubleshooting LED Circuits

The flow chart of Figure 5-3 does not include simple LED illumination problems. If the TM/EP unit (during a specific operation) functions normally but the associated LED does not illuminate when it should, troubleshoot the related LED circuitry.

5.7.6 Troubleshooting Guidelines

The troubleshooting flow chart of Figure 5-3 is based on the following premises:

1. Repair procedures will be limited to the replacement of modular subassemblies or repair of defective connections.

2. Discovery of problem areas is based on use of the sequential steps of the checkout procedures of paragraph 5.6. The individual flow diagrams are based on the likelihood of first encountering the particular problem at the listed checkout step.

3. When checking a signal or voltage level that is indicated, it is assumed that access to the point to be checked will be made by use of a PCB extender or by assembly removal, as required.

4. Unless a specific voltage is given in the flow diagram, voltage measurements are based on IC (TTL) logic levels, i.e.:

Low = 0.0 to +0.8 Vdc
High = +2.4 to +5.2 Vdc

5. When the checking of wiring for continuity or shorts is indicated, the reference signal name can be used to locate the line in Figure 6-1.

6. When a list of possible repair procedures is given, the list is in the order of the greatest likelihood of effecting repair.

7. When making checks for those possible problems not listed in the flow diagrams, it should be borne in mind that all control switches in the TM/EP have active low outputs, i.e., the output of the control should be at a low logic level when the switch is "ON."

5.8 TM/EP DISASSEMBLY/ACCESS

To gain maintenance-access to specific TM/EP items for removal, adjustment, alignment and/or repair, it may be necessary to disassemble certain indicator related TM/EP assemblies or parts before the intended item is reached on which one or more maintenance tasks can be performed. The following paragraphs provide such procedures.

5.8.1 TM/EP Low Voltage Power Supply (LVPS) (Removal)

1. Loosen four captive twist screws that secure the indicator upper front access cover to the indicator frame/chassis assembly. Remove cover.

WARNING

Removal of indicator upper front cover, opens the main interlock switch and removes power from indicator internal assemblies. Do not in any way override the interlock switch to activate power.

2 Remove the indicator stabilize torsion bar by removing the two mounting bolts and washers.

3. Remove two Phillips head screws and washers from upper lip of sweep output assembly A3.

4. Lower A3 assembly into service position.

5. Remove J1 plug to TM/EP LVPS.

6. Remove three Phillips head screws and washers securing front portion of TM/EP LVPS to indicator chassis.

7. Remove TM/EP LVPS.

5.8.2 Access to Indicator TM/EP Items

1. Loosen two captive twist screws that secure the indicator bezel and control panel to the top of the indicator frame assembly.

NOTE

The indicator bezel cannot be raised to its full upright position when the reflection plotter or viewing hood is in place. Removal of these items are required to achieve maximum opening.

2. Grasp the front lower edge of the indicator bezel and control panel and raise it to its full upright position. Access to the TM/EP component side of the indicator bezel and control panel is now possible.

5.8.3 Access to Indicator J6 and TB4

1. Perform steps 1 and 2 of paragraph 5.8.1.

2. Remove three mounting screws and washers on the right in addition to loosing three screws on the left, securing indicator digital card assembly A2 to the indicator chassis assembly.

3. Gently remove the indicator digital card assembly A2 to the right and out from its opening and carefully set it on the floor. Be sure not to damage or jam A2 connecting cable harness in the process.

4. Using a flashlight, locate J6 and TB4 inside the A2 assembly opening at the bottom of the indicator on the right side.

5.8.4 Access to TM/EP Headset Control Panel Items

1. Remove eight Phillips head mounting screws and washers from TM/ EP headset control panel and TM housing.

2. Gently pull TM/EP headset control panel forward as far as cable harness will permit.

3. Lay TM/EP headset control panel face down with component side facing up.

1. PROBLEM: CRT BLANK

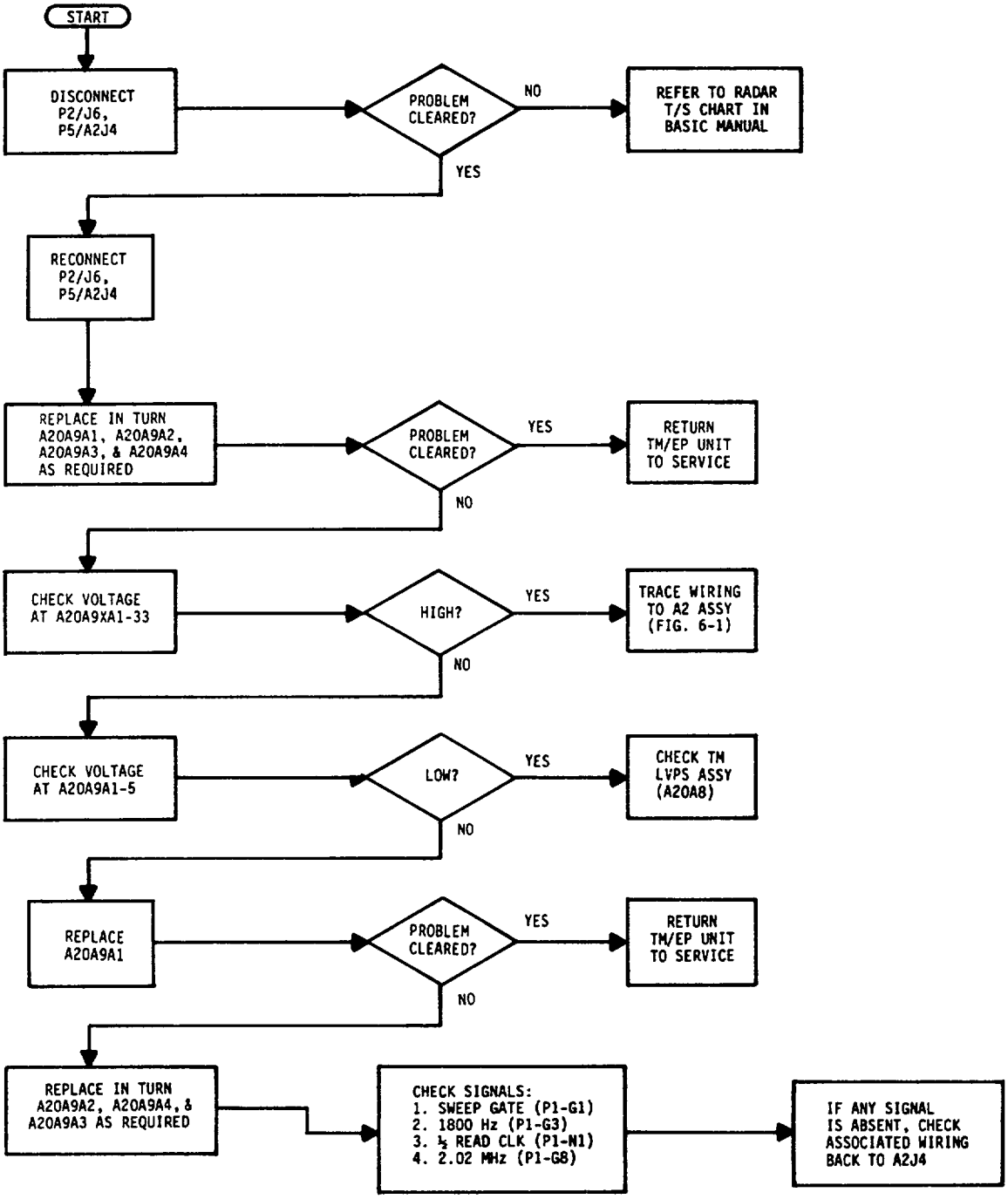


Figure 5-3 Troubleshooting Flow Chart (Sheet 1 of 12)

2. PROBLEM: TM/AC Video Absent (Target Mark and/or EBL)
(Para. 5.6.2, Step 3)

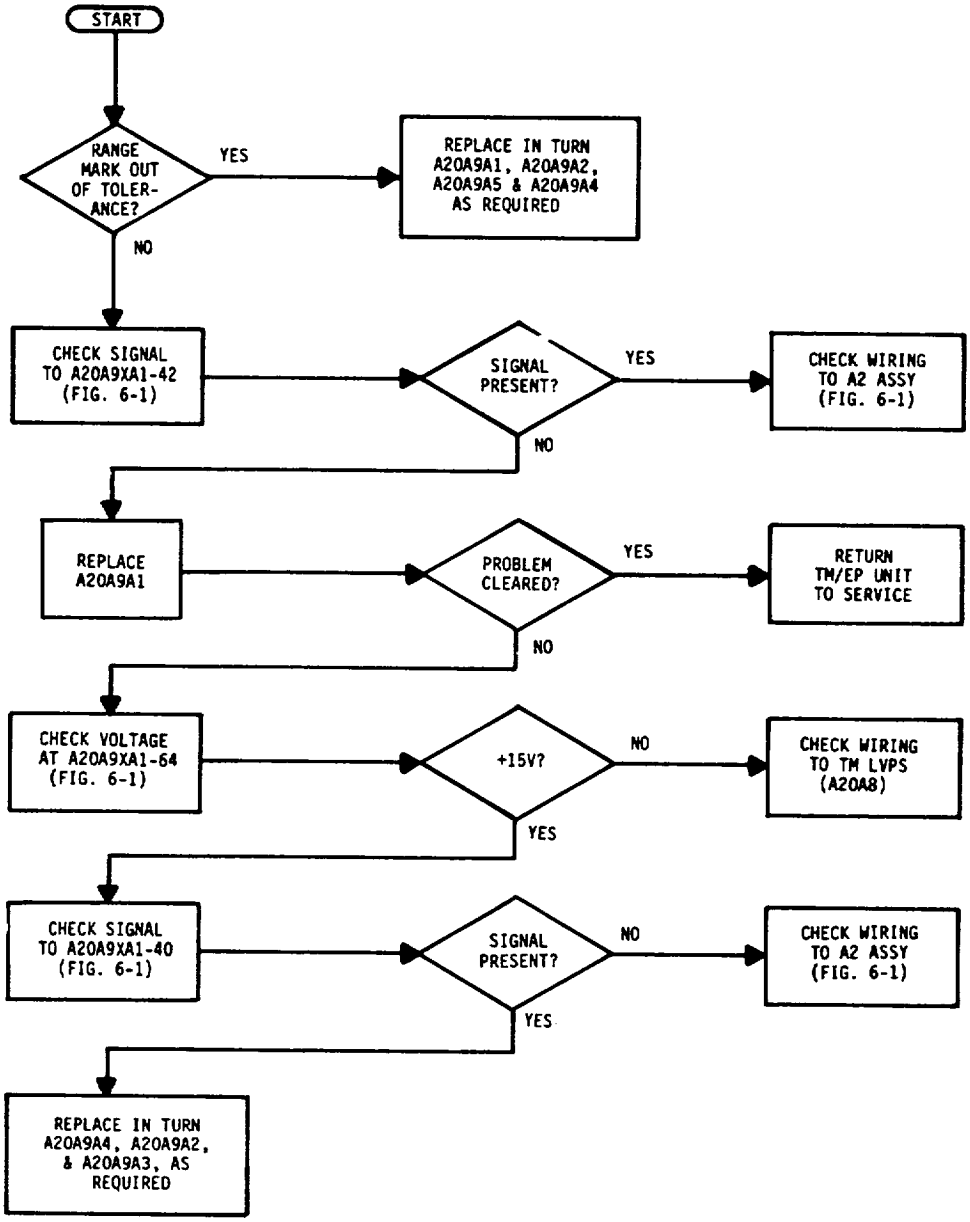
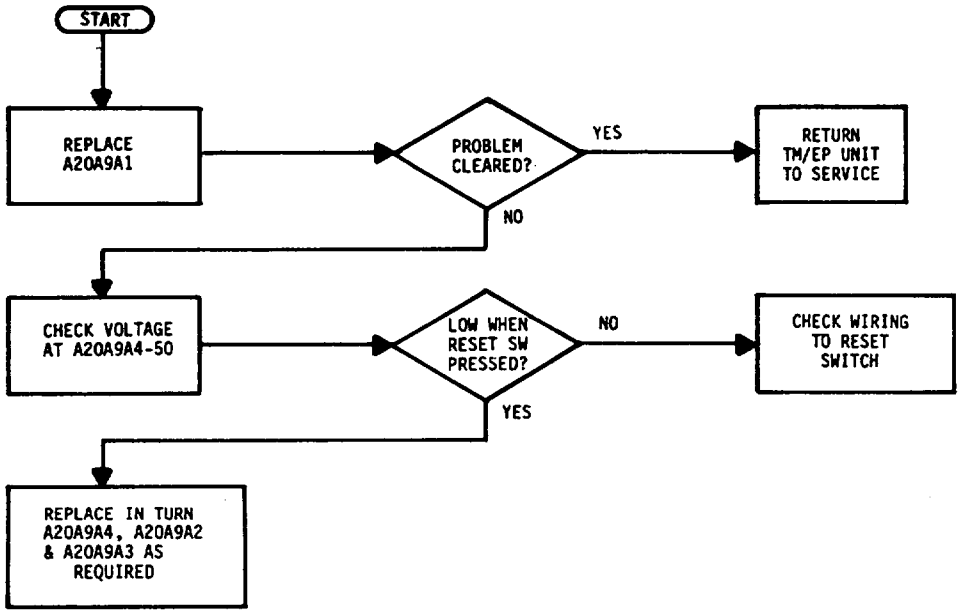


Figure 5-3 Troubleshooting Flow Chart (Sheet 2 of 12)

3. PROBLEM: No Manual RESET (Para. 5.6.2, Step 7)



4. PROBLEM: Incorrect Manual RESET (Para. 5.6.2, Steps 8 thru 11)

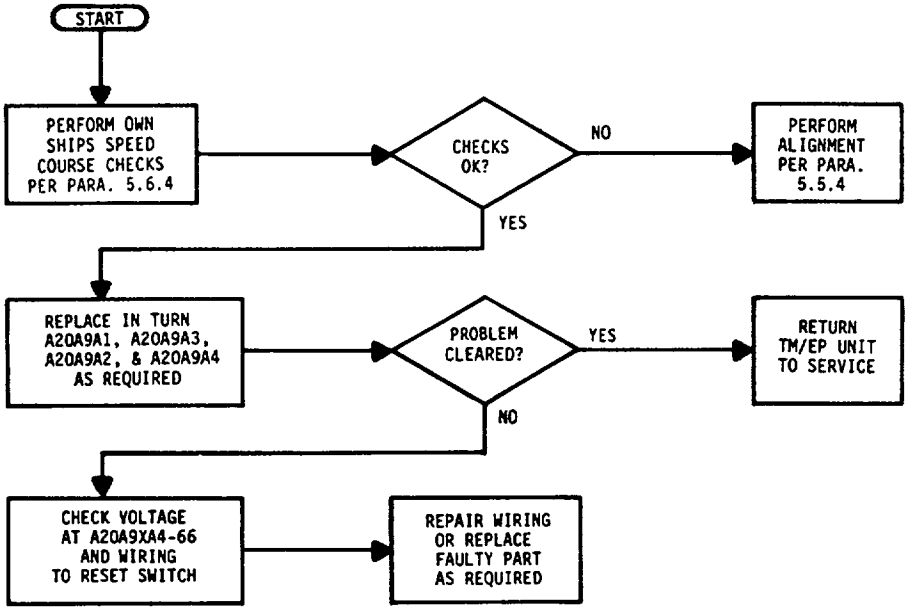


Figure 5-3 Troubleshooting Flow Chart (Sheet 3 of 12)

5. PROBLEM: No OFFSET Operation (Para. 5.6.2, Step 12)

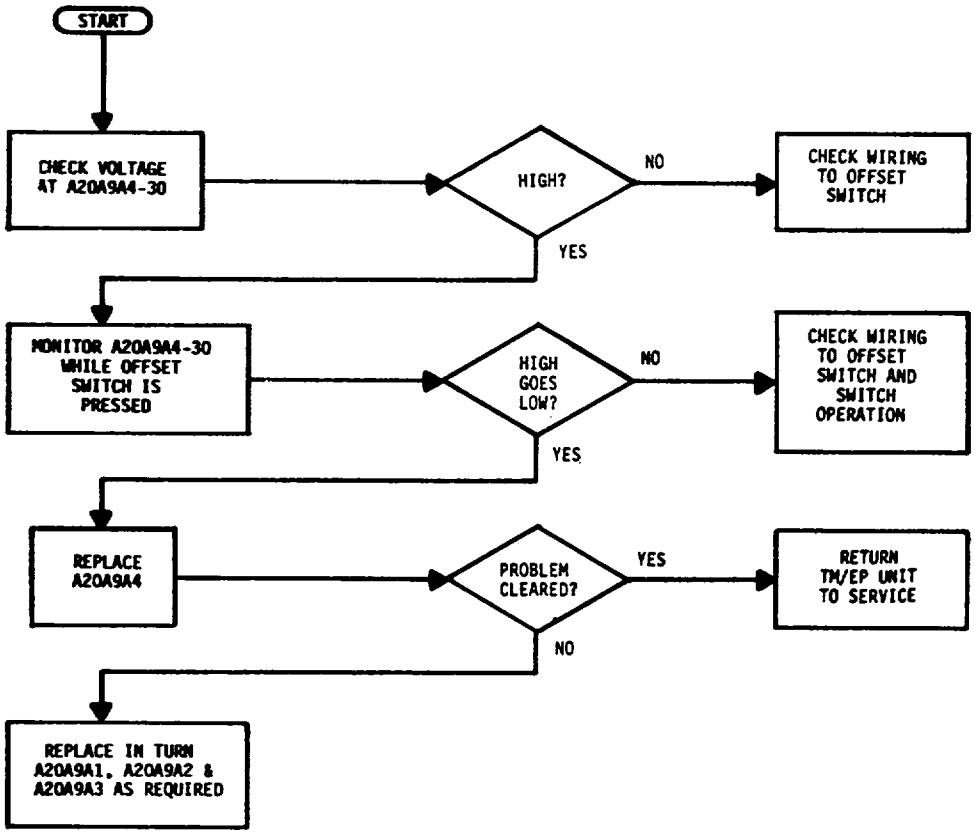
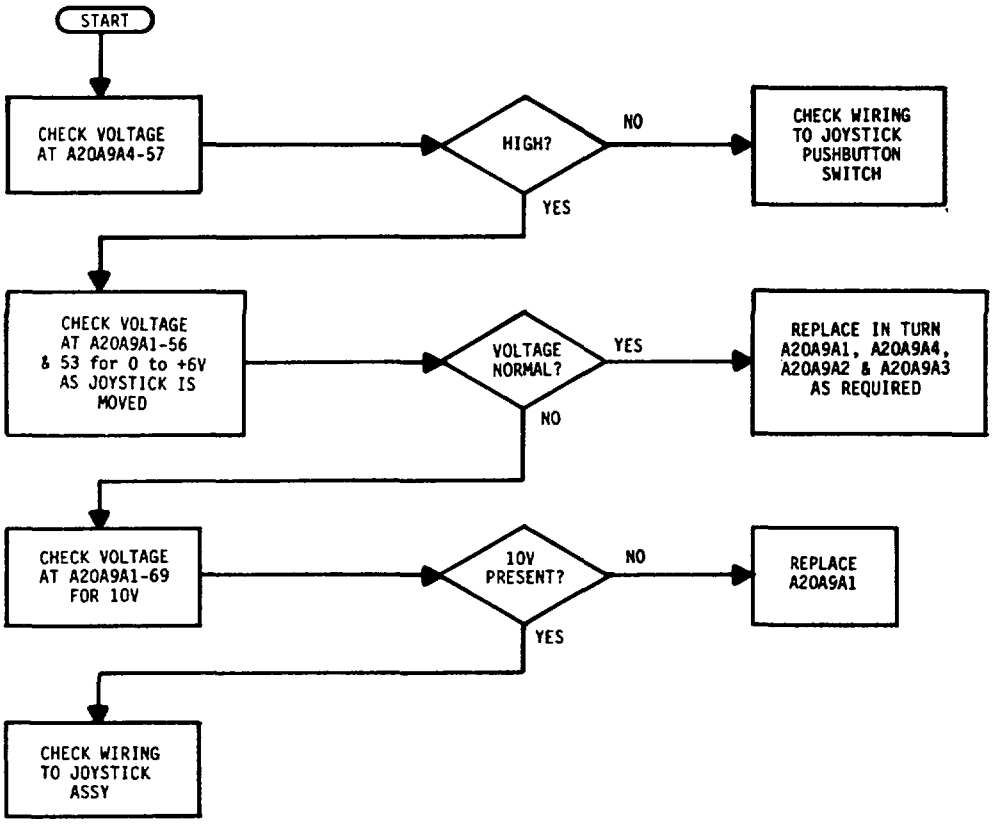


Figure 5-3 Troubleshooting Flow Chart (Sheet 4 of 12)

6. PROBLEM: OFFSET Display Displacement Error (Para. 5.6., Step 13)



7. PROBLEM: Speed Inaccuracy in LOG or MAN (Para. 5.6.4)

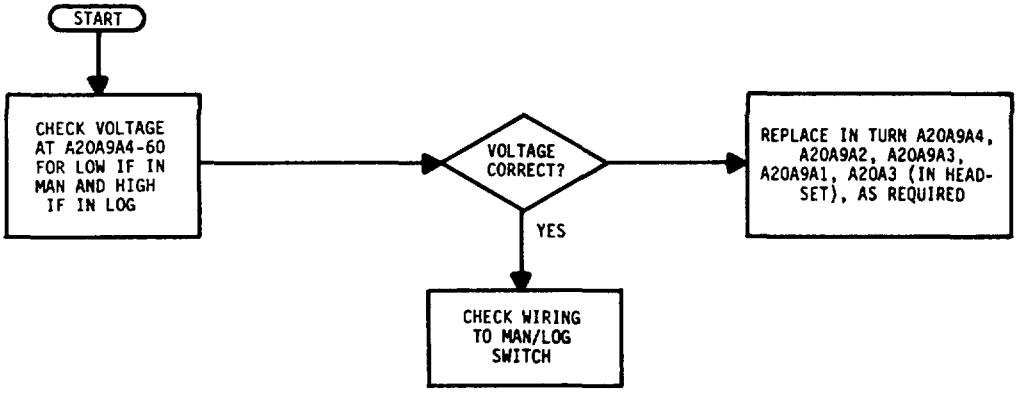
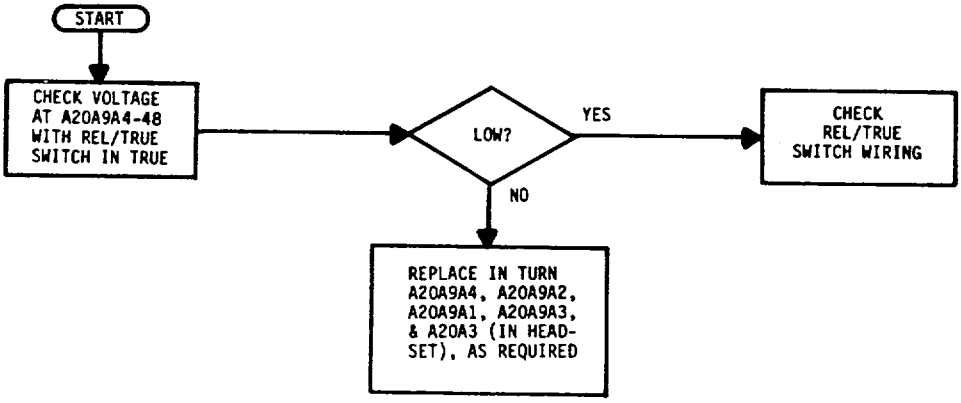
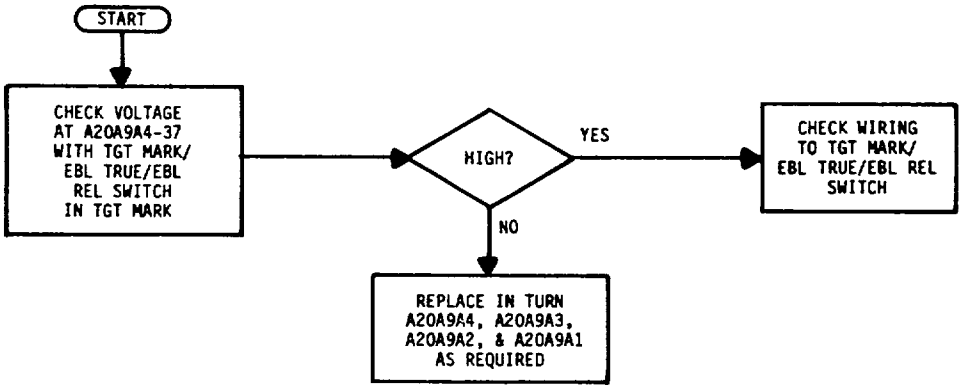


Figure 5-3 Troubleshooting Flow Chart (Sheet 5 of 12)

8. PROBLEM: No True Motion (Para. 5.6.3, Step 2)



9. PROBLEM: Cannot Plot Any Targets (Para. 5.6.4, Step 7)



10. PROBLEM: Cannot Plot All Eight Targets (Para. 5.6.5, Step 3)

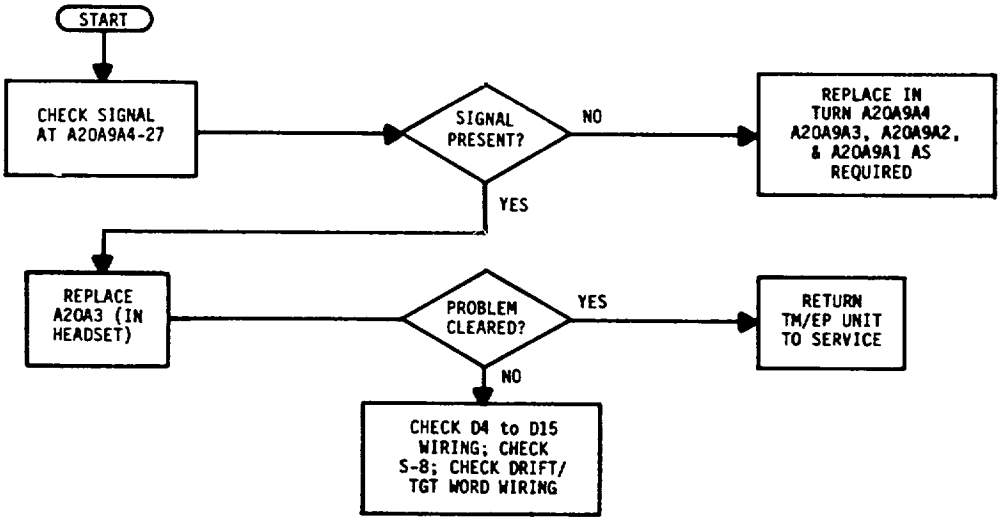
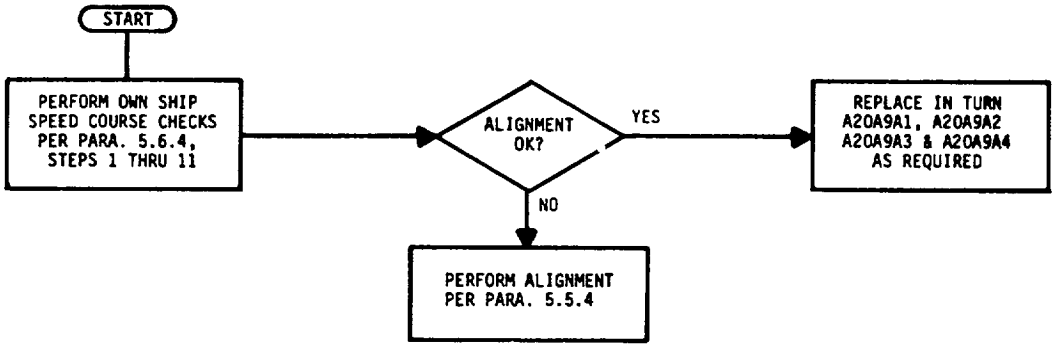
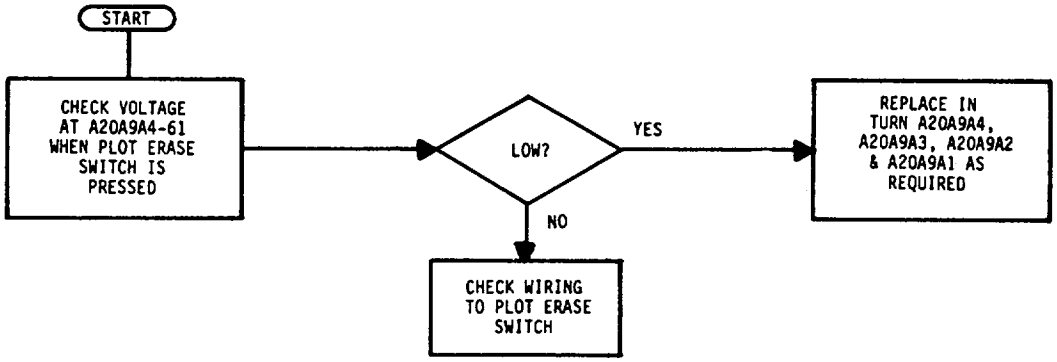


Figure 5-3 Troubleshooting Flow Chart (Sheet 6 of 12)

11. PROBLEM: Incorrect Target Mark Placement (Para. 5.6.4, Step 10)



12. PROBLEM: Cannot Erase Target (Para 5.6.5, Step 13)



13. PROBLEM: EBL Function Does Not Follow EBL Switch Setting (Para. 5.6.5, Steps 7 and 8)

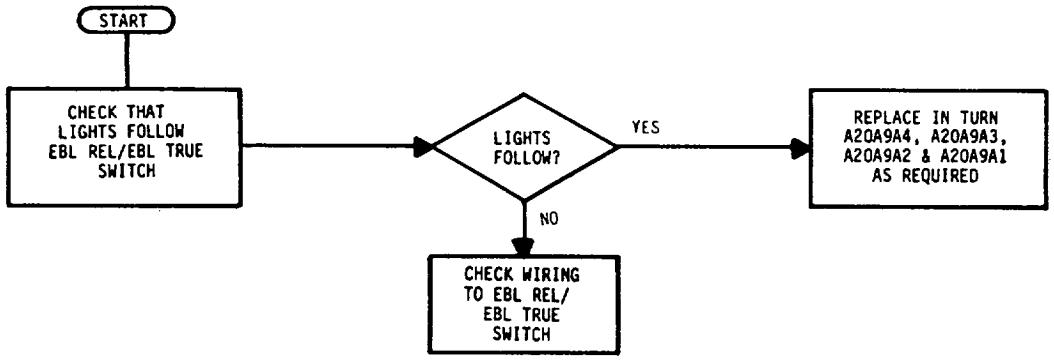


Figure 5-3 Troubleshooting Flow Chart (Sheet 7 of 12)

14. PROBLEM: Time Display Blank (Para. 5.6.5)

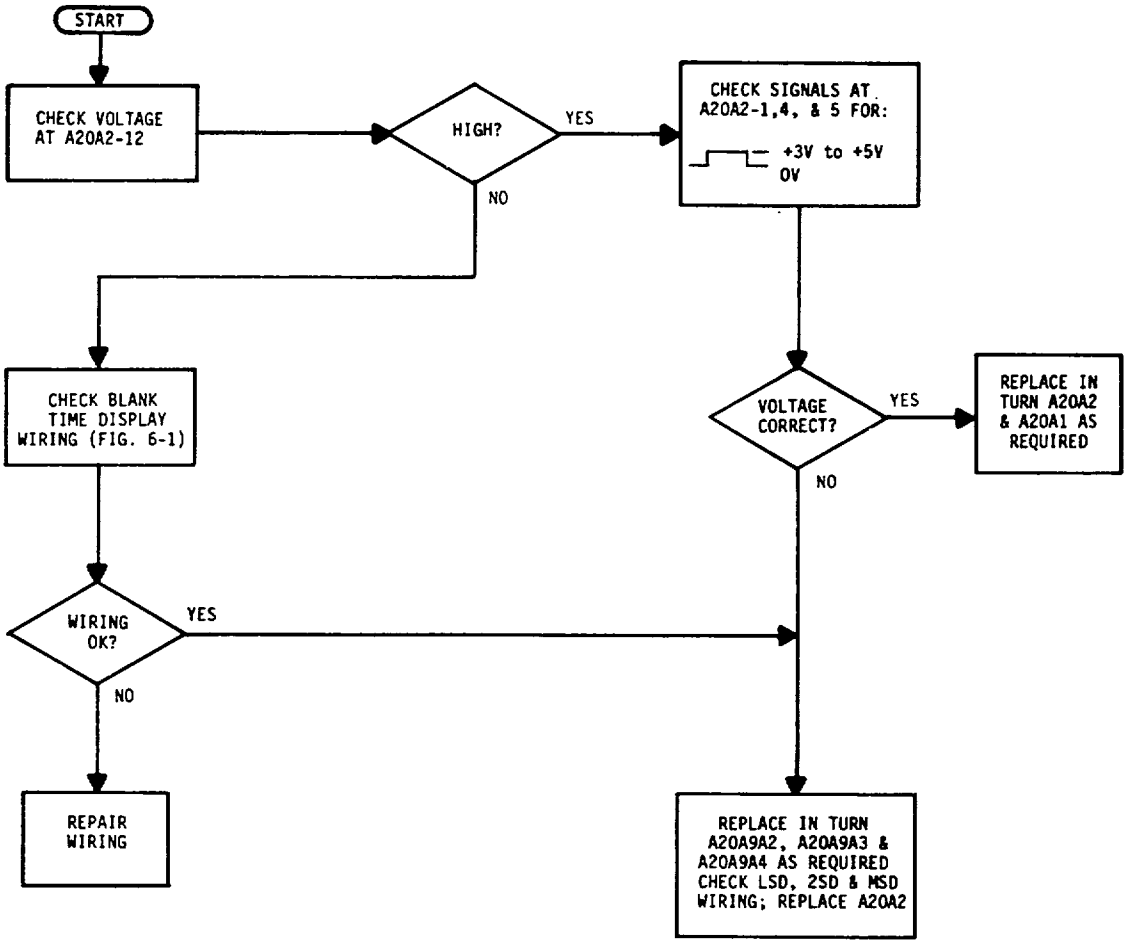


Figure 5-3 Troubleshooting Flow Chart (Sheet 8 of 12)

15. PROBLEM: Incorrect Time Display (Para. 5.6.5)

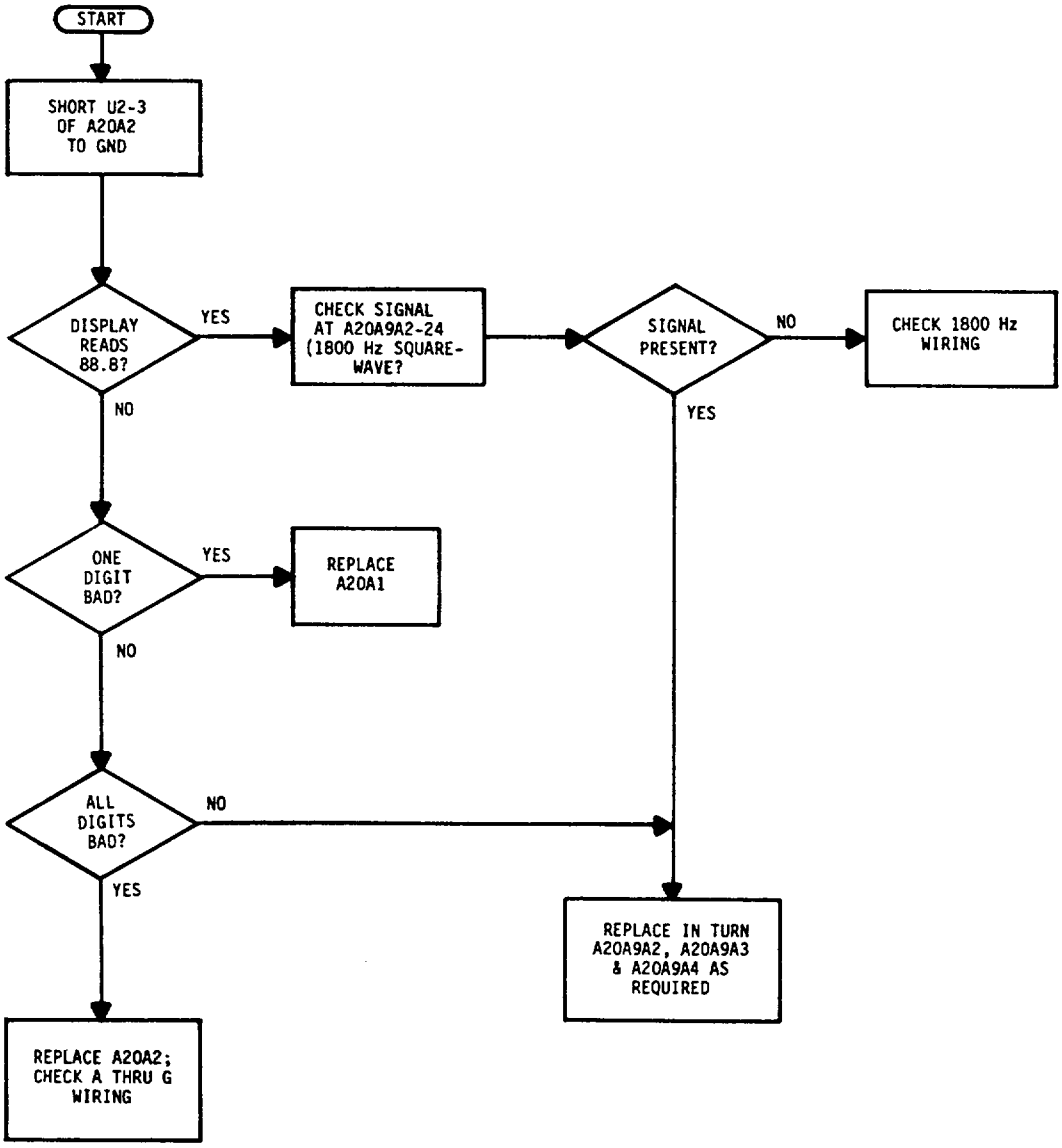
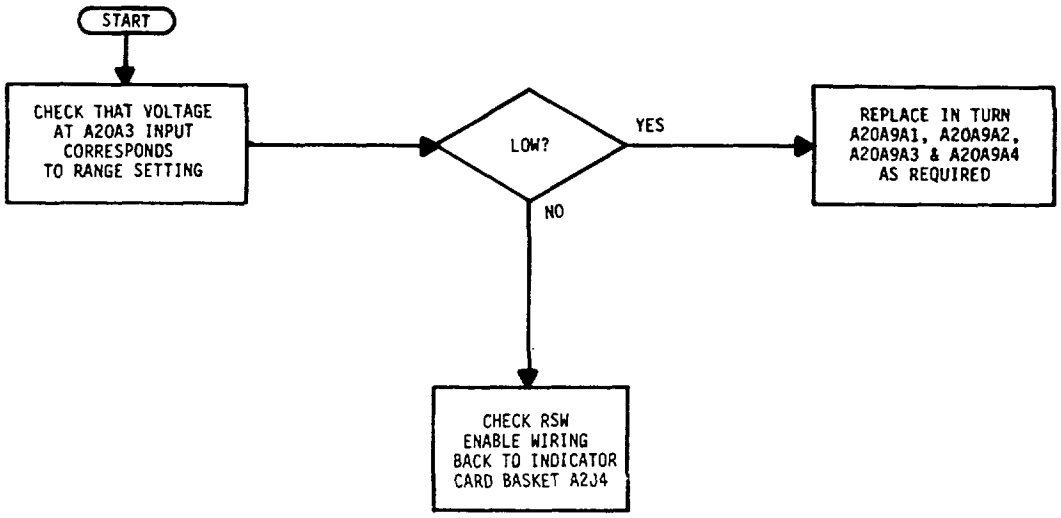


Figure 5-3 Troubleshooting Flow Chart (Sheet 9 of 12)

16. PROBLEM: Plot Inhibit Lights on Active TM/EP Ranges



17. PROBLEM: No EBL Time Mark

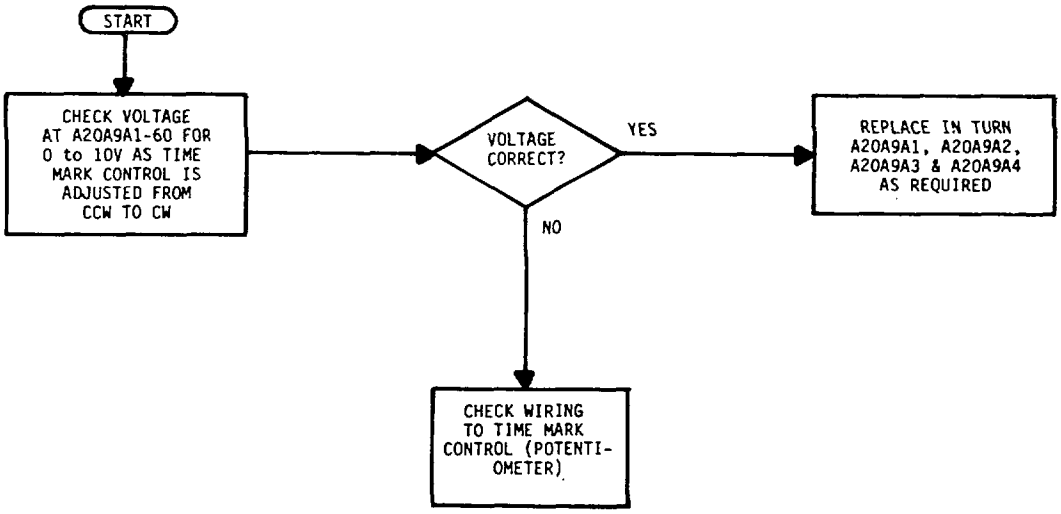


Figure 5-3 Troubleshooting Flow Chart (Sheet 10 of 12)

18. PROBLEM: Drift Speed Error

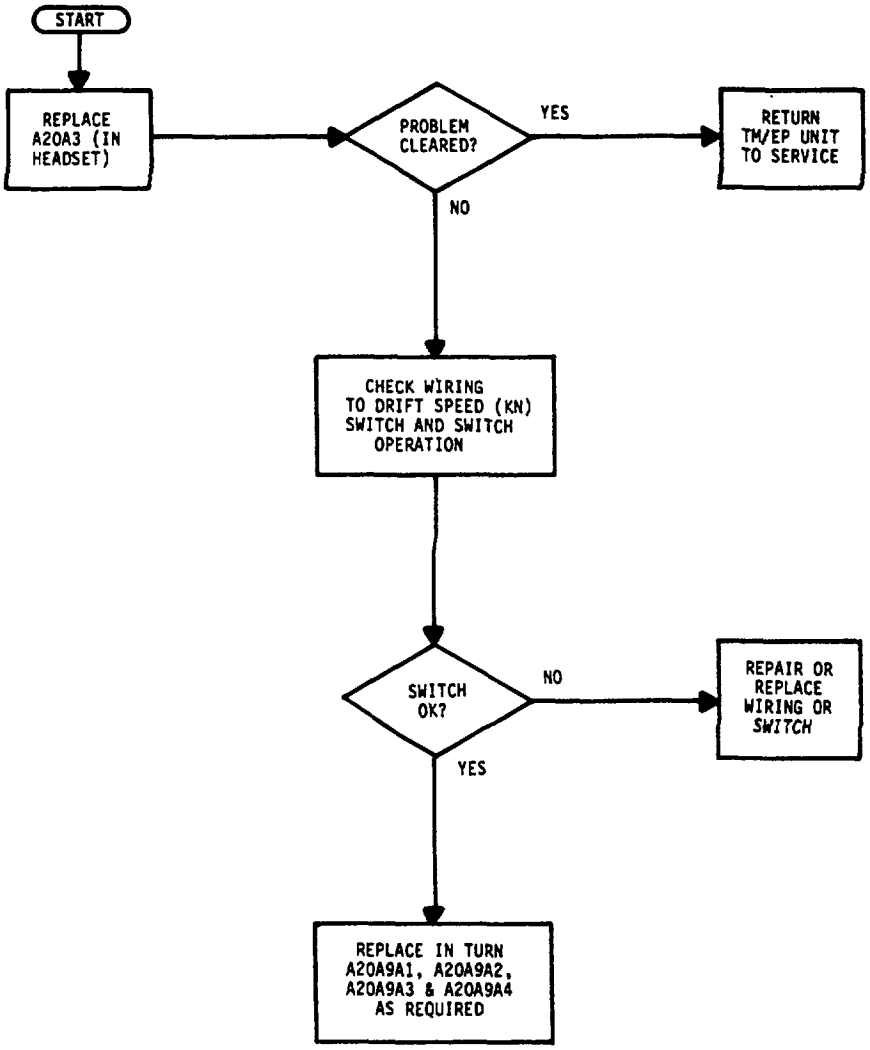


Figure 5-3 Troubleshooting Flow Chart (Sheet 11 of 12)

19. PROBLEM: Drift Direction Error (Para. 5.6.3, Step 9)

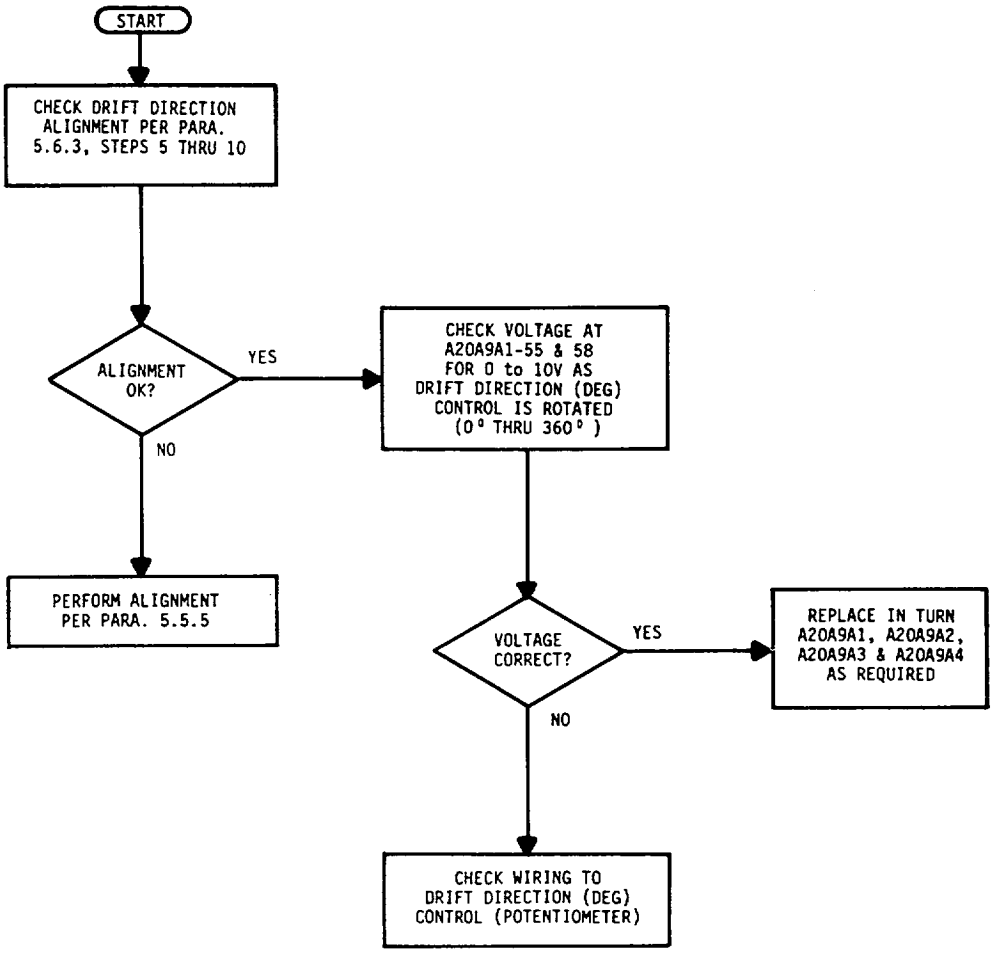


Figure 5-3 Troubleshooting Flow Chart (Sheet 12 of 12)

SECTION 6

PARTS LISTS AND DRAWINGS

6.1 GENERAL

This section contains the parts list of maintenance significance for the major assembly units of the true motion (TM) assembly. Also included are schematics and assembly drawings for reference and maintenance purposes. The parts lists are arranged in disassembly order and grouped together in tables according to the main assemblies of the system. Each table title references both the assembly part number and the appropriate figure number. Any assembly in a parts list requiring a further parts breakdown will refer to another table for that listing. The location numbers in the parts list correspond to the "find numbers" on the referenced assembly drawings.

To facilitate use of the parts list, all assemblies of the main unit are listed in a generation breakdown index listing preceding the parts list tables. The index breakdown gives the assembly part number as well as the parts list table and assembly drawing reference. The indent column shows the relationship of each assembly and subassembly.

6.2 TRUE MOTION/ELECTRONIC PLOTTING (TM/EP) UNIT (A20) PARTS LIST

The parts lists for the six major assemblies of the TM/EP unit (i.e., the TM headset, the digital card cage (card basket assembly), the low voltage power supply, the joystick assembly, the Sin/Cos (heading) potentiometer assembly and the TM EBL assembly) are presented in Tables 6-1 through 6-18. Also included are subassembly parts lists of the major assemblies.

The generation breakdown listing below provides an index of the parts list assemblies of significant importance which comprise the TM/EP unit.

Indent	Description	Part No.	Table No.	Assy Dwg.
A	True Motion Assy	168628-1	Table 6-1	Fig. 6-11
B	Headset Assy	984119-1	Table 6-2	Fig. 6-12
C	Time Display PCB Assy (VRM PCB Detail)	589465-1	Table 6-3	Fig. 6-13
C	Time Display Driver PCB Assy	168601-1	Table 6-4	Fig. 6-14
C	Switch and Lamp Buffer PCB Assy	168588-1	Table 6-5	Fig. 6-15
C	Headset Main Harness	168584-1	Table 6-6	Fig. 6-16
B	TM/LVPS Final Assy	982221-1	Table 6-7	Fig. 6-17
C	TM/LVPS Control PCB Assy	982220-1	Table 6-8	Fig. 6-18
B	Card Basket Assy	165816-1	Table 6-9	Fig. 6-19
C	Analog PCB Assy	167003-1	Table 6-10	Fig. 6-20
C	Digital PCB Assy	166999-1	Table 6-11	Fig. 6-21
C	Memory PCB Assy	167009-2	Table 6-12	Fig. 6-22
C	Processor PCB Assy	167006-1	Table 6-13	Fig. 6-23
B	Joystick Assy	982254-1	Table 6-14	Fig. 6-24
C	Jumper Kit	982255-1	Table 6-15	N/A
B	Sine Cosine Pot	169130-2	Table 6-16	Fig. 6-25
B	EBL Assy (TM)	589466-2	Table 6-17	Fig. 6-26
C	Circuit Card Assy	589468-2	Table 6-18	Fig. 6-27

Table 6-1 168628-1 True Motion Assy (Refer to Figure 6-11)

Location	Description	Part Number	Symbol
1	Headset Assy	984119-1	
2	TMPS Final Assy	982221-1	A20A8
3	Card Basket Assy	165816-1	A20A9
4	Jumper List	165835-1	
5	Joystick Assy	982254-1	
6	Sine Cosine Pot	169130-2	A20R5
7	Cable Clamp	168733-1	
8	Wshr, Flat	236-1149P5	
9	Gasket, Duct Suppor	168605-1	
10	Wshr, Lock	236-1150P2	
11	Screw	207-7195P17	
12	Wshr, Flat	236-1149P14	
13	Wshr, Lock	236-1150P5	
14	SC8-32 Pams. 50SS	207-7195P411	
15	Wshr, Flat	236-1149P11	
16	Flex Coupling	586976-1	
17	NSK Assy	168394-V	
18	EBL Assy (TM)	589466-2	A2A9
22	SC10-32 Pams.63SS	207-7195P493	
23	SC8-32 Pams.63SS	207-7195P413	
24	Wshr, Lock	236-1150P4	
25	Display, Lighted	166346-7	
26	Clip, Dspl Light	168007-1	
27	Gasket, Dspl Light	168006-1	
28	SCR Pnh Mach	207-7195P1	
29	Wshr, Flat	236-1149P2	
30	Wshr, Lock	236-1150P1	
31	Cover Plate	166482-1	
32	Bracket	589564-1	
33	Lockwasher #6	236-1150P3	
34	Nut, 6-32 Hex, SS	203-1166P3	
35	Tape, Vinyl	253-7201P15	
36	TMU Prom Desig Mat	983787	
37	TMU Manual	983785	
38	Computer File TMU	983786	

Table 6-2 984119-1 Headset Assy (Refer to Figure 6-12)

Location	Description	Part Number	Symbol
27	VRM PCB Detail	589465-1	A1
28	PCB Assy A2	168601-1	A2
29	PCB Assy A3	168588-1	A3
30	Cap, D, .01UF, 50V	235-7207P28	C1
26	RF Choke, Fltr Hash	588951-2	L1
33	Conn Elec	166030-1	P6
34	Res, VW, 15, 25W	29-027	R1
35	Sine Cosine Pot	169130-1	R2
36	Res, V, 10K, 2W	240-1316P14	R3

Table 6-2 984119-1 Headset Assy (cont'd)

Location	Description	Part Number	Symbol
37	Switch	168547-1	S1
37	Switch	168547-1	S2
38	Switch Toggle	165806-6	S3
37	Switch	168547-1	S4
41	Switch	165788-3	S5
38	Switch Toggle	165806-6	S6
40	Switch	165788-2	S7
39	Switch	165788-1	S8
42	Switch	169442-1	S9
38	Switch Toggle	165806-6	S10
32	Diode Light Emit	589722-2	DS1
32	Diode Light Emit	589722-2	DS2
31	Diode, Lit-Emit, Grn	167793-1	DS3
31	Diode, Lit-Emit, Grn	167793-1	DS4
31	Diode, Lit-Emit, Grn	167793-1	DS7
32	Diode Light Emit	589722-2	DS8
31	Diode, Lit-Emit, Grn	167793-1	DS9
31	Diode, Lit-Emit, Grn	167793-1	DS10
32	Diode Light Emit	589722-2	DS11
31	Diode, Lit-Emit, Grn	167793-1	DS12
31	Diode, Lit-Emit, Grn	167793-1	DS13
31	Diode, Lit-Emit, Grn	167793-1	DS14
31	Diode, Lit-Emit, Grn	167793-1	DS15
31	Diode, Lit-Emit, Grn	167793-1	DS16
31	Diode, Lit-Emit, Grn	167793-1	DS17
69	Speaker PM, 8 Ohm	169316-1	LS1
43	Conn Card Edge	276-7264P5	XA2
44	Conn	42-1441	XA3
1	Housing, TM	168536-1	
2	Support	165783-1	
3	Panel, Mtg	984117-1	
4	TM Pnl Indicating	984118-1	
5	Support Angle	984115-1	
7	Gasket	984116-1	
8	Gasket, TM Display	168535-1	
9	Gasket	165792-1	
10	Gasket	165792-2	
11	Gasket	165792-3	
12	Schematic, TM A20	168437	
13	Main Harness	168584-1	
14	Switch Harness	168581-1	
15	Panel Harness	168582-1	
16	Jumper List	168583-1	
17	Ty-Rap	362-7195P1	
18	Spacer	168541-2	
19	Spacer	168541-1	
20	Guard Switch	168546-1	
21	Lock, Shaft	231-1142G1	
22	Term, Tur	4-366	

Table 6-2 984119-1 Headset Assy (cont'd)

Location	Description	Part Number	Symbol
23	Cable Clamp	214-1043P5	
24	Cable Clamp 1/2 In	214-1043P7	
25	D Washer	214-7186P2	
46	Socket Led	589723-1	
47	Lug #6	4-114	
48	Lug, Sldr	4-131	
49	Knob, Round	231-1055G30	
51	SC4-40 Pams.31SS	207-7195P165	
52	SC4-40 Pams.50SS	207-7195P171	
53	SC6-32 Pams.50SS	207-7195P331	
54	SC6-32 Pams.38SS	207-7195P327	
55	Screw, Rework	166378-2	
56	Screw, Cap	207-7197P76	
57	Wshr, Lock	236-1150P2	
58	LW Int	236-1152P23	
59	FW 4 SS/P	6-4000-13	
60	Lockwasher #6	236-1150P3	
61	Washer, Lock	236-1152P25	
62	Wshr, Lock	236-1150P5	
64	Hex Nut	2-703	
65	Nut Hex Nyloc 4-40	203-1011P37	
66	Nut, 6-32 Hex, SS	203-1166P3	
67	Spacer	169225-1	
68	0 Ring	169229-1	
70	Spacer	168541-4	
71	Standoff, Hex	210-7194P23	
72	SC4-40 Pams. 25SS	207-7195P163	
77	Nut, Packing	588007-4	

Table 6-3 589465-1 Time Display PCB Assy (VRM PCB Detail) (Figure 6-13)

Location	Description	Part Number	Symbol
	Display, Led	165402-1	U1
	Display, Led	165402-1	U2
	Display, Led	165402-1	U3
1	Time Display PCB	165611-1	

Table 6-4 168601-1 Time Display Driver PCB Assy (Refer to Figure 6-14)

Location	Description	Part Number	Symbol
1	TMU Time Drvr PCB	168600-1	A2
	Cap, 4.7MF, 10V, T	235-7395P21	C1
	Cap, D, .05MF, 12V, C	235-7426P3	C2
	Cap, D, .05MF, 12V, C	235-7426P3	C3
	Cap, D, .05MF, 12V, C	235-7426P3	C4
	Cap, D, .05MF, 12V, C	235-7426P3	C5
	Cap, D, .05MF, 12V, C	235-7426P3	C6

Table 6-4 168601-1 Time Display Driver PCB Assy (cont'd)

Location	Description	Part Number	Symbol
	Cap, 33MF 10V, T	235-7395P26	C7
	Cap, F, 2.2UF, 10V	235-7395P19	C8
	Cap, D, .05MF, 12V, C	235-7426P3	C9
	Cap, D, .05MF, 12V, C	235-7426P3	C10
	Cap, D, .05MF, 12V, C	235-7426P3	C11
	Xstr, 2N2907A	386-7249P58	Q1
	Xstr, 2N2907A	386-7249P58	Q2
	Xstr, 2N2907A	386-7249P58	Q3
	Res, 470 Ohm, 1/4W	280-1171P61	R1
	Res, 470 Ohm, 1/4W	280-1171P61	R2
	Res, 470 Ohm, 1/4W	280-1171P61	R3
	Res, 1.OK, 1/4W	280-1171P73	R4
	Res, 68K, 1/4W	280-1171P139	R5
	Res, 8.2K, 1/4W	280-1171P106	R6
	Res, 15K, 1/4W	280-1171P115	R7
	Res, 1.0K, 1/4W	280-1171P73	R8
	Res, 620 Ohm, 1/4W	280-1171P66	R9
	Res, 22 Ohm, .5W	280-1145P13	R10
	Res, V, 100, 1/2W	586370-1	R11
	IC SN7400	386-7300P1	U1
	IC	586306-4	U2
	IC, Res, Network, 100	166995-1	U3
	IC555	587995-1	U4
	IC555	587995-1	U5
	Diode, 1N4148, S	322-7220P1	CR1
2	Pad	586795-1	

Table 6-5 168588-1 Switch and Lamp Buffer PCB Assy (Refer to Figure 6-15)

Location	Description	Part Number	Symbol
	Cap Fxd Tant	235-7388P6	C1
	Cap, D, .05MF, 12V, C	235-7426P3	C2
	Cap, D, .05MF, 12V, C	235-7426P3	C3
	Cap, D, .05MF, 12V, C	235-7426P3	C4
	Cap, D, .05MF, 12V, C	235-7426P3	C5
	Cap, D, .05MF, 12V, C	235-7426P3	C6
	Cap, D, .05MF, 12V, C	235-7426P3	C7
	Cap, D, .05MF, 12V, C	235-7426P3	C8
	Cap, 150PF, 300V, M	235-7053P105	C9
	Cap, 150PF, 300V, M	235-7053P105	C10
	Cap, 150PF, 300V, M	235-7053P105	C11
	Res, 120 Ohm, 1/4W	280-1171P40	R1
	Res, 120 Ohm, 1/4W	280-1171P40	R2
	Res, 120 Ohm, 1/4W	280-1171P40	R3
	IC Hex Buff	166978-2	U1
	IC Hex Buff	166978-2	U2
	IC Hex Buff	166978-2	U3
	IC Hex Buff	166978-2	U4

Table 6-5 168588-1 Switch and Lamp Buffer PCB Assy (cont'd)

Location	Description	Part Number	Symbol
	IC Hex Buff	166978-1	U5
	IC Hex Buff	166978-1	U6
	IC SN7408	587948-1	U7
	IC, Res, Netwrk, 1.0K	167381-2	U8
	IC, Res, Netwrk, 1.0K	167381-2	U9
	IC, Res, Network, 330	167381-3	U10
1	Buffer PCB	168587-1	

Table 6-6 168584-1 Headset Main Harness (Refer to Figure 6-16)

Location	Description	Part Number	Symbol
41	Connector	166105-1	P1
42	Conn. Elec. Multi	166681-1	P2
43	Conn, P, 20, F	166681-2	P3
38	Conn. Elec. Multi	166247-2	P4
51	Connector Elec	166609-2	P5
	Term, Solderless	227-7213P2	
1	Wire 24 Awg White	273-7228P68	
2	Wire 24 Awg Black	273-7228P69	
3	Wire 24 Awg Brown	273-7228P60	
4	Wire 24 GA Red	273-7228P61	
5	Wire	273-7228P63	
6	Wire 24 Awg Green	273-7228P64	
7	Wire 24 Awg Blue	273-7228P65	
8	Wire 24 Awg Viole	273-7228P66	
9	Wire 24 Awg Grey	273-7228P67	
10	Wire	273-7228P70	
11	Wire	273-7228P75	
12	Wire	273-7228P71	
13	Wire	273-7228P76	
14	Wire	273-7228P73	
15	Wire	273-7228P72	
16	Wire	273-7228P74	
17	Wire	273-7228P78	
18	Wire	273-7228P77	
19	Wire 24 Awg Orang	273-7228P62	
20	Wire Hkup Pvc	273-7228P118	
21	Wire Hkup Pvc	273-7228P119	
23	Slvg	267-7177P107	
24	Braid 3 1/2 In.	273-1032P4	
25	Ty-Rap	362-7195P1	
26	Retainer Nylon	362-7195P2	
27	Wire, Hookup	273-7228P126	
28	Wire, Hookup	273-7228P117	
29	Wire, Hookup	273-7228P121	
30	Wire, Strd, Hookup	273-7187P40	
31	Wire, Strd, Hookup	273-7187P41	
32	Wire, Strd, Hookup	273-7187P8	

Table 6-6 168584-1 Headset Main Harness (cont'd)

Location	Description	Part Number	Symbol
33	Contact, Elec	166106-1	
34	Connector Elec	166609-1	
35	Contact	166683-1	
36	Contact	166683-2	
37	Conn. Elec Multi.	166247-3	
39	Cable. Elec. #20	165730-1	
40	Cable, Elec	168635-1	
44	Clamp	166686-2	
45	Guide Pin Elec Con	166687-2	
46	Locking Spring	166684-2	
47	Guide Socket Conn.	166688-2	
48	Tape, Acetate-Cloth	95-162-1	
50	Elec. Connector	166684-1	
52	Conn. Retaining Brk	166727-3	
53	Pin Elec Contact	166682-4	
54	Guide Pin	166687-1	
55	Guide Socket	166688-1	
66	Ferrule	588073-5	
67	Wire 22 GA Grn	21-6015-55	

Table 6-7 982221-1 TM/LVPS Final Assy (Refer to Figure 6-17)

Location	Description	Part Number	Symbol
11	Capacitor	586052-1	C1
12	Cap 50MFD 150V	235-7353P186	C2
14	Cap, D, .01MF, 25V, C	235-7426P1	C3
13	Cap, Elctlt, AL, 7.5V	165315-1	C4
18	Spark Gap-250V	589645-1	E1
19	Fuse, Glass Tube	226-7177P20	F1
19	Fuse, Glass Tube	226-7177P20	F2
20	Fuse, F, AGC1.5, 250V	226-7176P41	F3
21	Choke SW Reg	589646-1	L2
22	Choke Assy 5V	166220-1	L4
23	Xstr, 2N3902	18-212	Q1
23	Xstr, 2N3902	18-212	Q2
24	Transistor	585748-1	Q3
25	Res, W, 1.0, 5W	280-7201P10	R1
29	Res, 39K, 2W	280-1147P131	R2
28	Res, 6.8K, 2W	280-1147P104	R3
29	Res, 39K, 2W	280-1147P131	R4
26	Res, 10 Ohm, .5W	280-1145P1	R5
27	Res, W, 4.75, 25W	165029-162	R6
88	Res, 270, 1W	280-1146P52	R7
31	Pwr Xfmf Assy	167407-1	T1
64	Harness	168634-1	W1
68	Harness	168634-2	W2
69	Harness	168634-3	W3
15	Dio, R, B, 600V/Leg, S	322-7214P6	CR1

Table 6-7 982221-1 TM/LVPS Final Assy (cont'd)

Location	Description	Part Number	Symbol
17	Pwr. Diode TRWSD41	165861-1	CR2
16	Diode, MR821	588605-2	CR3
30	Res, 150VRM, .85W	589647-5	RV1
8	Conn	M39024/10-01	TP1
8	Conn	M39024/10-01	TP2
8	Conn	M39024/10-01	TP3
32	Diode SW IN5375	322-7250P143	VR1
7	Hldr, Fuse	343-1010P1	XF1
7	Hldr, Fuse	343-1010P1	XF2
7	Hldr, Fuse	343-1010P1	XF3
1	Chassis TM P/S	167391-1	
2	Cover TM Pwr Sup	167392-1	
3	Strap, Cap	169548-1	
4	Term Gnd Turret	589705-2	
5	Term.Insul	589876-1	
6	Term	589876-2	
33	Wshr, Mica	3-371	
34	Wshr, Insul Bfr	3-372	
35	FW	3-075	
36	Solder Lug	4-179	
37	LW 10	6-4012-5	
39	SC4-40 Pams.31SS	207-7195P165	
40	Wshr, Lock	236-1150P2	
41	Wshr, Lock	236-1040P2	
42	Lockwasher #6	236-1150P3	
43	SC6-32 Pams.38SS	207-7195P327	
44	Scrw, Thd, Ph, 6 X 1/2	208-7190P12	
45	SC6-32 Pams.63SS	207-7195P333	
46	Washer Flat #6	236-1149P8	
47	Nut, 6-32 Hex, SS	203-1166P3	
48	SC4-40 Flms.44SS	207-7196P329	
49	SC8-32 Pams.75SS	207-7195P415	
50	Nut, 8-32 Hex, SS	203-1166P4	
51	Wshr, Lock	236-1150P4	
52	Wshr, Flat	236-1149P11	
53	Terminal Solder #1	227-1070P4	
54	Tape, Vinyl Foam	253-7201P7	
55	Scr Pnh Mach	207-7195P183	
56	Wshr, Fibre	236-1130P1	
58	Insulator Xistor	222-7188P11	
59	Insulating Washer	222-7188P31	
60	Pin	589542-1	
61	Nut, .25-20 Hex, SS	203-1001P9	
62	Wshr, Flat	236-1149P17	
63	Wshr, Lock	236-1150P6	
65	Jumper Kit	168633-1	
66	TMPS Schematic	982218	
67	TM PCB Assy	982220-1	
72	Socket Xstr T066	589712-1	

Table 6-7 982221-1 TM/LVPS Final Assy (cont'd)

Location	Description	Part Number	Symbol
73	Fhms 4-40 X 3/8	207-7196P167	
74	Flatwshr Plain	236-1108P1	
75	Hx. Nut	203-1058P1	
76	Socket Xstr	586065-2	
77	SC4-40 Flms.63SS	207-7196P173	
78	Nut, 4-40 Hex, SS	203-1166P2	
79	Joint Compound	95-981	
80	Hex Nut	2-703	
81	Hex Nut 10-32	6-3000-5	
82	Screw, Self-Locking	167838-3	
83	Washer, Flat, Fibre	236-7179P5	
84	Wshr, Insul Bfr	3-308	
85	Guide Pin Elec Conn	166687-2	
86	Guide Socket Conn	166688-2	
87	Spring Catch Conn	166685-2	

Table 6-8 982220-1 TM/LVPS Control PCB Assy (Refer to Figure 6-18)

Location	Description	Part Number	Symbol
11	Cap, 47MF, 35V, T	235-7395P101	C5
16	Cap, 33MF, 15V, TT	235-7395P41	C6
9	Capacitor	235-7353P222	C7
10	Cap, 2000PF, 300V, M	235-7355P52	C8
24	Capacitor 0.1UF 10	235-7442P1	C9
25	Cap 0.01UF 630V	235-7442P4	C10
23	Cap, D, .01MF, 25V, C	235-7426P1	C11
22	Cap, 2.2MF, 50V, T	235-7395P94	C14
14	Cap, 33MF, 10V, T	235-7395P26	C15
15	Cap, 100MF, 10V, T	235-7395P29	C16
14	Cap, 33MF, 10V, T	235-7395P26	C17
15	Cap, 100MF, 10V, T	235-7395P29	C18
24	Capacitor 0.1UF 10	235-7442P1	C19
8	Cap, 510PF, 300V, M, 5	235-7053P164	C20
20	Cap, 1.0UF, 35V, T	235-7395P76	C21
18	Cap, 15MF, 20V, T	235-7395P53	C22
29	Cap Tub Myl .0082	235-7445P7	C23
18	Cap, 15MF, 20V, T	235-7395P53	C24
26	Cap Met.My. .22UF	235-7442P7	C26
64	Cap .47UF 10V	586058-3	C27
8	Cap, 510PF, 300V, M, 5	235-7053P164	C28
21	Cap, 4.7MF, 35V, T	235-7395P80	C29
25	Cap 0.01UF 630V	235-7442P4	C30
28	Cap Tub Myl .0068	235-7445P6	C31
19	Cap, 100MF, 20V, T	235-7395P58	C34
19	Cap, 100MF, 20V, T	235-7395P58	C36
19	Cap, 100MF, 20V, T	235-7395P58	C37
19	Cap, 100MF, 20V, T	235-7395P58	C39
17	Cap, 2.2MF, 20V, T	235-7395P48	C41

Table 6-8 982220-1 TM/LVPS Control PCB Assy (cont'd)

Location	Description	Part Number	Symbol
15	Cap, 100MF, 10V, T	235-7395P29	C46
25	Cap, 0.01UF 630V	235-7442P4	C47
22	Cap, 2.2MF, 50V, T	235-7395P94	C48
13	Cap, 1.0MF, 10V, T	235-7395P17	C49
25	Cap, 0.01UF 630V	235-7442P4	C50
15	Cap, 100MF, 10V, T	235-7395P29	C51
19	Cap, 10MF, 20V, T	235-7395P58	C52
19	Cap, 100MF, 20V, T	235-7395P58	C53
25	Cap, 0.01UF 630V	235-7442P4	C54
27	Cap, T, .033UF, 80V	235-7445P14	C55
22	Cap, 2.2MF, 50V, T	235-7395P94	C56
12	Cap	586385-4	C57
81	Choke 1/2MH Fltr	589726-1	L1
81	Choke 1/2MH Fltr	589726-1	L3
78	Xstr, Sil, NPN.M-Cur	588613-1	Q4
78	Xstr, Sil, NPN.M-Cur	588613-1	Q5
62	Xstr, 2N2222A	386-7249P57	Q6
78	Xstr, Sil, NPN.M-Cur	588613-1	Q7
78	Xstr, Sil, NPN.M-Cur	588613-1	Q8
62	Xstr, 2N2222A	386-7249P57	Q9
82	Xstr Sil Tip50	589802-4	Q10
62	Xstr, 2N2222A	386-7249P57	Q11
41	Res, 75K, 1/4W	280-1171P141	R7
36	Res, 3.9K, 2W	280-1147P94	R9
53	Res, 2.7K, 1/4W	280-1171P88	R10
39	Res, 15K, 1/4W, F	585108-109	R11
53	Res, 2.7K, 1/4W	280-1171P88	R12
52	Res, 2.2K, 1/4W	280-1171P85	R13
47	Res, 470 Ohm, 1/4W	280-1171P61	R14
42	Res, 560K, 1/4W	280-1171P172	R15
32	Res, 2.7K, .5W	280-1145P88	R16
33	Res, 47K, 1W	280-1146P133	R17
49	Res, 1.00K, 1/4W	280-1171P73	R18
49	Res, 1.0OK, 1/4W	280-1171P73	R19
46	Res, 270 Ohm, 1/4W	280-1171P52	R21
44	Res, 100 Ohm, 1/4W	280-1171P37	R22
43	Res, 68 Ohm, 1/4W	280-1171P31	R23
49	Res, 1.0K, 1/4W	280-1171P73	R24
44	Res, 100 Ohm, 1/4W	280-1171P37	R25
57	Res, W, .33 Ohm, 2W	280-7177P2	R26
49	Res, 1.0 K, 1/4W	280-1171P73	R28
49	Res, 1.0 K, 1/4W	280-1171P73	R29
48	Res, 820 Ohm, 1/4W	280-1171P70	R30
54	Res, 3.6K, 1/4W	280-1171P93	R31
66	Res, V, 1.0 K, 1/2W	586370-4	R33
66	Res, V, 1.0 K, 1/2W	586370-4	R34
50	Res, 1.5K, 1/4W	280-1171P79	R35
56	Res, 4.7K, 1/4W	280-1171P97	R36
47	Res, 470 Ohm, 1/4W	280-1171P61	R37

Table 6-8 982220-1 TM/LVPS Control PCB Assy (cont'd)

Location	Description	Part Number	Symbol
52	Res, 2.2K, 1/4W	280-1171P85	R38
49	Res, 1.0K, 1/4W	280-1171P73	R39
49	Res, 1.0K, 1/4W	280-1171P73	R40
47	Res, 470 Ohm, 1/4W	280-1171P61	R41
38	Res, 10K, 1/4W	280-1171P109	R42
56	Res, 4.7K, 1/4W	280-1171P97	R43
34	Res, 100, 1W	280-1146P37	R44
34	Res, 100, 1W	280-1146P37	R45
49	Res, 1.0K, 1/4W	280-1171P73	R46
49	Res, 1.0K, 1/4W	280-1171P73	R47
35	Res, 47K, 2W	280-1147P133	R48
35	Res, 47K, 2W	280-1147P133	R49
45	Res, 220 Ohm, 1/4W	280-1171P49	R50
37	Res, 8.2K, 1/4W	280-1171P106	R51
47	Res, 470 Ohm, 1/4W	280-1171P61	R52
40	Res, 27K, 1/4W	280-1171P124	R53
56	Res, 4.7K, 1/4W	280-1171P97	R54
49	Res, 1.0K, 1/4W	280-1171P73	R55
31	Res, 220 Ohm, .5W	280-1145P49	R56
44	Res, 100 Ohm, 1/4W	280-1171P37	R57
58	Res, 1.0 Ohm, 3W	280-7180P2	R58
63	Res, 1.0K, 1/4W, F	585108-11	R59
38	Res, 10K, 1/4W	280-1171P109	R60
44	Res, 100 Ohm, 1/4W	280-1171P37	R65
55	Res, 3.0K, 1/4W	280-1171P90	R66
51	Res, 2.0K, 1/4W	280-1171P84	R67
80	TX. Start-Up HCM003	589652-1	T1
79	Transformer, Pulse	588952-1	T3
79	Transformer, Pulse	588952-1	T4
79	Transformer, Pulse	588952-1	T6
72	IC555	587995-1	U2
72	IC555	587995-1	U3
65	IC, RC723D, 6.2V	586062-1	U4
72	IC555	587995-1	U5
72	IC555	587995-1	U7
61	5CR 1D201	322-7259P2	CR4
67	Diode Silicon Rect	586378-3	CR5
71	Diode, S16, S	587565-4	CR6
69	Diode, R, S, 400V	586379-6	CR7
68	Rect/Diode	586379-1	CR8
68	Rect/Diode	586379-1	CR9
68	Rect/Diode	586379-1	CR10
68	Rect/Diode	586379-1	CR11
67	Diode Silicon Rect	586378-3	CR12
68	Rect/Diode	586379-1	CR13
68	Rect/Diode	586379-1	CR14
68	Rect/Diode	586379-1	CR15
69	Diode, R, S, 400V	586379-6	CR17
69	Diode, R, S, 400V	586379-6	CR18

Table 6-8 982220-1 TM/LVPS Control PCB Assy (cont'd)

Location	Description	Part Number	Symbol
59	Diode, 1N4148, S	322-7220P1	CR24
68	Rect/Diode	586379-1	CR25
59	Diode, 1N4148, S	322-7220P1	CR26
59	Diode, 1N4148, S	322-7220P1	CR27
59	Diode, 1N4148, S	322-7220P1	CR28
69	Diode, R, S, 400V	586379-6	CR29
59	Diode, 1N4148, S	322-7220P1	CR31
59	Diode, 1N4148, S	322-7220P1	CR32
59	Diode, 1N4148, S	322-7220P1	CR33
59	Diode, 1N4148, S	322-7220P1	CR34
70	Diode, S11, SEN-R-28	587565-1	CR35
73	Diode, Z, IN5242B	588101-15	VR5
77	Diode, Z, IN5234B	588101-9	VR6
75	Diode, Z, IN5230B	588101-6	VR7
74	Diode, Z, IN5223B	588101-2	VR9
68	Diode SW IN5375	322-7250P143	VR10
76	Diode, Z, IN5227B	588101-4	VR11
30	Res, 12 Ohm, .5W	280-1145P4	R20A
30	Res, 12 Ohm, .5W	280-1145P4	R20B
30	Res, 12 Ohm, .5W	280-1145P4	R27A
30	Res, 12 Ohm, .5W	280-1145P4	R27B
1	T.M. PCB Dwg	982219-1	
2	TMPS Schematic	982218	
3	SC6-32 Pams.25SS	207-7195P 325	
4	Lockwasher #6	236-1150P3	
5	Nut, 6-32 Hex, SS	203-1166P3	
6	Pad	586795-1	
7	Retainer Nylon	362-7195P2	

Table 6-9 165816-1 Card Basket Assy (Refer to Figure 6-19)

Location	Description	Part Number	Symbol
1	Conn Assy Elec	165813-1	
2	Card Rack	165809-1	
3	Analog PCB Assy	167003-1	A1
4	Digital PCB Assy	166999-1	A4
5	Memory PCB Assy	167009-2	A3
6	Processor PCB Assy	167006-1	A2
7	SC6-32 Pams.38SS	207-7195P327	
8	FW 6	6-4000-14	
10	Support, Bracket	165815-1	
11	Standoff Hex	210-7194P20	
13	Guard	165817-1	
15	Lockwasher #6	236-1150P3	
16	SC6-32 Pams.44SS	207-7195P329	
17	Bus Bar	166246-1	
18	Bracket Conn	165836-1	
19	Conn. Elec Multi	166247-1	P2

Table 6-9 165816-1 Card Basket Assy (cont'd)

Location	Description	Part Number	Symbol
20	Switch	167405-1	A9S1
21	Jumper List Card Bskt	169166-1	

Table 6-10 167003-1 Analog PCB Assy (Refer to Figure 6-20)

Location	Description	Part Number	Symbol
	Cap Fxd Tant	235-7388P6	C1
	Cap Fxd Tant	235-7388P6	C2
	Cap Fxd Tant	235-7388P6	C3
	Cap, LV, .1MFD	235-7448P17	C4
	Cap, 10PF, 300V, M, 10	235-7053P7	C5
	Cap, Low Voltage	235-7448P1	C6
	Cap, Low Voltage	235-7448P1	C7
	Cap, Low Voltage	235-7448P1	C8
	Cap, Low Voltage	235-7448P1	C9'
	Cap, Low Voltage	235-7448P1	C10
	Cap, Low Voltage	235-7448P1	C11
	Cap, Low Voltage	235-7448P1	C12
	Cap, Low Voltage	235-7448P1	C13
	Cap, Low Voltage	235-7448P1	C14
	Cap, Low Voltage	235-7448P1	C15
	Cap, Low Voltage	235-7448P1	C16
	Cap, Low Voltage	235-7448P1	C17
	Cap, Low Voltage	235-7448P1	C18
	Cap, Low Voltage	235-7448P1	C19
	Cap, Low Voltage	235-7448P1	C20
	Cap, Low Voltage	235-7448P1	C21
	Cap, Low Voltage	235-7448P1	C22
	Cap, Low Voltage	235-7448P1	C23
	Cap, Low Voltage	235-7448P1	C24
	Cap, Low Voltage	235-7448P1	C25
	Cap, Low Voltage	235-7448P1	C26
	Cap, Low Voltage	235-7448P1	C27
	Cap, Low Voltage	235-7448P1	C28
	Cap, Low Voltage	235-7448P1	C29
	Cap, Low Voltage	235-7448P1	C30
	Cap, Low Voltage	235-7448P1	C31
	Cap, Low Voltage	235-7448P1	C32
	Cap, Low Voltage	235-7448P1	C33
	Cap, Low Voltage	235-7448P1	C34
	Cap, Low Voltage	235-7448P1	C35
	Cap, Low Voltage	235-7448P1	C36
	Cap, 15MF, 20V, T	235-7395P53	C41
	Cap, 15MF, 20V, T	235-7395P53	C42
	Cap, Low Voltage	235-7448P1	C43
	Cap, Low Voltage	235-7448P1	C44
	Cap, Low Voltage	235-7448P1	C45
	Cap, Low Voltage	235-7448P1	C46

Table 6-10 167003-1 Analog PCB Assy (cont'd)

Location	Description	Part Number	Symbol
	Cap, D, 100PF, 600V	235-7207P8	C47
	Cap, 466PF, 300V, M	235-7355P233	C48
	Cap, 466PF, 300V, M	235-7355P233	C49
	Cap, 10MF, 20V, T	235-7395P52	C50
	Ferrite Bead	297-7204P2	L1
2	Conn, Plug, Elec	166104-1	P1
	Res, V, 200, 3/4W	586371-2	R1
	Res, V, 200, 3/4W	586371-2	R2
	Res, V, 200, 3/4W	586371-2	R3
	Res, V, 10K, 3/4W	586371-7	R4
	Res, 4.7K, 1/4W	280-1171P97	R13
	Res, 1.0K, 1/4W	280-1171P73	R14
	Res, 910 Ohm, 1/4W	280-1171P72	R15
	Res, 2.7K, 1/4W	280-1171P88	R16
	Res, 121, 1/8W, F	586055-30	R17
	Res, 1.0K, 1/4W	280-1171P73	R18
	Res, 1.0K, 1/4W	280-1171P73	R19
	Res, 2.7K, 1/4W	280-1171P88	R20
	Res, 910 Ohm, 1/4W	280-1171P72	R21
	Res, 121, 1/8W, F	586055-30	R22
	Res, 2.4K, 1/4W	280-1171P87	R23
	Res, 1 Meg, 1/4W	280-1171P181	R24
	Res, 3.3K, 1/4W	280-1171P91	R26
	Res, 22 Ohm, 1/4W	280-1171P13	R27
	Res, 22 Ohm, 1/4W	280-1171P13	R28
	Res, V, 10K, 3/4W	586371-7	R29
	Res, 180K, 1/4W	280-1171P154	R30
	Res, 120 Ohm, 1/4W	280-1171P40	R31
	Res, 68 Ohm, 1/4W	280-1171P31	R32
	Res, 120 Ohm, 1/4W	280-1171P40	R33
	Res, 15, 1/2W, F	585326-27	R34
	Res, 68 Ohm, 1/4W	280-1171P31	R35
	Res, 120 Ohm, 1/4W	280-1171P40	R36
	IC, 74161	165893-1	U1
	IC, 74161	165893-1	U2
	IC, 74161	165893-1	U3
	IC	166974-1	U4
	IC.DM8551	166048-1	U5
	IC MC1723L	166277-1	U7
	IC, SN74H11	166977-1	U8
	IC, SN7400	386-7300P1	U9
	IC 7474	587953-1	U10
	IC. DM8551	166048-1	U11
	IC. DM8551	166048-1	U12
	IC.DAC-100	166021-1	U13
	IC.DAC-100	166021-1	U14
	IC, SN7404	386-7299P1	U15
	IC	166974-1	U16
	IC	166974-1	U17

Table 6-10 167003-1 Analog PCB Assy (cont'd)

Location	Description	Part Number	Symbol
	IC.DM8551	166048-1	U18
	IC.DAC-100	166021-1	U20
	IC, Quad, Amp	167012-1	U21
	IC.DM8551	166048-1	U22
	IC 74174	587945-1	U23
	IC, SN74LS175N	166974-2	U24
	IC.DM8551	166048-1	U25
	IC, Res, Netwrk, 3.3K	167381-1	U26
	IC	166970-1	U27
	IC	166971-1	U28
	IC, SN7404	386-7299P1	U29
	IC, SN7404	386-7299P1	U30
	IC, SN7404	386-7299P1	U31
	IC 74174	587945-1	U32
	IC	166973-1	U34
	IC	166970-1	U35
	Diode, 1N4148, S	322-7220P1	CR1
	Diode, 1N4148, S	322-7220P1	CR2
	Diode, 1N4148, S	322-7220P1	CR3
	Diode, 1N4148, S	322-7220P1	CR4
	Diode, 1N4148, S	322-7220P1	CR5
	Diode, 1N4148,	322-7220P1	CR6
	Diode, Z, IN5234B	588101-9	VR1
	Diode, Zener	585096-27	VR2
	Diode, Zener	585096-27	VR3
	Diode, Z, S	166969-1	VR4
	Diode, Z, S	166969-1	VR5
1	PCB Cont Dwg	167002-1	
3	BHMS 2-56 X 3/8	207-7195P9	
4	Schematic	167004	
5	Card Ejector	167061-1	
6	Wire Tnd Copr 22AW	273-7190P1	
7	Nut, 2-56 Hex, SS	203-1166P1	
8	Sealant Loctite	230-7607P18	

Table 6-11 166999-1 Digital PCB Assy (Refer to Figure 6-21)

Location	Description	Part Number	Symbol
	Cap Fxd Tant	235-7388P6	C1
	Cap, D, .05MF, 12V, C	235-7426P3	C2
	Cap, D, .05MF, 12V, C	235-7426P3	C3
	Cap, D, .05MF, 12V, C	235-7426P3	C4
	Cap, D, .05MF, 12V, C	235-7426P3	C5
	Cap, D, .05MF, 12V, C	235-7426P3	C6
	Cap, D, .05MF, 12V, C	235-7426P3	C7
	Cap, D, .05MF, 12V, C	235-7426P3	C8
	Cap, D, .05MF, 12V, C	235-7426P3	C9
	Cap, D, .05MF, 12V, C	235-7426P3	C10

Table 6-11 166999-1 Digital PCB Assy (cont'd)

Location	Description	Part Number	Symbol
	Cap, D, .05MF, 12V, C	235-7426P3	CH
	Cap, D, .05MF, 12V, C	235-7426P3	C12
	Cap, D, .05MF, 12V, C	235-7426P3	C13
	Cap, D, .05MF, 12V, C	235-7426P3	C14
	Cap, D, .05MF, 12V, C	235-7426P3	C15
	Cap, D, .05MF, 12V, C	235-7426P3	C16
	Cap, D, .05MF, 12V, C	235-7426P3	C17
	Cap, D, 100PF, 600V	235-7207P8	C18
	Cap, 15MF, 20V, T	235-7395P53	C19
	Cap, D, .05MF, 12V, C	235-7426P3	C20
2	Conn, Plug, Elec	166104-1	P1
	Xstr, 2N2222A	386-7249P57	Q1
	Res, 1.0K, 1/4W	280-1171P73	R1
	Res, 1.0K, 1/4W	280-1171P73	R2
	Res, 1.0K, 1/4W	280-1171P73	R3
	Res, 1.0K, 1/4W	280-1171P73	R4
	Res, 330 Ohm, 1/4W	280-1171P5573	R5
	Res, 120 Ohm, 1/4W	280-1171P4055	R6
	Res, 100 Ohm, 1/4W	280-1171P4937	R7
	Res, 220 Ohm, 1/4W	280-1171P109	R8
	Res, 10K, 1/4W	280-1171P10976	R9
	Res, 1.2K, 1/4W	280-1171P76	R10
	Res, 470K, 1/4W	280-1171P16973	R11
	Res, 1.0K, 1/4W	280-1171P73	R12
	Res, 1.0K, 1/4W	280-1171P73	R13
	Res, 1.0K, 1/4W	280-1171P73	R14
	Res, 1.0K, 1/4W	280-1171P73	R15
	Res, 330 Ohm, 1/4W	280-1171P55	R20
	IC 7474	587953-1	U1
	IC SN7400	386-7300P1	U2
	IC 7474	587953-1	U3
	IC	166973-1	U4
	IC 7474	587953-1	U5
	IC 7474	587953-1	U6
	IC SN7400	386-7300P1	U8
	IC SN7404	386-7299P1	U9
	IC 7474	587953-1	U10
	IC, L, SN74SUO	166975-1	U11
	IC, L, SN74SUO	166975-1	U12
	IC, SN7404	386-7299P1	U13
	IC, SN7400	386-7300P1	U14
	IC, SN7400	386-7300P1	U15
	IC, SN7400	386-7300P1	U16
	IC, SN7404	386-7299P1	U17
	IC, SN7404	386-7299P1	U18
	IC, L, SN74SUO	166975-1	U19
	IC, SN7410	587949-1	U20
	IC, SN7410	587949-1	U21
	IC.74S112	165896-1	U22

Table 6-11 166999-1 Digital PCB Assy (cont'd)

Location	Description	Part Number	Symbol
	IC 7474	587953-1	U23
	IC, SN7408	587948-1	U24
	IC, L, SN74SUO	166975-1	U25
	IC, SN7404	386-7299P1	U26
	IC Hex Buff	166978-1	U27
	IC, SN7420N	589887-1	U28
	IC, SN7408	587948-1	U29
	IC, L, SN74SUO	166975-1	U30
	IC, SN7430	587951-1	U31
	IC, L, SN74SUO	166975-1	U32
	IC	166973-1	U33
	IC	166973-1	U34
	IC, SN7400	386-7300P 1	U35
	Diode, 1N4148, S	322-7220P1	CR1
	Diode, 1N4148, S	322-7220P1	CR2
	Diode, 1N4148, S	322-7220P1	CR3
	Diode, 1N4148, S	322-7220P1	CR4
	5CR 1D201	322-7259P2	CR5
	Diode, Z, IN5234B	588101-9	VR1
1	Digital PCB	167000-1	
3	BHMS 2-56 X 3/8	207-7195P9	
4	Schematic	167001	
5	Card Ejector	167061-1	
6	Wire, Solid, Hookup	273-7188P1	
7	Nut, 2-56 Hex, SS	203-1166P1	
8	Sealant Loctite	230-7607P18	

Table 6-12 167009-2 Memory PCB Assy (Refer to Figure 6-22)

Location	Description	Part Number	Symbol
31	Cap Fxd Tant	235-7388P6	C1
32	Cap, D, .05MF, 12V, C	235-7426P3	C2
32	Cap, D, .05MF, 12V, C	235-7426P3	C3
32	Cap, D, .05MF, 12V, C	235-7426P3	C4
32	Cap, D, .05MF, 12V, C	235-7426P3	C5
32	Cap, D, .05MF, 12V, C	235-7426P3	C6
32	Cap, D, .05MF, 12V, C	235-7426P 3	C7
32	Cap, D, .05MF, 12V, C	235-7426P3	C8
32	Cap, D, .05MF, 12V, C	235-7426P3	C9
32	Cap, D, .05MF, 12V, C	235-7426P3	C10
32	Cap, D, .05MF, 12V, C	235-7426P3	C11
32	Cap, D, .05MF, 12V, C	235-7426P3	C12
32	Cap, D, .05MF, 12V, C	235-7426P3	C13
32	Cap, D, .05MF, 12V, C	235-7426P3	C14
32	Cap, D, .05MF, 12V, C	235-7426P3	C15
32	Cap, D, .05MF, 12V, C	235-7426P3	C16
32	Cap, D, .05MF, 12V, C	235-7426P3	C17
32	Cap, D, .05MF, 12V, C	235-7426P3	C18

Table 6-12 167009-2 Memory PCB Assy (cont'd)

Location	Description	Part Number	Symbol
32	Cap, D, .05MF, 12V, C	235-7426P3	C19
32	Cap, D, .05MF, 12V, C	235-7426P3	C20
32	Cap, D, .05MF, 12V, C	235-7426P3	C21
32	Cap, D, .05MF, 12V, C	235-7426P3	C22
32	Cap, D, .05MF, 12V, C	235-7426P3	C23
32	Cap, D, .05MF, 12V, C	235-7426P3	C24
32	Cap, D, .05MF, 12V, C	235-7426P3	C25
32	Cap, D, .05MF, 12V, C	235-7426P3	C26
32	Cap, D, .05MF, 12V, C	235-7426P3	C27
32	Cap, D, .05MF, 12V, C	235-7426P3	C28
32	Cap, D, .05MF, 12V, C	235-7426P3	C29
32	Cap, D, .05MF, 12V, C	235-7426P3	C30
30	Cap, 22PF, 300V, M, 5	235-7053P21	C31
29	Cap, 500PF, 300V, M, 5	235-7053P160	C32
2	Conn, Plug, Elec	166104-1	P1
33	Res, .0K, 1,/4W	280-1171P73	R1
41	Res, 3.3K, 1/4W	280-1171P91	R3
41	Res, 3.3K, 1/4W	280-1171P91	R4
41	Res, 3.3K, 1/4W	280-1171P91	R5
41	Res, 3.3K, 1/4W	280-1171P91	R6
41	Res, 3.3K, 1/4W	280-1171P91	R7
41	Res, 3.3K, 1/4W	280-1171P91	R8
41	Res, 3.3K, 1/4W	280-1171P91	R9
41	Res, 3.3K, 1/4W	280-1171P91	R10
41	Res, 3.3K, 1/4W	280-1171P91	R11
41	Res, 3.3K, 1/4W	280-1171P91	R12
41	Res, 3.3K, 1/4W	280-1171P91	R13
41	Res, 3.3K, 1/4W	280-1171P91	R14
41	Res, 3.3K, 1/4W	280-1171P91	R15
41	Res, 3.3K, 1/4W	280-1171P91	R16
41	Res, 3.3K, 1/4W	280-1171P91	R17
41	Res, 3.3K, 1/4W	280-1171P91	R18
26	IC Prog Prom	983791-1	U1
16	IC Hex Buff	166978-2	U2
17	IC, 576BIT, B1 RAM	167013-1	U3
17	IC, 576BIT, B1 RAM	167013-1	U5
36	IC SN7410	587949-1	U6
37	IC 7474	587953-1	U7
15	IC Hex Buff	166978-1	U8
16	IC Hex Buff	166978-2	U9
35	IC, SN7408	587948-1	U13
34	IC, SN7400	386-7300P1	U14
13	IC, 74161	165893-1	U15
13	IC, 74161	165893-1	U16
17	IC, 576BIT, B1 RAM	167013-1	U17
17	IC, 576BIT, B1 RAM	167013-1	U19
27	IC Prog Prom	983790-1	U20
16	IC Hex Buff	166978-2	U21
13	IC, 74161	165893-1	U22

Table 6-12 167009-2 Memory PCB Assy (cont'd)

Location	Description	Part Number	Symbol
19	IC Prog Prom	983798-1	U23
21	IC Prog Prom	983796-1	U24
23	IC Prog Prom	983794-1	U25
25	IC Prog Prom	983792-1	U26
28	IC, Mult	168570-1	U27
12	IC.SN74S04	165886-1	U28
15	IC Hex Buff	166978-1	U29
18	IC Prog Prom	983799-1	U30
20	IC Prog Prom	983797-1	U31
22	IC Prog Prom	983795-1	U32
24	IC Prog Prom	983793-1	U33
28	IC, Mult	168570-1	U34
14	IC	166972-1	U35
38	Diode, Z, IN5234B	588101-9	VR1
1	Memory PCB	167008-1	
3	Bhms 2-56 X 3/8	207-7195P9	
5	Schematic	167010	
6	Card Ejector	167061-1	
7	Wire, Solid, Hookup	273-7188P1	
8	Wire, Solid, Hookup	273-7188P10	
9	Cem, Gen Purpose	230-7206P1	
10	Nut, 2-56 Hex, SS	203-1166P1	
11	Sealant Loctite	230-7607P18	

Table 6-13 167006-1 Processor PCB Assy (Refer to Figure 6-23)

Location	Description	Part Number	Symbol
	Cap Fxd Tant	235-7388P6	C1
	Cap, D, .05MF, 12V, C	235-7426P3	C2
	Cap, D, .05MF, 12V, C	235-7426P3	C3
	Cap, D, .05MF, 12V, C	235-7426P3	C4
	Cap, D, .05MF, 12V, C	235-7426P3	C5
	Cap, D, .05MF, 12V, C	235-7426P3	C6
	Cap, D, .05MF, 12V, C	235-7426P3	C7
	Cap, D, .05MF, 12V, C	235-7426P3	C8
	Cap, D, .05MF, 12V, C	235-7426P3	C9
	Cap, D, .05MF, 12V, C	235-7426P3	C10
	Cap, D, .05MF, 12V, C	235-7426P3	C11
	Cap, D, .05MF, 12V, C	235-7426P3	C12
	Cap, D, .05MF, 12V, C	235-7426P3	C13
	Cap, D, .05MF, 12V, C	235-7426P3	C14
	Cap, D, .05MF, 12V, C	235-7426P3	C15
	Cap, D, .05MF, 12V, C	235-7426P3	C16
	Cap, D, .05MF, 12V, C	235-7426P3	C17
	Cap, D, .05MF, 12V, C	235-7426P3	C18
	Cap, D, .05MF, 12V, C	235-7426P3	C19
	Cap, D, .05MF, 12V, C	235-7426P3	C20
	Cap, D, .05MF, 12V, C	235-7426P3	C21

Table 6-13 167006-1 Processor PCB Any (cont'd)

Location	Description	Part Number	Symbol
	Cap, D, .05MF, 12V, C	235-7426P3	C22
	Cap, D, .05MF, 12V, C	235-7426P3	C23
	Cap, D, .05MF, 12V, C	235-7426P3	C24
	Cap, D, .05MF, 12V, C	235-7426P3	C25
	Cap, D, .05MF, 12V, C	235-7426P3	C26
	Cap, D, .05MF, 12V, C	235-7426P3	C27
	Cap, D, .05MF, 12V, C	235-7426P3	C28
	Cap, D, .05MF, 12V, C	235-7426P3	C29
	Cap, D, .05MF, 12V, C	235-7426P3	C30
	Cap, D, .05MF, 12V, C	235-7426P3	C31
	Cap, 500PF, 300V, M, 5	235-7053P160	C37
	Cap, D, 100PF, 600V	235-7207P8	C38
	Cap, D, 100PF, 600V	235-7207P 8	C39
	Ferrite Bead	297-7204P2	L1
2	Conn, Plug, Elec	166104-1	P1
	Xstr, 2N2222	386-7249P52	Q1
	Res, 120 Ohm, 1/4W	280-1171P40	R1
	Res, 120 Ohm, 1/4W	280-1171P40	R2
	Res, 150 Ohm, 1/4W	280-1171P43	R3
	Res, 1.0K, 1/4W	280-1171P73	R4
	Res, 1.0K, 1/4W	280-1171P73	R5
	Res, 1.0K, 1/4W	280-1171P73	R6
	Res, 120 Ohm, 1/4W	280-1171P40	R8
	Res, 3.0K, 1/4W	280-1171P90	R9
	IC	166976-1	U1
	IC	166976-1	U2
	IC	166976-1	U4
	IC	166976-1	U5
	IC	166974-1	U6
	IC	166974-1	U7
	IC, SN74LS175N	166974-2	U8
	IC, SN74LS175N	166974-2	U9
	IC	166974-1	U10
	IC	166974-1	U11
	IC, SN7400	386-7300P1	U12
	IC 7474	587953-1	U13
	IC 7474	587953-1	U14
	IC Hex Buff	166978-1	U15
	IC.DM8551	166048-1	U16
	IC.DM8551	166048-1	U17
	IC, SN7404	386-7299P1	U18
	IC, SN7408	587948-1	U19
	IC, SN7400	386-7300P1	U20
	IC.DM8551	166048-1	U21
	IC.DM8551	166048-1	U22
	IC Hex Buff	166978-1	U23
	IC.DM8551	166048-1	U24
	IC Hex Buff	166978-1	U25
	IC 7474	587953-1	U26

Table 6-13 167006-1 Processor PCB Assy (cont'd)

Location	Description	Part Number	Symbol
	IC, SN74LS175N	166974-2	U27
	IC Hex Buff	166978-1	U28
	IC.DM8551	166048-1	U29
	IC.DM8551	166048-1	U30
	IC, SN7408	587948-1	U32
	IC	166979-1	U33
	IC 7474	587953-1	U34
	IC, SN74LS175N	166974-2	U35
	Diode, Z, IN5234B	588101-9	VR1
1	Processor PCB	167005-1	
3	Bhms 2-56 X 3/8	207-7195P9	
4	Pad	586795-1	
5	Schematic	167007	
6	Card Ejector	167061-1	
7	Wire 22 GA Wht	21-6019-99	
8	Cem, Gen Purpose	230-7206P1	
9	Wire, Solid, Hookup	273-7188P1	
10	Wire Tnd Copr 22AW	273-7190P1	
11	Nut, 2-56 Hex, SS	203-1166P1	
12	Sealant Loctite	230-7607P18	

Table 6-14 982254-1 Joystick Assy (Refer to Figure 6-24)

Location	Description	Part Number	Symbol
1	Joystick	165749-1	
3	Jumper Kit	982255-1	
4	Ty-Rap	362-7195P1	

Table 6-15 982255-1 Jumper Kit

Location	Description	Part Number	Symbol
1	Conn Bloc Multi	589657-6	
3	Wire 22 Awg Vio	273-7187P6	
4	Wire	273-7228P71	
5	Wire 24 Awg Black	273-7228P69	
6	Wire 24 Awg Orang	273-7228P62	
7	Wire 24 Awg Brown	273-7228P60	
8	Wire	273-7228P74	
2	Wire 22 Awg W/Brn	273-7187P14	
9	Wire, Strd, Hookup	273-7187P3	
10	Conn Bloc Multi	589657-5	

Table 6-16 169130-2 Sine Cosine Pot (Refer to Figure 6-25)

Location	Description	Part Number	Symbol
1	Res, V, 10K/QD, 1.25W	166199-2	
2	Res, V, 100K, 1W	167456-14	
3	RTV Compound	82-707	
4	Wire 24 Awg White	273-7228P68	

Table 6-17 589466-2 EBL Assy (TM) (Refer to Figure 6-26)

Location	Description	Part Number	Symbol
1	Circuit Card Assy	589468-2	
2	Res, V, 2.5K, 1/2W	169529-1	R13
3	Res, V, 10K/QD, 1.25W	165404-4	R14
4	Knob Cursor	231-1057G17	
5	Gasket, Dspl Light	168006-1	
6	Nut, Packing	588007-2	
7	Bracket, Mtg	981428-1	
8	Gear	981429-1	
9	Gear	589573-1	
10	Pin, Scale Drive	589493-1	
11	Washer, Lock	236-1152P27	
13	SC10-32 Pamns.63SS	207-7195P493	
14	Pin, Spring	293-1022P237	
15	Pin, Spring	293-1022P233	
16	Ring, Retaining	165419-1	
17	Washer, PL FL Met	236-1001P9	
18	Spring, CPRSN	288-7187P1	
19	Display, Lighted	166346-11	DS13
20	Display, Lighted	166346-3	DS14
23	Wire Tnd Copr 22AW	273-7190P1	
24	Sleeving 22 Clear	267-7178P15	
25	Bushing	165409-1	
26	Clip, Dspl Light	168007-1	
27	SCR Pnh Mach	207-7195P1	
28	Wshr, Flat	236-1149P2	
29	Wshr, Lock	236-1150P1	
30	Pkg Assy	169056-1	

Table 6-18 589468-2 Circuit Card Assy (Refer to Figure 6-27)

Location	Description	Part Number	Symbol
	Cap, D, .05MF, 12V, C	235-7426P3	C1
	Cap, 150PF, 300V, M	235-7053P105	C2
	Cap, D, .05MF, 12V, C	235-7426P3	C3
	Cap, 150PF, 300V, M	235-7053P105	C4
	Cap, 4.7MF, 25V, T	235-7395P63	C5
	Capacitor 0.1UF 10	235-7442P1	C6
	Capacitor 0.1UF 10	235-7442P1	C7
	Capacitor 0.1UF 10	235-7442P1	C8

Table 6-18 589468-2 Circuit Card Assy (cont'd)

Location	Description	Part Number	Symbol
	Capacitor 0.1UF 10	235-7442P1	C9
	Cap, D, .001UF, 600V	235-7207P14	C10
	Cap, D, .001UF, 600V	235-7207P14	C11
	Cap, 4.7MF, 25V, T	235-7395P63	C12
	Cap, 4.7MF, 25V, T	235-7395P63	C13
	Capacitor 0.1UF 10	235-7442P1	C14
	Cap, 4.7MF, 25V, T	235-7395P63	C15
	Capacitor 0.1UF 10	235-7442P1	C16
	Cap, 4.7MF, 25V, T	235-7395P63	C17
	Cap, 4.7MF, 25V, T	235-7395P63	C18
	Capacitor 0.1UF 10	235-7442P1	C19
	Cap 5.0MF 50V	235-7215P6	C20
	Cap, D, .05MF, 12V, C	235-7426P3	C21
	Cap, D, .05MF, 12V, C	235-7426P3	C22
	Coil	375-7404P17	L1
	Coil	375-7404P17	L2
	Choke, RF	589710-1	L3
	Xstr, 2N2219A	386-7249P32	Q1
	Xstr, 2N2905A	386-7249P40	Q2
	Xstr, 2N2905A	386-7249P40	Q3
	Xstr, 2N2905A	386-7249P40	Q4
	Xstr, 2N2905A	386-7249P40	Q5
	Xstr, 2N2219A	386-7249P32	Q6
	Transistor	166011-1	Q7
	Transistor	166011-1	Q8
	Transistor	166011-1	Q9
	Transistor	166011-1	Q10
	Transistor	166011-1	Q11
	Transistor	166011-1	Q12
	Transistor	166011-1	Q13
	Transistor	166011-1	Q14
	Res, 1.0K, 1/4W	280-1171P73	R1
	Res, 1.0K, 1/4W	280-1171P73	R2
	Res, 150 Ohm, 1/4W	280-1171P43	R3
	Res, 100 Ohm, 1/4W	280-1171P37	R4
	Res, 1.0K, 1/4W, F	585108-11	R5
	Res, 1.0K, 1/4W, F	585108-11	R6
	Res, 680, 1/4W, F	585108-95	R7
	Res, 15K, 1/4W, F	585108-109	R8
	Res, 15K, 1/4W, F	585108-109	R9
	Res, 6.8K, 1/4W	280-1171P103	R10
	Res, 680, 1/4W, F	585108-95	R11
	Res, 15K, 1/4W, F	585108-109	R12
	Res, 15K, 1/4W, F	585108-109	R13
	Res, 1.0K, 1/4W, F	585108-11	R14
	Res, 100 Ohm, 1/4W	280-1171P37	R15
	Res, 1.0K, 1/4W, F	585108-11	R16
	Res, 1.0K, 1/4W	280-1171P73	R17
	Res, 1.0K, 1/4W	280-1171P73	R18

Table 6-18 589468-2 Circuit Card Assy (cont'd)

Location	Description	Part Number	Symbol
	Res, 150 Ohm, 1/4W	280-1171P43	R19
	Res, V, 10K, 1/2W	586370-16	R23
	Res, 1.8K, 1/4W, F	585108-23	R24
	Res, 100K, 1/4W	280-1171P145	R25
	Res, 100K, 1/4W	280-1171P145	R26
	Res, 100K, 1/4W	280-1171P145	R27
	Res, 10K, 1/4W	280-1171P109	R28
	Res, 1.0K, 1/4W	280-1171P73	R29
	Res, V, 2K, 1W	585504-8	R30
	Res, 3.9K, 1/4W, F	585108-40	R31
	Res, 1.0K, 1/4W	280-1171P73	R32
	Res, 10K, 1/4W	280-1171P109	R33
	Res, V, 2K, 1W	585504-8	R34
	Res, 3.9K, 1/4W, F	585108-40	R35
	Res, V, 10K, 1/2W	586370-16	R39
	Res, 1.8K, 1/4W, F	585108-23	R40
	Res, 100K, 1/4W	280-1171P145	R41
	Res, 100K, 1/4W	280-1171P145	R42
	Res, V, 2K, 1W	585504-8	R43
	Res, 3.9K, 1/4W, F	585108-40	R44
	Res, 1.0K, 1/4W, F	585108-11	R45
	Res, 5.1K, 1/4W, F	585108-45	R46
	Res, 1.8K, 1/4W, F	585108-23	R47
	Res, 1.8K, 1/4W, F	585108-23	R48
	Res, 2.2K, 1/4W, F	585108-27	R49
	Res, 2.2K, 1/4W, F	585108-27	R50
	Res, 100K, 1/4W	280-1171P145	R51
	Res, 100K, 1/4W	280-1171P145	R52
	Res, 100K, 1/4W	280-1171P145	R53
	Res, 1.8K, 1/4W, F	585108-23	R54
	Res, 1.8K, 1/4W, F	585108-23	R55
	Res, 2.2K, 1/4W, F	585108-27	R56
	Res, 2.2K, 1/4W, F	585108-27	R57
	Res, 2.7K, 1/4W	280-1171P88	R58
	Res, 3.9K, 1/4W, F	585108-40	R59
	Res, 2.7K, 1/4W	280-1171P88	R60
	Res, 3.9K, 1/4W, F	585108-40	R61
	Res, 18K, 1/4W, F	585108-113	R62
	Res, 18K, 1/4W, F	585108-113	R63
	Res, V, 2K, 1W	585504-8	R64
	Res, 3.9K, 1/4W, F	585108-40	R65
	Res, 1.0K, 1/4W, F	585108-11	R66
	Res, 5.1K, 1/4W, F	585108-45	R67
	Res, 22 Ohm, 1/4W	280-1171P13	R68
	Res, 22 Ohm, 1/4W	280-1171P13	R69
	Res, V, 25K, 1W	585504-12	R70
	Res, 71.5K, 1/4W, F	280-7213P371	R71
	Res, V, 2K, 1W	585504-8	R72
	Res, V, 2K, 1W	585504-8	R73

Table 6-18 589468-2 Circuit Card Assy (cont'd)

Location	Description	Part Number	Symbol
	Res, 22 Ohm, 1/4W	280-1171P13	R74
	Res, 22 Ohm, 1/4W	280-1171P13	R75
	Res, 22 Ohm, 1/4W	280-1171P13	R76
	Res, 22 Ohm, 1/4W	280-1171P13	R77
	Res, 120K, 1/4W	280-1171P148	R78
	Res, 120K, 1/4W	280-1171P148	R79
	IC 7474	587953-1	U1
	IC, SN7493N	386-7307P1	U2
	IC, SN7430	587951-1	U3
	IC, SN7400	386-7300P1	U4
	IC MA747	165897-1	U5
	IC MA747	165897-1	U6
	IC	166049-1	U7
	IC	166049-1	U8
	IC	166049-1	U9
	IC MA747	165897-1	U10
	IC	166049-1	U11
	IC Volt Reg	165856-1	U12
	Diode, 1N4148, S	322-7220P1	CR1
	Diode, 1N4148, S	322-7220P1	CR2
	Diode, 1N4148, S	322-7220P1	CR3
	Diode, 1N4148, S	322-7220P1	CR4
	Diode, 1N4148, S	322-7220P1	CR5
	Diode, 1N4148, S	322-7220P1	CR6
	Diode, 1N4148, S	322-7220P1	CR7
	Diode, 1N4148, S	322-7220P1	CR8
	Diode, 1N4148, S	322-7220P1	CR9
	Diode, 1N4148, S	322-7220P1	CR10
	Diode, 1N4148, S	322-7220P1	CR11
	Test Point-White	227-7210P1	TP1
	Test Pt Red	227-7210P2	TP2
	Test Jack PCB Gree	227-7210P4	TP3
1	Printed Wiring Bd.	589505-1	
2	Pad	586795-1	
3	Jumper List	167404-2	

6.3 DRAWINGS

The schematic diagrams and assembly drawings listed in this section are applicable to the TM/EP unit. These drawings are used primarily to support other sections of the manual along with providing technical source data for trouble-shooting and maintaining the equipment. Figures 6-1 through 6-10 list schematic diagrams while Figures 6-11 through 6-27 list the assembly drawings. Both listings include the drawing size, number, and the latest revision.

Schematic Diagram

Figure	Title	Drawing No.	Rev.
6-1	True Motion Interconnection (A20)	J168437	F
6-2	Time Display PCB (A20A1)	C589539	A
6-3	Time Display Driver PCB (A20A2)	D168435	E
6-4	Switch and Lamp Buffer PCB (A20A3)	D168436	A
6-5	TM Low Voltage Power Supply (A20A8)	E982218	B
6-6	Analog PCB (A20A9A1)	E167004	B
6-7	Processor PCB (A20A9A2)	E167007	A
6-8	Memory PCB (A20A9A3)	E167010	A
6-9	Digital PCB (A20A9A4)	E167001	D
6-10	EBL/Switching Circuit Card Assy (A2A9)	E589469	K

Assembly Drawing

6-11	True Motion/Electronic Plotting (TM/EP)	E168628	F
6-12	TM/EP Headset	E168580	G
6-13	Time Display PCB (A20A1)	C589465	C
6-14	Time Display Driver PCB (A20A2)	D168601	E
6-15	Switch and Lamp Buffer PCB (A20A3)	D168588	B
6-16	Headset Main Harness	E168584	C
6-17	TM Low Voltage Power Supply (A20A8)	E982221	A
6-18	TM (LVPS) Control PCB	D982220	B
6-19	Card Basket	E165816	G
6-20	Analog PCB (A20A9A1)	E167003	D
6-21	Digital PCB (A20A9A2)	D166999	F
6-22	Memory PCB (A20A9A3)	E167009	E
6-23	Processor PCB (A20A9A4)	D167006	C
6-24	Joystick	A982254	A
6-25	Sine Cosine Potentiometer	B169130	A
6-26	TM/EBL Assembly	D589466	J
6-27	TM/EBL Circuit Card	E589468	D

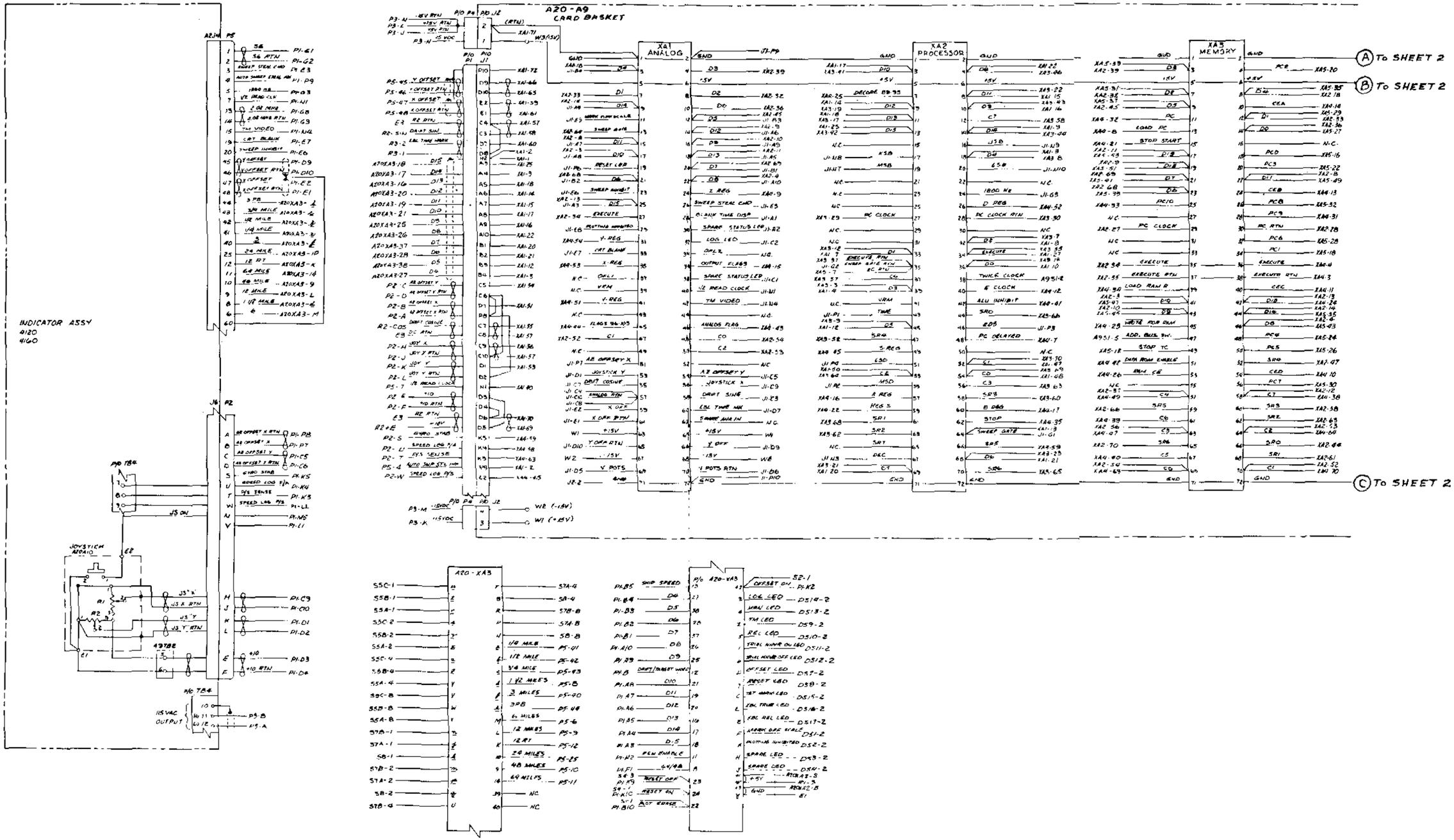


Figure 6-1 True Motion Interconnection (A20) Schematic Diagram (Sheet 1 of 2) J168437 Rev. F

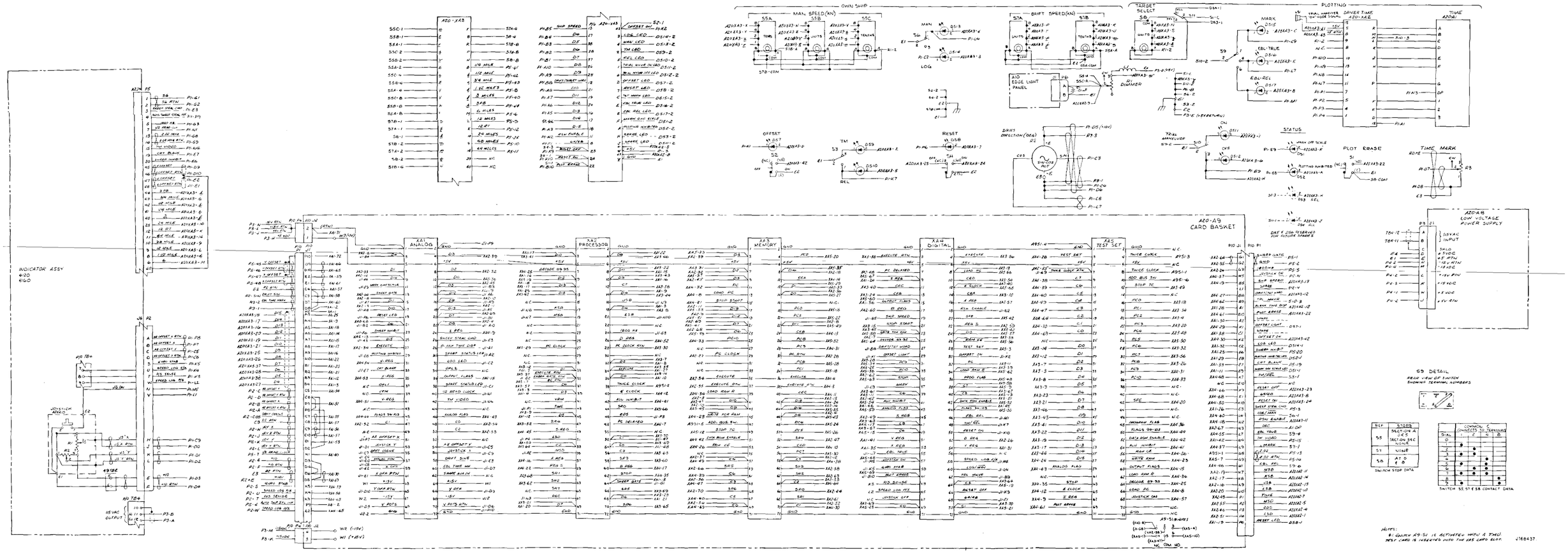
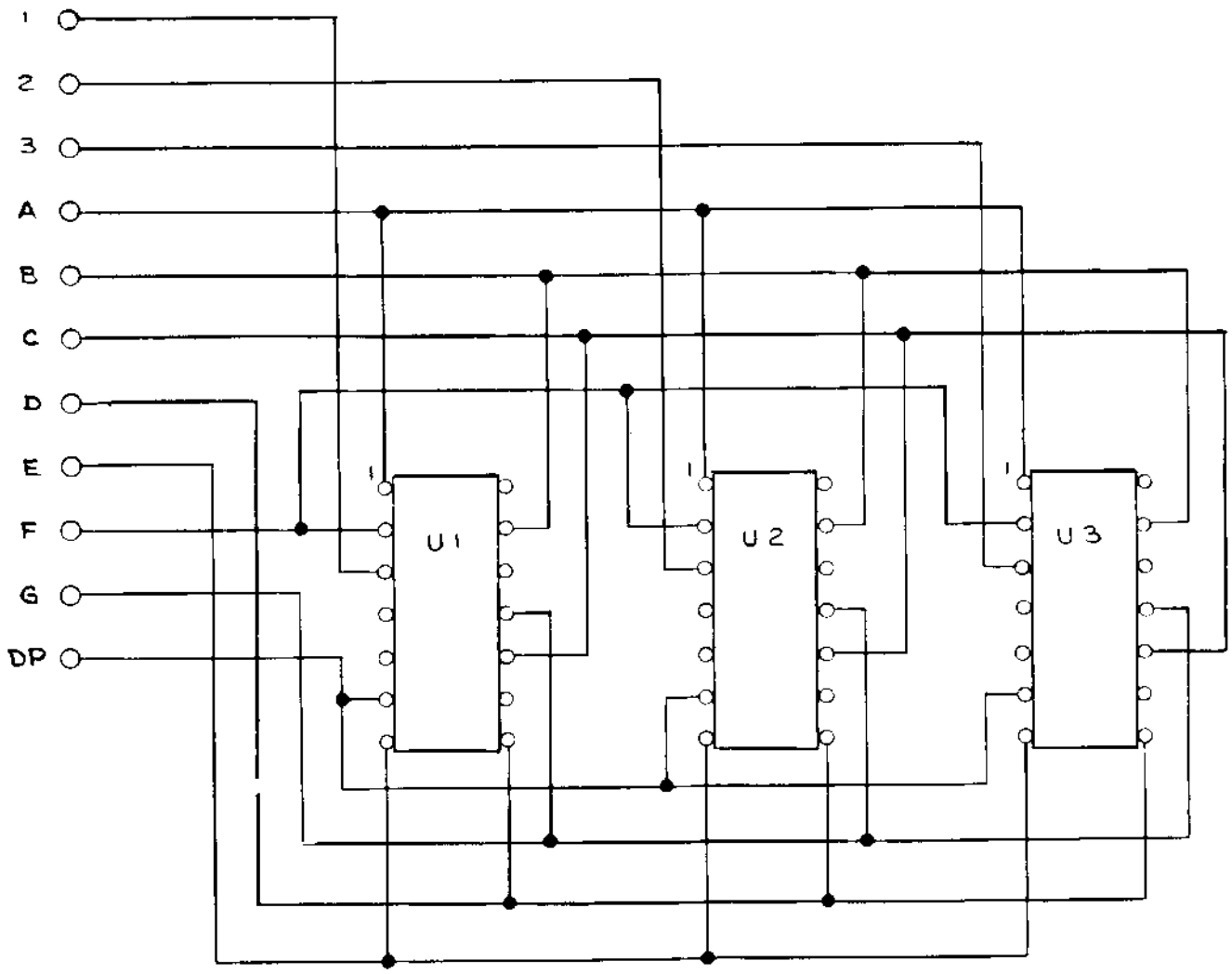
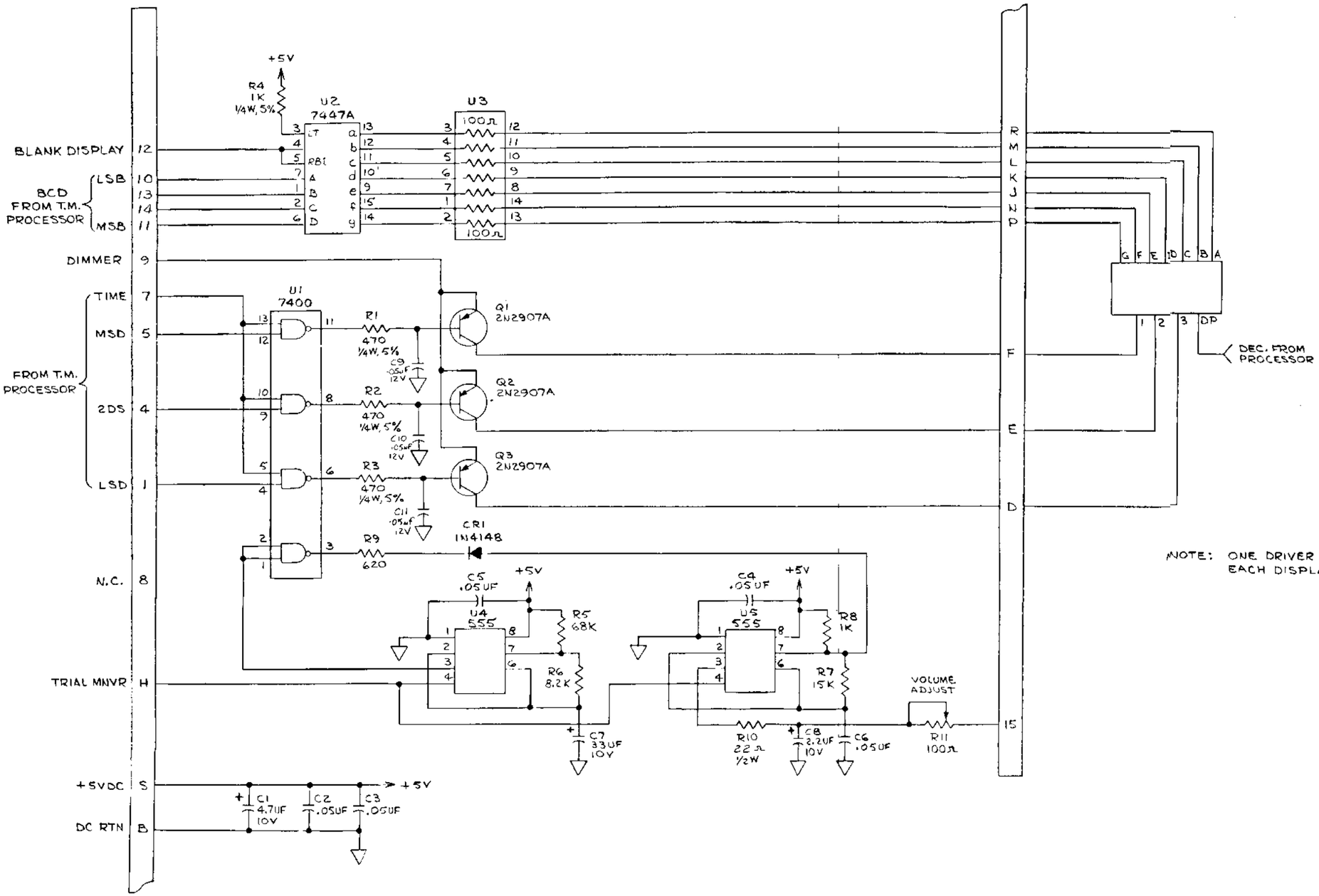


Figure 6-1. True Motion Interconnection (A20) (Sheet 2 of 2) Schematic Diagram



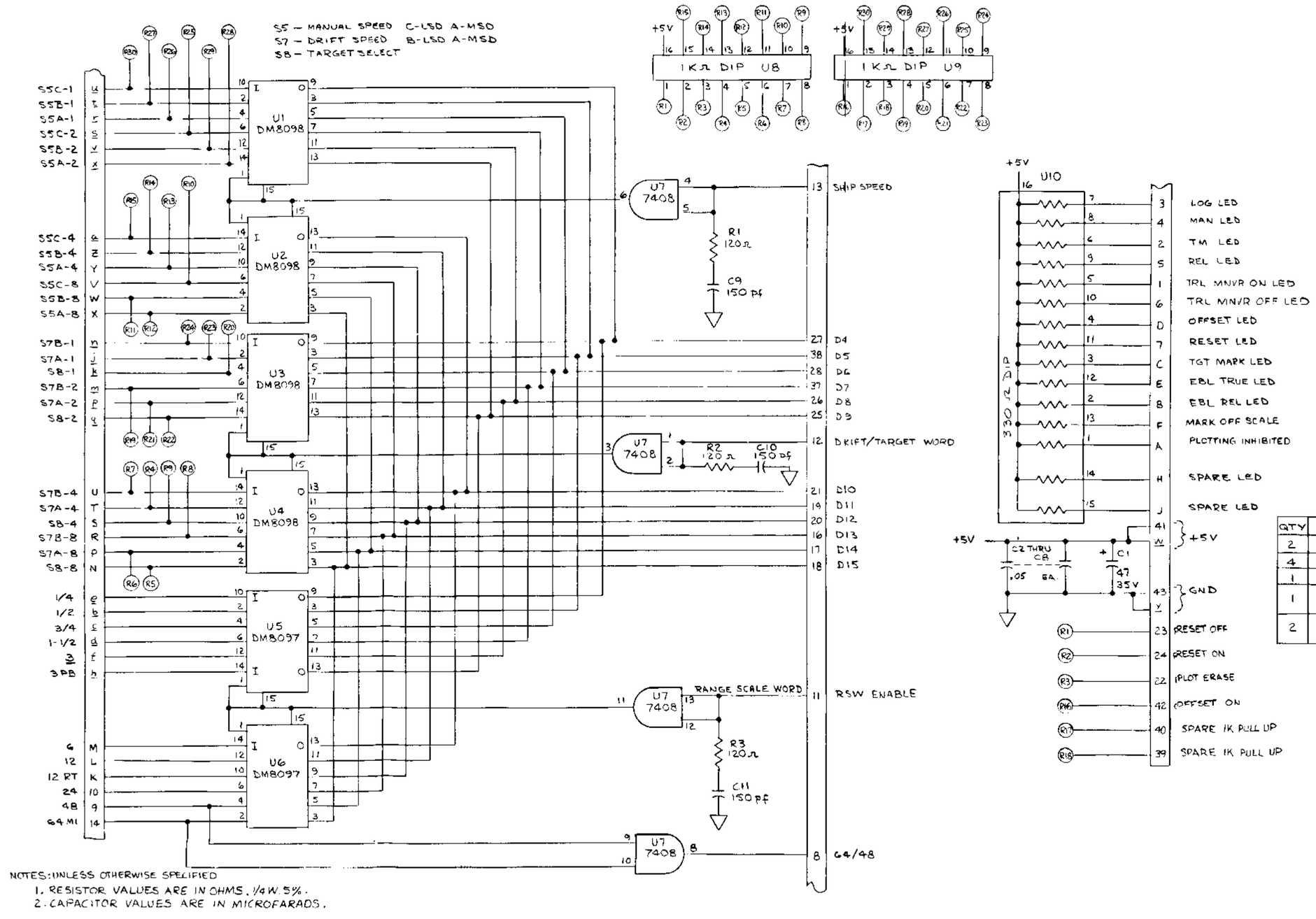
C589539 Rev. A

Figure 6-2. Time display PCB (A20A1) Schematic Diagram



DESIG	QTY	+5		GND	
U1	1	PIN 14		PIN 7	
U2	1	16		8	

Figure 6-3. Time Display Driver PCB (A20A2) Schematic Diagram



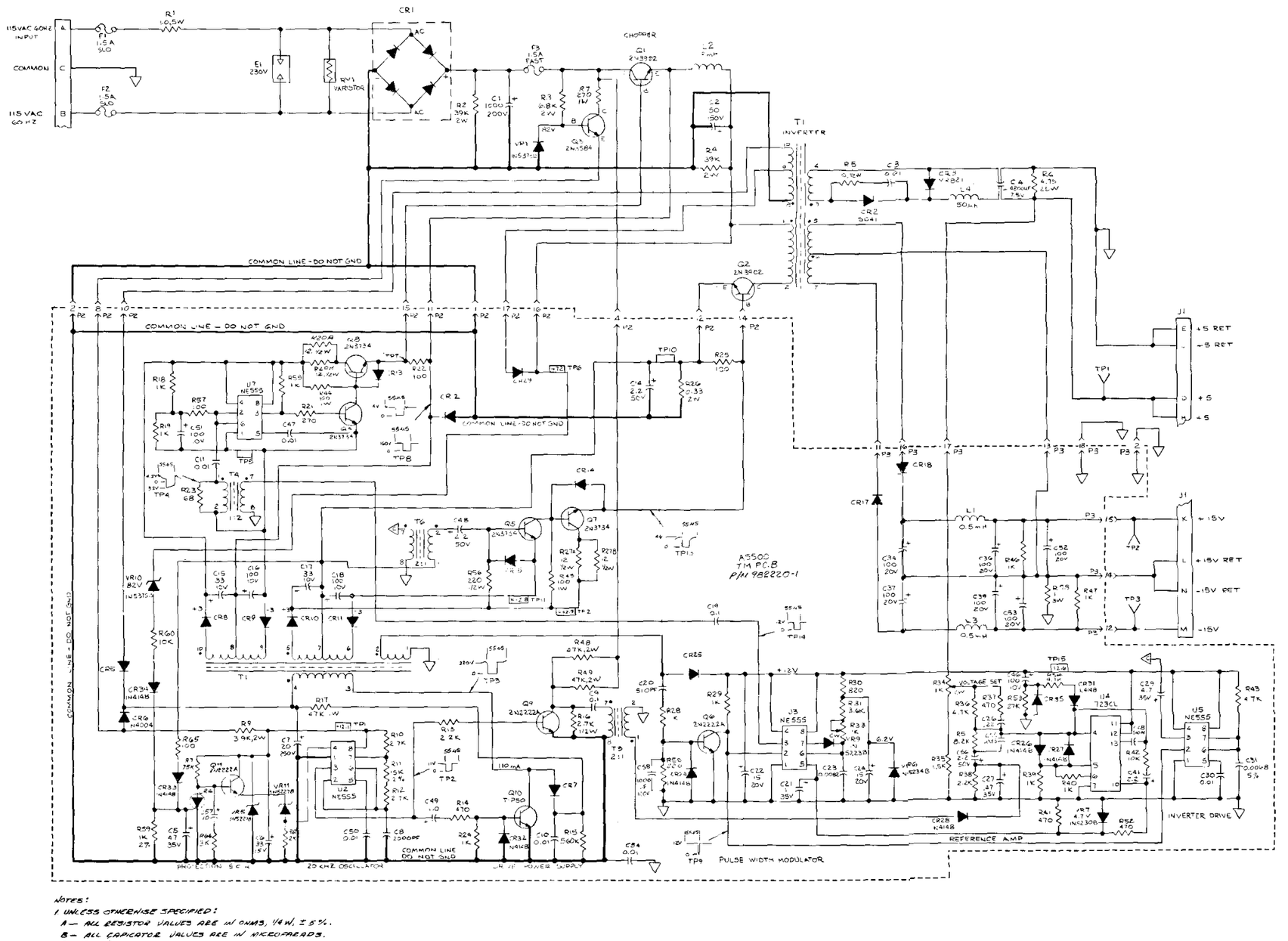
NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTOR VALUES ARE IN OHMS, 1/4 W 5%.
2. CAPACITOR VALUES ARE IN MICROFARADS.

QTY	DESIGNATION	+5V	GND	NOTES
2	U5, U6	16	8	
4	U1, U2, U3, U4	16	8	
1	U7	14	7	
1	U10	16	—	
2	U8, U9	16	—	

D168436

D168436 Rev. A

Figure 6-4. Switch and Lamp Buffer PCB (A20A3) Schematic Diagram



NOTES:
1. UNLESS OTHERWISE SPECIFIED:
   A — ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, ± 5%.
   B — ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. [ ] = VOLTS D.C.

E982218

Figure 6-5. TM Low Voltage Power Supply (A20A8) Schematic Diagram

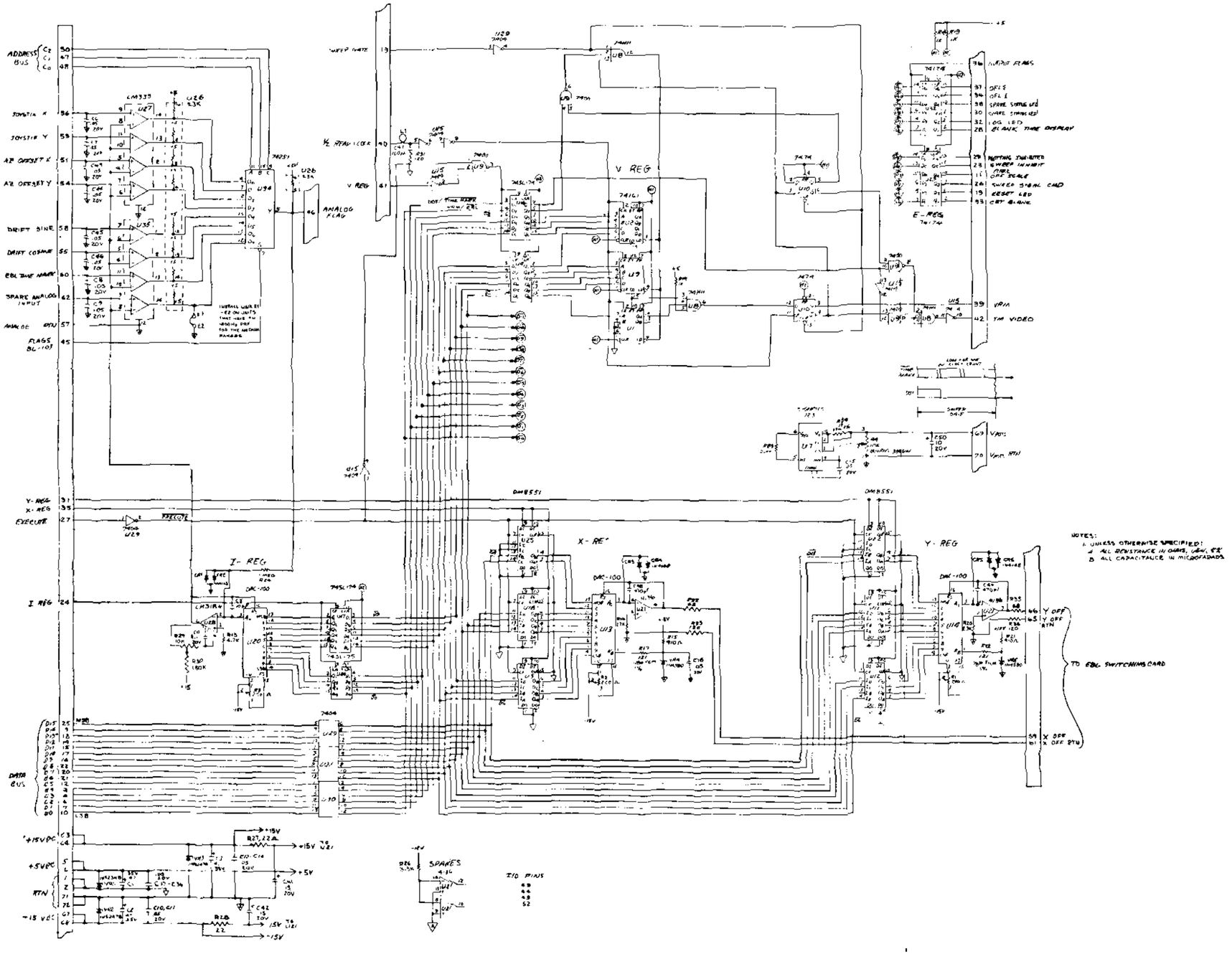


Figure 6-6. Analog PCB (A20A9A1) Schematic Diagram E167004 Rev. B

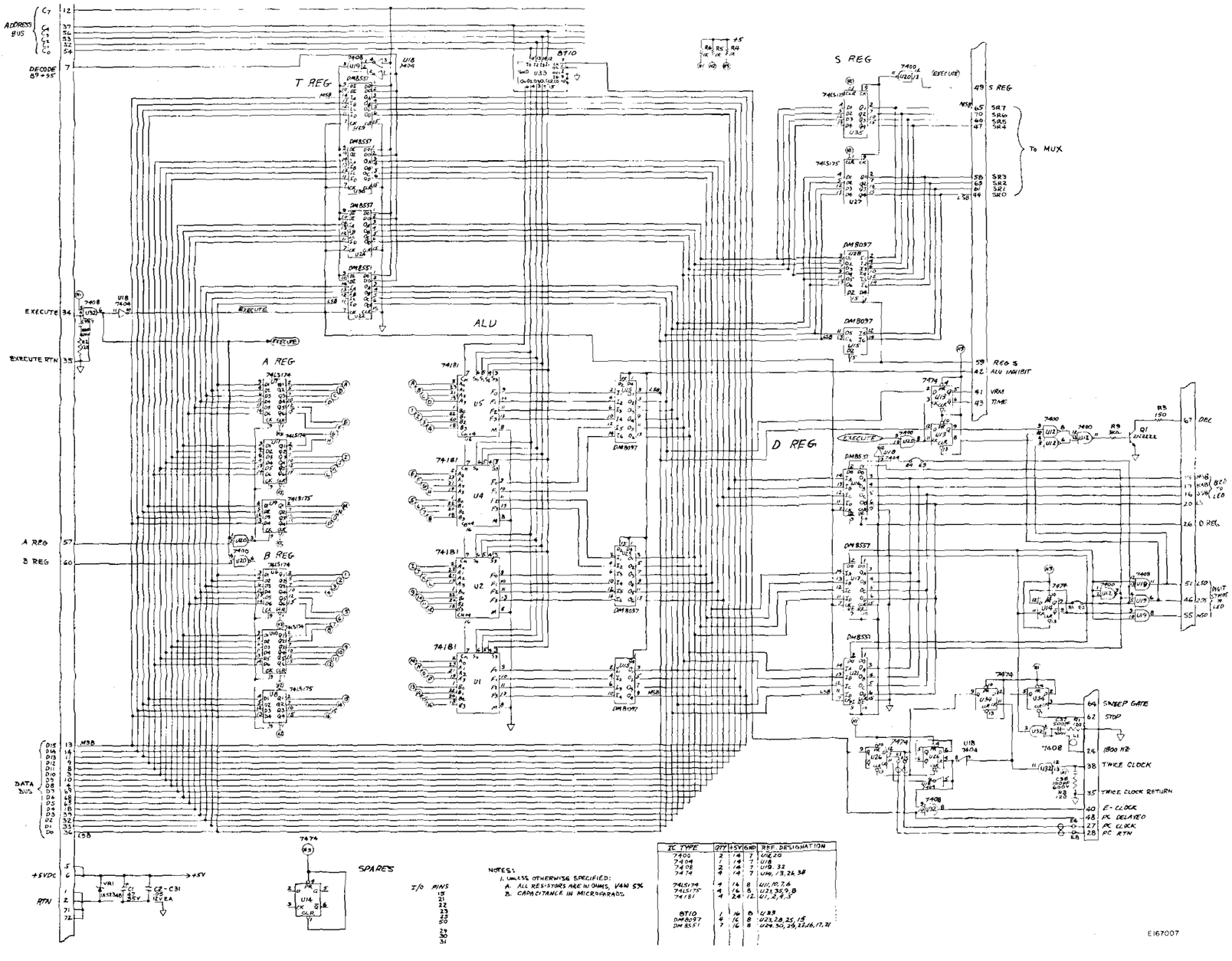
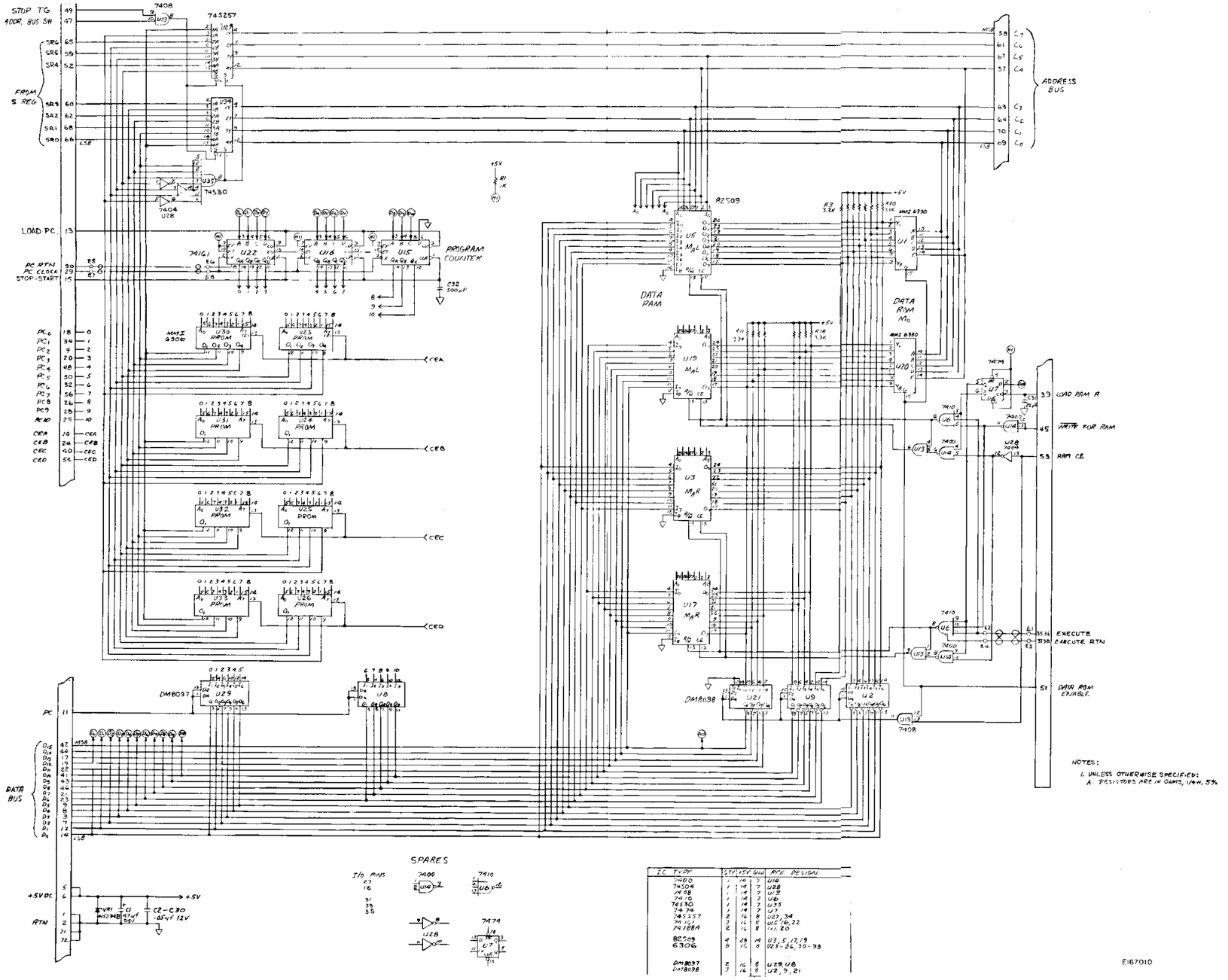
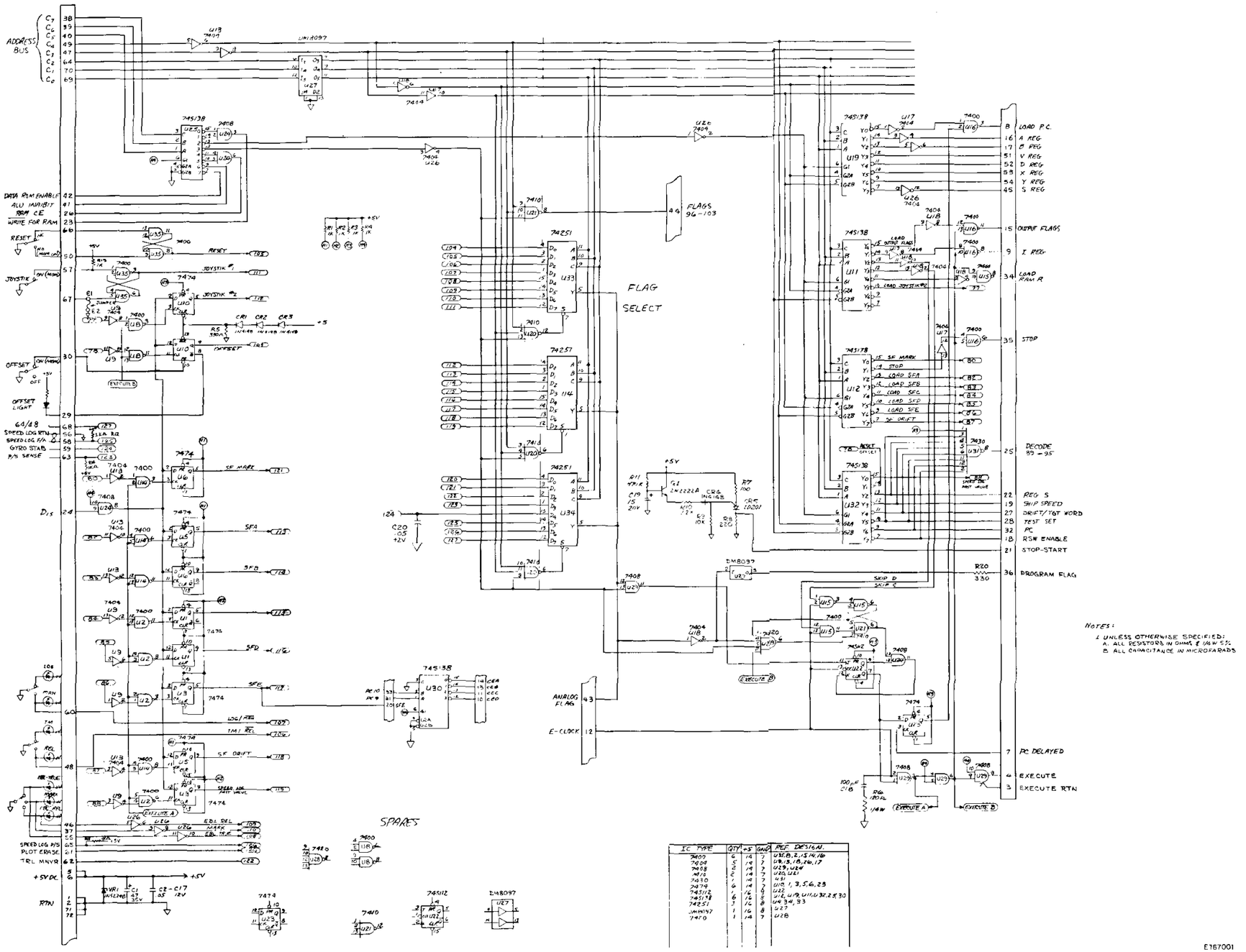


Figure 6-7. Processor PCB (A20A9A2A) Schematic Diagram



IC TYPE	QTY	+5V	GND	REF. DESIGN
7400	1	14	7	U18
74S04	1	14	7	U28
M98	1	14	7	U19
7410	1	14	7	U6
74S30	1	14	7	U35
74 74	1	14	7	U7
74S257	2	16	8	U27, 34
74161	3	16	8	U12, 16, 22
74188A	2	16	8	U1, 20
82S09	4	28	14	U3, 5, 17, 19
6306	8	16	8	U23-26, 30-33
DM8097	2	16	8	U29, U8
DM8098	3	16	8	U2, 9, 21

Figure 6-8. Memory PCB (A20A9A3) Schematic Diagram



IC TYPE	QTY	+5	GND	REF. DESIGN.
7400	6	14	7	U3,8,2,15,16,10
7404	5	14	7	U9,3,18,26,17
7408	5	14	7	U29, U24
7410	5	14	7	U20, U21
7430	1	14	7	U31
7474	6	14	7	U10, 1, 3, 5, 6, 23
74S112	1	16	8	U22
74S138	6	16	8	U12, U19, U11, U32, 25, 30
74251	3	16	8	U4, 34, 33
UM1097	1	16	8	U27
7410	1	14	7	U28

Figure 6-9. Digital PCB (A20A9A4) Schematic Diagram

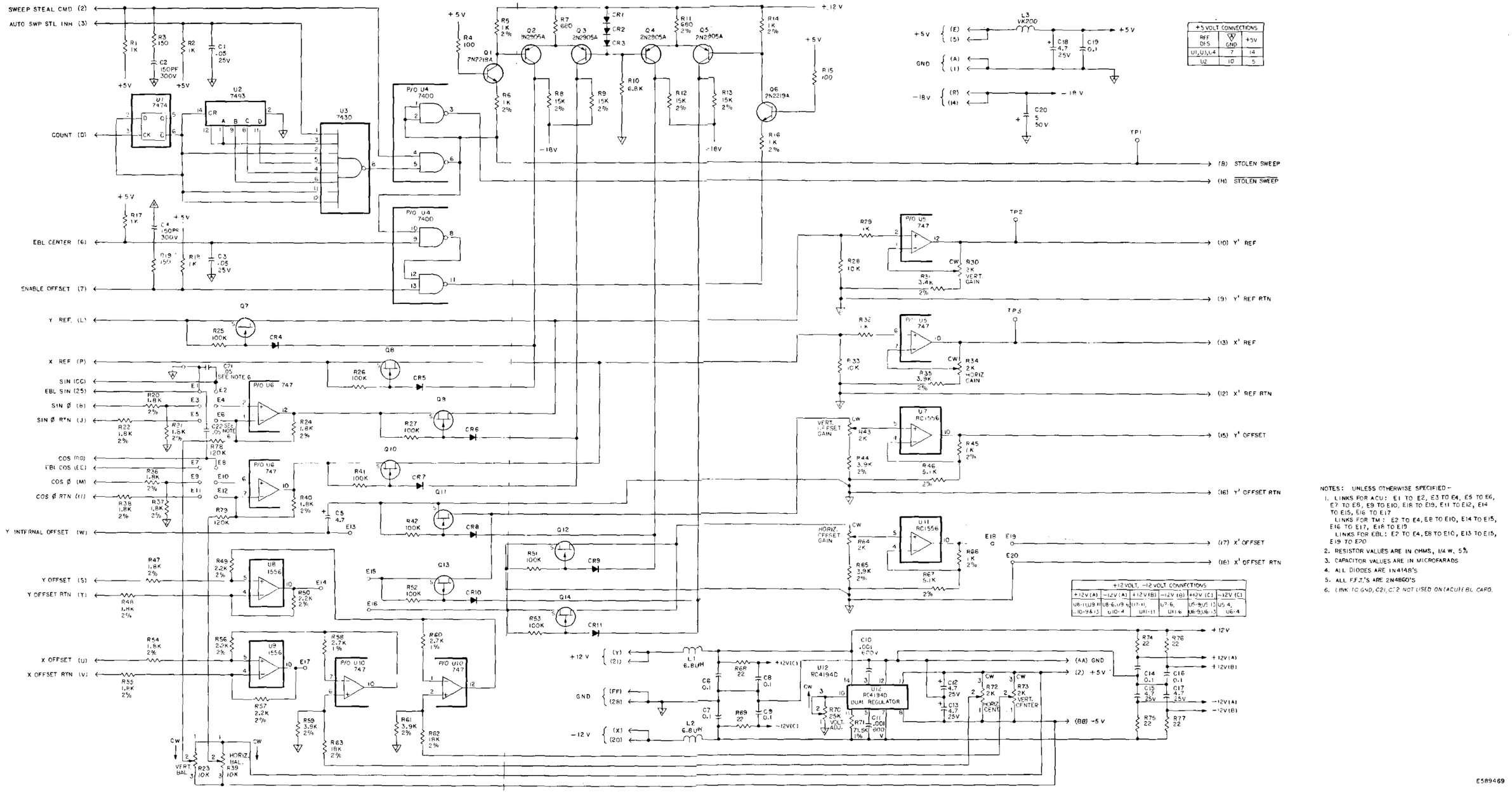


Figure 6-10. EBL Switching/Circuit Card Assy (A2A9) Schematic Diagram

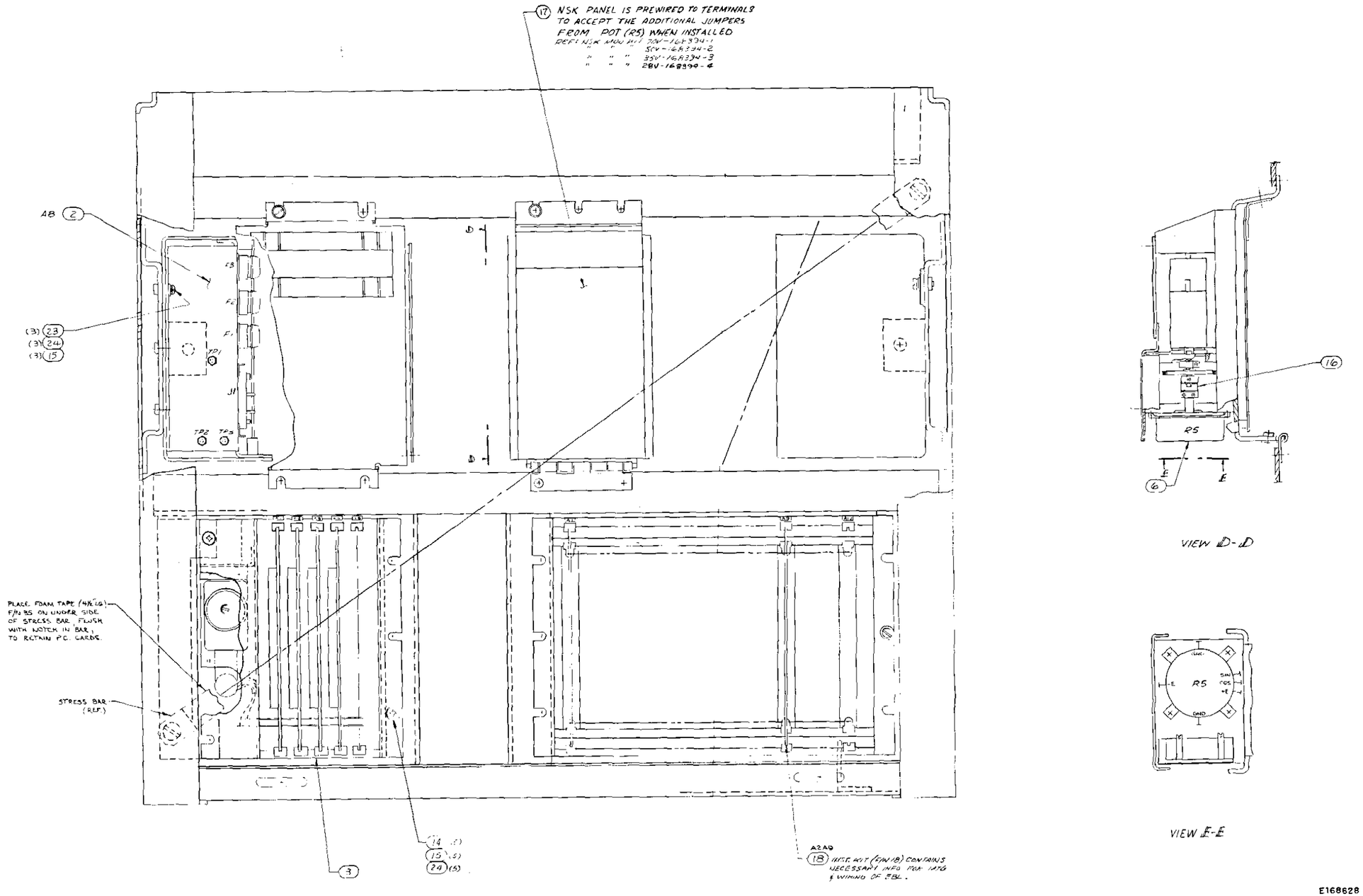


Figure 6-11. True Motion/Electronic Plotting (TM / EP) (Sheet 1 of 2) Assembly Drawing

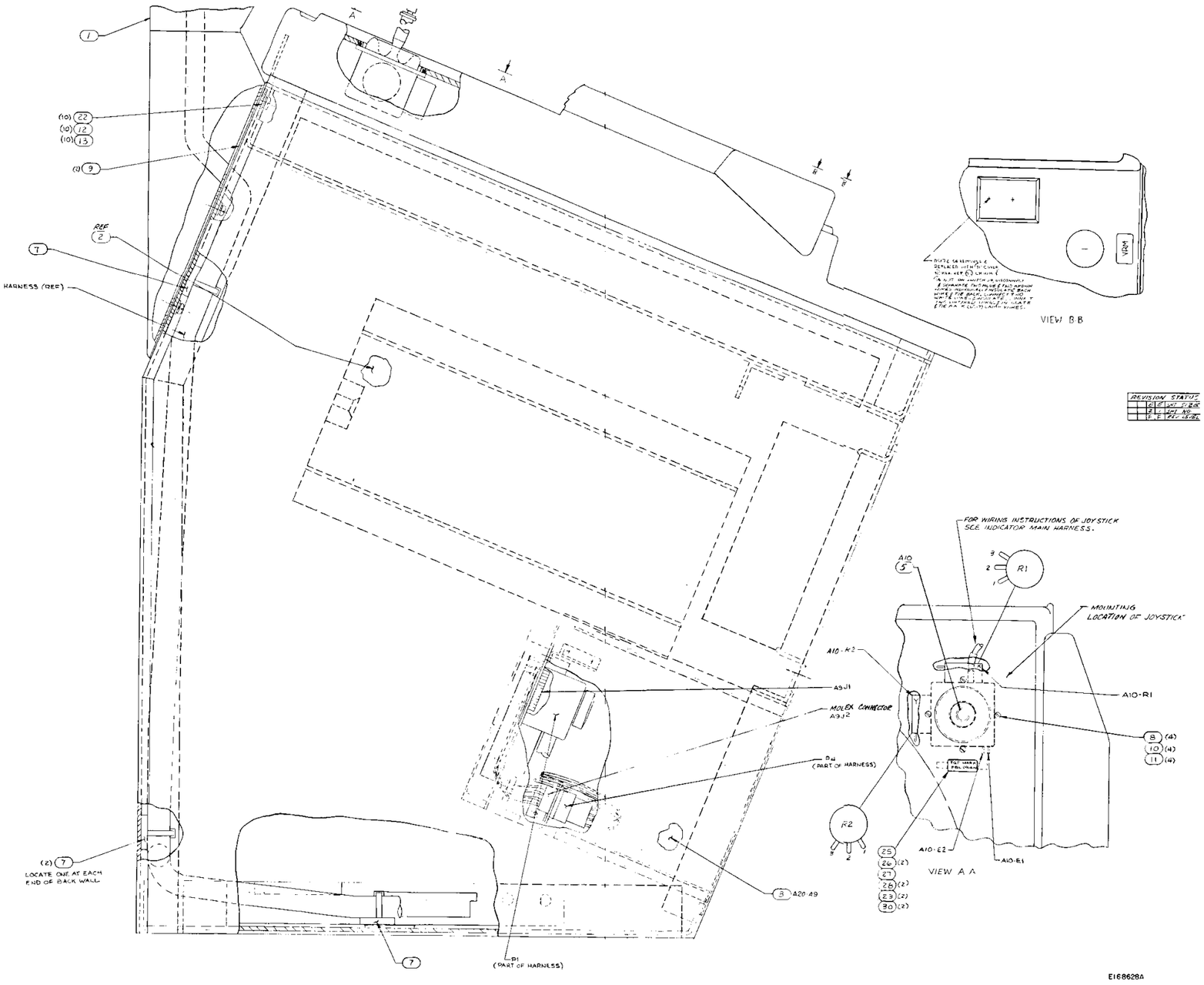
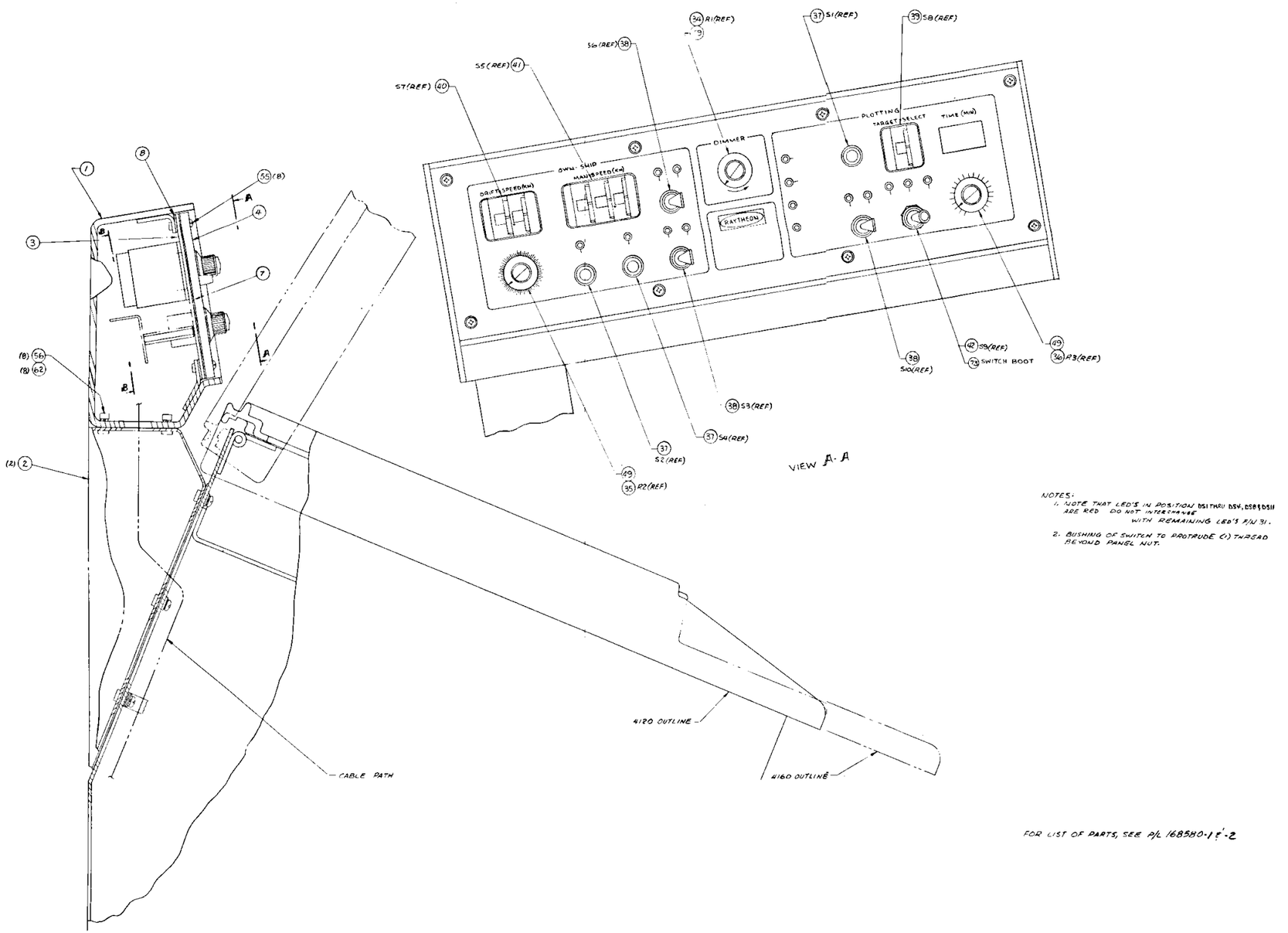


Figure 6-11. True Motion/Electronic Plotting (TM / EP) (Sheet 2 of 2) Assembly Drawing



NOTES:
1. NOTE THAT LED'S IN POSITION DS1 THRU DS4, DS8 & DS11 ARE RED DO NOT INTERCHANGE WITH REMAINING LED'S P/N 31.
2. BUSHING OF SWITCH TO PROTRUDE (.) THREAD BEYOND PANEL NUT.

FOR LIST OF PARTS, SEE P/L 168580-1 & -2

E168580

Figure 6-12. TM/EP Headset Assembly Drawing (Sheet 1 of 2)

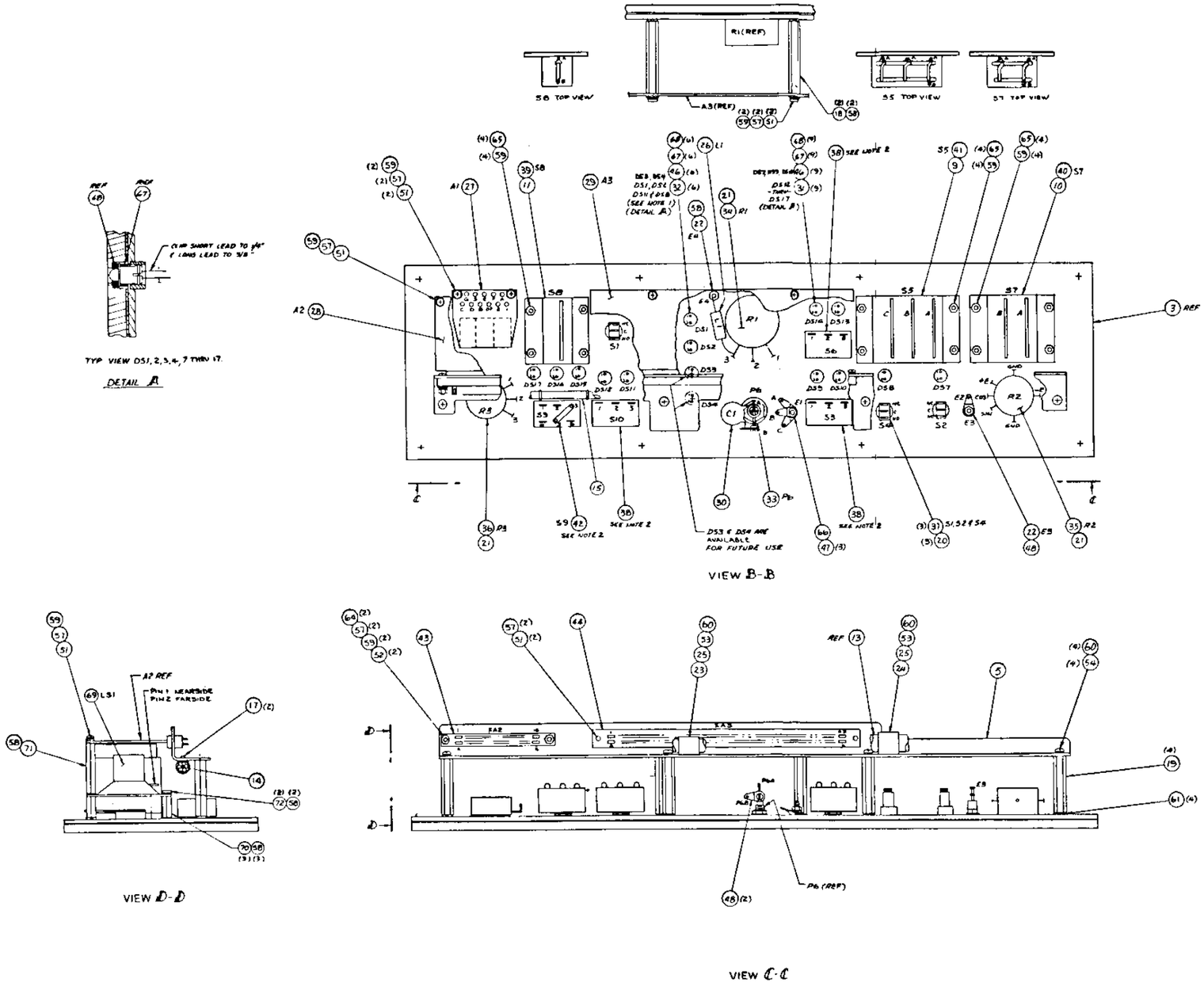


Figure 6-12 TM/EP Headset Assembly Drawing (Sheet 2 of 2)

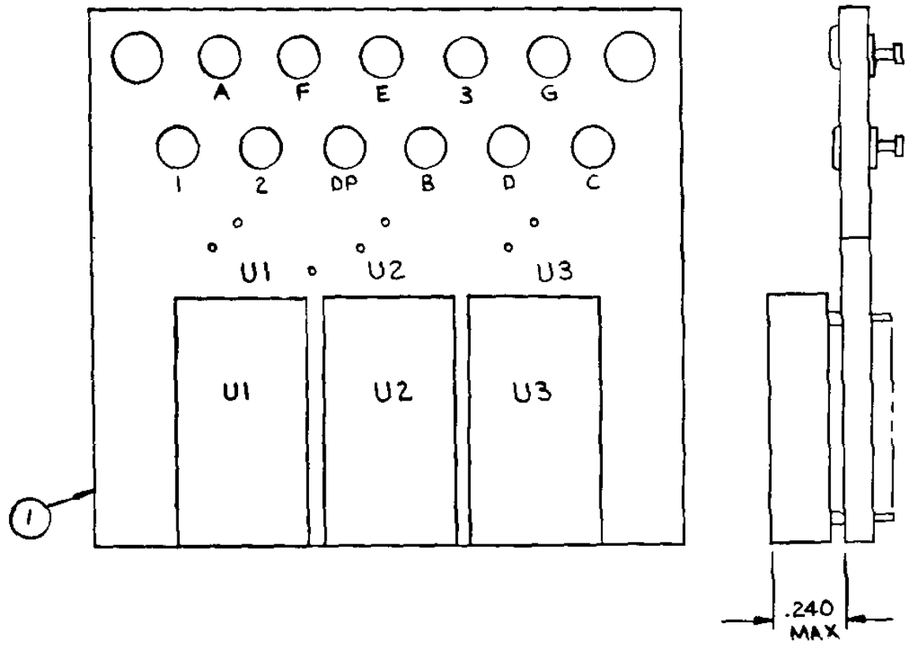


Figure 6-13 Time Display PCB (A20A1) Assembly Drawing

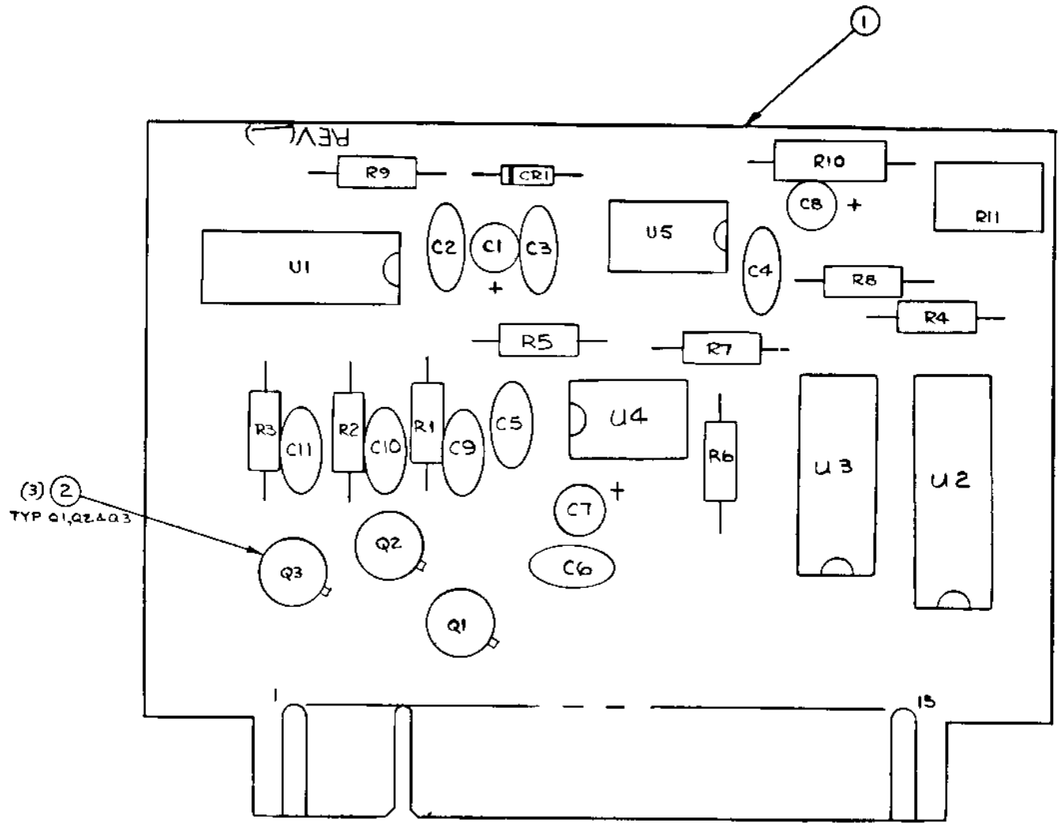
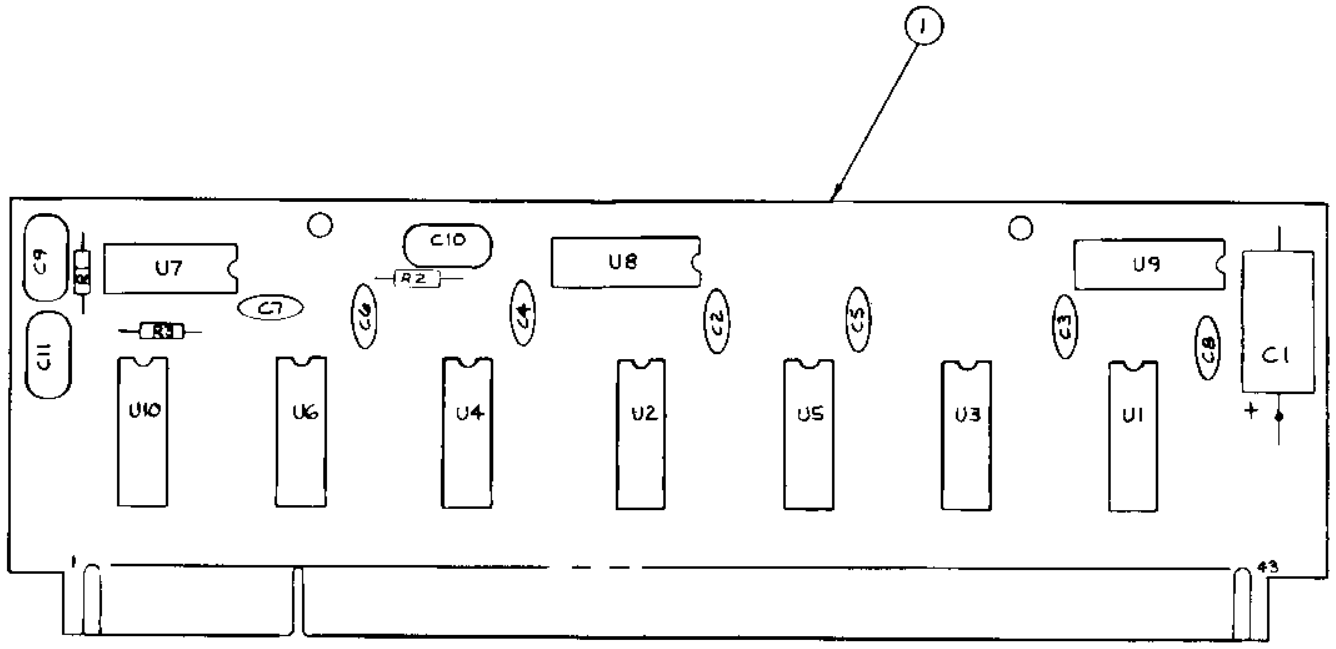


Figure 6-14 Time Display Driver PCB (A20A2) Assembly Drawing



D168588 Rev. B

Figure 6-15 Switch and Lamp Buffer PCB (A20A3) Assembly Drawing

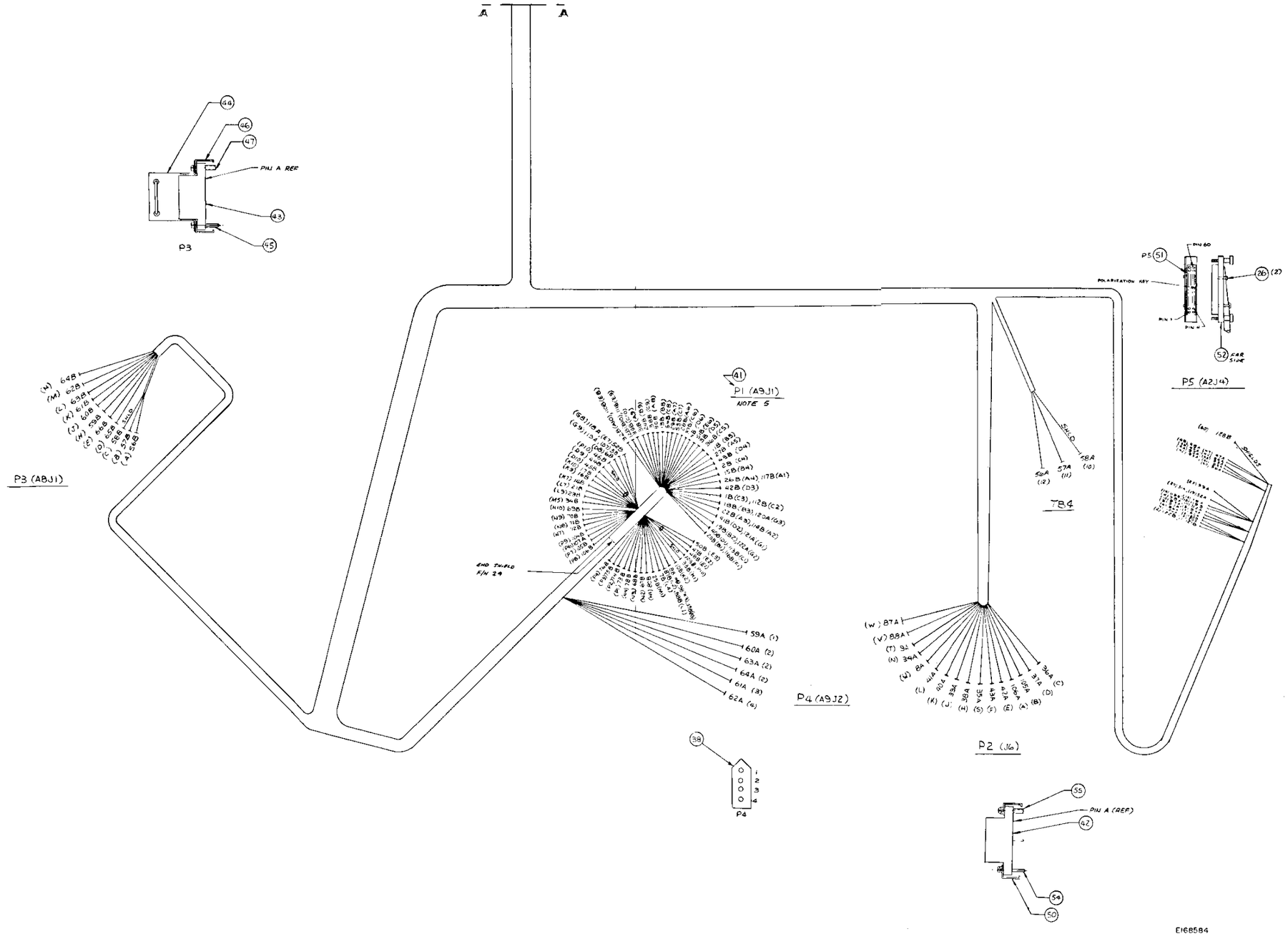


Figure 6-16 Headset Main Harness Assembly Drawing (Sheet 1 of 2)

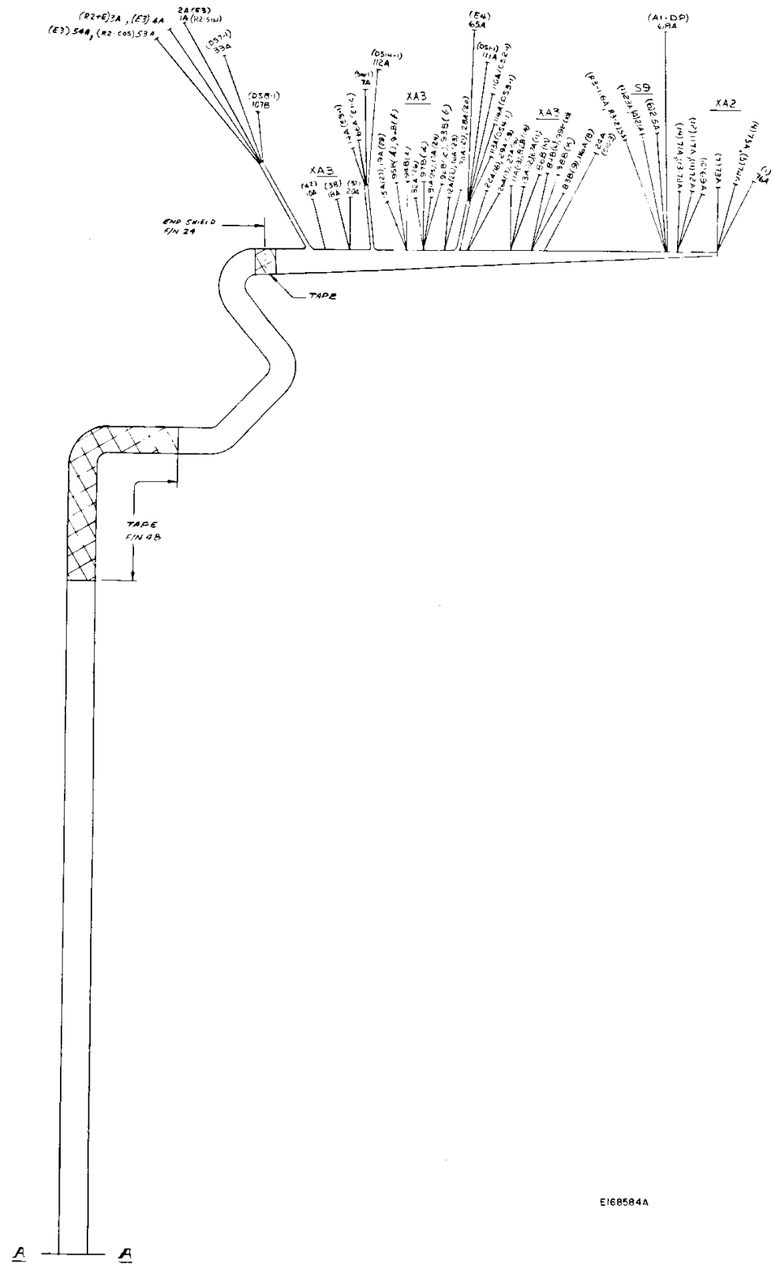


Figure 6-16 Headset Main Harness Assembly Drawing (Sheet 2 of 2)

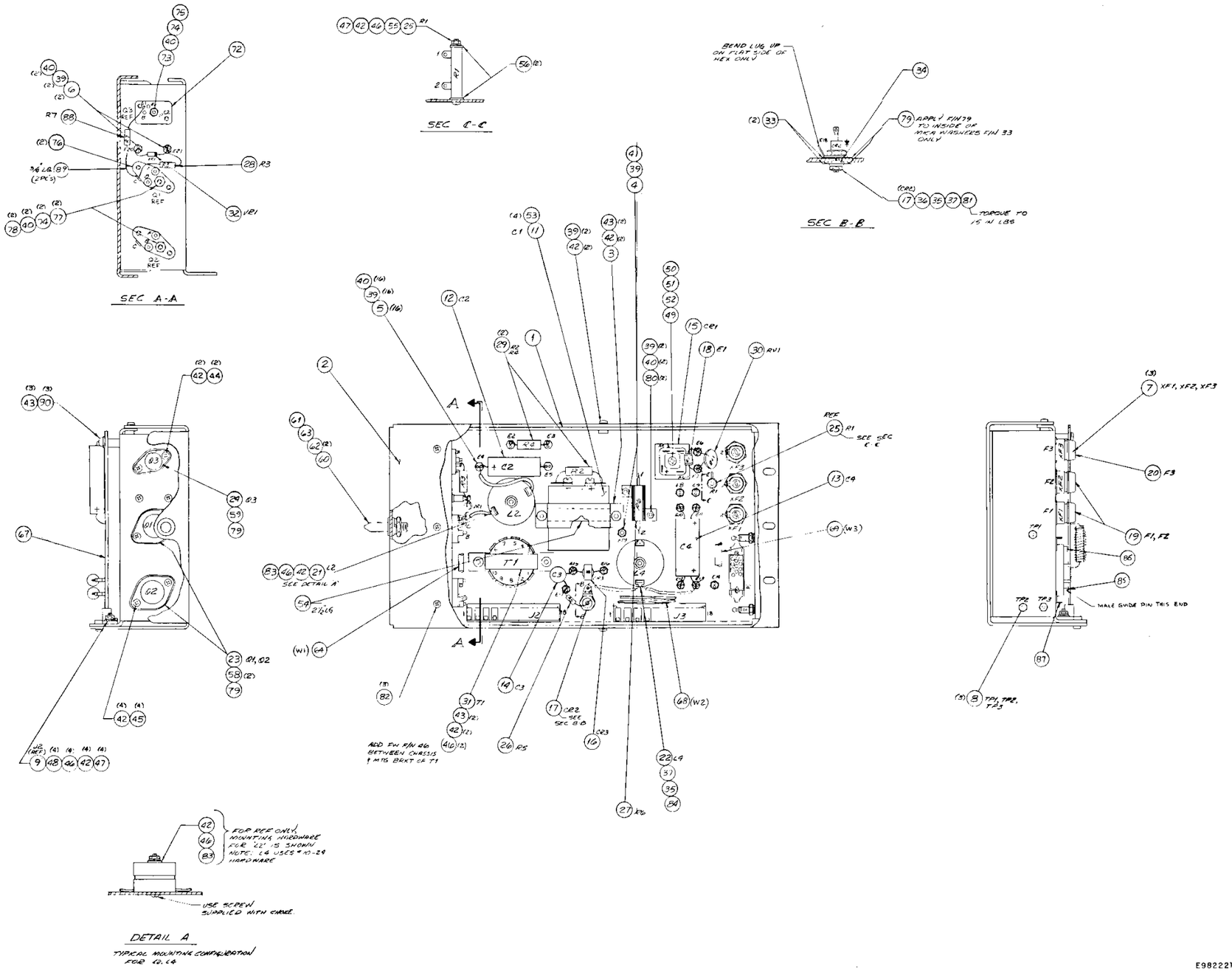
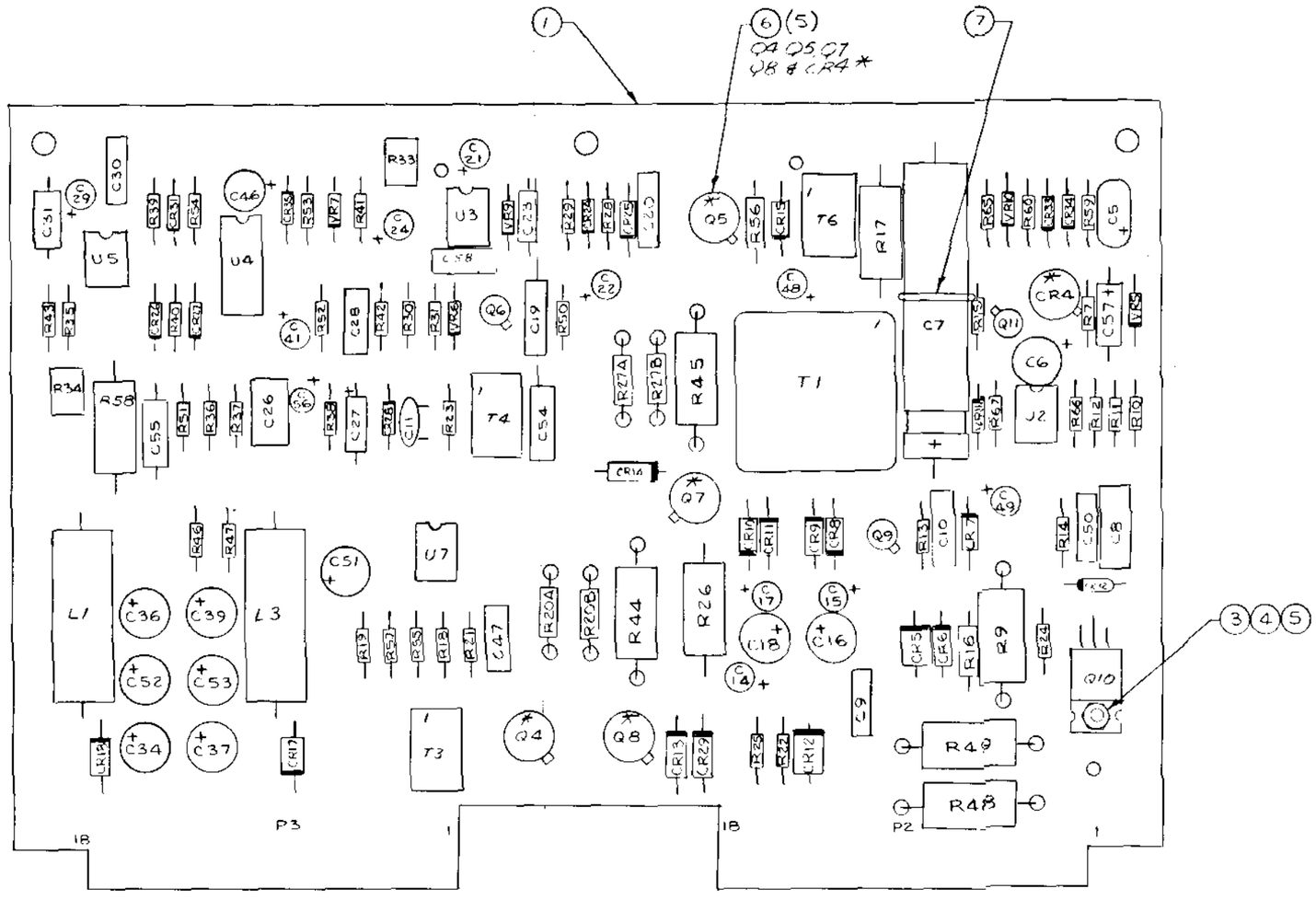


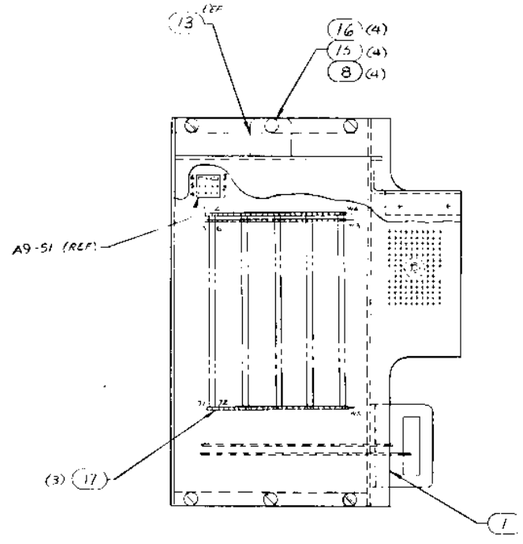
Figure 6-17 TM Low Voltage Power Supply (A20A8) Assembly Drawing



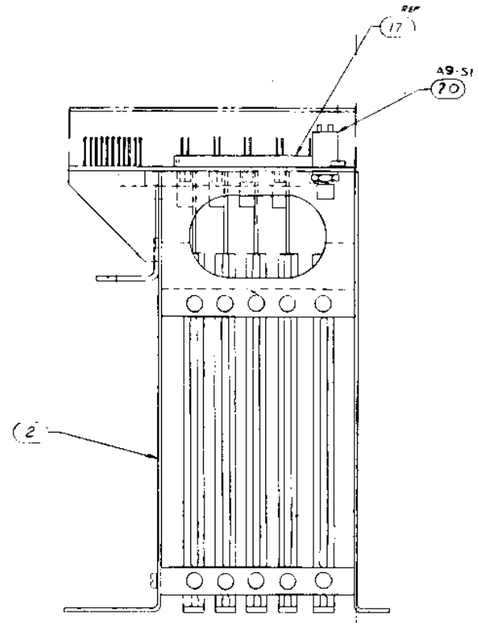
NOTES:
1. ALL ELECTRICAL COMPONENTS ARE KEYED TO PARTS LIST BY REFERENCE DESIGNATIONS
2. REF SCHEMATIC E982218

D982220

Figure 6-18 TM (LVPS) Control PCB Assembly Drawing



VIEW A-A



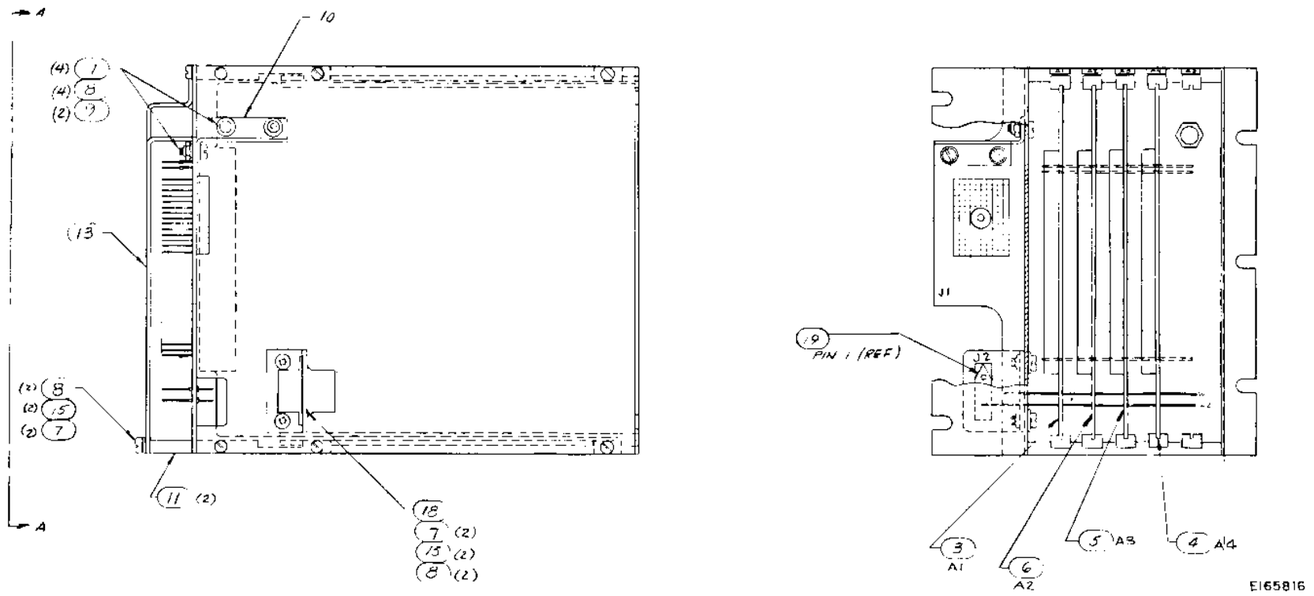
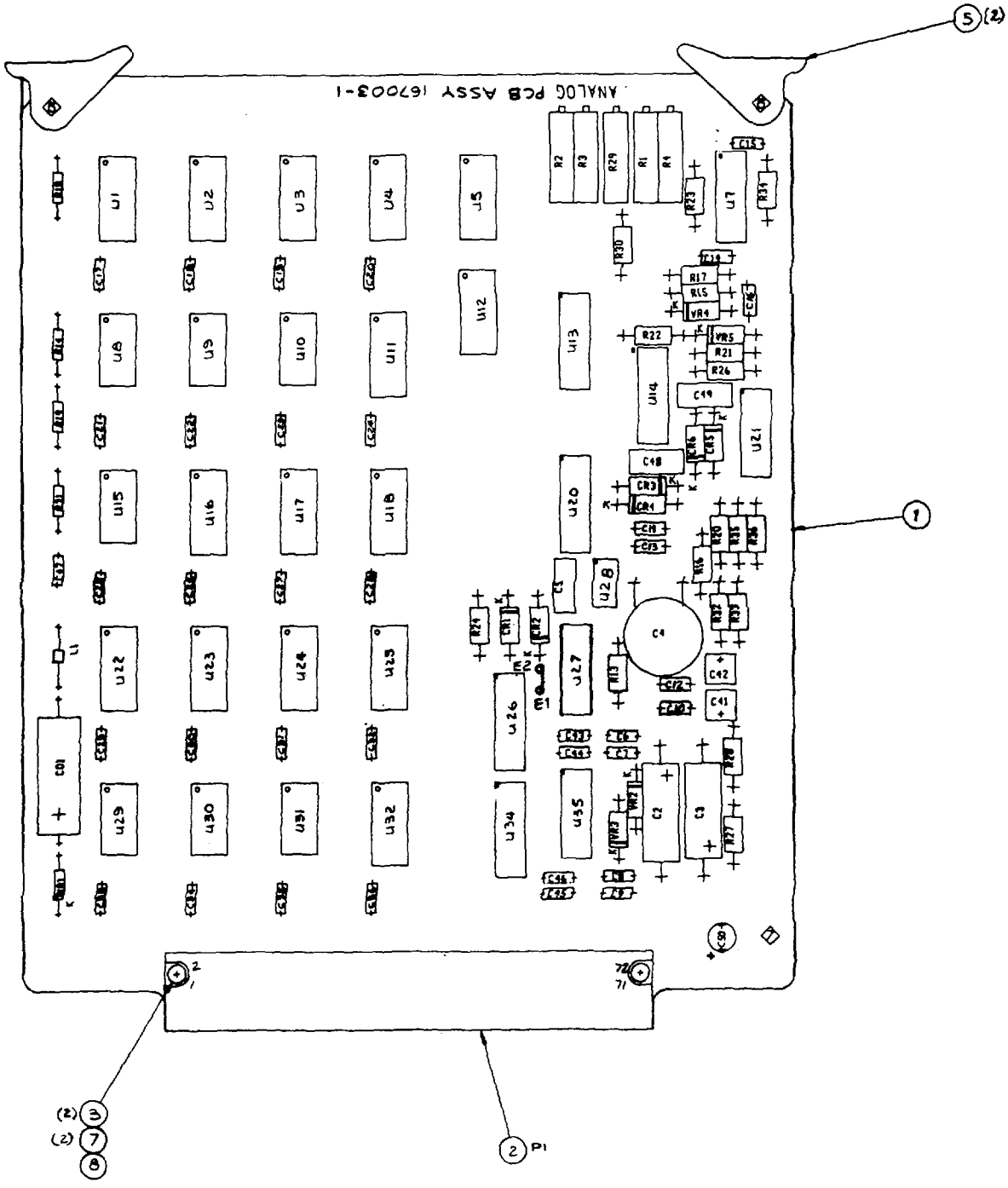


Figure 6-19 Card Basket Assembly Drawing



E167003 Rev. D

Figure 6-20 Analog PCB (A20A9A1) Assembly Drawing

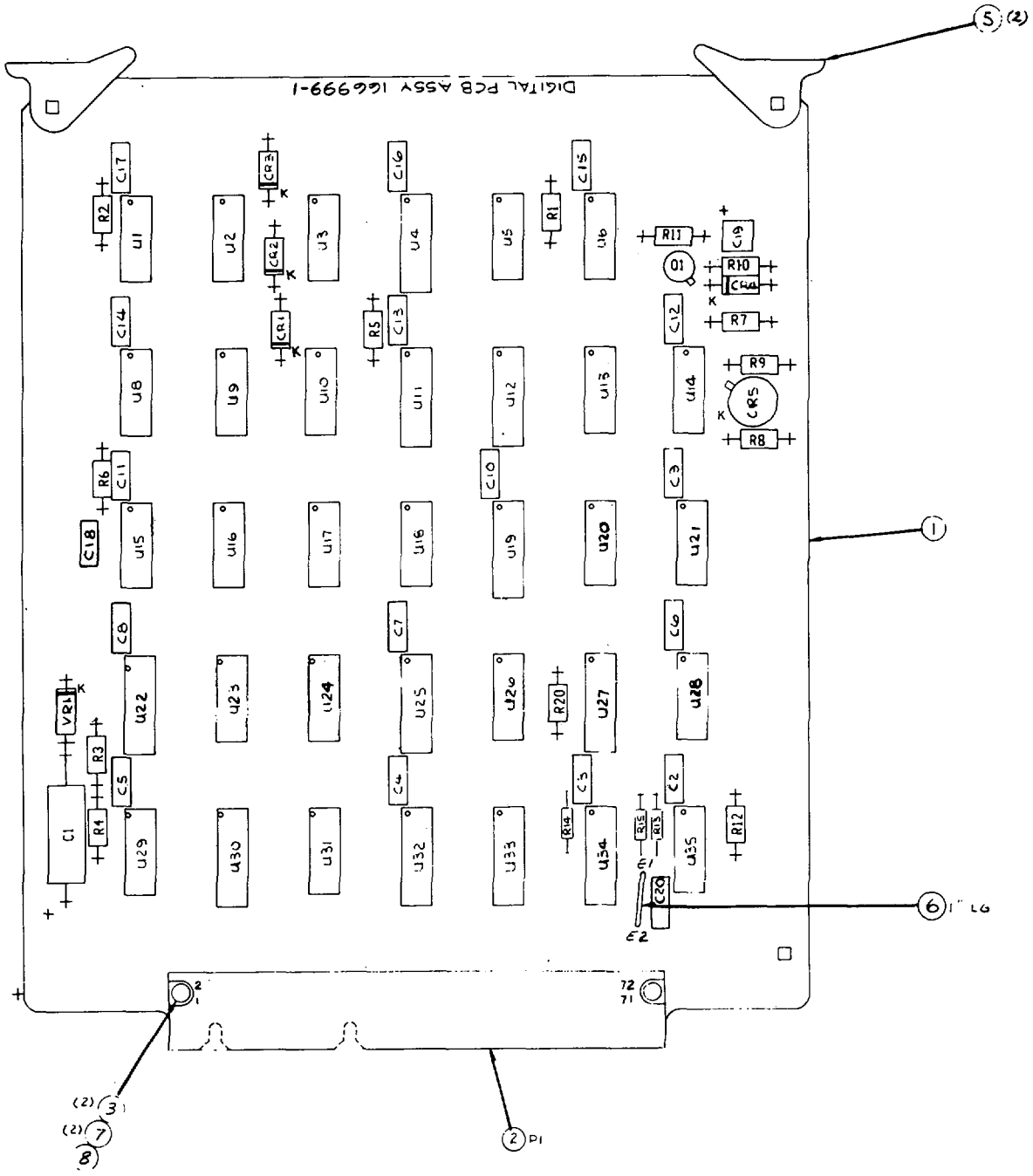
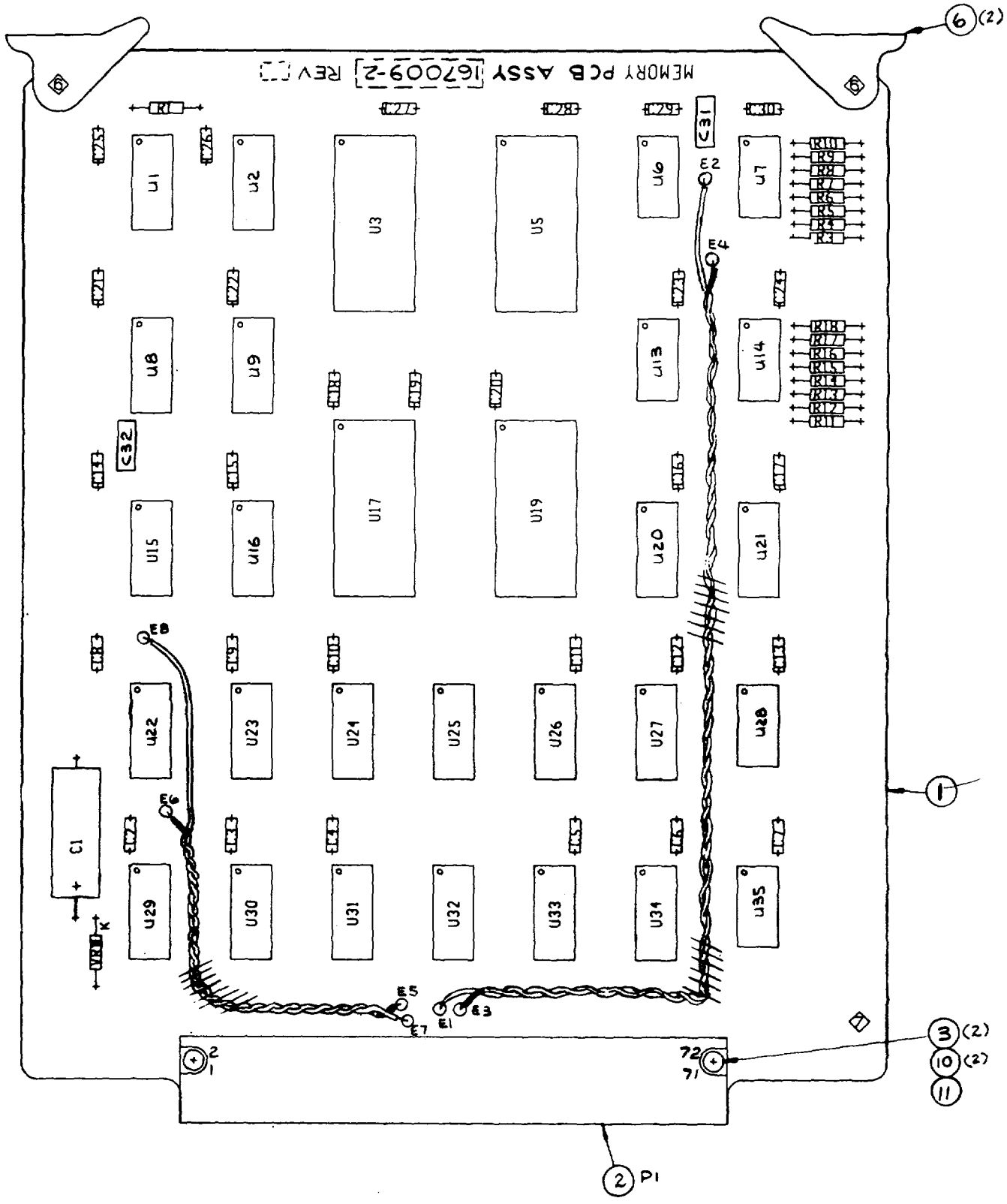
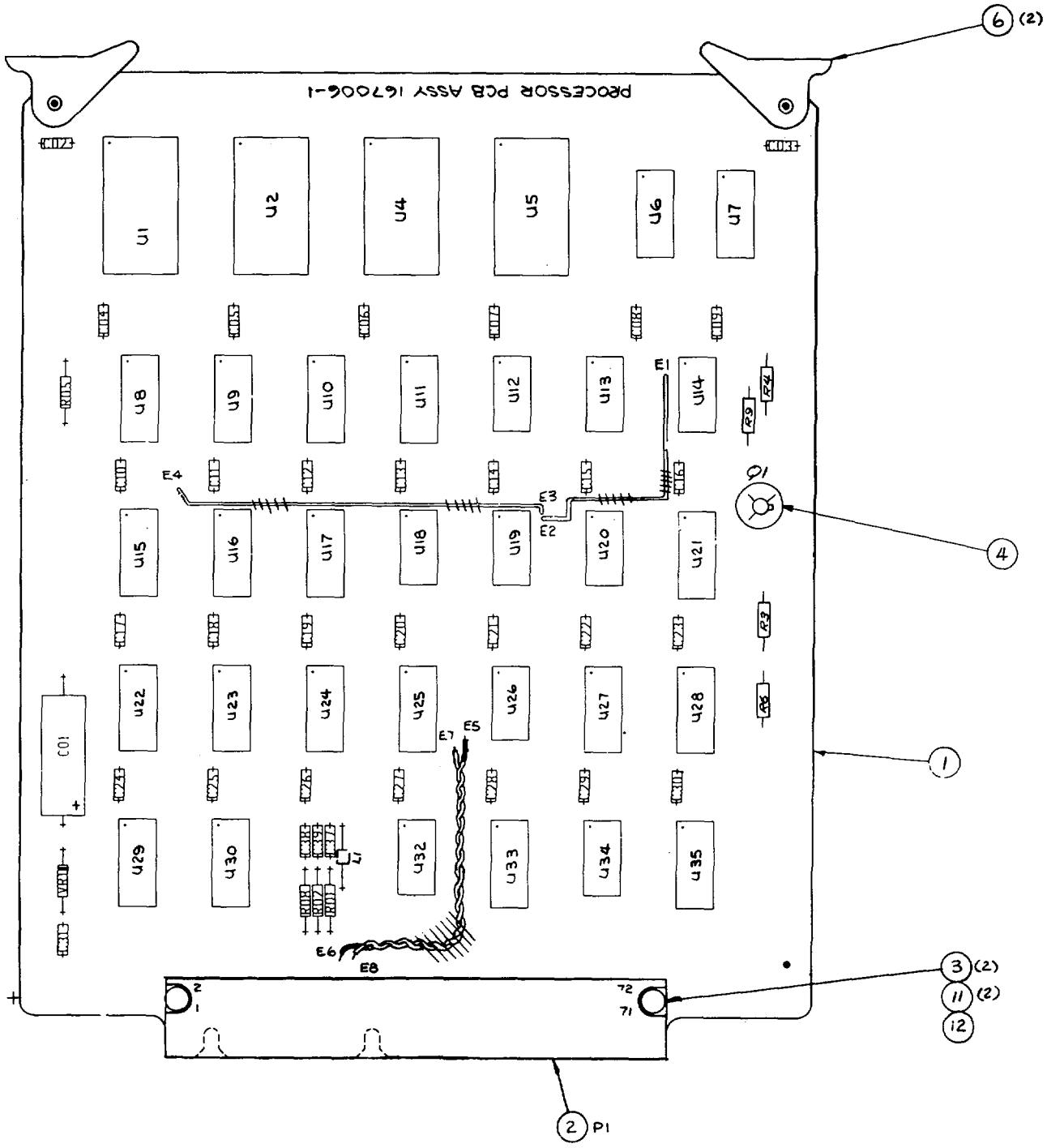


Figure 6-21 Digital PCB (A20A9A2) Assembly Drawing



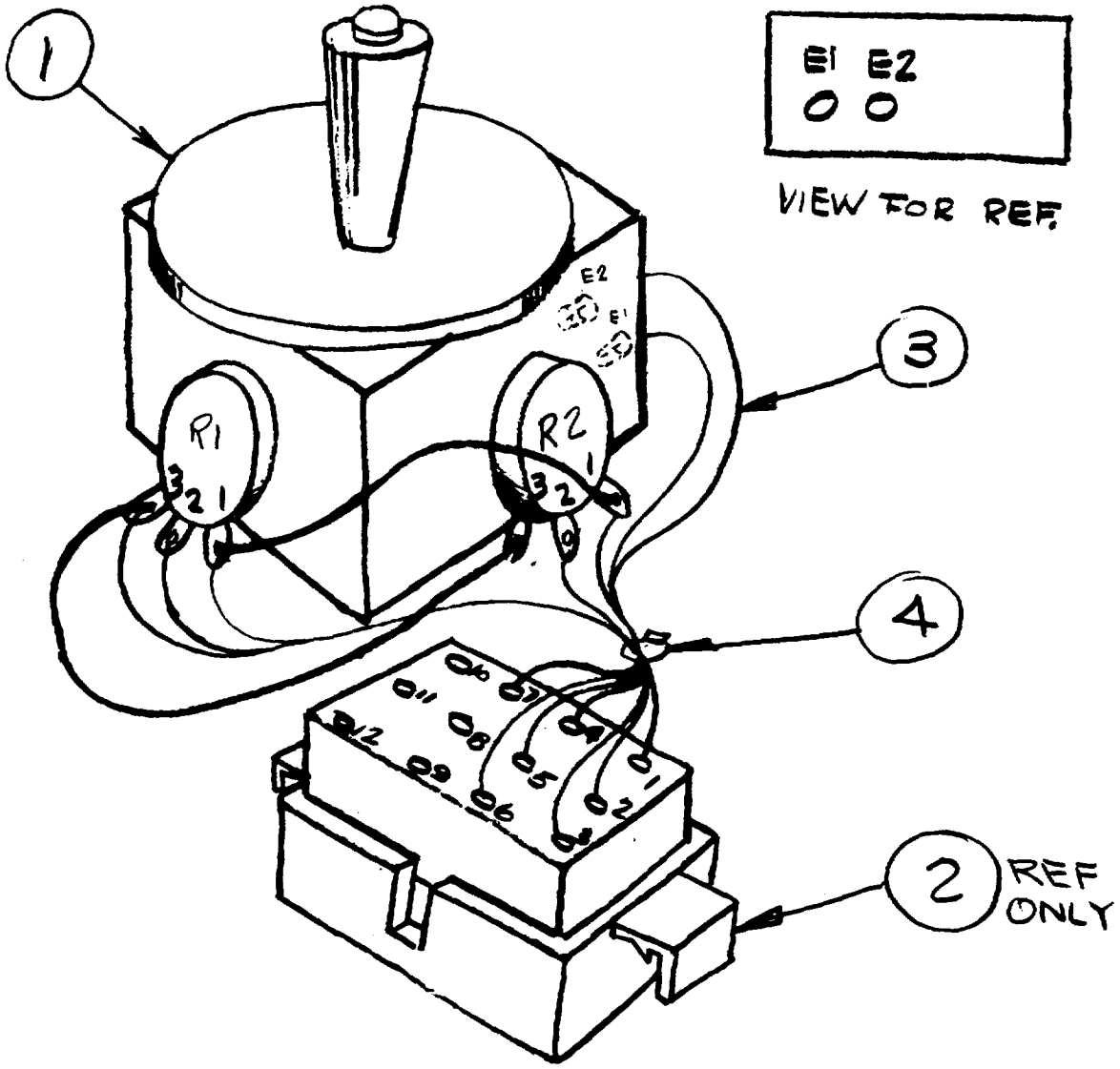
E167009 Rev. E

Figure 6-22 Memory PCB (A20A9A3) Assembly Drawing



D167006 Rev. C

Figure 6-23 Processor PCB (A20A9A4) Assembly Drawing



A982254 Rev. A

Figure 6-24 Joystick Assembly Drawing

NOTES:

1. EQUIP. REQ'D: 1-10.000V ±10mV SUPPLY
1-5 DIGIT VOLTMETER (ACCURATE TO 4 DIGITS)

2. PROCEDURE FOR ASSEMBLY & ADJUSTMENT

a) ATTACH POT. F/N #2 TO POT F/N #1 APPROX. AS SHOWN, USING RTV F/N #3, BEND & CUT LEADS ON POT. F/N #2 AS INDICATED.

b) JUMPER BOTH GND. TERMINALS ON POT F/N #1 USING #24 WHITE WIRE F/N #4.

c) JUMPER PIN #1 TO E + USING #24 WHITE WIRE F/N #4.

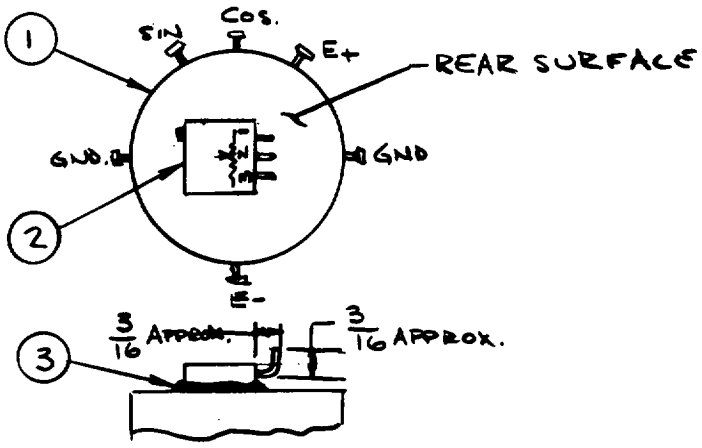
d) JUMPER PIN #2 TO GND. USING #24 WHITE WIRE F/N#4.

e) JUMPER FIN #3 TO E - USING #24 WHITE WIRE F/N #4.

f) APPLY 10.000V ±10mV FROM E+ TO E-.

g) ADJUST POT F/N #2 UNTIL VOLTAGE AT GND. PIN WITH RESPECT TO E - PIN READS 5.000V±10mV.

h) SEAL ADJ. SCREW ON POT F/N #2 WITH RADIO CEMENT.



B169130 Rev. A

Figure 6-25 Sine Cosine Potentiometer Assembly Drawing

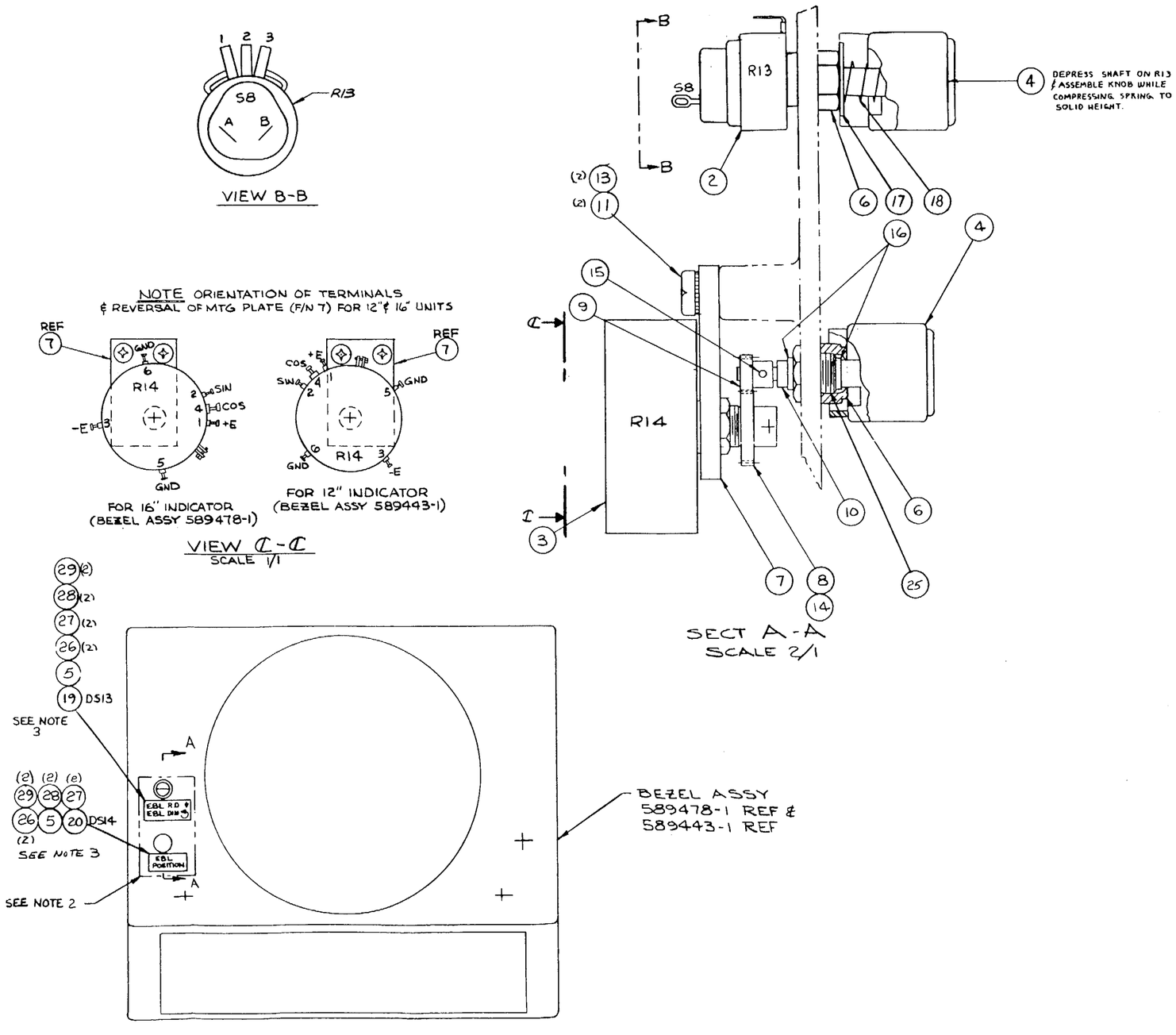


Figure 6-26 TM/EBL Assembly Drawing

7. THESE COMPONENTS NOT TO BE INSTALLED IN -2 OR -3.
8. THESE COMPONENTS NOT TO BE INSTALLED IN -3 ONLY.
9. FOR JUMPER WIRES SEE F/N 3 (JUMPER LIST).
10. BOARD MAY BE INSPECTED FOR COATING UNIFORMITY & OVERSPRAY BY PLACING BOARD UNDER AN ULTRA-VIOLET LIGHT SOURCE.
11. COAT BOARD ALL OVER WITH ULTRAVIOLET FLUORESCING COATING PER SPEC. A980135. MASK CONN. FINGERS, POTS & ETC.

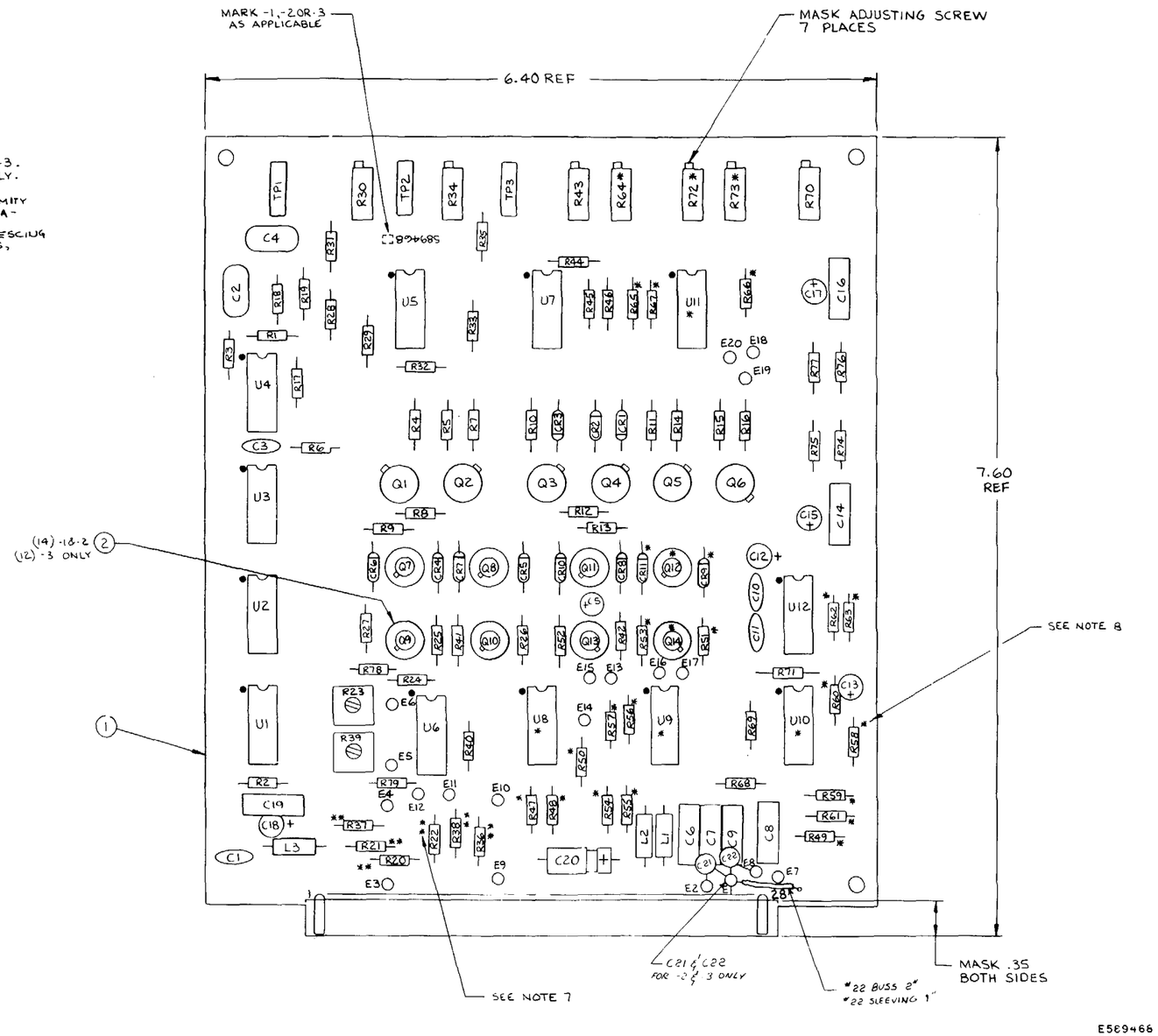


Figure 6-27. TM/EBL Circuit Card Assembly Drawing

APPENDIX A

GLOSSARY OF TERMS

This section of the manual contains a list of terms which are either peculiar to the TM/EP or may be unfamiliar to the user. The definitions supplied for standard industry terms describe the usage in this manual and may not be applicable to other systems.

Term	Definition
active high	produces the desired reaction when the inputs are at a logic 1 (high) level
active low	produces the desired results when the inputs are at a logic 0 (low) level
Address	the binary number identifying the location of a particular datum or function in memory
Address Bus	the lines carrying the individual bits of the Address
ADC	Analog to Digital Converter - converts voltage levels to their digital word equivalents
ALU	Arithmetic Logic Unit - performs arithmetic or logical manipulations of 1 or 2 input words
Address decoders	devices for converting the binary Address word to a single line signal
A Register	stores data for one input to the ALU
Az Offset X	sine function of Ship's Heading
Az Offset Y	cosine function of Ship's Heading
Address Bus Switched	signal diverting the control of the processor Address Bus to the Test Card
BCD	Binary Coded Decimal - a system for coding decimal numbers into binary form. The binary groups are limited to a maximum number of 9 (1001) and scaled by factors of ten to provide higher decimal digits
Binary	a number system based on 2. Each successive digit is twice the value of the previous
Binary word	sixteen binary bits (65,536 possible combinations)

Term	Definition
bit	a single binary digit
B Register	stores data for the second input to the ALU
bug	a bright spot on the CRT used to mark target position when used with reference to plotting or a bright spot on the EBL line indicating VRM range when used as VRM bug.
Bus	transmission line or group of lines connecting several components with signals traveling in both directions (at different times). Signals usually binarily related but not absolutely necessary
byte	eight binary bits (1/2 binary word) representing 0 through 7 bits or 8 through 15 bits
C(0-7)	individual bit lines of the Control (Address) Bus
CE(A-D)	Chip Enable inputs to the Program PROMs - enable outputs of the selected PROM devices
complement	inverted data of the original formatted data (logic 1 = low logic level and logic 0 = high logic level)
D(0-15)	individual bit lines of the Data Bus
DAC	Digital to Analog Converter - converts a binary word to a voltage level equivalent
data	information in numerical or logical form
Data Bus	group of lines used for carrying data throughout the system
decode	detect the presence of a particular binary word or group of words and produce a single output
dot	same as bug or spot
D Register	stores TIME display data
drift	movement of a vessel due to wind and currents
DRIFT SPEED	data representing ship's movement due to drift
DRIFT/TGT WORD	signal designating whether received data represents DRIFT SPEED or TARGET SELECT data
EBL	Electronic Bearing Line - provides an electrical bearing cursor line displayed on the CRT. Its origin coincides with the ship's position and it is

Term	Definition
	rotatable through 360° to permit rapid echo bearing determination.
EBL TIME Mark	spaces in the EBL representing the elapsed plotting time
E Clock	1 MHz pulse train used in processor timing
enable	provide a signal or level at one input to a logic gate that allows a signal at a second input to be passed through the gate
flag	a signal (logic high, logic low or pulse) that signals the processor to switch to a new routine
GYRO STAB	mode of radar operation wherein the top of the CRT always represents North
inhibit	signal level on an input to a logic gate that prevents a signal on another input from passing through the gate
instruction	the word on the Control (Address) Bus that determines which operation is to be performed
I Register	stores data for ADC operation
Joystick	electronic control used to position marks on the CRT by X and Y offset
load	enter data into a device
logic 0	for TTL ICs, a voltage less than 0.8 VDC
logic 1	for TTL ICs, a voltage greater than 2.4 VDC
logic high	logic 1
logic low	logic 0
LSB	Least Significant Bit - lowest order bit in a word
LSD	Least Significant Digit - lowest order digit in a number
MAN SPEED	manually entered ship's speed data
MAN/LOG	signal selecting speed inputs from manual switches or ship's speed log
Mark	dot on CRT representing target being plotted

Term	Definition
memory	device for storing data (bits, bytes, or words) for later use
MSB	Most Significant Bit - highest order bit in a word
MSD	Most Significant Digit - highest order digit in a number
MUX	Multiplexer - device for use in controlling a single line (or Bus) from multiple inputs by time sharing
NSK	North Stabilization Kit - allows the PPI presentation to be orientated to North. The PPI heading line flash will indicate the ship's heading on the relative bearing scale.
Offset	displacement of sweep origin from the CRT center
operation	a single processor function
PC	Program Count - specific step in a program expressed as a binary number
PC(0-10)	individual bit lines of the PC Bus
PC Clock	1 MHz signal which times program steps
PC Delayed	1 MHz signal, delayed from PC Clock by 90°, used for processor timing
program	the order in which instructions are given to the processor components
PROM	Programmable Read Only Memory - data storage IC, in which the data is stored after manufacture and once stored, cannot be changed
RAM	Random Access Memory - data storage device, in which the stored data can. be entered or changed electrically during normal operation
REL Mark	Relative Mark - dot on CRT representing the position of the Target at start of plot offset by Own Ship's movement
Reset	repositioning of the sweep origin to .7 CRT radius on the counter heading
RSW	Range Select Word - data representing the position of the RANGE select switch on the indicator

Term	Definition
register	a one word memory circuit
ROM	Read Only Memory - data storage device in which the data is stored during manufacture and cannot be changed
routine	a set of instructions within a program that cause the processor to perform a specific task
SF(X)	Software settable Flag - 1 bit register indicating sign
Speed Log	electronic/electrical device for indicating distance travelled in 1/200 nm steps
spot	same as bug or dot
SR(0-7)	individual bit lines of the S Register Bus
strobe	normally a narrow pulse that is used to time the operation of devices so that address and data values are stable during the operation
subroutine	a routine that may be repeated several times within a program
TM	True Motion
Trial Maneuver	electronic means of determining the results of a proposed change in heading and/or speed
true	data in its normal positive logic state (logic 1= high level and logic 0 = low logic level)
X Offset	displacement of the sweep origin from CRT center in an East/West direction (side to side)
Y Offset	displacement of the sweep origin from the CRT center in a North/South direction (up and down)

APPENDIX B

CONFIGURATION RECORD

The Configuration Record provides a means for orderly retention of service and bulletins and modification procedures. Upon completion of any field modification, the vessel's radar log book must be annotated to indicate the field change reference number and the date of modification.

All field bulletins applicable to the product should be filed in this section of the manual. Entries should be made in the Configuration Record below when one of the bulletins results in a change to the TM/EP radar.

BULLETIN NO.	DATE	REASON

☆ U.S. GOVERNMENT PRINTING OFFICE: 1995 - 388-421 (41051)

RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL MANUALS

SOMETHING WRONG WITH THIS MANUAL?

THEN. . .JOT DOWN THE DOPE ABOUT IT ON THIS FORM, TEAR IT OUT, FOLD IT AND DROP IT IN THE MAIL!

FROM: (YOUR UNIT'S COMPLETE ADDRESS)
Commander
Stateside Army Depot
ATTN: AMSTA-US
Stateside, N.J. 07703

DATE 10 July 1975

PUBLICATION NUMBER	DATE	TITLE
TM 11-5840-340-12	23 Jan 74	Radar Set AN/[illegible]-76

BE EXACT. . .PIN-POINT WHERE IT IS

PAGE NO.	PARAGRAPH	FIGURE NO.	TABLE NO.	IN THIS SPACE TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT:
2-25	2-28			Recommend that the installation antenna alignment procedure be changed throughout to specify a 2° IFF antenna lag rather than 1°. REASON: Experience has shown that with only a 1° lag, the antenna servo system is too sensitive to wind gusting in excess of [illegible] knots, and has a tendency to rapidly accelerate and decelerate as it hunts, causing strain to the drive train. Hunting is minimized by adjusting the lag to 2° without degradation of operation.
3-10	3-3		3-1	Item 5, Function column. Change "2 db" to "3db." REASON: The adjustment procedure for the TRANS POWER FAULT indicator calls for a 3 db (500 watts) adjustment to light the TRANS POWER FAULT indicator.
5-6	5-8			Add new step f.1 to read, "Replace cover plate removed in step e.1, above." REASON: To replace the cover plate.
		F03		Zone C 3. On J1-2, change "+24 VDC to "+5 VDC." REASON: This is the output line of the 5 VDC power supply. + 24 VDC is the input voltage.

TEAR ALONG DOTTED LINE

TYPED NAME, GRADE OR TITLE, AND TELEPHONE NUMBER
SSG I. M. DeSpiritof 999-1776

SIGN HERE: SSG I. M. DeSpiritof

DA FORM 1 AUG 74 2028-2

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DATE

PUBLICATION NUMBER	DATE	TITLE
TM 11-5840-360-14-2	30 Nov 81	Radar Set AN/SPS-64(V)5

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PAGE NO.	PARAGRAPH	FIGURE NO.	TABLE NO.

IN THIS SPACE TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT:

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