FLEXIBLE VOICE TRANSCRIPTION RECORDER/REPRODUCER

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AN/TNH-21

PART NUMBER 67-00-00

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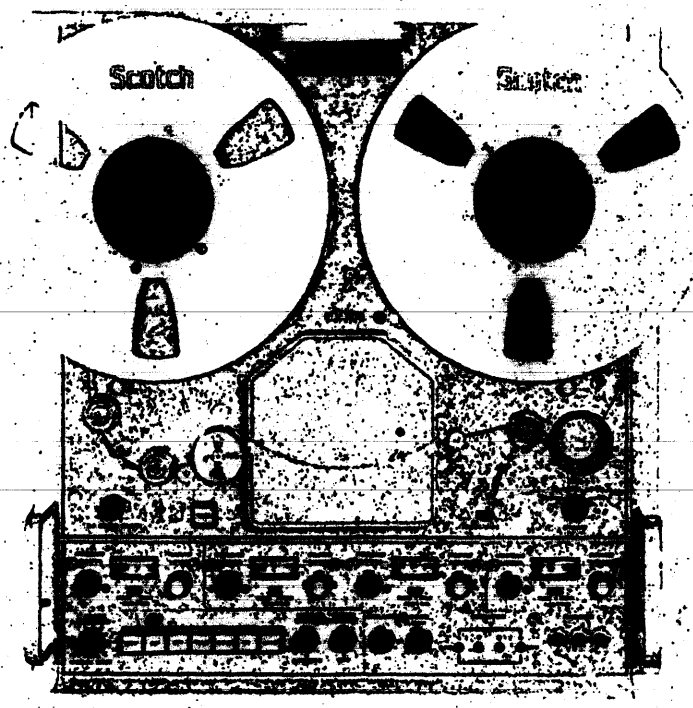


INSTRUCTION MANUAL

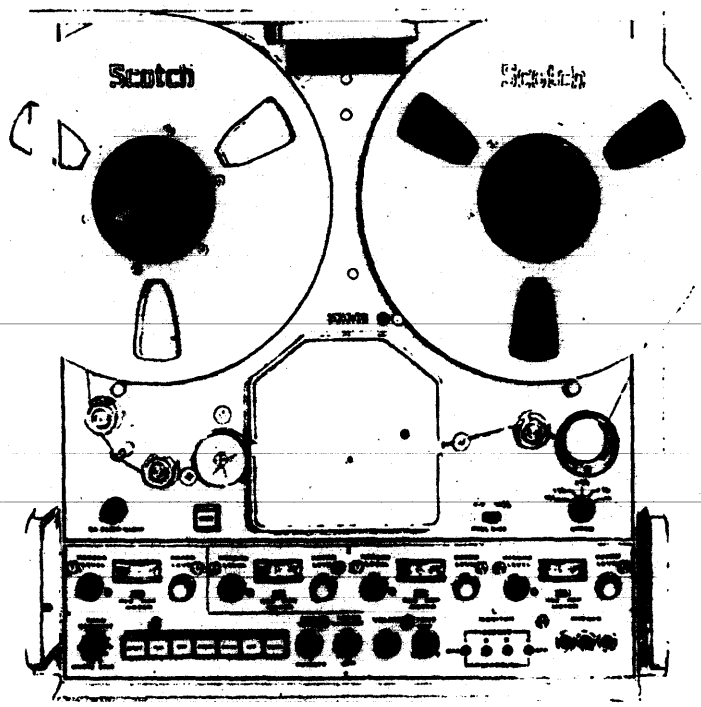
Mincom Division 3M COMPANY
300 S UTH LEWIS ROAD • CAMARILLO, CALIFORNIA 93 1

M67 RRM 8-72

FLEXIBLE VOICE TRANSCRIPTION RECORDER/REPRODUCER

AN/TNH-21

PART NUMBER 67-00-00



INSTRUCTION MANUAL

Mincom Division 3M COMPANY
300 SOUTH LEWIS ROAD • CAMARILLO, CALIFORNIA 93010

M67 RRM 8-72

DOCID: 3700720

INSTRUMENTATION TAPE RECORDERS

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Issue, date and manual number are:

Issue . . 1 . . Aug. 1972

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NOTE

Issue 1 of this manual, dated Aug. 1972 is for AN/TNH-21 (XR-3-128), Serial Numbers 1 through 25.

This manual is Catalog No. 83-5990-1277.

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SECTION I
GENERAL DESCRIPTION

1-1. GENERAL

1-2. The Flexible Voice Transcription Recorder/Reproducer, AN/TNH-21, Part Number 67-00-00, is manufactured by the Mincom Division of the 3M Company in Camarillo, California.

1-3. The AN/TNH-21 is a reel-to-reel, intermediate band, magnetic tape recorder/reproducer. It records and reproduces four tracks of data on 1/4 inch magnetic tape, and can use 4, 7, or 10-1/2 inch reels, either plastic or with NAB hubs. The recorder has five tape speeds and frequency ranges. In addition to the usual tape recorder modes of play, record, stop, rewind, and fast forward, the AN/TNH-21 has two special modes; a variable speed search mode, and a repeat mode that allows continuous repetition of a variable length of tape. Also, the tape speed is variable in the play mode, +50 to -30 percent.

1-4. The record input and reproduce output connectors are on the rear chassis. The play, stop, and rewind modes; and the search speed can be remotely controlled through the remote control connector on the rear chassis. Record and/or reproduce signals can be monitored by earphones from the front of the recorder.

1-5. EQUIPMENT DESCRIPTION

1-6. Functionally, the recorder consists of a tape transport, and signal electronics. Physically, it consists of five major assemblies: The top plate assembly, the rear chassis assembly, the logic pc board assembly, the record and reproduce pc board assembly (4 each), and the monitor pc board assembly. See figures 1-1 through 1-4, and table 1-1.

1-7. **TAPE TRANSPORT ASSEMBLY.** The tape transport assembly contains the mechanical and electromechanical tape handling components, that is, the reel motors, capstan motor, rotating tape guides, inertia idler, tachometer, tape tension sensor, REEL SIZE, tape SPEED, and POWER switches, fail safe brake, and reel revolution counter. Also, under the head cover are the erase, record, and play heads, fixed tape guides, capstan and idler, end-of-tape sensor, and preamplifier pc board assembly.

1-8. **REAR CHASSIS ASSEMBLY.** The rear chassis assembly contains the power supply components, power supply pc board, interconnecting wiring, external connectors, and connectors and interconnection wiring for the plug-in pc board assemblies. The power supply pc board assembly plugs into A7A and A7B on the rear chassis assembly. It contains components of the power supply regulators, bias and erase oscillator, reel motor and capstan motor drivers, and solenoid drivers.

1-9. **LOGIC PC BOARD ASSEMBLY.** The logic pc board assembly is a plug-in module containing the mode controls, SCAN SEGMENT controls, search SRCH SPEED control, and the capstan SPEED VERNIER control. The pc board contains the tape transport logic circuitry, and the capstan servo circuitry.

1-10. **MONITOR PC BOARD ASSEMBLY.** The monitor pc board assembly is a plug-in module and contains the monitor controls and monit r circuitry, the search servo circuitry, and the up-down counter for the repeat function.

1-11. **RECORD AND REPRODUCE PC BOARD ASSEMBLY.** There are four identical record and reproduce pc board assemblies. These are plug-in modules; each contains the complete record and reproduce electronics for one channel; except for the record bias and erase oscillator. On the front panel is the record and reproduce level controls, monitor meter and meter switch. Internally on each board is an input and output BAL switch for selecting either a balanced or unbalanced to ground input and/or output.

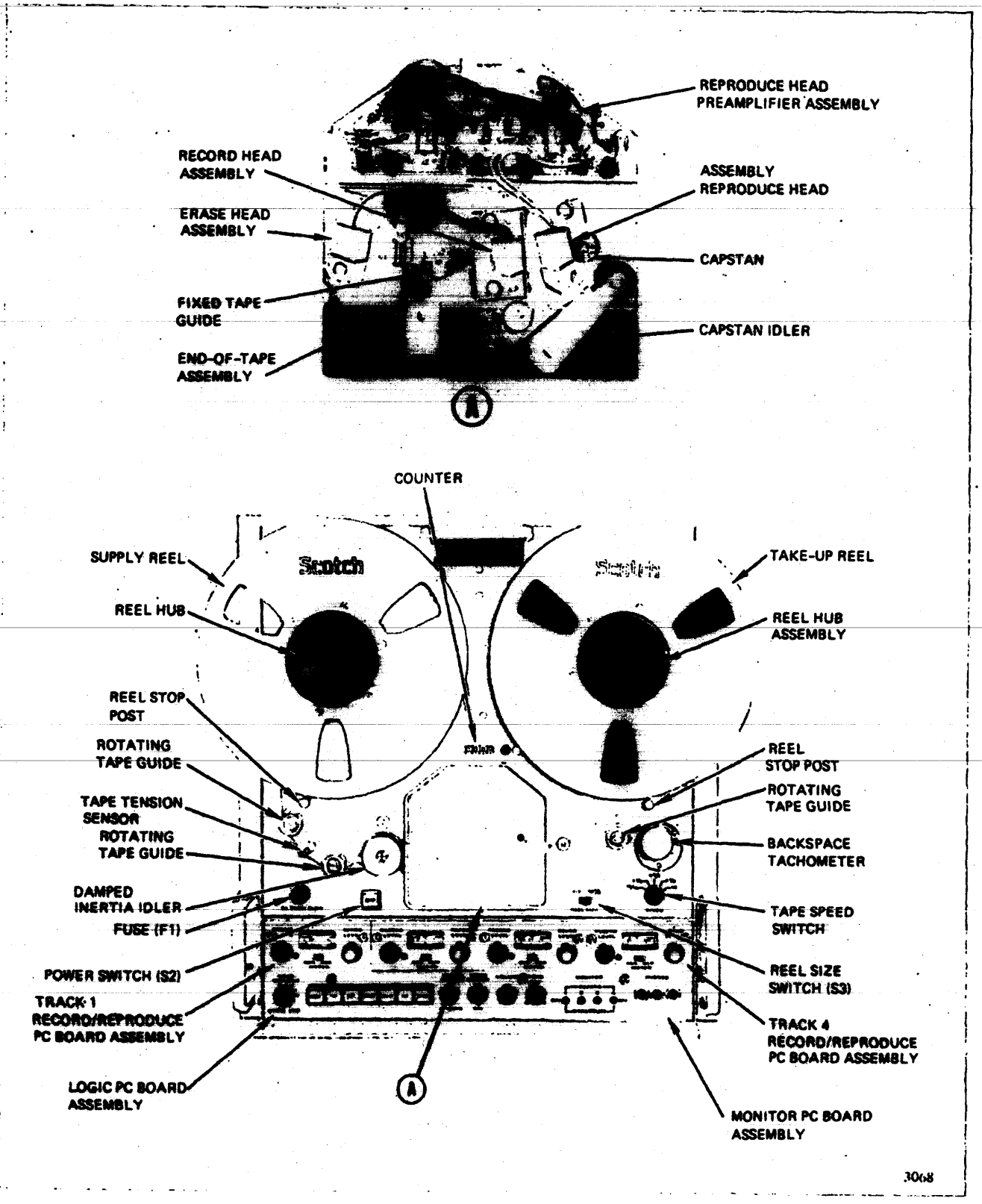


Figure 1-1. Flexible Voice Transcription Recorder/Reproducer, AN/TNH-21 (XR-3-128), Front View

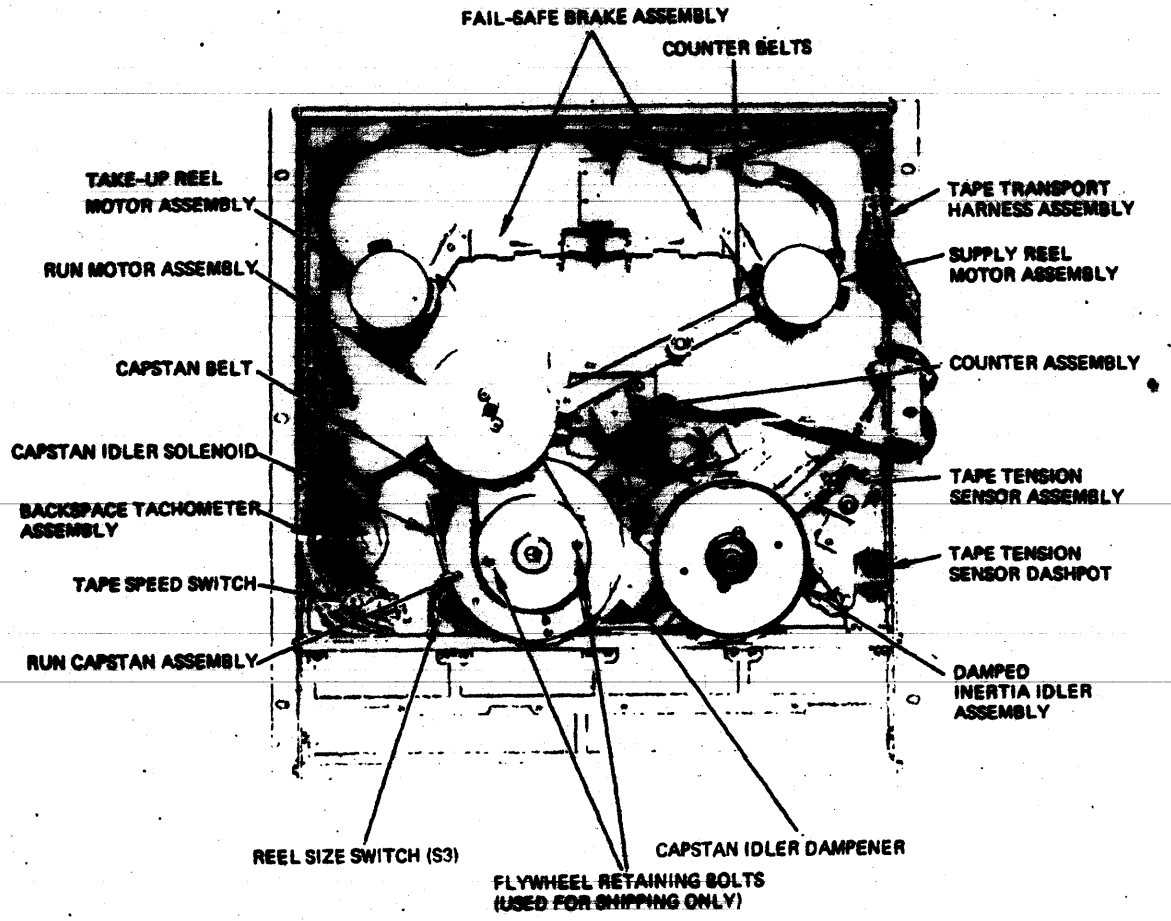


Figure 1-2. Tape Transport, Rear View

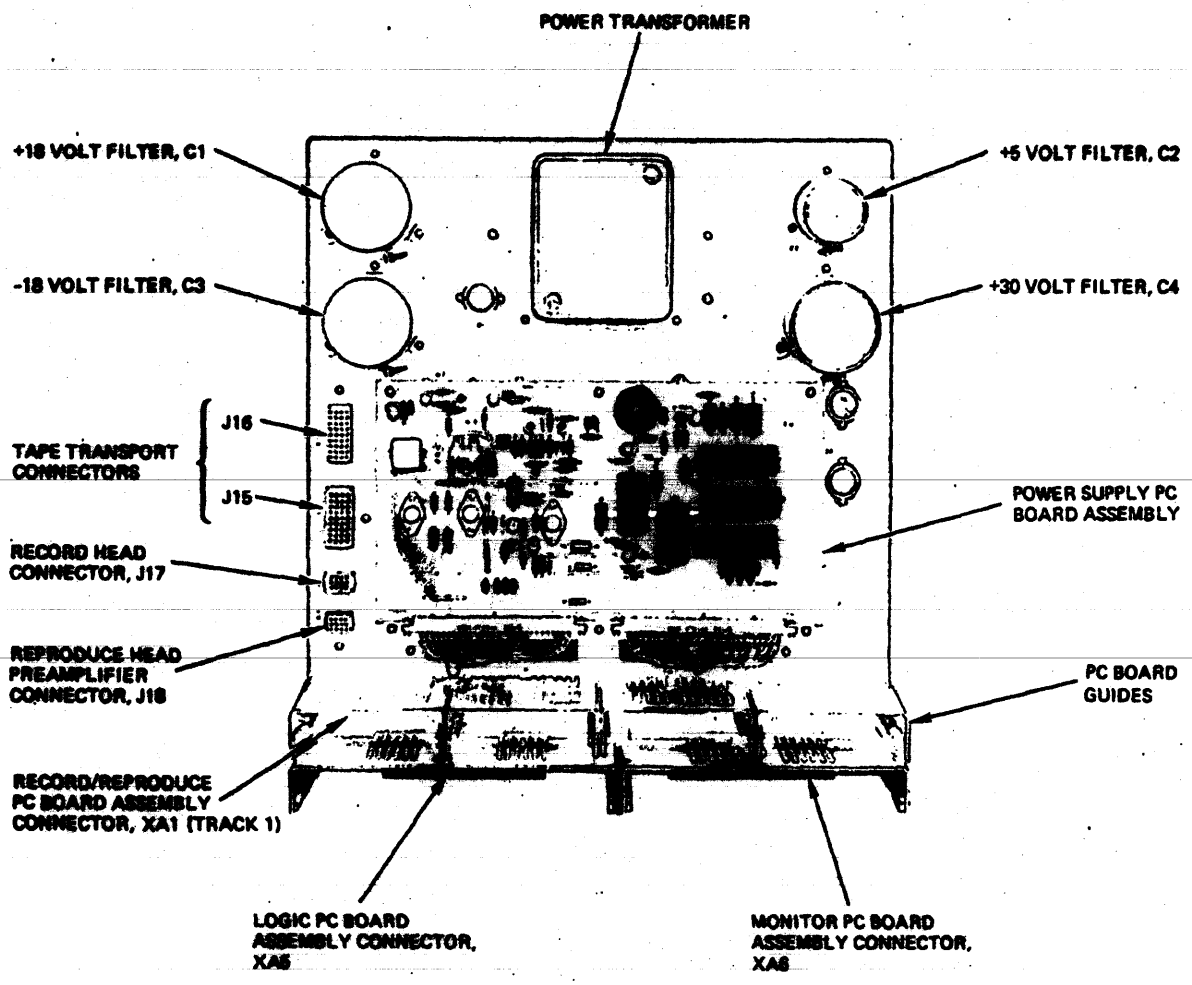


Figure 1-3. Rear Chassis Assembly, Front View

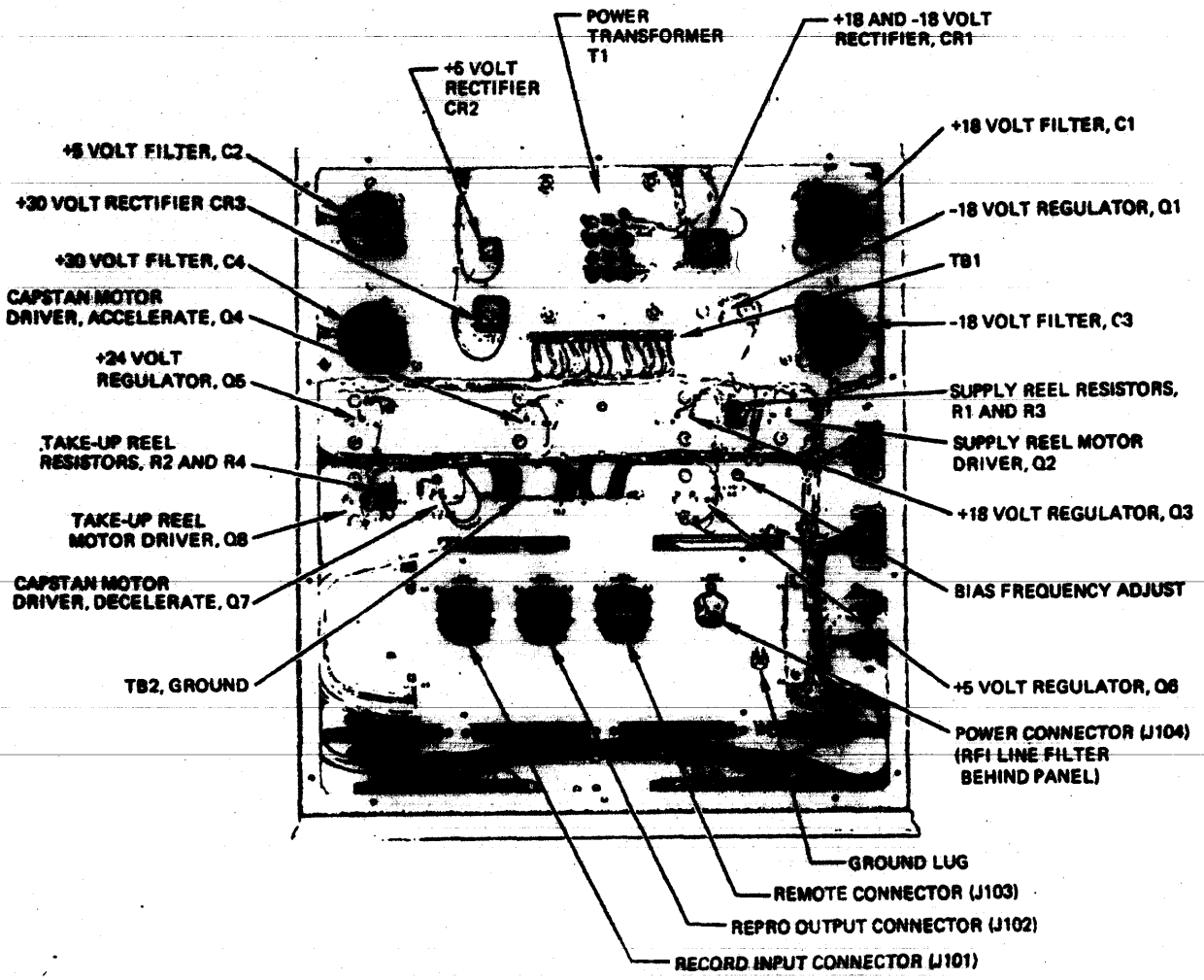


Figure 1-4. Rear Chassis Assembly, Rear View (Back Cover Removed)

1-12. ACCESSORY KIT

1-13. The Accessory Kit is contained in a compartment at the top of the shipping container. It consists of two extender boards; one for the logic, and the monitor and repeat control pc boards, and one for the record/reproduce pc board. It also contains a manual and mating connectors for the RECORD, REPRO, and REMOTE connectors.

1-14. SPECIFICATIONS

1-15. Specifications are presented in table 1-2. Performance specifications are based upon operation and maintenance according to the procedure presented in this manual. Deviation from the procedures or modification of the equipment may result in degradation of the performance.

Table 1-1. List of Equipment

EQUIPMENT	DESCRIPTION
Flexible Voice Transcription Recorder/Reproducer, AN/TNH-21 (XR-3-128) (67-00-00)	This is the complete recorder/reproducer with four channels of signal electronics.
Tape Transport Assembly (67-03-00)	The tape transport assembly contains the tape handling components of the tape transport, the magnetic heads, reproduce preamplifier assembly and the frame assembly for the front half of the recorder. These assemblies are: run capstan idler assembly, inertia idler assembly, reel motor assemblies, back-space tachometer assembly, tape guide assemblies, run motor assembly, reel revolution counter assembly, fail-safe brake assembly, end-of-tape assembly, tension sensor assembly, tape transport harness, erase head assembly, record head assembly, reproduce head assembly, and the preamplifier pc board assembly.
Run Capstan Assembly (67-01-00)	The run capstan assembly drives the tape at the proper tape speed in the play and record modes. It consists of the capstan shaft, magnetic flywheel, tachometer printed circuit board, magnetic pole piece, and housing assembly; the actuator arm, solenoid, and dashpot.
Damped Inertia Idler Assembly (67-52-00)	The damped inertia idler assembly is a high mass, viscous damped rotating idler that reduces perturbations in the tape. It consists of the large idler and flywheel assembly located on the left hand side of the magnetic heads.
Reel Motor Assembly (67-04-00, -01 Supply Reel, -02 Take-up Reel)	There are two reel motor assemblies, supply and take-up. They attach to the transport plate and consist of a reel motor, reel spindle, reel base, brake tire, reel motor pulley and motor.
Backspace Tachometer Assembly (67-05-00)	The backspace tachometer assembly is the last tape path component before the take-up reel. It consists of two photo-transistors and two light sources, two reticles, a tachometer disc connected to a rotating idler in the tape path, and associated wiring and hardware. The tachometer produces two outputs; one is used for the search servo, and to drive the repeat up-down counter, and the phase relation between the two outputs is used for a direction sensor signal.

Table 1-1. List of Equipment (Cont.)

EQUIPMENT	DESCRIPTION
Tape Guide Assembly (67-06-00)	This is the rotating tape guide assembly and includes the tape guide, bearings, and base. There are three rotating tape guides, two on the supply reel side and one on the take-up reel side. They attach to the transport plate by a single No. 8 screw and are adjustable for tracking by a screw on top of the guide.
Run Motor Assembly (67-07-00)	The run capstan motor assembly includes the motor, motor pulley, flywheel, and housing.
Reel Revolution Counter Assembly (67-11-00)	The reel revolution counter assembly consists of the counter, idler pulley, reset solenoid, brackets, and belts. It is connected by belts to, and indicates revolutions of, the supply reel.
Fail-Safe Brake Assembly (67-12-00)	The fail-safe brake assembly is located on the back of the transport plate, between the reel motors. The brakes are disengaged in standby and all operating modes, and engaged when power is off. The fail-safe brake assembly consists of a solenoid to disengage the brakes, and a friction brake for each reel. The brakes are engaged by springs when power is removed from the solenoid.
End-of-Tape Assembly (67-14-00)	The end-of-tape sensor assembly is located under the head cover, between the erase and record heads. It consists of a lamp, phototransistor, and wiring. It is arranged in the tape path so that when tape is threaded, the tape interrupts the light from the lamp to the phototransistor.
Tension Sensor Assembly (67-20-00)	The tension sensor assembly is located on the back of the transport plate, and has an arm that protrudes through the transport plate and into the tape path between the two rotating tape guides on the supply reel side of the recorder. It senses the tape tension and provides an output signal to the reel servo. The tension sensor assembly consists of an arm, flag, dashpot,spring, and bracket containing a lamp, photocell, and capacitor.
Tape Transport Harness Assembly (67-03-20)	The tape transport harness assembly contains the SPEED switch, REEL SIZE switch, and POWER switch; and the wiring and connectors for the transport plate assembly, and interconnection to the rear chassis.
Erase Head Assembly (67-10-10)	The erase head is the left-hand head located under the head covers. The erase head assembly consists of the erase head, mounting plate, cable and connector. The erase head is not repairable and must be replaced as a complete assembly.
Record Head Assembly (67-10-20)	The record head assembly is the center head under the head cover. It consists of a four track record head, mounting plate, and cable and connector. The record head assembly is not repairable and must be replaced as a complete assembly.

Table 1-1. List of Equipment (Cont.)

EQUIPMENT	DESCRIPTION
Reproduce Head Assembly (67-10-30)	The reproduce head assembly is the right-hand head under the head cover. It consists of a four track reproduce head and mounting plate. The reproduce head azimuth is adjustable by turning the azimuth adjust screw adjacent to the head. The head assembly is not repairable and must be replaced as a complete assembly.
Reproduce Head Preamplifier Assembly (67-22-00)	The reproduce head preamplifier assembly is a pc board assembly located under the upper head cover. It contains two, dual IC amplifiers providing four channels of amplification. The reproduce head is hardwired to the preamplifier pc board and the signal outputs are through a cable and connector (P18) to the rear chassis assembly.
Record/Reproduce PC Board Assembly (67-23-00)	Four record/reproduce pc board assemblies are used in the recorder. Each assembly contains the record electronics and bias mixing circuitry, the reproduce tape speed equalizers and output amplifier, and the meter and meter amplifier. The RECORD LEVEL, REPRO LEVEL, meter, METER REC/REP switch are located on the front panel.
Logic PC Board Assembly (67-21-00)	The logic pc board assembly is located in the lower left-hand corner of the recorder, and contains the tape transport logic and capstan servo circuitry. On its front panel are the mode controls, SCAN SEGMENT, SRCH SPEED, and capstan SPEED VERNIER controls.
Monitor PC Board Assembly (67-24-00)	The monitor pc board assembly is located in the lower right-hand corner of the recorder. It contains the audio monitoring circuitry, search servo circuitry, up-down counter circuitry for the repeat function. The audio monitoring controls are located on the front panel.
Rear Chassis Assembly (67-16-00)	The rear chassis assembly consists of the chassis containing the power supply transformer, filter capacitors, and power transistors, the harness assembly, the power supply pc board assembly, card guides, and the power cord. Also, the rear, side, top, and bottom covers are a part of the rear chassis assembly.
Rear Chassis Harness Assembly (67-16-20)	The rear chassis harness assembly consists of the wiring and connectors of the rear chassis, including the connectors for all of the plug-in pc boards and external connectors.
Power Supply PC Board Assembly (67-25-00)	The power supply pc board assembly plugs into connector A7A and A7B on the rear chassis. It contains components of the power supply regulators, the bias and erase oscillator, reel motor and capstan motor circuitry and solenoid drivers.

Table 1-1. List of Equipment (Cont.)

EQUIPMENT	DESCRIPTION
Power Cable Assembly (67-16-10)	This is the primary power cable. It contains a molded three prong plug on one end and an MS type connector on the other end for connecting to the recorder.
Shipping Container (67-27-00)	The shipping container consists of a wooden outer container, a cardboard inner container and polyfoam cushions between the inner and outer containers. There is a compartment at the top of the inner container for accessories. The inner cardboard container is sealed in a vapor barrier bag for overseas shipment.
Accessory Kit (67-29-00)	The accessory kit consists of the logic and monitor pc board extender, record/reproduce pc board extender, instruction manual, and mating connectors for the RECORD, REPRO, and REMOTE connectors. It also contains a plastic container for the capstan belt, and a modified Allen wrench for capstan belt tension adjustment.
Record/Reproduce PC Board Extender (67-31-00)	This is the extender board for the record/reproduce pc board assembly. It allows the record/reproduce board to be operated while extended from the recorder for maintenance purposes. This board is a part of the accessory kit.
Logic and Monitor PC Board Extender (67-30-00)	This is the extender board for the logic and monitor pc board assemblies. It allows the logic or monitor pc board assembly to be operated while extended from the recorder for maintenance purposes. This board is part of the accessory kit.

Table 1-2. Specifications

CHARACTERISTIC	SPECIFICATION
GENERAL	
Finish	Light grey semigloss enamel, non glare.
Size	Occupies 19-1/4 inches of vertical rack space in a standard CY597 19-inch rack with a depth of not more than 15 inches. When 10 1/2-inch reels are used, they project 1-1/2 inches on each side beyond the 19 inch panel space.
Weight	Less than 90 lbs.
Power	115 volts ±20 volts ac single phase ac, 48 -62 Hz power consumption will not exceed 250 watts at 115 volts, 60 Hz nominal input.
Ground	A readily accessible grounding stud, for attaching a ground wire is provided.
Connectors	External chassis connectors are AN type or equivalent. Mating connectors are provided.
Temperature	Operating - 0° to 55°C. Storage – 54°C to +70°C

Table 1-2. Specifications (Cont.)

CHARACTERISTIC	SPECIFICATION
Altitude	Operating to 10,000 feet. Non-operating to 40,000 feet.
Humidity	Operating and non-operating 5% to 100% without condensation.
RFI	Meets the intent of RE and RS tests for class 1C equipment as described in Table II of MIL-STD-461A.
Shock and Vibration	Per MIL-STD-810B, test Method 514 Procedure X Curve AV and Method 516 Procedures II and V during shipment by common carrier and bench handling.
Handles	Three handles are provided for removal of the equipment from the rack.
MECHANICAL	
Tape Transport	
Reel Sizes	Accepts standard NAB reels in the range of 4 inches to 10-1/2 inches O.D.
Magnetic Tape	1/4-inch magnetic tape, 3M 150 or equivalent, is recommended. The tape transport can handle 1/4-inch tapes of 0.5 mils to 1.5 mils in thickness.
Tape Speeds	Tape speeds are selected with a five position rotary switch for 15, 7-1/2, 3-3/4, 1-7/8, and 15/16 ips.
Tape Speed Stability	±0.25% end-to-end of reel at all fixed speeds.
Tape Speed Accuracy	±0.25% end-to-end of reel at all fixed speeds.
Vernier Speed	A vernier speed control provides for +50% to -30% speed variable from any selected speed, with a speed stability of ±0.5% once the percent offset has been selected.
Search Mode	Capable of continuously adjusting forward speed from 2 ips through 60 ips. Speed stability of ±1.5% from end-to-end of reel for any selected speed within the range. Tape flutter measured from a pre-recorded tape (15 ips record speed) not more than 1.0% rms over a 0.5 to 250 Hz bandwidth with a selected search speed of approximately 15 ips, 2% rms at 3-3/4 ips.
Repeat Scan	Provides for immediate and continual repetition of up to ten (10) seconds of tape by activation of the repeat pushbutton switch. The repeat function also allows vernier speed control and functions at any tape speed.

Table 1-2. Specifications (Cont.)

CHARACTERISTIC	SPECIFICATIONS
Fast Forward/Rewind Speed	At least 180 ips (average).
Start Time	Time required to reach 95% of operating speed from ready condition will not exceed 0.25 seconds at 15/16 ips, 1-7/8 ips, and 3-3/4 ips, and 1.0 second at 7-1/2 ips and 15 ips.
Stop Time	Less than 1.0 second from any fixed tape speed.
Operating Controls	All operating controls are functionally grouped on the lower portion of the system front panel.
Transport Controls	Backlighted Pushbuttons for: POWER RECORD REPEAT REWIND PLAY FORWARD STOP SEARCH Transport speeds selected by five position rotary switch. Speed vernier control with OFF position provides for variable play speed. Search speed potentiometer permits continuous adjustment of forward speed. Scan segment potentiometers with concentric shafts provide repeat scan limit controls.
Mode Interlocks	Transport mode-to-mode controls are electrically interlocked to allow any sequence of commands without causing tape damage or machine malfunction. Recorded data is protected by an interlock that inhibits the record mode unless PLAY and RECORD are simultaneously actuated.
Level Controls	Record level potentiometer, one per module. Reproduce Level potentiometer, one per module. Bias Level potentiometer, one per module. Monitor Volume potentiometer. Monitor tone potentiometer.
Monitor Channel Select	4 three position toggle switches, one per voice channel, permit record, reproduce or off selection for each channel. Provides for any combination of inputs and outputs to a single output consisting of three phone jacks in parallel.
Meter	Vu meter switch selectable for record or reproduce. One meter for each analog module.
Remote Control	Provision for foot pedal remote control is provided by rear chassis AN connector with contacts in parallel with play, rewind, stop, search, and variable search speed control. Includes provision for remote light indicator for each mode.

Table 1-2. Specifications (Cont.)

CHARACTERISTIC	SPECIFICATION
Reel Revolution Counter	Four digit counter, with automatic and manual reset, provided to determine the approximate location of any point during the recording. Automatic reset occurs at tape runout in the rewind mode. Capable of displaying a change for each hub rotation.
Fail Safe	Function in the event of tape breakage, end-of-reel, or power failure in any mode.
Wow and Flutter	Cumulative flutter, peak-to-peak, 95% of time.

Tape Speed	Measurement Bandwidth	% Flutter Peak-to-Peak
15	0.2 Hz to 2.5 kHz	Less than 0.4
7-1/2	0.2 Hz to 1.2 kHz	Less than 0.5
3-3/4	0.2 Hz to 625 kHz	Less than 0.7
1-7/8	0.2 Hz to 312 Hz	Less than 1.0
15/16	0.2 Hz to 156 Hz	Less than 1.5

ELECTRICAL

Analog Electronics	System is equipped with four plug-in analog record/reproduce modules housed below the transport. Front panel of each module is equipped with a record level control, reproduce level control, bias adjustment and a meter with a selector switch for record or reproduce monitoring.
Frequency Response	

Tape Speed	Bandwidth (±3 dB)	Signal/Noise Ratio (dB)*
15	200 Hz to 64 kHz	Greater than 30 dB
7-1/2	200 Hz to 32 kHz	Greater than 30 dB
3-3/4	200 Hz to 16 kHz	Greater than 30 dB
1-7/8	200 Hz to 8 kHz	Greater than 30 dB
15/16	200 Hz to 4 kHz	Greater than 30 dB

*Signal-to-noise (rms to rms) is referenced to the nominal output of 0.77 volt rms at 1% 3rd harmonic distortion of a 1 kHz signal at all tape speeds, using 3M Brand 150 tape or equivalent.

Crosstalk	-40 dB maximum between any two channels across the system bandwidth.
Input Level	Nominal input level is 0.77 volts rms (0 dBm). Capable of accepting input levels of -30 to +12 dBm.
Input Impedance	10,000 ohms ±20% transformer coupled; balanced or unbalanced to ground, switch selectable.

Table 1-2. Specifications (Cont.)

CHARACTERISTIC	SPECIFICATION
Output Level	Nominal output level is 0.77 volts rms (0 dBm). A signal recorded at 12 dB below normal record level may be reproduced at 0 dBm output level.
Output Impedance	600 ohms ±20% transformer coupled; balanced or unbalanced to ground, switch selectable.
Reproduce Equalization	Each of the four reproduce channels has equalization for five transport speeds. Equalization is automatically selected with transport speed selection.
Monitor Electronics	A single channel of monitor electronics, located on one plug-in module, is switch selectable to any combination of record inputs or reproduce outputs. Volume control, tone control, monitor select switches, and three sets of headphone jacks are located on the module front panel.
Output Level	Will drive up to three 600 ohm headsets in parallel at a level of 0.77 volts rms with a reserve gain of 12 dB.
Crossover	Differential bass versus treble characteristic with a 1.0 kHz crossover. Control potentiometer provides a range of at least ±12 dB at 200 Hz and 3.2 kHz.
Squelch	Squelch circuit disables monitor amplifier output during fast forward, and rewind modes, and during the backspace portion of the repeat mode.
Heads	
Configuration	Four tracks on 1/4 inch wide tape which are symmetrical with respect to the tape center line. Center to center spacing of the tracks is 0.067 +0.001, -0.000 inch.
Record Head	Four track in-line head stack. Fixed mount with no adjustments. Track width 0.043, +0.000, -0.005 inch.
Reproduce Head	Four track in-line head stack with azimuth adjustment. Track width is 0.043 +0.000, -0.005 inch.
Erase Head	Full track (0.240 inch width). Simultaneously energized with the record head to provide 56 dB erasure of saturated tapes.
Channel Designation	Four channels consecutively numbered from 1 to 4 across the width of the tape. Channel 1 appears at top when tape moves from left to right with coated side facing away from observer.

SECTION II
INSTALLATION

2-1. GENERAL

2-2. The AN/TNH-21 is designed for installation in a standard 19-inch equipment rack, although it may be installed in any reasonable location. Installation consists of unpacking the recorder, location considerations, physical installation, unbolting the capstan flywheel, installing the capstan belt, and proper power and signal interface and connections.

2-3. UNPACKING (See figure 2-1.)

2-4. The recorder and accessories are shipped in a special wooden outer container and cardboard inner container with fitted polyfoam cushions between the wooden and cardboard container. The accessory kit, power cable, and capstan belt are in a compartment at the top of the inner cardboard container. If the recorder is packed for overseas shipment, the inner cardboard container is sealed in a vapor barrier bag and three, 8 unit bags of desiccant are added to the accessory compartment. The shipping container is reusable and should not be destroyed in the process of unpacking the recorder. The procedure is as follows:

1. Place the shipping container on the floor in the upright position. Inspect for any noticeable shipping damage. If any, notify the delivering carrier and shipper immediately. If there is no damage, proceed with the unpacking.
2. Remove the three, 3/4-inch steel shipping bands.
3. The top of the shipping container is nailed on. Pry the top off with a crowbar or appropriate tool, and remove the top.

WARNING

Nails will be protruding from the under side of the top. Drive the nails out and remove with a claw hammer.

4. Remove the top polyfoam cushion.

NOTE

When the recorder is packed for overseas shipment, the inner cardboard container is sealed in a vapor barrier bag and three, 8 unit bags of desiccant are placed in the accessory compartment.

5. If applicable, open the vapor barrier bag.
6. Open the inner cardboard container. It is taped with shipping tape.
7. Remove the accessories from the accessory compartment.
8. Lift out the triple walled cardboard accessory compartment spacer.
9. Lift out the bottom of the accessory compartment, and remove the plastic covering the front of the recorder.
10. Lift the recorder by its handles and remove from the shipping container. The cardboard spacers on the sides, top, and bottom of the recorder are taped together and will be removed with the recorder.
11. Place the recorder on a secure surface and remove the spacers taped around the top, bottom, and sides.

2-5. LOCATION CONSIDERATIONS

2-6. The recorder can be installed in any location as long as reasonable judgment is used. It is designed for installation in a standard 19-inch equipment rack although this is not necessary. Installation should not be in an extremely dusty or damp area. Strong magnetic fields, such as that created by power transformers and large electric motors, should be avoided. Installation above any equipment that produces a large amount of heat, such as vacuum tube equipment, should be

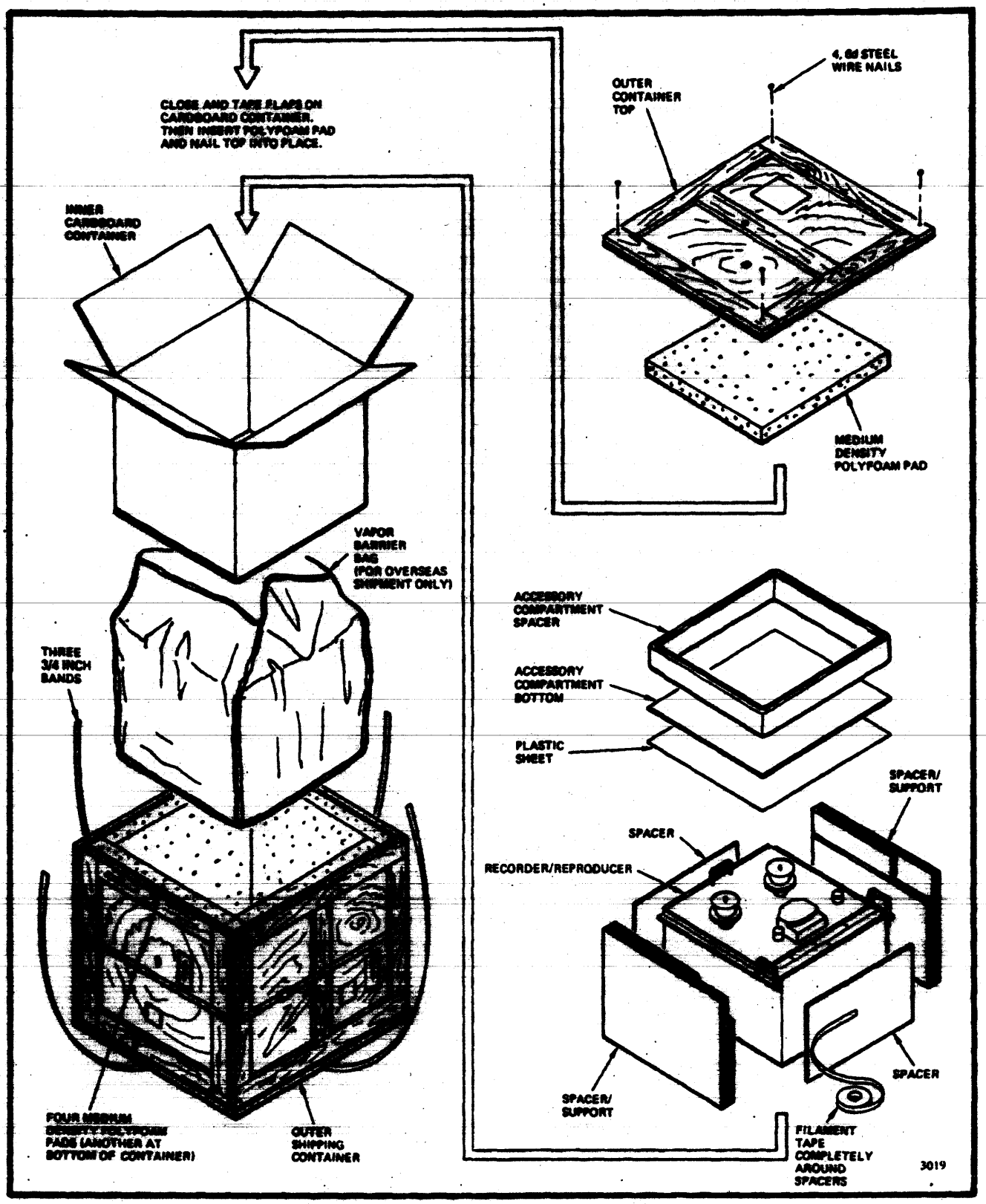


Figure 2-1. Shipping Container, Exploded View

avoided. Adequate clearance should be allowed at the the bottom, top, and sides to provide proper air circulation, and at the rear of the recorder for cable connection. See figure 2-2 for the recorder dimensions.

2-7. RACK INSTALLATION

2-8. The recorder requires 19-1/4 inches of vertical rack space, and 12 inches of cabinet depth for the recorder excluding interfacing. When 10-1/2 inch reels are used, the reels will project 1-1/2 inches on each side of the recorder. The recorder is secured in the equipment rack by screws, washers, and lockwashers.

2-9. When the recorder is shipped, the capstan belt is removed and stored in the accessory compartment of the shipping container, and the capstan flywheel is secured by two 10-32 x 2 inch socket head bolts. It is best to remove the flywheel retaining bolts after the recorder is installed; however, this requires access to the inside of the recorder from either the top or side. If this will not be convenient, the flywheel retaining bolts may be removed and the capstan belt installed before the recorder is installed.

CAUTION

Once the capstan retaining bolts are removed, and the capstan belt is installed, the flywheel is free to turn. A severe jolt to the recorder can cause the belt to come off and/or damage the capstan bearings; therefore, use reasonable care when installing the recorder.

2-10. At least two people are required to install the recorder in a rack. If access to the inside of the recorder will not be convenient after installation, install the capstan belt and remove the retaining bolts from the flywheel as described in paragraph 2-11. Install the recorder in the equipment rack using six 10-32 x 3/4 inch screws, washers, and lockwashers.

2-11. CAPSTAN FLYWHEEL RETAINING BOLT REMOVAL AND BELT INSTALLATION. Remove the capstan flywheel retaining bolts and install the capstan belt as follows:

1. Remove the top cover from the recorder.
2. Using a 5/32 Allen wrench, remove the two 10-32 x 2 inch socket head bolts from the end of the capstan flywheel. See figure 1-2.
3. Place the capstan belt over the capstan motor pulley, and then around the flywheel while slowly rotating the flywheel by hand.
4. Reinstall the top cover of the recorder.

2-12. INTERFACE INFORMATION

2-13. Interface consists of the proper power, signal, and remote control connections. The power cable is furnished and mating external connectors are furnished for the signal and remote control connectors. A remote control unit is not provided.

2-14. POWER. The recorder requires 115 volts ±20 volts, single phase, 48 to 62 Hz power. The recorder requires a maximum of 250 watts. Connect the power cable to the POWER connector J109, and a proper ac power source.

2-15. RECORD INTERFACE. The nominal record input signal is 0.778 volts rms (0 dBm) into a 10,000 ohm, balanced or unbalanced load. The record inputs are connected to the RECORD connector, J101. See figure 2-3 for wiring details.

2-16. REPRODUCE INTERFACE. The reproduce output signal is nominally 0.778 volts rms (0 dBm) and is adjustable by the REPRO control from 0 to +12 dBm into a 600 ohm load. The reproduce outputs are connected to the REPRO connector J102. See figure 2-4 for wiring details.

2-17. REMOTE CONTROL INTERFACE. The stop, play, rewind, and search modes; and the search speed may be remotely controlled. The connections are made at the REMOTE connector, J103. See figure 2-5 for wiring details.

2-18. RESHIPMENT AND STORAGE

2-19. If the recorder is reshipped or stored after once installed, the capstan belt must be removed and the flywheel retaining bolts reinstalled. This is

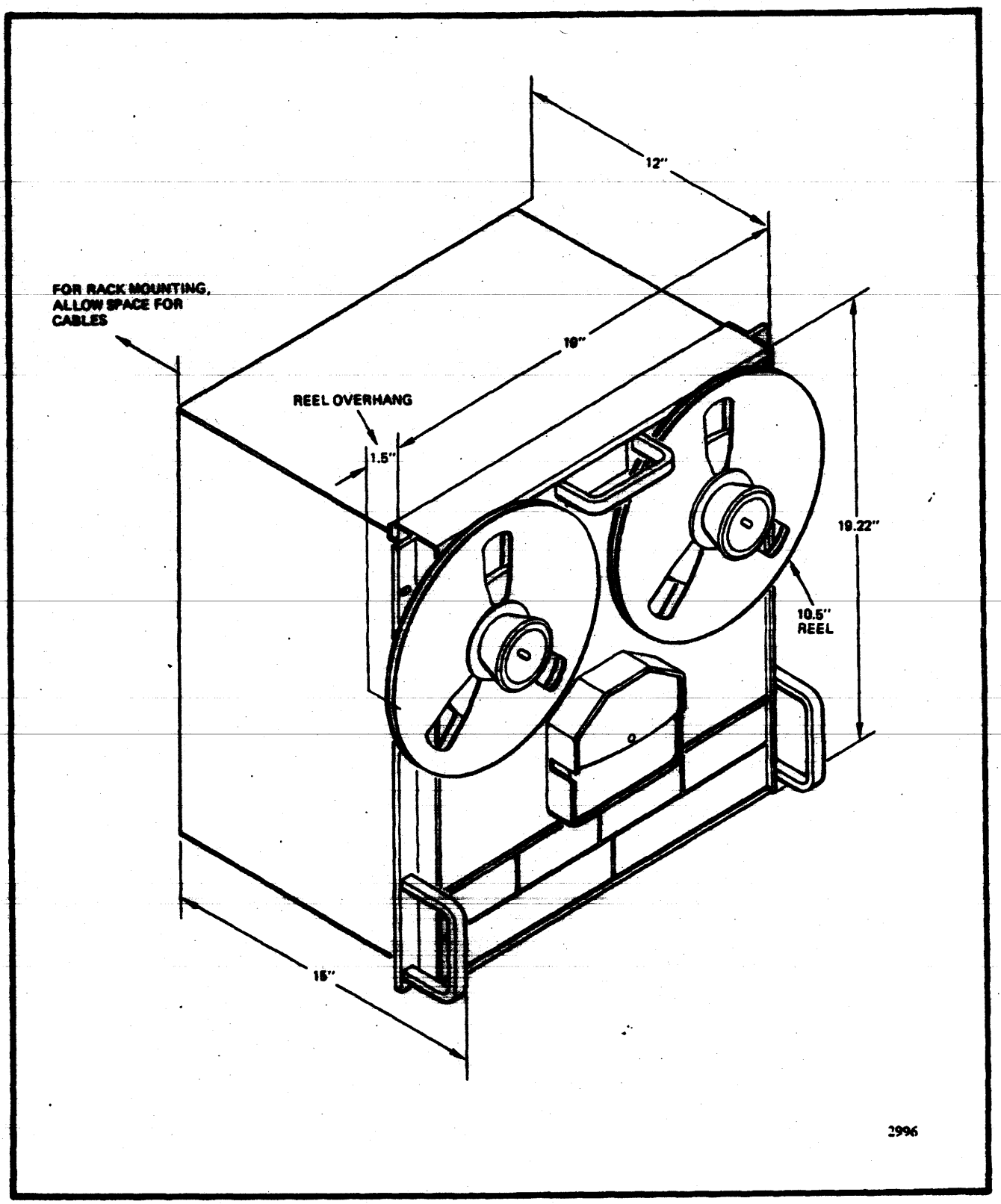


Figure 2-2. AN/TNH-21 Outline Dimensions

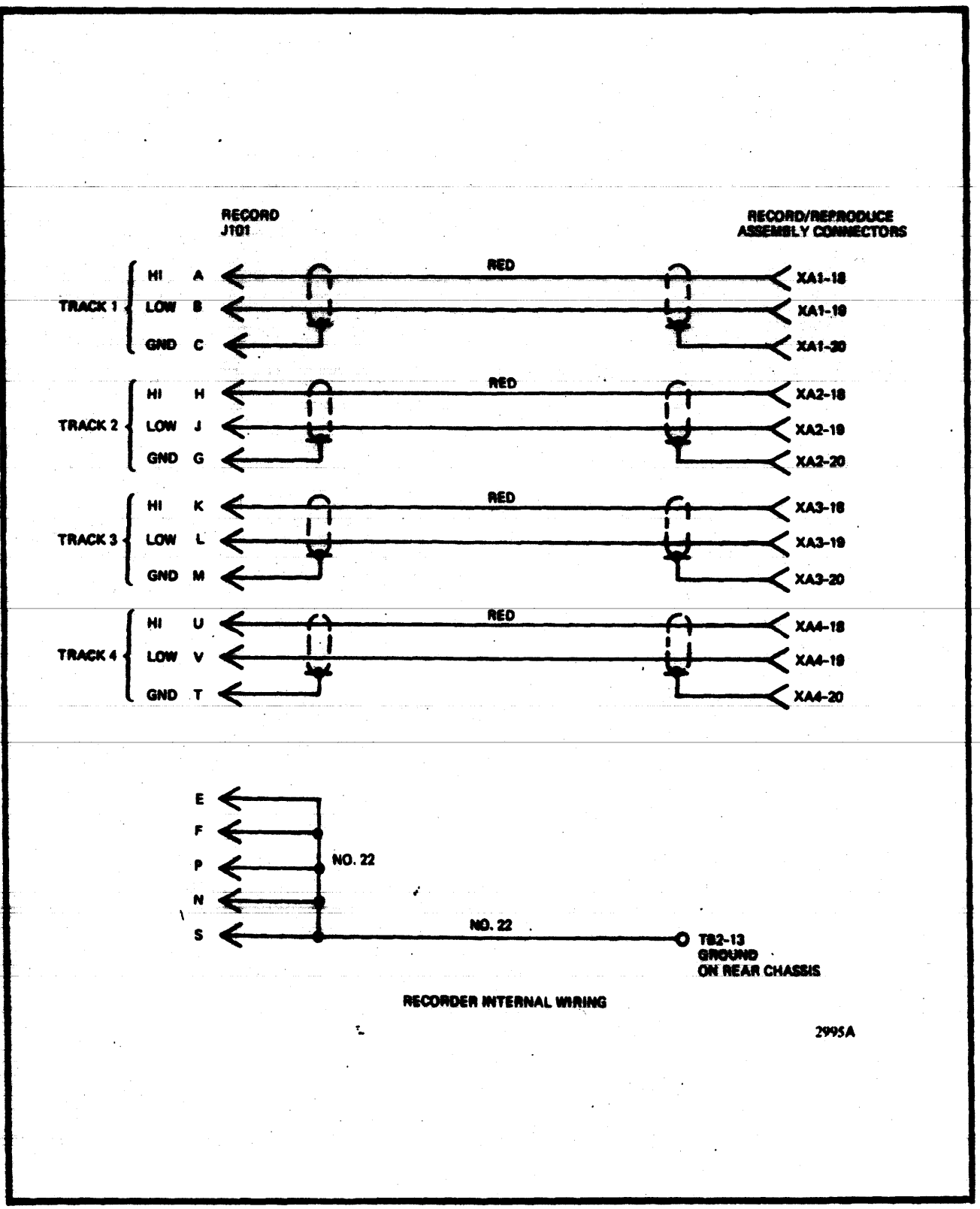


Figure 2-3. Record Input Interface Connections

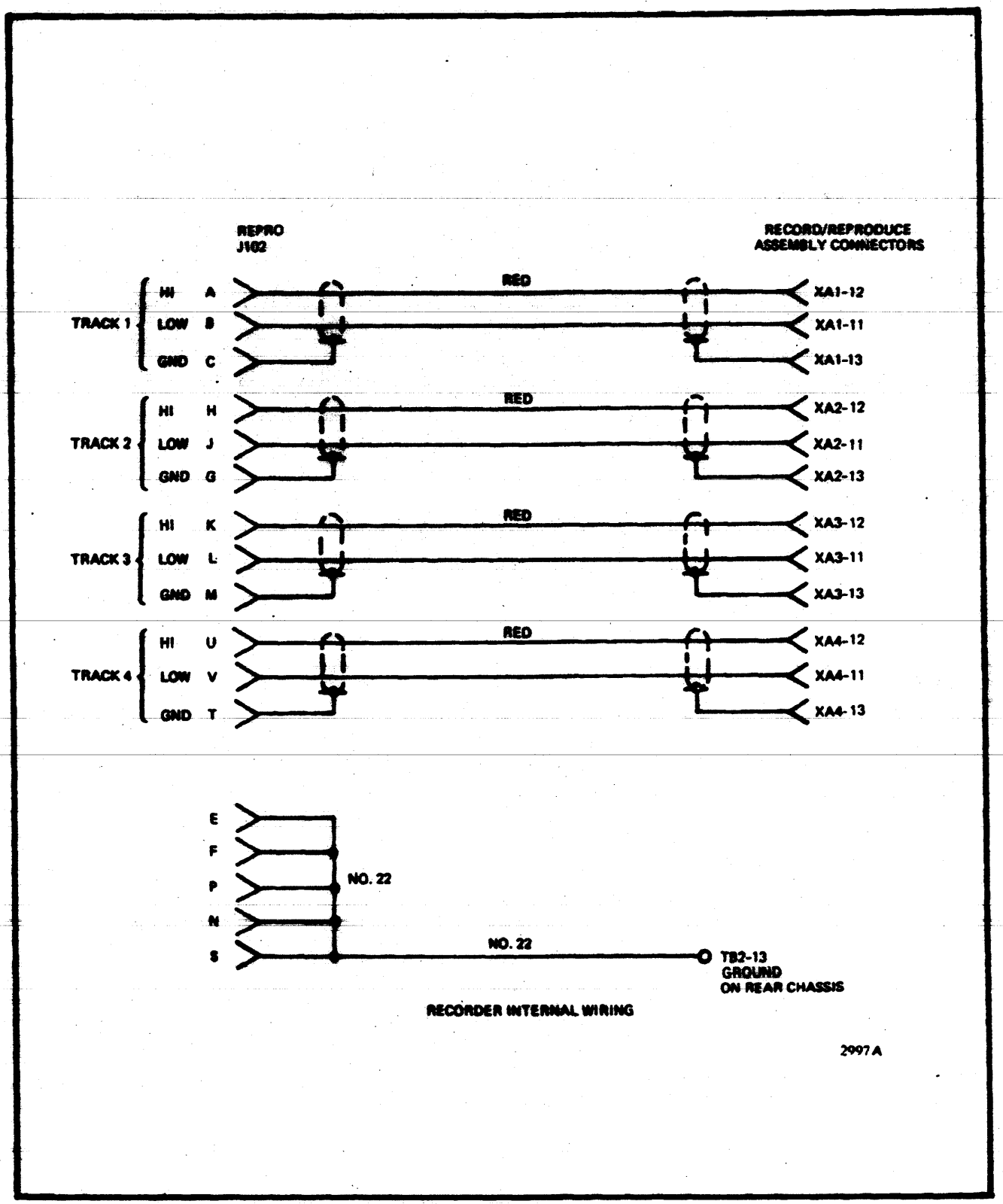


Figure 2-4. Reproduce Output Interface Connections

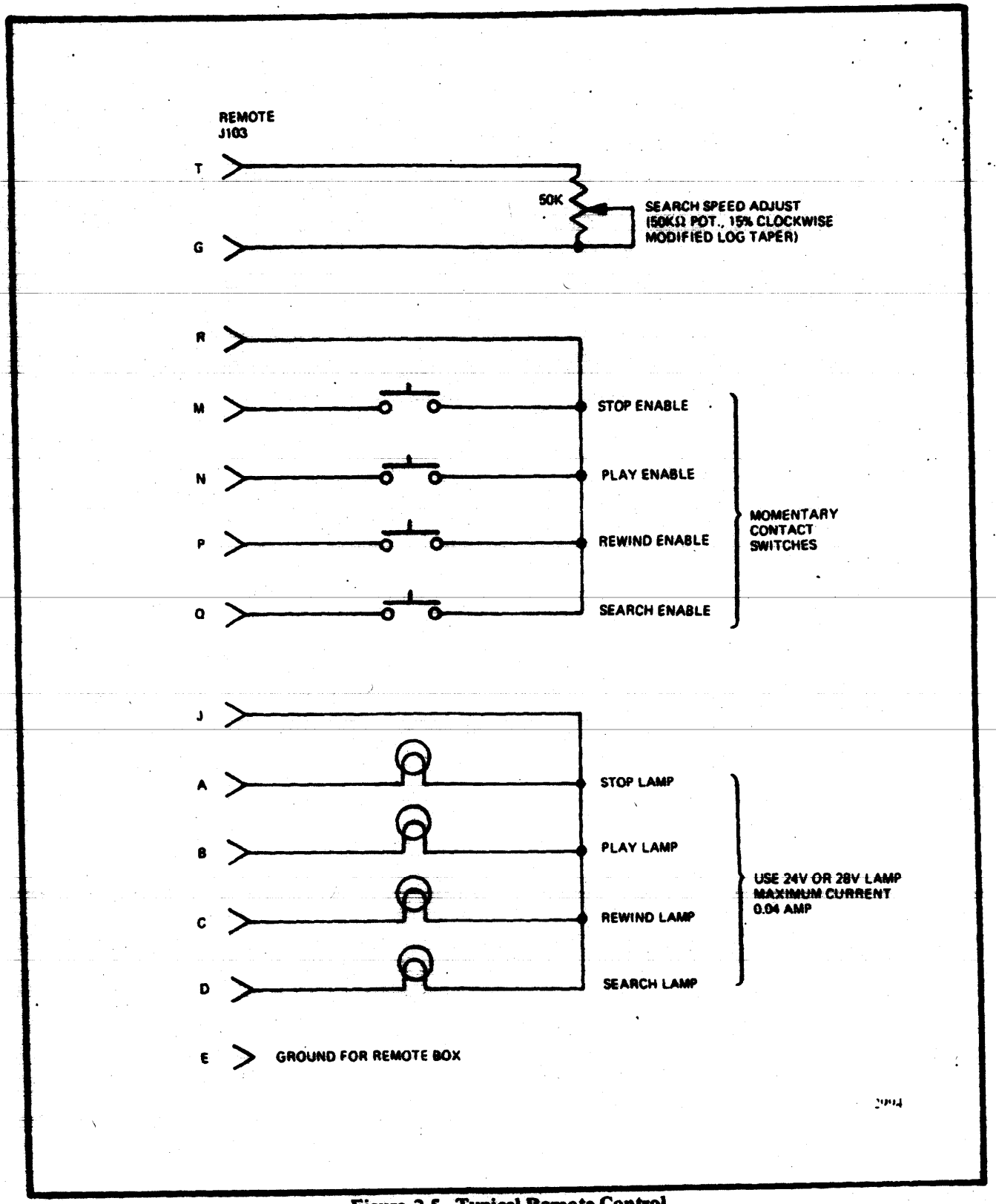


Figure 2-5. Typical Remote Control

accomplished by reversing the procedure in para-2-11. When the recorder is to be packed for shipment or storage, the original shipping container is recommended. Follow the reverse of the unpacking procedure in paragraph 2-3. See figure 2-1. To maintain moisture tight integrity if the recorder is to be shipped overseas, or stored for an extended period of time, a vapor barrier bag should be used and fresh (active) desiccant should be placed in the accessory compartment of the shipping container.

SECTION III
OPERATION

3-1. GENERAL

3-2. All operating functions of the AN/TNH-21 Flexible Voice Transcription Recorder/Reproducer are performed from the front of the recorder. There are three groups of controls: tape transport, signal electronics (record and reproduce), and monitor electronics. See figure 3-1. The AN/TNH-21 is a reel-to-reel, intermediate band tape recorder. It performs the usual recorder function (record, play, fast, forward, and rewind) plus such functions as variable speed search; and repeat scanning of a variable width segment of tape, and at variable tape speeds. The tape speed (capstan speed) is also variable except in the record mode. All operating controls and indicators are located on the front panel, except the input and output balance switches which are located internally on the Record/Reproduce Boards.

3-3. Operation consists of threading tape, applying power, selecting tape speed, and mode of operation; signal and monitoring adjustments. Before operating the recorder, read and understand the description of the operating control and indicator listed in table 3-1, and illustrated in figure 3-1.

3-4. CONTROLS AND INDICATORS

3-5. Operating controls are illustrated in figure 3-1, and listed and described in table 3-1. They are listed in three categories: tape transport, sig-signal electronics, and monitor electronics.

3-6. TAPE THREADING AND REEL INSTALLATION

3-7. The recorder can use either 4, 7, or 10-1/2 inch reels; either plastic reels, or reels with NAB hubs. Install reels, and thread tape as follows:

NOTE

Power may be either on or off.

CAUTION

When installing and removing reels with NAB hubs, the reels are not held in place when the reel hubs are removed. The post immediately below the reels are to protect the tape guides should the reels fall, however, caution should be exercised to prevent the reels from hitting any of the tape transport parts, especially the tape handling parts. Even the slightest knock to a rotating tape guide could have a degrading effect on the recorders performance.

1. Remove the reel hubs from the supply and take-up reel shafts by pressing the release lever and pulling on the hub.
2. Place the full reel of tape on the supply reel shaft so that the tape unwinds from the left side of the reel. When installing a plastic reel, simply slip the reel onto the reel shaft. When installing a NAB reel, hold the reel about the center of the reel shaft until the reel hub is installed. Install the reel hubs by pressing onto the reel shaft until the reel is engaged; then, press the reel hub in until the spring loading within the reel hub is compressed.
3. Install an empty reel on the supply reel shaft following the procedure in step 2, above.
4. Slide the lower head cover down to the thread tape position.
5. Unwind about 4 feet of tape and thread the tape as shown in figure 3-2. Take a couple of turns around the take-up reel and turn the reel until there is tape tension.
6. Slide the head cover up to the operate position.

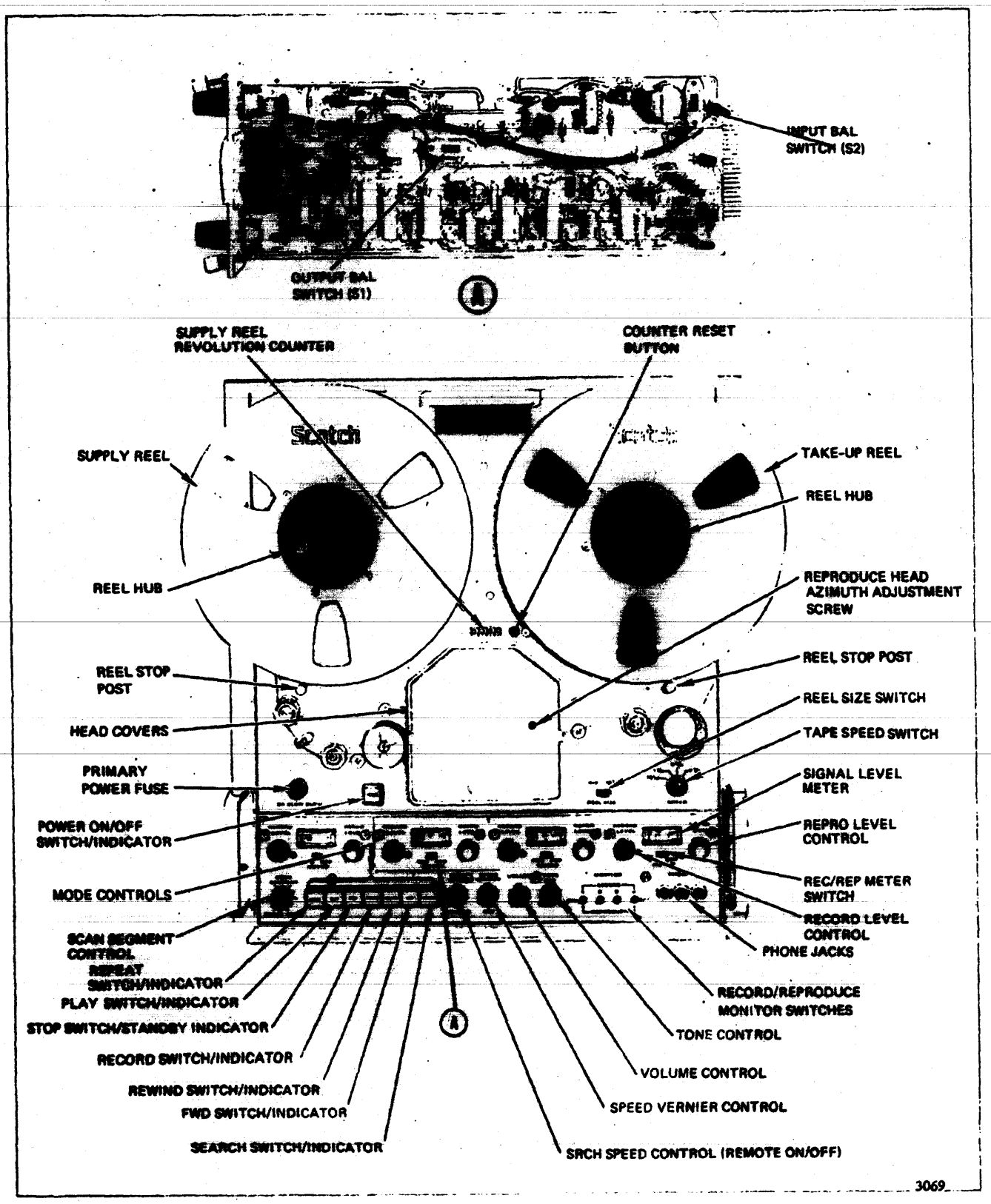


Figure 3-1. Controls and Indicators

Table 3-1. Controls and Indicators

CONTROL/INDICATOR	FUNCTION
POWER (S2)	Master power switch and indicator. Controls primary ac power. Push on-push off. The indicator operates from the 28 volt supply.
Fuse (F1)	5 ampere, slo-blo; overload protection in the primary ac line.
SPEED (S1)	Selects one of five standard, fixed, play/record tape speeds: 15/16, 1-7/8, 3-3/4, 7-1/2, or 15 ips.
REEL SIZE (S3)	Changes the reel motor torques to compensate for different reel sizes.
Counter	Four digit counter with manual and automatic reset. Counts supply reel rotations. The counter can be reset manually by pressing the adjacent button, or is automatically reset at end-of-tape (tape runout) when the recorder is in the rewind mode.
TAPE TRANSPORT LOGIC BOARD	
SCAN SEGMENT (R107 and R111)	The SCAN SEGMENT controls are operative only when the recorder is in the repeat mode. They adjust the length of the repeat scan segment from 10 seconds to near zero. The BEGIN control (◎ - larger knob) adjusts the point where the play segment begins. The END control (● - smaller knob) adjusts the end of the play segment.
REPEAT (S2)	Repeat mode control and indicator. In the repeat mode, the recorder will repeat a segment of tape from near zero to 10 seconds in length, as determined by the SCAN SEGMENT controls.
PLAY (S6)	Play mode control and indicator. When the PLAY button is pressed, the recorder will go into the play mode and reproduce the data recorded on the tape at the selected tape speed.
STOP (S8)	Stops tape motion, and initiates the standby mode. When the STOP button is pressed, tape motion stops and the recorder is removed from the mode it is in, and goes into the standby mode. When the STOP button/indicator is lit, it indicates that the recorder is in standby, and any mode of operation can be initiated. When power is first applied, or after the tape path has been broken, such as when a new reel of tape is threaded, the STOP button must be pressed to initiate standby before any other mode can be initiated.
RECORD (S5)	Record mode control and indicator. The RECORD button activates the record electronics (including erase electronics) when pressed simultaneously with the PLAY button.

Table 3-1. Controls and Indicators (Cont.)

CONTROL/INDICATOR	FUNCTION
REWIND (S9)	Rewind mode control and indicator. When the REWIND button is pressed, the rewind mode is initiated. When the button lights, it indicates that the recorder is in the rewind mode. When stopping from any forward mode, the recorder will momentarily go into the rewind mode for braking. This will be indicated by the REWIND button/indicator.
FWD (S7)	Fast forward mode control and indicator. When the FWD button is pressed, the recorder goes into the fast forward mode. The FWD button/indicator lights when the recorder is in the fast forward mode, and lights momentarily during dynamic braking from any reverse mode.
SEARCH (S3)	Search mode control and indicator. The SEARCH button/indicator initiates and indicates the variable speed search mode. In the search mode, the tape is moved forward under reel servo control and at a speed determined by the setting of the SRCH SPEED control.
SRCH SPEED (S1 and R3)	Varies the tape speed when the recorder is in the search mode. When the control is in the REMOTE position, the tape speed can only be varied by a remote control (not supplied).
SPEED VERNIER (S4 and R114)	Capstan vernier speed control. The SPEED VERNIER control, varies the tape speed between -30 and +50 percent of that selected by the SPEED switch. With the SPEED VERNIER in the OFF position, the selected tape speed is maintained. NOTE: The SPEED VERNIER is not operable in the record mode; tape speed is determined solely by the setting of the SPEED selector switch.
RECORD/REPRODUCE BOARD	
RECORD LEVEL (R37)	Adjusts the input signal to the proper record level.
Meter (M1)	Signal level meter. Indicates the record level and reproduce output signal level determined by the setting of the METER switch. In the REC position, 0 vu (100%) represents the normal record level for 1% third harmonic distortion. In the REP position, 0 vu (100%) represents 0 dBm (0.778 volts rms) at the REPRO connector, J102, on the rear connector panel of the recorder.
METER, REC/REP (S3)	Selects the signal monitored by the meter. Record level in the REC position, and reproduce, output level in the REP position.
REPRO LEVEL (R36)	Adjusts the output level of the reproduced signal. Effects both the signal to the REPRO connector, J102, and the monitor board.

Table 3-1. Controls and Indicators (Cont.)

CONTROL/INDICATOR	FUNCTION
BAL Switches (S1 - Output, S2 - Input)	Input and output balance switches located on the signal electronics board. When in the balance position (BAL→) input and/or output is 10,000/600 ohms, respectively, balanced. In the other direction, the input and/or output is unbalanced to ground.
MONITOR BOARD	
VOLUME (R92)	Volume control for the monitor PHONES jacks. Effects all three jacks; does not effect the signals at the REPRO connector, J102, or the RECORD connector, J101.
TONE, B/OFF/T (R87)	Tone control for the monitor PHONES jacks. Does not effect the signals at the REPRO connector, J102, or the RECORD connector, J101. In the center, OFF, position, the monitor signal has a flat frequency response. When the TONE control is maximum ccw, at B (bass), the monitor signal is at least +12 dB at 200 Hz and at least −12 dB at 3.2 kHz with a 1 kHz crossover. When the TONE control is maximum cw, at T (treble), the monitor signal is at least −12 dB at 200 Hz and at least +12 dB at 3.2 kHz with a 1 kHz crossover.
MONITOR, RECORD/ OFF/REPRODUCE (S1, S2, S3, and S4)	Selects the signal(s) to be monitored at the PHONES jacks. In the RECORD position(s), the record signal(s) is monitored. In the REPRODUCE position(s), the reproduce output(s) is monitored. The center position is OFF. The MONITOR switches may be set in any combination without effecting the record or reproduce signal. All channels may be monitored at one time and any combination of record, and reproduce may be monitored.
PHONES (J1, J2, and J3)	Phone jacks for three 600 ohm earphones. The PHONES jacks are connected in parallel.

7. Set the REEL SIZE switch to the position corresponding to the reel size installed.

8. Set the reel revolution counter to 0000 by pressing the reset button.

3-8. REEL REMOVAL

3-9. Before the reels are removed, it is a good practice (although not necessary) to always rewind the tape to the supply reel as follows:

1. If power is not on, press the POWER button, the button/indicator will light, indicating power is on.

2. Press the STOP button to initiate the standby mode. The STOP button will light.

3. Press the REWIND button, the button/ indicator will light. Let the tape run out. The counter will automatically reset to 0000, and the recorder will stop.

CAUTION

If NAB reels are to be removed, hold the reel in place when removing the reel hub or the reel may fall off the recorder.

4. Hold the reel in place with one hand, press the reel hub release lever and pull

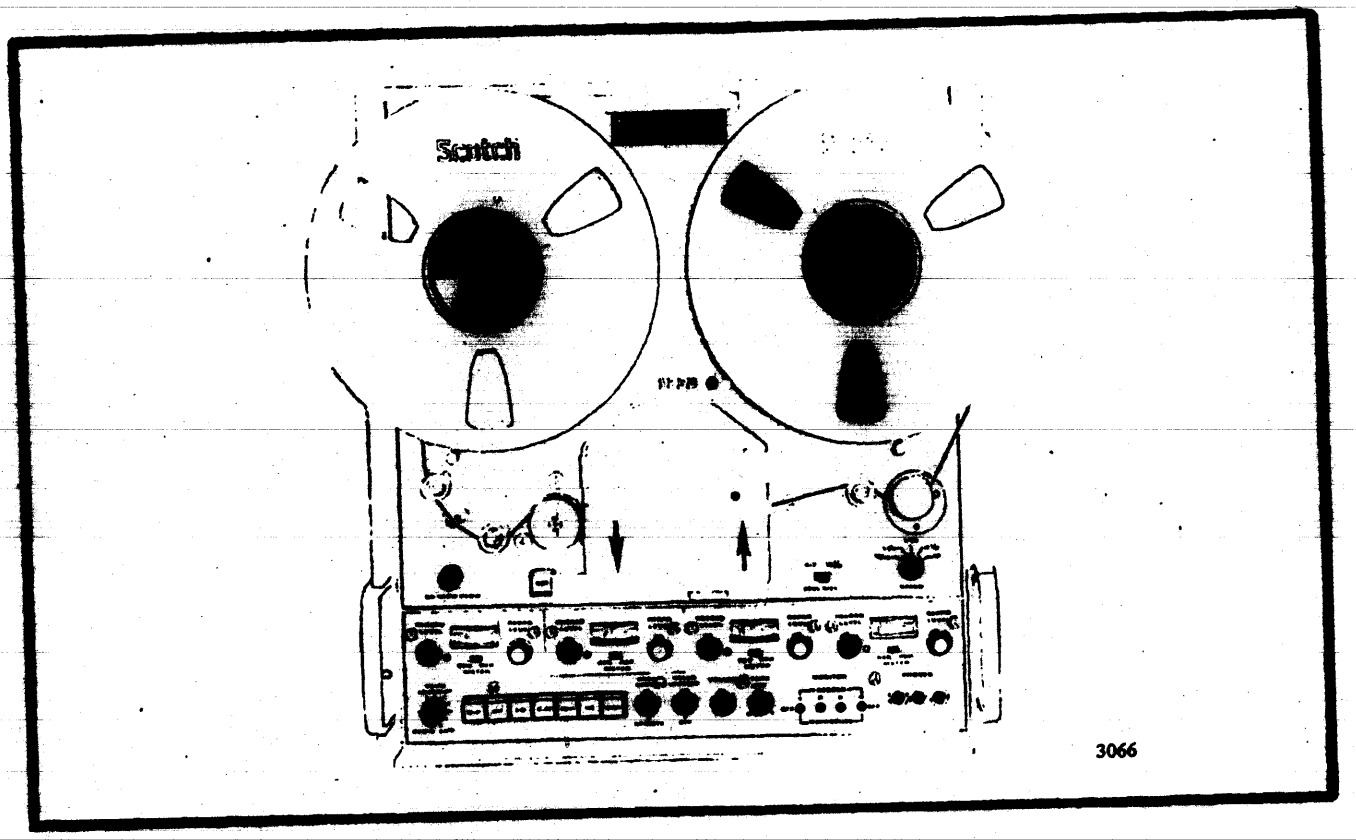


Figure 3-2. Tape Threading Path

the reel hub off with the other hand. The reel may now be removed from the recorder.

3-10. OPERATION

3-11. There are seven modes of operation, including standby (STOP); all are selected by the mode control button/indicators on the logic board. Any mode may be selected while the recorder is in any other mode. The button/indicators light to indicate the mode the recorder is in. In some modes, indicators other than the selected mode will light momentarily. This is normal since the indicators indicate the actual logic condition. For example, if the recorder is stopping from a forward mode, it will momentarily go into the rewind mode for dynamic braking. The REWIND indicator will light indicating this condition. The following describes each mode.

CAUTION

Always remove power before removing or installing any of the plug-in circuit boards.

NOTE

Before operating the recorder, check the position of the input and output BAL switches unless they are known to be correct. The switches are located on the signal electronics boards. When set in the direction of the arrow (→) the input impedance is 10,000 ohms balanced, and the output impedance is 600 ohms balanced. When in the position opposite the direction of the arrow, the impedance is unbalanced to ground. To check

the switches, unscrew the 2 fasteners on each board and pull the board from the recorder. S1, in the center of the board, is the output balance switch; and S2, at the back of the board, is the input balance switch. Set the BAL switches to the desired position and reinstall the signal electronics board and secure the two screw fasteners. Check the signal electronics board for each channel.

3-12. **STANDBY (STOP).** Before any mode can be initiated, the standby mode must be achieved as follows:

1. Install and thread a reel of tape (3M 150 or equivalent) as previously described.

2. Press the POWER and then the STOP button. The POWER and STOP (standby) indicators should light.

3-13. **FAST FORWARD (FWD).** The fast forward mode moves tape rapidly from the supply reel to the take-up reel. It can be selected at any time by pressing the FWD button/indicator, and removed by selecting any other mode. If the fast forward mode continues until tape runs out, the recorder will stop automatically. Tape must be rethreaded and the standby mode must be reestablished before another mode can be selected. In the fast forward mode, the monitor electronics are disabled by a squelch circuit. The reproduce outputs on the rear of the recorder (REPRO, J102) are not effected.

3-14. **REWIND.** The rewind mode operates the same as the fast forward (FWD) mode except it moves tape from the take-up reel to the supply reel; and if tape runs out in the rewind mode, the reel revolution counter will automatically reset to 0000.

3-15. **PLAY.** The play mode reproduces recorded tapes. The reproduced signals are available at the REPRO connector, J102, on the rear of the recorder and may be monitored at the monitor PHONES jacks on the front of the recorder. The tape speed is controlled by the capstan and determined by the setting of the SPEED switch. The capstan speed (tape speed) may be varied +50 to -30 percent by the SPEED VERNIER control. To reproduce a recorded tape, proceed as follows:

1. Thread the tape to be reproduced on the recorder and obtain the standby mode as previously described.

2. Set the SPEED switch to the tape speed at which the reel of tape was recorded.

3. Press the PLAY button/indicator. Tape motion should start and the PLAY button/indicator light.

4. Place the METER switch of each channel to the REP position.

5. Adjust the REPRO LEVEL control of each channel for 0 vu on the reproduce signal peaks. This adjustment effects the signal level to the REPRO connector on the rear of the recorder, and also to the monitor. 0 vu on the meter is 0 dBm (0.778 volts rms) at the REPRO connector.

NOTE

The normal output from the recorder is at the REPRO connector, J102, on the rear of the recorder. The signals can also be monitored from the front of the recorder, visually by the meter, and audibly from the monitor panel (see the paragraph in this section on monitoring).

6. The play mode may be canceled at any time by selecting any other mode, or if tape runs out the recorder will stop automatically. If tape runs out, the standby mode must be reestablished after tape is rethreaded, before any mode can be selected.

3-16. **RECORD.** In the record mode, data signals from the RECORD connector, J101, on the rear panel of the recorder are recorded on the tape. The bandwidth is determined by the tape speed; therefore, when recording data, refer to the

specifications, table 1-2, in Section I of this manual to determine the best tape speed. If the tape speed is too slow, high frequency data will be lost; if the tape speed is faster than necessary, the tape will not be used efficiently. To record data proceed as follows:

1. Connect the signal inputs to the RECORD connector, J101, on the rear of the recorder.

2. Thread a reel of 3M 150 or equivalent tape on the recorder and obtain the standby mode as previously described.

NOTE

For future reference, it may be desirable to note location of the tape recording by taking reading from the reel revolution counter.

3. Set the SPEED switch to the tape speed that will provide the desired bandwidth. Refer to table 1-2, specifications.

4. Place the METER switch of each channel to the REC position.

5. Adjust the RECORD LEVEL control of each channel for 0 vu (100%) on the signal peaks, or for the maximum anticipated input.

NOTE

If data signals are not present to set the record levels, they may be set after the recorder is in the record mode and tape is moving, or they may be simulated by applying a 1 kHz signal at the maximum anticipated input level to the appropriate pins (see figure 2-2) of the RECORD connector, J101.

6. Simultaneously, press the PLAY and RECORD buttons. Both button/indicators should light and tape will begin moving under capstan control at the selected speed.

NOTE

The SPEED VERNIER is not effective in the record mode. The record signal can be monitored visually by the meters or audibly from the monitor panel (see paragraph in this section on monitoring). When recording, either the record and/or reproduce signals may be monitored. Monitoring the reproduce signal ("down stream monitoring") may be the more meaningful because it is a reproduction of the signal being recorded.

7. The record mode may be canceled at any time by selecting any other mode, or if tape runs out the recorder will stop automatically. If tape runs out, the standby mode must be reestablished after tape is rethreaded, before any mode can be selected.

3-17. **SEARCH.** The search mode is a variable speed, forward mode for searching a recorded reel of tape to locate data. In the search mode, tape speed is controlled by a reel servo and is adjustable by the SRCH SPEED control from 2 ips to 60 ips. The monitor electronics are active in the search mode. To operate the search mode, proceed as follows:

1. Thread the tape on the recorder and obtain the standby mode as previously described.

2. Set the SRCH SPEED control to any position other than REMOTE; unless a remote control is connected to the recorder, and is going to be used to control the search tape speed.

CAUTION

Do not set the SRCH SPEED control to REMOTE unless a remote search control is connected to the recorder. If the SRCH SPEED control is set to REMOTE without a remote search

control, the recorder will not operate properly when the search mode is selected.

3. Press the SEARCH button. The button/indicator should light and tape movement begin.

NOTE

If the reel revolution counter is being used to locate a portion of the tape, press the FWD button and then the SEARCH button as the counter approaches the desired reading.

4. Set the SRCH SPEED control to the desired tape speed. The search mode may be canceled by selecting any other mode, or the search mode will continue until tape runs out, in which case, the recorder will come to a stop and the standby mode must be reestablished before another mode can be selected.

3-18. REPEAT. The repeat mode continuously repeats a segment of tape from 10 seconds to near zero in length. Both the beginning and the end of the scan segment are adjustable by the SCAN SEGMENT controls. The point where the REPEAT button is pressed is the end of the scan segment. The tape will immediately backspace the length of the scan segment to the begin play point (determined by the BEGIN control setting), and then go into the play mode. The play mode will continue to the end of the scan segment (determined by the END control setting), and then backspace again. This will continue until another mode is selected. The procedure is as follows:

1. Thread tape on the recorder and obtain the standby mode as previously described.

2. Set the SPEED switch to the proper tape speed.

3. Locate the segment of tape to be repeated in any appropriate mode and press the REPEAT button at the point where the scan segment is to end. The REPEAT button/indicator will light and the tape will backspace the length of the scan segment and go into the play mode.

NOTE

The SCAN SEGMENT controls may be set to any position; however, a setting midway between the maximum and minimum scan length in most cases will provide the best results since this will allow adjustment of both ends of the scan segment in both directions when the repeat mode is selected. The capstan SPEED VERNIER control may be used in the repeat mode the same as the play mode. It will vary the play tape speed +50 to -30 percent. This will effect the time it takes to scan the segment of tape, but the length of tape will remain the same (determined by the SCAN SEGMENT controls).

4. The repeat mode will continue until it is canceled by selecting another mode.

3-19. MONITORING. The normal signal input and output from the recorder is at the RECORD and REPRO connectors on the rear panel of the recorder. These signals may be monitored from the front of the recorder by up to three 600 ohm earphones. None of the monitor functions have any effect on the recorder input or output signals. The monitor is operative in the play, record, and search modes, and the play portion of the repeat mode. In the standby (stop), rewind, and fast forward modes, and in the backspace portion of the repeat mode, a squelch circuit disables the monitor output. Monitor operation is as follows:

1. Plug in 600 ohm earphones into the PHONES jack.

2. Place the recorder in operation in the desired mode.

3. Set the MONITOR switches as desired. The center position is off, in the up, RECORD position, the record input

signal is monitored, and in the down, REPRODUCE position, the reproduce output is monitored. The signals can be monitored in any combination. The switches can be set in any position without effecting the recorder operation.

4. Set the VOLUME and TONE controls as desired. See table 3-1 for an explanation of the TONE control.

3-20. **REMOTE.** The REMOTE connector, J103, on the rear connector panel provides for parallel remote control and indications of the play, stop, and rewind modes; and for a search speed control when the SRCH SPEED control is in the REMOTE position.

SECTION IV
MAINTENANCE

4-1. GENERAL

4-2. Maintenance is of prime importance for reliability and useful life of all magnetic tape systems. The maintenance includes preventive and corrective maintenance. Preventive maintenance helps prevent malfunctions or breakdowns. The corrective maintenance includes procedures for electrical and mechanical adjustments, and troubleshooting aids.

4-3. FIELD SERVICE

4-4. Regularly scheduled maintenance service is available from the Mincom Field Engineering Office on a contract basis, or service may be obtained on an emergency basis through the same office. In either case, every effort is made to provide the best service in the minimum amount of time. For the Field Engineering Offices, refer to the list in the front of this manual.

4-5. PREVENTIVE MAINTENANCE

4-6. Preventive maintenance consists of visual inspection of the system and cleaning of the tape handling surfaces, to reduce friction and wear. Daily checks should be performed prior to operation, and periodic checks should be made as dictated by the tape speed and the environment in which the recorder is operating. High tape speeds, high temperatures, or a dusty or humid environment necessitate an increase in the frequency of inspections. The AN/TNH-21 electronics is all solid state and very stable in normal operation. If this type of equipment is working properly, it is generally the best practice to leave it alone. Normal head wear will, however, necessitate periodic signal electronics readjustment to maintain optimum performance.

NOTE

The motor brushes are a very reliable and long life item. They will probably last the life of the recorder. However, if they are ever removed for inspection, note the orientation of the brush and be sure it is reinserted in the same position it was in before removal.

4-7. **VISUAL INSPECTION.** A visual inspection of the system should be made each time it is operated so that possible malfunctions can be reduced. Table 4-1 lists the most important areas for inspection. Inspection during alignment or troubleshooting should be made of the capstan belt, internal connectors, and cables. All connectors and plug-in assemblies should be checked for complete and correct seating. Cables must be kept clear of moving parts, to make sure that shorting does not occur. Check the ventilating holes in the cover panels to make sure that air circulation is not restricted.

4-8. **CLEANING.** The tape handling surfaces should be cleaned periodically. The time between cleanings will depend on the amount of use and the environment, since increased temperature, dust, and humidity will cause the tape handling surfaces to become dirty quicker. The best practice is to clean these surfaces just prior to recording or reproducing. See table 4-2. Always remove the magnetic tape prior to any cleaning of the tape path parts. The capstan motor pulley, capstan flywheel, and belt should be checked periodically and if necessary cleaned.

CAUTION

Avoid contacting any tape handling surfaces with tools or any hard object. Avoid finger contact with the magnetic head surfaces.

When using cleaning agents, avoid excess to prevent them from getting into any of the sealed bearings. The bearings are all permanently lubricated and this could result in damage to the bearings.

The coating on the backspace tachometer shaft may be damaged by use of strong cleaning agents. Use only a dry cotton swab, and if necessary, lightly dampened with distilled water.

Table 4-1. Inspection Guide

INSPECTION AREA	COMMENTS
Tape path components (guides, capstan, magnetic heads)	Inspect for damage, cleanliness, and proper function.
Signal input and output connectors	Inspect for proper connection, load terminations, and damaged wiring or connectors.
Input power	Inspect for proper connection to power source.
Ventilation	Inspect for air flow obstruction.
Connectors and plug-in assemblies (PC boards)	Inspect for complete and correct seating and apparent damage.
Cables	Inspect for proper clearance from moving parts; check also for wear or pinch damage.
Hub Assembly	Inspect for proper alignment to accept supply and take-up reels before loading.
Reels	Inspect for damaged, bent, or out of round reels.
Controls and Indicators	Visually inspect for damage. Check for burned-out indicator lamps, and malfunctioning meters when first initiating each mode.

Table 4-2. Cleaning and Lubrication

COMPONENT(S)	CLEANING AGENT	COMMENTS
Capstan belt, backspace tachometer, and capstan idler	Distilled water and cotton swab	Clean as required.
Tape guides, tension sensor, capstan, capstan motor pulley, and flywheel	90% isopropyl alcohol or Freon TF (DuPont) and cotton swab	Clean as required.
Erase, record, and reproduce heads	Mincom head cleaner 83-9830-0075 and cotton swab (Freon Xylene cleaner)	Clean before each recording.
Ventilating holes	90% isopropyl alcohol, Freon TF (DuPont) or solvent and compressed air	Remove cover panels, clean, and blow dry with compressed air. Clean as required.

4-9. Most of the time a dry cotton swab is all that is required to clean any of the tape handling surfaces. Use cleaning agents only if necessary.

4-10. CORRECTIVE MAINTENANCE

4-11. Corrective maintenance consists of adjustments and troubleshooting. The system adjustments are intended for both a complete system alignment and individual subsystem adjustments.

4-12. The adjustments are grouped into four categories: power supplies, tape transport mechanical, tape transport electrical, and signal electronics. The power supplies are first and since they supply power to the rest of the system, it is very important that they are functioning properly before making any other adjustments.

CAUTION

Always remove power before disconnecting any of the recorder connectors, and never apply power with either of the connectors disconnected through which the capstan motor circuit is connected. Without the capstan motor connected when power is applied, excessive power dissipation will occur in feedback resistors R21, R22, and R23 in the capstan motor control circuitry.

4-13. **USE OF EXTENDER BOARDS.** There are two extender boards provided with the recorder and are required for maintenance. One for the record/reproduce pc board (67-31-00), and one for the monitor and logic pc boards (67-30-00). These extender boards allow the recorder pc boards to be operated while extended from the recorder for access during maintenance. When maintenance procedures require the use of the extender boards, install the boards as follows:

CAUTION

Always press the POWER button to remove power from the recorder when removing and installing pc boards. The POWER button must not be lighted.

1. Remove the pc board from the recorder.
2. Install the extender board into the recorder. Press firmly to be sure the extender is completely inserted into the connector.

NOTE

The Monitor and Logic Extender board is narrower than the logic pc board; therefore, when installing the extender board in the logic slot, line up the pc connectors very carefully. In all other cases, the extender boards fit into the guide slots and will line up automatically.

3. Install the removed board on the extender. Determine that the two boards are completely mated.
4. Reapply recorder power by pressing the POWER button; observe that the POWER button lights.

NOTE

Whenever power is removed, the standby mode must be reobtained by pressing the STOP button when power is reapplied.

4-14. To remove an extender board, press the POWER button to remove power, remove the recorder board from the extender, remove the extender board from the recorder, and replace the recorder board in the recorder. Reapply power if required.

4-15. **TEST EQUIPMENT.** Table 4-3 is a list of recommended test equipment required for system operation, maintenance, and troubleshooting. Equivalent equipment may be used.

4-16. **POWER SUPPLIES.** Only one of the power supplies is adjustable, the +5 volt supply. The others are controlled by zener diodes; however, they should be checked and if out of tolerance, corrective action must be taken. See table 4-4. Do not indiscriminately adjust the +5 volt supply or change power supply components; only if out of tolerance, then a complete system alignment is to be performed. If only a partial alignment is to be performed, changing the supply voltages can adversely effect parts of the system not readjusted.

4-17. To check the power supply voltages, proceed as follows:

1. Place the logic pc board on an extender.

Table 4-3. List of Test Equipment

EQUIPMENT	DESCRIPTION AND USE
Volt/Ohm Meter (Simpson 260)	Direct current voltmeter capable of measuring to 50 volts dc for power supply checks, and for general servicing and troubleshooting.
Record/Reproduce PC Board Extender (67-31-00)	Allows a record/reproduce pc board to be operated while extended from the recorder for maintenance purposes.
Logic and Monitor PC Board Extender (67-30-00)	Allows the monitor or logic pc board to be operated while extended from the recorder for maintenance purposes.
Magnetic Tape (3M 150)	10-1/2 inch reel of magnetic tape.
Empty Reel	10-1/2 inch empty reel.
Frequency Counter (Systron 1013)	Used to adjust capstan servo reference oscillator and bias oscillator.
Dual-Beam Oscilloscope (Tektronix 502A)	Used to adjust 250 kHz record bias, capstan servo, backspace tachometer, and general servicing and troubleshooting. The dual trace feature is required for backspace tachometer adjustments and direction sensor servicing.
Signal Generator (Krohn-Hite 4200)	Low distortion sine wave signal source for signal electronics alignment.
AC, VTVM (Hewlett-Packard 400D) (2 recommended)	An rms and dB reading ac, vtvm capable of measuring 0.01 to 10 volts. Used for signal electronics alignment and general servicing and troubleshooting.
600 ohm terminating resistor	Reproduce output termination.
Wave Analyzer (Quan-Tech Laboratories 303)	A frequency selective voltmeter used to measure 3rd harmonic distortion for setting the normal record level.
Spring Scale (Chatillon Precision Instruments 719-5)	A spring scale capable of measuring up to 5 lbs. Used to set capstan idler force, and capstan belt tension.
Thickness (Feeler) Gage	Used to set capstan to capstan idler roller gap to 0.030-inches.
Allen Wrench-Modified (67-29-02)	Used to loosen the capstan motor bolts when adjusting the capstan belt tension.

Table 4-4. Logic PC Board Power Supply Voltages

VOLTAGE	ON LOGIC PC BOARD CHECK AT	TOLERANCE
+5 volts	TP8	±0.25 volts
-18 volts	U25-4	±1.5 volts
+18 volts	U25-7	±1.5 volts
+21.9 volts (Note 1)	Pin 3	±2.2 volts

NOTES: 1. The +21.9 volts comes from 24 volt supply on the power supply pc board where it is dropped by CR6, CR7, and CR8.

Table 4-5. Regulated Power Supply Voltages

VOLTAGE	CHECK AT	TOLERANCE	ADJUSTMENT OR REFERENCE DIODE
+5 volts (Note 3)	Q6 - Emitter	±0.25 volts	R26
-18 volts	Q1 - Emitter	±1.5 volts	VR1
+18 volts	Q3 - Emitter	±1.5 volts	VR2 (Note 2)
+24 volts	Q5 - Emitter	±2.5 volts	VR3 (Note 2)

NOTES:
1. The voltages are checked at the emitter of the appropriate power transistor on the rear chassis, and the adjustment and reference diodes are on the power supply pc board.
2. If the +18 volt zener diode, VR2, is defective, it will also effect the +24 volt supply.
3. If both the +18 volt and +5 volt supplies are inoperative, troubleshoot the +18 volt supply first.

2. Connect the power cable to the POWER connector, J104, and a 115 volt, 50 or 60 Hz source. Press the POWER button on the front of the recorder. The button should light.

3. Using a dc voltmeter, check the power supply voltages listed in table 4-4. If they are correct, press the POWER button off and remove the logic pc board from the extender. If they are not correct, proceed to the next step.

4. Remove the rear and top panels.

5. Using a dc voltmeter, check the voltages listed in table 4-5 and perform any corrective action necessary. Refer to the technical description of the rear chassis, and power supply pc board assembly in Section V.

NOTE

If other electrical adjustments are to be performed, leave the power connected and the recorder power on, and the covers removed. If no other electrical adjustments are to be made, turn the record power off by pressing the POWER button and replace the recorder panels, and remove the logic board from the extender.

4-18. TAPE TRANSPORT MECHANICAL ADJUSTMENTS. The tape transport mechanical adjustments consist of reel table heights, rotating tape guides, fail-safe brakes, capstan idler solenoid, and capstan idler dampener adjustments. None of these adjustments should be made as a matter of routine. They should be performed only when there is definite reason to believe they are out of adjustment, or if required by a part replacement. Then perform only the mechanical adjustments required.

4-19. Reel Table Height Adjustment. The reel tables must be at the proper height or the tape will rub on the reel flanges. This will effect the tape tracking and probably increase flutter. If a reel table is removed, or becomes loose, install it as follows:

1. Remove the top recorder panel.
2. Loosen the single setscrew about 1/4 turn using a 7/64 Allen wrench.

NOTE

The setscrew must be aligned with the flat part of the motor shaft.

3. Measuring from the tape transport plate to the outer edge of the reel table, position the reel table to a height of approximately 0.26 inches and tighten the setscrew.
4. Depress the fail-safe brake solenoid, and rotate the reel table by turning the reel spindle. There shall be no noticeable wobble of the reel table or eccentricity of the spindle shaft.
5. Replace the recorder panel.

4-20. Fail-Safe Brake Adjustment. The fail-safe brakes will only require adjustment if a part is replaced, or if a part is inadvertently bent. The procedure is as follows:

1. Remove the top panel.

2. Notice the U bracket attached to the fail-safe brake solenoid arm. This bracket should be loose; that is, applying no pressure to the brake arms. There should be approximately 1/16 inch clearance between between the bottom of the slots in the U bracket and the brake arm. Bend the brake arm assembly to obtain this condition.

3. Press the U bracket firmly against the solenoid. The brakes should release and the reel motor should rotate freely.

4. Release the U bracket. The brakes should be applied making it difficult to rotate the reel motors (supply reel ccw, and take-up reel cw).

5. Replace the recorder panel.

4-21. Capstan Idler Force Adjustment. Proper capstan idler force is critical to the performance of the recorder. If there is insufficient force, tape slippage will occur causing increased wow and flutter, especially at the end of the reel. If the force is too great, it will cause excessive wear of the capstan bearings and idler, or the solenoid may not be able to pull-in against the dampener. The capstan idler force is set by positioning the actuator solenoid as follows:

1. Remove the top and side panels.

2. Remove the lower head cover.

NOTE

The head cover is held on by two clips. Slide the cover down and remove by pulling out on one side at a time.

3. Place a loop of small string around the capstan idler roller shaft.

4. Insure that the recorder is connected to a 115 volt, 50 or 60 Hz power source, and then press the POWER button. The button should light.

CAUTION

When the recorder is in the play mode, be careful that the loop of string does not wind around the idler or shaft.

5. Thread tape onto the recording according to the instructions in the Operation Section. Set the SPEED switch to 3-3/4 ips. Press the STOP button.

6. Hook a spring scale into the string loop on the capstan idler, and press the PLAY button.

7. Pull down on the spring scale at a right angle to the idler arm until the capstan stops driving the tape. At this point, the spring scale should read 56 ±2 ounces.

8. If the capstan idler force is not correct, press the STOP button and the POWER button to remove power, loosen the four screws holding the capstan idler solenoid, and move it up to increase the force and down to decrease the force. Retighten the solenoid screws.

9. Reapply power by pressing the POWER button, press the STOP button for the standby mode, and repeat steps 6, 7, and 8 until the capstan idler force is 56 ±2 ounces.

10. Press the POWER button to remove power, remove the string from the capstan idler, and replace the recorder panels, and lower head cover.

4-22. Capstan Idler Dashpot. The capstan idler dashpot allows the idler to contact the tape and capstan gently. If there is not enough dampening and the idler closes too fast, tape will momentarily be thrown from the capstan faster than the take-up reel can accept it. This results in rough tape handling and could damage the tape. If there is too much dampening, the start time of the play mode will be increased accordingly. Adjust the capstan idler dashpot as follows:

1. Remove the top and side panels.

2. Press the capstan idler lever in at the solenoid as though it were being actuated by the solenoid, until it is felt contacting the dashpot. At this point, the gap between the capstan and the idler roller should be 0.030 ±0.005 inches.

3. If necessary, loosen the lock nuts on the dashpot and turn up or down

until the gap at the contact is 0.030 ±0.005 inches. Retighten the lock nuts.

4. Replace the recorder panels.

4-23. Capstan Belt Adjustment. Correct capstan belt tension is essential to minimum flutter and maximum reliability of capstan motor bearings. If the belt is too loose, flutter will increase, and the motor may not be able to synchronize with the capstan. This will be noticed by the motor changing speed. If the belt is too tight, the bearing will wear very rapidly and the motor noise may be coupled through the belt to the capstan. Adjust the capstan belt tension as follows:

1. Remove the top and side panels.

CAUTION

Do not press hard on the capstan belt, it could damage the motor bearings.

2. Insert a 1/4" diameter by 1-1/2" (maximum) bolt into one of the two holes in the capstan flywheel.

3. Connect a spring scale (5 lb. capacity) to the bolt in the flywheel, and while holding the capstan motor pulley and belt to keep from turning, pull on the spring scale at right angles to the axis of the bolt holes in the flywheel. The flywheel should begin to slip at a pulling force of 4 ±1/4 lbs.

4. If the belt tension is not correct, use modified Allen wrench (67-29-02) and loosen the three Allen head bolts securing the capstan motor, and repeat steps 3 and 4 until the capstan belt tension is correct.

5. Replace the recorder cover panels.

4-24. Tape Guide Adjustment. The three rotating tape guides are adjustable by turning the screw in the front center of the guide. The two fixed tape guides in the head area are not adjustable and establish a reference to which the rotating guides are adjusted. The guides are adjusted so that there is no tape curl, either ingoing or outgoing. Tape curl is most obvious on the base (shiny) side of the tape at the edge of the tape guides. Adjust the guide in the direction of the curl; that is, if the curl is on the inside, adjust the guide in by turning the adjustment screw cw.

4-25. To adjust the tape guides, proceed as follows:

1. Insure that the recorder is connected to a 115 volt, 50 or 60 Hz source and press the POWER button. The button should light.

2. Thread tape on the recorder according to the instructions in the Operation Section, and set the SPEED switch to 15 ips.

3. Obtain the standby mode by pressing the STOP button. The STOP button will light.

4. Press the PLAY button and observe the tape passing through the tape guides.

5. Check the tape guide on the take-up reel side, and adjust as necessary.

NOTE

The backspace tachometer also functions as a tape guide for the take-up reel. Tape should pack in the center of the reel. If it does not, adjust the reel table height. The position of the backspace tachometer is not adjustable.

6. Check the two rotating tape guides on the supply reel side. Note tape guide next to the inertia idler. If there is tape curl on the outgoing tape, adjust this guide. If there is ingoing tape curl, adjust the guide nearest the supply reel. If the guide nearest the supply reel has any tape curl, adjust that guide. If this guide cannot be adjusted, check the reel table height, and be sure that the reel flanges are not touching the tape.

NOTE

If the tape curl on the supply reel side is excessive or difficult to adjust, adjust the tape guide next to the inertia idler to 0.375 inches, surface-to-tape height. That is, the lower tape edge or top of the lower tape guide flange to the tape transport surface. Then readjust the tape guide nearest the supply reel.

4-26. Backspace Tachometer Adjustments. If a backspace tachometer lamp, transistor, or tachometer disc is replaced, or if the phasing reticles

are disturbed, the tachometer must be realigned. The lamp filaments must be aligned to produce the proper tachometer pulse; and the phasing reticles between the tachometer disc and the transistors must be aligned to produce signals phased 90 degrees apart for direction sensor operation. Align the backspace tachometer as follows:

1. Remove the right side panel.

CAUTION

Be very careful not to bend or damage the tachometer disc.

2. Remove the tachometer assembly mounting bolts and while holding the tape guide part, remove the tachometer from the recorder. Do not disconnect the tachometer connector.

3. Place the monitor pc board on an extender board.

4. Insure that the recorder is connected to 115 volt, 50 or 60 Hz power source and press the POWER button. The button should light. Also, both tachometer lamps should light.

5. Connect a dual beam oscilloscope to TP1 and TP4 on the monitor pc board.

NOTE

The clearance between the reticles and the tachometer disc should be 0.020 ±5-inches. If necessary, loosen the lock nut and adjust the tachometer disc. Reapply a small amount of Loctite (red) to the lock nut.

6. Rotate tachometer shaft by hand. The signal at TP1 and TP4 should be approximately 6 volts peak-to-peak. The waveform should be an approximate sine wave, but will vary because of the lamp filament and transistor characteristic.

7. If the waveform at TP1 is not correct, adjust lamp DS1 by rotating or moving in and out as necessary. Rotate for wave shape and move in and out for amplitude. If the waveform at TP4 is not correct, adjust DS2.

8. Connect the dual beam oscilloscope to TP2 and TP5. Trigger on TP5.

9. Rotate the tachometer shaft ccw by hand and adjust the oscilloscope so that TP5 waveform is below TP2. TP5 should be a short positive pulse, the leading edge of which is at the center of every other negative TP2 pulse. If this is not the case, very slightly loosen the screw securing one of the phasing reticles between the tachometer disc and the transistor, and position the reticle until the pulses are properly phased. Tighten phasing reticle screw.

10. Repeat steps 5 and 6. If necessary, repeat step 9.

11. Reinstall the tachometer into the recorder. Press the FWD button and allow tape to reach full speed.

12. The oscilloscope should be connected as in step 8. The pulse should be as in step 9.

13. Press the STOP button and then the POWER button. Disconnect the oscilloscope, remove the monitor pc board from the extender board and reinstall in the recorder. Reinstall the recorder panels.

4-27. TAPE TRANSPORT ELECTRICAL ADJUSTMENTS. Tape transport electrical adjustments consist of adjusting the end-of-tape sensor sensitivity and dashpot, tape tension sensor, capstan servo, repeat, and search servo. All tape transport circuits are solid-state electronics and therefore, very stable. Routine adjustment of the tape transport electronics is not recommended. Tape transport adjustments should be made only when there is reason to suspect improper adjustment, and then only the function under question should be adjusted.

4-28. End-of-Tape Sensor Sensitivity. This procedure adjusts the sensitivity of the end-of-tape sensor. The procedure is as follows:

NOTE

This procedure assumes that power is on, and that the top cover panel is removed from the recorder.

1. Install and thread tape according to the instructions in the Operation Section of this manual.

2. Obtain the standby mode by pressing the STOP button. The STOP button must light.

3. On the power supply pc board, adjust R11 fully cw.

4. Slide the head cover down and remove the tape from between the end-of-tape sensor. The STOP button should remain lighted.

5. Slide the head cover up (closed) and adjust R11 ccw until the STOP button light goes out. Press the STOP button. The light should remain out.

6. Slide the head cover down and rethread the tape between the end-of-tape sensor. Press the STOP button, it should light.

7. Remove the tape from between the end-of-tape sensor. The STOP button light should go out. If it does not, adjust R11 ccw until it does. Repeat steps 6 and 7 until the operation of the end-of-tape sensor is positive.

NOTE

If the recorder goes into the fail safe (tape motion stops and the STOP button light is out) when changing from one tape motion mode to another, the end-of-tape sensor is probably too sensitive. Adjust R11 slightly cw. If the recorder does not go into the fail safe mode when tape runs out, the end-of-tape sensor is not sensitive enough; adjust R11 ccw.

8. Rethread the tape and slide the head cover up (closed).

NOTE

If the adjustment procedure is to be continued, press the STOP button to obtain the standby mode. If no more adjustments are to be performed, press the POWER button to turn off the power and replace the recorder cover panels that were removed.

4-29. Tape Tension Sensor Adjustment. This procedure adjusts the tape tension sensor and dashpot so that it will provide the proper supply reel torque in the play, record, and search modes. The procedure is as follows:

1. Insure that the power is off; POWER button light out. Press the POWER button if it is lighted.

2. If tape is threaded on the recorder, remove it from the tape tension sensor path.

3. Remove the rear cover panel, and the left side cover panel.

4. Minimize the tension sensor spring tension by bending the terminal lug to which the spring is attached. (It should be at approximately a 45° angle with its mounting surface.)

5. Open the dashpot valve by turning the 1/4-inch hex nut on the bottom of the dashpot ccw until the dashpot does not dampen the tension sensor travel.

6. Close the dashpot valve in quarter turn increments until there is noticeable dampening by the dashpot.

7. Install and thread tape according to the instructions in the Operation Section of the manual.

8. Press the POWER button to apply power.

9. Press the STOP button to obtain the standby mode. The STOP button should light.

10. Set the SPEED switch to 15/16 ips.

11. Connect a dc voltmeter across R1 on the rear chassis.

12. Wind tape to beginning of reel.

13. Press the PLAY button and adjust the tape tension sensor mask for 0.25 to

0.30 volts across R1 by loosening the screw attaching the terminal lug and mask, and repositioning the mask as necessary.

NOTE

Shield the tension sensor photoresistor from external light to insure correct adjustment.

14. Press the FWD button and wind the tape until 1/4-inch tape pack remains on the supply reel.

15. Press the PLAY button. The meter should read between 0.15 and 0.17 volts.

NOTE

Shield the tension sensor photoresistor from external light to insure correct adjustment.

16. Press the STOP button, and then the POWER button. Replace the recorder panels.

NOTE

If the adjustment procedures are to be continued, leave the tape threaded, and power connected.

4-30. Capstan Servo Adjustment. This procedure adjusts the capstan servo reference oscillator (tape speed reference), and capstan servo offset. The procedure is as follows:

NOTE

This procedure assumes that power is connected (POWER button off) and that tape is threaded.

1. Place the logic pc board on an extender board.
2. Set the SPEED VERNIER control to OFF.
3. Connect the frequency counter to TP2 on the logic pc board.
4. Set the SPEED switch to 15 ips.
5. Press the POWER button. The POWER button should light.
6. The frequency counter shall read 284.540 Hz, ±0.284 Hz. (No more than 284.824 Hz, and no less than 284.256 Hz.) Adjust C23 on the logic pc board as necessary.

(3,5144 msec ± .0035 msec.)

7. Connect the oscilloscope to TP4 on the logic pc board. Set the oscilloscope for 0.2 milliseconds per CM sweep rate and internal positive trigger.
8. Adjust R52 for 9.8 CM on the oscilloscope (58 percent positive duty cycle).
9. Set the SPEED switch to 15/16 ips, and allow the capstan motor to stabilize.
10. Connect the oscilloscope to U25-6 (or junction of R45 and R39).
11. Adjust R11 for a carrier amplitude of 0.6 volts peak-to-peak.
12. Press the POWER button. Disconnect the test equipment.

NOTE

If the adjustment procedures are to be continued, leave the tape threaded, power connected and the logic pc board on the extender board. If not, remove the logic board from the extender and reinstall the recorder.

4-31. Repeat Adjustments. The repeat adjustments consist of setting R106 and R110 on the logic pc board for the proper scan segment and best repeatability. The procedure is as follows:

NOTE

This procedure assumes that power is connected, and that tape is threaded.

1. Connect a 24 volt lamp, or voltmeter (50 volt range) between J103-B (+) and J103-J (–) of the REMOTE connector on the rear panel. This must be visible from the front of the recorder.
2. Remove the left-hand panel, and then press the POWER button. The button should light.
3. Press the STOP button to obtain the standby mode. The STOP button should light.

4. Set the SCAN SEGMENT, BEGIN ⊙ control fully cw, and the END • control fully ccw. Set the SPEED switch to 15 ips.

5. Open the head cover and place a small piece of splicing tape on the magnetic tape in the vicinity of the backspace tachometer. Reference its location to some mechanical part.

6. Press the REPEAT button. At the end of the first play portion, the marker must be within 1-inch of its original position. Adjust R110 for the least amount of error. R110 is accessible through the center hole in the card guide.

7. Let the tape cycle ten times. At the end of the tenth cycle (end of play/start of backspace), the splicing tape marker should be within 4.5 inches of the starting reference point.

8. When the play mode starts, it will be indicated by 21 volts at the remote play indicator output J103-B. Adjust R106 on the logic pc board for approximately 11 seconds of play mode time (10 seconds minimum).

9. Press the STOP button, and then the POWER button, and then press the POWER button again to reapply power. The recorder must not immediately go into the play mode. If it does, adjust R110 slightly ccw, until the recorder drops out of the play mode.

10. Press the STOP button and then the POWER button. Disconnect the test equipment from the REMOTE connector, and remove the splicing tape from the magnetic tape.

NOTE

If the adjustments are to be continued, leave the power connected, and tape threaded. Close the head cover. Replace the recorder panel.

4-32. **Search Adjustments.** The search adjustments consist of setting the maximum and the minimum tape speeds, and the servo gain. The procedure is as follows:

NOTE

This procedure assumes that power is connected and that tape is threaded. 7-inch reels are recommended for this procedure; however, if they are not available, the reel size normally used on the recorder may be used for this procedure. Insure that the REEL SIZE switch is set for the reel size used.

1. Place the monitor pc board on an extender board, and connect a frequency counter to TP2 (the no. 1 tachometer).

2. Set the SRCH SPEED control for minimum speed (maximum ccw), but not to REMOTE.

3. Set the SPEED switch to any speed less than 15 ips.

4. Press the POWER button. The button should light.

5. Press the STOP button to obtain the standby mode. The STOP button should light.

6. Wind the tape to mid reel (equal amounts of tape on both reels).

7. Press the SEARCH button, and observe the frequency counter (tachometer frequency). It should indicate approximately 181.0 Hz. If necessary, adjust R28 on the monitor pc board.

8. Wind the tape to near the end of the reel. With the SRCH SPEED control still at minimum speed (ccw), press the SEARCH button, and adjust the gain control (R32) cw until the reels begin to oscillate. Then, adjust R32 ccw until the reels stop oscillating, and then 1/2 turn more ccw.

9. Check the tachometer frequency (TP2) at the end of reel; rewind the tape to the beginning of the reel and check the frequency. It must be 181 ±2.7 Hz at the beginning of the reel, mid reel, and end of reel. If it is not, readjust R28.

NOTE

The tachometer (TP2 on the monitor pc board) indicates 90.5 cycles per inch of tape. 181 Hz is 2 ips, and 5430 Hz is 60 ips.

10. Set the SRCH SPEED control for maximum speed, full cw.

11. Wind the tape to mid reel and press the SEARCH button.

12. The frequency counter should indicate approximately 5430 Hz. If necessary, adjust R146.

13. Wind the tape to the beginning of the reel, and check the frequency. Rewind the tape to the end of the reel and check the frequency. The frequency must be 5430 ±81.5 Hz. If necessary, readjust R146.

14. If is was necessary to adjust R28 in step 9 or R146 in step 13, repeat steps 7 through 13 as necessary.

15. Press the STOP button and then the POWER button. Disconnect the counter and remove the monitor pc board from the extender and reinstall in the recorder. This completes the tape transport electronics alignment.

4-33. SIGNAL ELECTRONICS ALIGNMENT. The signal electronics alignment consists of bias and record level adjustment, reproduce head azimuthing, reproduce tape speed equalizer adjustment and monitor meter adjustment. These adjustments should be performed periodically to maintain optimum performance because they are effected by head wear. Also, any time that the type of magnetic tape used is changed, the signal electronics should be realigned. The frequency of signal electronics alignment will vary a great deal depending upon the tape speed at which the recorder is operated and the type of magnetic tape used. Higher tape speeds will cause the heads to wear more rapidly and will require more frequent alignment. Also, some types of magnetic tapes are more abrasive than other types, resulting in more rapid head wear.

4-34. When any part of the signal electronics alignment is required, the complete procedure should be performed since a change in the record or reproduce characteristic will affect the other. The following procedure assumes that all four channels are to be aligned. If all four channels are not to be aligned, the bias and erase oscillator, and the reproduce head azimuthing must be known to be correct. In this case, eliminate these steps from the procedure.

1. Thread a reel of recommended tape on the recorder as described in the Operation Section of this manual.

2. Place the record/reproduce pc board of the channel to be aligned on the record/reproduce extender board (67-31-00). Set the BAL switches, S1 and S2 to the unbalanced position, opposite to the direction of the arrow (→).

3. Remove the top panel from the recorder.

4. Insure that the power cable is connected to a 115 volt, 50 or 60 Hz source, and press the POWER button. The button should light.

5. Press the STOP button. The button should light, indicating the standby mode.

NOTE

Steps 6 and 8 are performed only once and for the first channel aligned.

6. Connect a frequency counter to pin 24 on the record/reproduce pc board connector.

7. Place the recorder in the record mode by simultaneously pressing the PLAY and RECORD buttons. Both buttons should light.

8. Adjust C15 on the power supply pc board for 250 kHz. Disconnect the counter.

9. Connect an oscilloscope to TP3 on the record/reproduce pc board.

10. Adjust L12 for 0.5 volts, peak-to-peak, 250 kHz bias on the oscilloscope.

11. Press the STOP button and disconnect the oscilloscope.

12. Connect the signal generator and ac vtvm to the RECORD input (J101) for all four channels (see figure 2-3), and set the input signal to 64 kHz at 0 dBm.

NOTE

0 dBm is referenced to 1 milliwatt into a 600 ohm lead; (i.e., 0 dBm equals 0.778 volts rms).

13. Connect the oscilloscope, an ac vtvm, and 600 ohm terminating resistor to the reproduce output for the channel being aligned (see figure 2-4).

14. Set the SPEED switch to 15 ips and place the recorder in the record mode.

15. Set the METER switch to REC and adjust the RECORD LEVEL control for 0 vu on the front panel meter.

16. Set the METER switch to REP and adjust the REPRO LEVEL control to a convenient level slightly below 0 vu.

17. Adjust bias control R49 for peak reproduce output.

18. While observing the reproduce output on the oscilloscope, increase the record level (RECORD LEVEL control and/or input signal) to record saturation, indicated by compression (clipping) of the reproduced signal. Then decrease in record input 6 to 8 dB.

NOTE

Steps 19 through 24 are performed only when aligning the first channel. Do not repeat when aligning the remaining channels.

19. Set all four METER switches to REP and adjust each REPRO LEVEL control for 0 vu on the front panel meter.

20. Adjust the reproduce head azimuth screw for peak output on channel 4. Note this level as 0 dB and adjust channel 1, 2, and 3 REPRO LEVEL controls for 0 vu.

NOTE

It should never be necessary to turn the reproduce head azimuth screw over 1/4 turn to obtain a peak.

21. Adjust the reproduce azimuth screw to peak channel 3. Note the direction the azimuth screw was turned, and the amount the channel 4 reproduce signal decreases. If the screw was turned ccw, note as a minus (-) value; and if turned cw, note as a plus (+) value.

22. Readjust the azimuth screw for peak on channel 4, and repeat step 19 for channel 1 and 2.

23. Note the high and low readings, and determine the point half way between the two maximums.

24. Repeak channel 4. Turn the azimuth screw in the direction indicated by the value determined in step 23 (ccw if -, or cw if +) until the channel 4 signal decreases that amount. For example, if the half way point in step 23 was +1 vu, turn the azimuth screw cw until the channel 4 signal decreases 1 vu. If the half way point was -0.5 vu, turn the azimuth screw ccw until the channel 4 signal decreases 0.5 vu.

25. For the channel being aligned, adjust bias control R49 for peak reproduce output; then, cw until the reproduce output decreases 3 dB. Repeat steps 9 and 10, and if necessary, readjust R49 for 3 dB of overbias.

26. Set the input signal generator to 1 kHz at 0 dBm.

27. Adjust the REPRO LEVEL control to 0 dB on the ac vtvm. Maintain this output level through steps 28 and 29.

28. Connect a wave analyzer to the reproduce output, and tune to the 1 kHz signal.

29. Set the wave analyzer to 3 kHz and adjust the RECORD LEVEL control for 1 percent 3rd harmonic distortion (-40 dB or 0.01 volts). Be sure the fine tuning of the wave analyzer is peaked.

30. This is the normal record level. Set the METER switch to REC and adjust

the meter adjustment control, R45, for 0 vu on the front panel meter.

NOTE

The front panel meter for the record amplifier is now calibrated. 0 vu represents the normal record level; that is, the record level that will produce 1 percent 3rd harmonic distortion.

NOTE

The signal generator and ac vtvm should still be connected to the record inputs of all four channels, and an ac vtvm and 600 ohm termination connected to the reproduce output of the channel being aligned. The wave analyzer and oscilloscope may be removed from the output. The recorder should still be in the record mode at 15 ips.

31. Set the input signal generator to 1 kHz at 0 dBm. Maintain the input level at 0 dBm and the RECORD LEVEL at 0 vu for the remainder of the alignment procedure through step 39.

32. Set the METER switch to REP.

33. Adjust the REPRO LEVEL control for 0 dBm on the reproduce output ac vtvm.

34. Adjust the reproduce meter control, R59 for 0 vu on the front panel meter.

NOTE

The front panel meter is now calibrated for the reproduce amplifier. 0 vu represents 0 dBm (0.778 volts rms) at the REPRO output connector.

NOTE

Steps 35 through 39 adjust the five tape speed equalizers. The procedure is the same for each equalizer, only the tape speed, controls and frequencies are different. These are tabulated in table 4-6. The numbers in circles ◯ refer to the column in table 4-6.

35. Set the input signal generator to the mid frequency (1) and adjust the mid control (2) for 0 dBm reproduce output (see table 4-6).

36. Set the input signal generator to the high frequency (3) and adjust the high frequency control (4) for -2 dBm reproduce output.

37. Sweep the input signal generator through the bandwidth (5).

38. The reproduce output must stay within ±3 dBm of the 1 kHz reference frequency. If necessary, readjust the mid and high controls.

39. Repeat step 33, and steps 35 through 38 for each tape speed.

40. Press the STOP button and then the POWER button.

41. Remove the record/reproduce pc board from the extender and reinstall in the recorder.

NOTE

After the record/reproduce board is reinstalled in the recorder, the record bias must be readjusted. The signal generator and ac vtvm should still be connected to the record inputs of all four channels, and an ac vtvm and 600 ohm termination connected to the reproduce output of the channel being aligned.

42. Press the POWER button on. The POWER button should light.

43. Press the STOP button to obtain the standby mode. The STOP button should light.

44. Set the input signal generator to 64 kHz at -6 dBm.

45. Place the recorder in the record mode by simultaneously pressing the PLAY and RECORD buttons. Both buttons should light.

46. On the channel being aligned, adjust the bias control, R49, for peak reproduce output; then, cw until the reproduce output decreases 3 dB.

NOTE

The bias control, R49, is accessible through the hole in the front panel adjacent to RECORD LEVEL control.

47. Press the STOP button and then the POWER button.

48. This completes the signal electronics alignment for one channel. If the remaining channels are to be aligned, repeat the complete procedure for each channel except as noted.

49. Disconnect all test equipment and replace all recorder panels removed.

Table 4-6. Tape Speed Equalizer Adjustments

TAPE SPEED	MID FREQ ADJ			HIGH FREQ ADJ			BAND WIDTH ⑤
	FREQ ①	CONTROL ②	LEVEL	FREQ ③	CONTROL ④	LEVEL	
15 ips	10 kHz	R32	0 dBm	64 kHz	R31	-2 dBm	200 Hz to 64 kHz
7-1/2 ips	10 kHz	R27	0 dBm	32 kHz	R26	-2 dBm	200 Hz to 32 kHz
3-3/4 ips	8 kHz	R22	0 dBm	16 kHz	R21	-2 dBm	200 Hz to 16 kHz
1-7/8 ips	4 kHz	R17	0 dBm	8 kHz	R16	-2 dBm	200 Hz to 8 kHz
15/16 ips	2 kHz	R13	0 dBm	4 kHz	R12	-2 dBm	200 Hz to 4 kHz

NOTE: All levels are reproduce outputs and are referenced 0 dBm at 1 kHz.

SECTION V
TECHNICAL DESCRIPTION

5-1. GENERAL

5-2. The AN/TNH-21, Flexible Voice Transcription Recorder/Reproducer is an all solid state, four track, intermediate band tape recorder/reproducer. Functionally, it consists of a tape transport, signal electronics, monitor electronics, and power supply.

5-3. Functionally, the tape recorder may be considered as consisting of two subsystems. The tape transport and signal electronics. The tape transport provides the tape handling and movement, and the signal electronics drives the record and erase head, and amplifies and conditions the signal from the reproduce head.

5-4. The tape transport consists of logic, power drivers, mechanical and electromechanical components. The logic is contained on the logic pc board, and the monitor pc board. See figure 5-1. Motor circuitry and solenoid drivers are contained on the power supply pc board with motor power transistors heatsinked on the rear chassis. All of the mechanical and electromechanical tape handling components are located on the tape transport assembly.

5-5. The signal electronics consists of four record/reproduce pc board assemblies which plug into the rear chassis through the front chassis. A four channel reproduce head preamplifier assembly, a full track erase head, a four track reproduce head, and a four track record head, are located under the head cover. The bias and erase oscillator is located on the power supply pc board.

5-6. The monitor electronics is contained on the monitor pc board. The power supply components are located on the rear chassis and power supply pc board assembly. The power transformer, rectifiers, filter capacitor and regulator power transistors are mounted on the rear chassis; the regulators are on the power supply pc board.

5-7. SYSTEM DESCRIPTION

5-8. **SIGNAL ELECTRONICS.** The signal to be recorded is applied to the RECORD connector, J101, on the rear chassis. From there the signal is connected to the record/reproduce pc board where it is amplified, conditioned, and linearly mixed with the recording bias from the power supply pc board, then applied to the record head. An FET enables the record head during the record mode. The output of the record amplifier, prior to bias mixing, is also applied to the REC position of the METER switch and to the RECORD position of the appropriate monitor switch on the monitor pc board.

5-9. The erase head is driven during the record mode directly from the bias and erase oscillator on the power supply pc board. The system record logic controls the bias and erase amplifier.

5-10. The signal from the reproduce head is amplified by the reproduce head preamplifier located adjacent to the heads under the head cover. The reproduce head preamplifier assembly contains two, dual-amplifier integrated circuits providing four channels of amplification. From the reproduce head preamplifier, the signal is applied to the record/reproduce pc board. There it is put through the appropriate tape speed equalizer, amplified, and connected to the REPRO connector, J102, on the rear chassis. The reproduce signal is also connected to the REP position of the METER switch and to the REPRODUCE position of the appropriate monitor switch on the monitor pc board.

5-11. **MONITORING.** The record and reproduce output of each track is connected to the appropriate switches on the monitor pc board. The signal may be monitored with earphones in the play and record, repeat, and search modes by placing the switches in the desired position and adjusting the volume and tone controls. The record and reproduce signals can

be mixed in any possible combination of the switches without effecting the signals actually being recorded or reproduced.

5-12. **TAPE TRANSPORT.** The tape transport is a reel-to-reel type with a servo controlled dc capstan, dc reel motors. A tape tension servo controls the supply reel in the play and search modes. The tape recorder has the usual stop/standby, play, record, forward, and rewind modes; plus search and repeat modes. All modes are initiated by manual controls located on the logic pc board, and controlled and interlocked by solid state logic located on the logic pc board and monitor pc board.

5-13. There are three modes, or conditions involving stopping tape movement, and no tape movement: stop, standby, and fail-safe. The fail-safe mode exists when power is off, when power is first applied, and at end-of-tape or if the tape breaks. In the fail-safe mode there is no control of the tape by the tape transport logic. The mechanical fail-safe brakes are applied which will stop any tape movement, and restrain the reels. In the fail-safe mode, the STOP button light is out and no tape movement modes can be initiated; the standby mode must be obtained first. With power on and tape properly threaded, the standby mode is obtained by pressing the STOP button. When in the standby mode, the STOP button is lighted. The stop mode is an automatic transitional mode that occurs when the recorder goes from one tape motion mode to another mode. This is indicated by the mode control switch/indicators going on and off during the transition period. The sequence is different for each mode and is included with the explanation of that mode.

NOTE

The reel motor drivers are controlled through diode OR logic and the motor torque is determined by a resistor in series with the diode OR gates. In the play (and record), and the search modes, the supply reel is controlled through the supply reel OR gate by the tape tension sensor, and in the search mode, the take-up reel is controlled through the take-up reel OR gate by the search servo. The output of the reel control OR gates is connected through resistors and diodes to the REEL SIZE switch. This effects the input voltage to the reel motor control circuitry to compensate for different size reels.

5-14. When the forward mode is selected, the forward logic applies a voltage through a pair of control resistors to the reel motor drivers. The voltage to the take-up reel driver through a small value resistor provides a large torque on the take-up reel, and the signal to the supply reel driver through a larger value resistor provides a small holdback torque on the take-up reel. This causes the tape to move at a high rate of speed in the forward direction. The forward mode will continue until another mode is selected, or until tape runs out and light strikes the end-of-tape photo sensor which will put the recorder in the fail-safe mode. If another mode is selected while in the forward mode, the system logic will first go to the rewind mode for dynamic braking; that is, a large torque on the supply reel and a small torque on the take-up reel; through zero tape speed, and then to the mode selected. If tape runs out, the end-of-tape sensor will cause the logic to go into fail-safe, ceasing all control and releasing the fail-safe brakes. The fail-safe brakes will stop the reels.

5-15. The rewind mode operates the same as the forward mode except that the reel driver control resistors are of opposite value to those of the forward mode. This will cause the larger torque to be on the supply reel and the smaller holdback torque to be on the take-up reel. If another mode is selected while in the rewind mode, the system will react the same as when in the forward mode except that the logic will go to the forward mode for dynamic braking. If tape runs out while in the rewind mode, the reel revolution counter will automatically reset and the fail-safe brakes will be applied.

5-16. When the play mode is selected, the reel motors are torqued, the capstan idler is actuated, and the monitor amplifier is enabled. The capstan motor (and servo) is on whenever power is on. The take-up reel motor has a fixed voltage applied by the play logic and the supply reel torque is controlled by the tape tension sensor. Initially an accelerating voltage is applied to the take-up reel. The supply reel motor torque maintains tape tension, and the capstan provides precisely metered tape speeds; either fixed as selected by

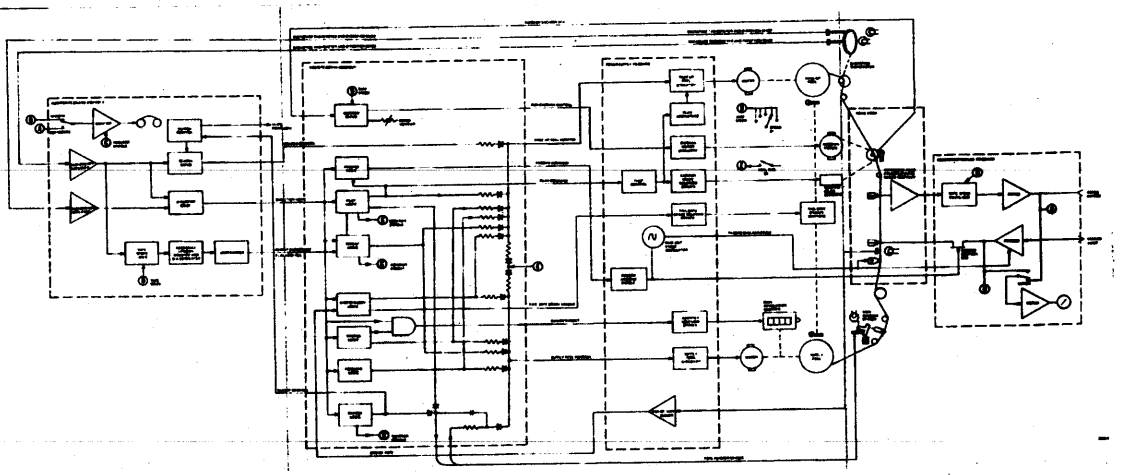


Figure 5-1. Flexible Voice Transcription Recorder/Reproducer, AN/TSEE-21, Block Diagram

the SPEED switch when the SPEED VERNIER control is in the OFF position, or variable by the same control. The capstan speed is sensed by a magnetic tachometer in the capstan assembly. The pulses produced by the capstan tachometer are compared with pulses from an oscillator in the capstan servo system on the logic pc board producing a control signal for the capstan motor circuitry on the power supply pc board. This drives the capstan at an exact speed determined by the SPEED switch and SPEED VERNIER controls. The play mode will continue until another mode is selected or until tape runs out. In either case, the same series of events will occur that were described for the termination of the forward mode.

5-17. The record mode is initiated by simultaneously pressing the PLAY and RECORD buttons. This establishes the play mode as previously described and activates the record and erase electronics. The only difference in the tape transport logic in the play and record modes is that in the record mode, the SPEED VERNIER is disabled and the capstan speed is determined solely by the setting of the SPEED switch. The record mode will continue until another mode is selected or until tape runs out. In either case, the record mode will drop out, and tape motion will stop as described for the forward and play modes.

5-18. The search mode is selected by pressing the SEARCH button. Search is a variable speed forward mode with the monitor amplifier enabled for locating prerecorded data. When the search mode is selected, the monitor amplifier is enabled, the 15 ips tape speed equalizers are selected, and the search servo and tape tension sensor are enabled. The tape speed is determined by the setting of the SRCH SPEED control and controlled by the search servo. The signal from one of the backspace tachometers is fed to the search servo on the monitor pc board, which through the take-up reel diode OR gate on the logic pc board, controls the take-up reel motor circuitry on the power supply pc board. The supply reel motor is controlled by the tape tension sensor through the supply reel diode OR gate on the logic pc board. The search mode will continue in a forward direction until another mode is selected or tape runs out. In either case, the same series of events and conditions will occur that occurs at the termination of the forward and play modes.

5-19. The repeat mode is selected by pressing the REPEAT button and adjusting the SCAN SEGMENT control for the desired length. This mode will repeatedly play a segment of tape, backspace and play it again until another mode is selected. The point where the repeat button is pressed, is the end of the scan segment. The repeat logic goes into a backspace mode with the reel motors torqued similarly to the rewind mode. A signal from the backspace tachometer goes to the monitor pc board where it is conditioned by the tape speed logic and counted by the backspace up-down counter. The output of the up-down counter is a comparator controlled by the SCAN SEGMENT controls on the logic pc board. When the up-down counter reaches a point set by the SCAN SEGMENT, BEGIN ○ control, the output of the comparator will cause the repeat logic on the logic pc board to go into the forward mode for dynamic braking and then go into the play mode. The play mode is the same as previously described except that the backspace up-down counter is counting the pulses from the backspace tachometer, and when the counter reaches the point set by the SCAN SEGMENT END ● control, the repeat logic will go into the rewind mode for dynamic braking and then into the backspace mode. This will continue until another mode is selected.

5-20. REPRODUCE HEAD PREAMPLIFIER ASSEMBLY

5-21. The reproduce head preamplifier assembly is a pc board located near the reproduce head under the upper head cover. It consists of four identical preamplifiers, one for each track, contained in two IC's. See figure 6-4. The reproduce head is hardwired directly to the reproduce preamplifier inputs. For track 1, the reproduce head is connected to terminals E1 and E2; E3 is the shield ground. The input is connected to pin 6 through R2, and pin 5 of U1. C2 is an ac bypass capacitor; and R13 is an impedance matching resistor for the reproduce head. R1 and R2 are gain determining resistors, and C1 provides amplifier compensation. R3 and R4 are voltage dropping resistors, and C3 and C4 are power supply decoupling. The output of the track preamplifier is connected from P18-1 and 4 (gnd); through a coaxial cable to XA1-2 and 3 (gnd) on the track 1 record/reproduce pc board assembly. Tracks 2, 3, and 4 are similar to track 1.

5-22. RECORD/REPRODUCE PC BOARD ASSEMBLY

5-23. The record/reproduce pc board assembly contains the record amplifier, and the reproduce tape speed equalizers and the reproduce output amplifier. See figure 6-5. It also contains the amplifier and switch for the front panel meter.

NOTE

The bias and erase oscillator is located on the power supply pc board assembly, and is covered in the description of that pc board.

5-24. **RECORD AMPLIFIER.** The record amplifier consists of an input transformer (T2), an IC amplifier (U2), an output emitter follower (Q8), and a record head enabling FET, Q10.

5-25. The record input signal from J101 on the rear chassis is connected through a coaxial cable to pins 18 and 19 of the record/reproduce pc board assembly. The record input is transformer coupled by T2. The input impedance is 10,000 ohms, balanced or unbalanced depending upon the setting of BAL switch S2. The record input signal from T2 is connected to the record amplifier (pin 5) through the RECORD LEVEL control, R37. C39, across the secondary, is for high frequency rolloff. The record signal is amplified by U2. R39 and R42 are power supply voltage dropping resistors. Capacitors C40 and C43 are power supply decoupling. R41 and R38 establish the gain of the amplifier; R40, C41, and C42 are for amplifier frequency compensation. The output from U2 is directly coupled to the base of emitter follower Q8. The output of Q8 provides the signal drive for the record head; and through R44, R45, and C45, supplies the record signal to the monitor meter switch, and through pin 16 to the monitor pc board. The record signal from the emitter of Q8 is coupled through C46, R48, and bias trap L12 and C48 to E4, where it is linearly mixed with the bias signal from the bias control R49. The bias signal originates from the bias and erase oscillator on the power supply pc board and is connected to pin 24 on the record/reproduce pc board. The bias oscillator is enabled only in the record mode. The mixed bias and record signal at E4 is connected to the high side of the record head track through pin 22, and returned from the low side of the record head track to pin 21. Pin 21 is connected to ground through FET, Q10. The gate of Q10 is connected to pin 4 which is the record enable from the power supply pc board. In the record mode, Q10 is gated on providing a path to ground for the record head. Current flow through the record head is inhibited by Q10 in all other modes.

5-26. **REPRODUCE AMPLIFIER.** The reproduce amplifier consists of an emitter follower (Q1), five tape speed equalizers (Q2 through Q6), a dual amplifier IC (U1), an output emitter follower Q7, and output transformer T1.

5-27. The reproduce signal from the reproduce head preamplifier is connected to pin 2 and pin 3 of the record/reproduce pc board. From pin 2 the reproduce signal is directly coupled to the base of emitter follower, Q1. C1, C2, and C3 are power supply decoupling capacitors. The signal from emitter follower Q1 is coupled through C4 to the tape speed equalizer bus. All of the tape speed equalizers are gated off except one selected by the tape speed logic. When not active, the tape speed equalizer FET's, Q2 through Q6, have +18 volts applied to their gates through 18K resistors R5 through R9, respectively. The tape speed selected will have a ground applied to the gate from the appropriate tape speed line, pins 6 through 10. The ground comes from Q32 on the Monitor pc board, through the SPEED switch, S1.

5-28. A magnetic tape recorder/reproducer head characteristically has a drop in amplitude in the mid and upper portion of its bandwidth. To produce a flat frequency response, the reproduce amplifier must have an opposite frequency response, that is, mid and high frequency boost. This is accomplished by the tape speed equalizer. Because this frequency characteristic is different for each tape speed, each tape speed must have a different equalizer.

5-29. The proper tape speed equalizer is selected by a ground at the appropriate FET gate. This allows the reproduce signal from Q1 to pass through the passive filter of the equalizer. Each equalizer has a mid and high frequency adjustment. For 15/16 ips, this is R12 for the high frequencies and R13 for the mid frequencies. The output from the equalizer is connected through the FET gate to the input (pin 5) of one half of IC amplifier U1. C26 and L11 form a 250 kHz bias trap for any record bias that may be in the reproduce signal.

5-30. Resistors R56 and R58, and capacitor C27 form an ac gain network for the first half of U1. C25 is for amplifier frequency compensation. The amplified signal from U1 is coupled through C52 to the REPRO LEVEL control, R36. From the REPRO LEVEL control, the signal is connected to the second half of IC U1 where it is again amplified. The operation of the second half of U1 is the same as the first half. The output at pin 13 is connected directly to the base of the output emitter follower Q7. T1, in the emitter circuit of Q7, is the output transformer. It provides a 600 ohm output impedance, balanced or unbalanced to ground depending upon the setting of BAL switch, S1. The reproduce monitor signal for the monitor meter and monitor pc board is taken from meter adjust potentiometer R59. The monitor signal is coupled through C29 to the REP side of the METER switch and through pin 14 to the monitor pc board.

5-31. **MONITOR METER.** The record signal from the record driver stage, Q8, and the reproduce output are connected to the appropriate side of the METER switch, S3. Since the meter amplifier has a fixed gain, the meter adjustment controls should be set during maintenance so that the meter reads 0 vu at the normal record and reproduce levels. For record, the meter adjustment R45 should be set for 0 vu when the RECORD LEVEL control, R37, is set to a level that produces 1% third harmonic distortion in the reproduce output. The reproduce meter adjustment, R59, is normally set for 0 vu with a reproduce output level of 0 dBm (0.778 volts rms), and the output terminated in 600 ohms.

5-32. The monitor signal from S3 is coupled through C49 to the base of meter amplifier Q9. The amplified signal from Q9 is coupled through C50, and meter rectifier CR1 to the front panel vu meter.

5-33. REAR CHASSIS, AND POWER SUPPLY PC BOARD ASSEMBLY

5-34. The rear chassis contains the power transformer, rectifiers, filters, and power transistors for the power supplies and motor drivers. See figure 6-2. The power supply pc board assembly contains regulators for the power supplies; solenoid drivers for the capstan idler, fail-safe brakes, and reel revolution counter; and motor circuitry for the supply and take-up reels, and the run capstan motor. It also contains the bias and erase oscillator, and some record enabling logic. See figure 6-7.

5-35. **REAR CHASSIS.** Primary ac power for the recorder is connected to J104 on the rear of the recorder. J104 is a part of RFI line filter FL1. From FL1, the ac power is connected through the POWER switch and FUSE on the front of the recorder to the primary of power transformer T1. T1 has four secondaries. Terminals 3 and 4, and bridge rectifier CR3 provide +30 volts unregulated, power for the +24 volt regulator (Q5), and power for the capstan motor driver power transistors (Q4 and Q7). Terminals 5, 6, and 7, bridge rectifier CR1 provide +21 and -21 volts unregulated power for the +18 and -18 volt regulators (Q3 and Q1, respectively), power for the supply and take-up reel motor driver power transistors (Q2 and Q8, respectively), and power for the reel motor circuitry. Terminals 8 and 9, and bridge rectifier CR2 provide power for the +5 volt regulator (Q6). Terminals 10 and 11 provide zener voltage for the -18 volt supply reference zener diode.

5-36. **+5 VOLT REGULATOR.** Bridge rectifier CR2 supplies the unregulated power for the +5 volt regulator Q6. The base of Q6 is controlled by regulator amplifier U1 on the power supply pc board. Power for U1 is supplied to pin 3 from the +18 volt regulated supply and pin 2 from the unregulated 5 volt supply. The voltage reference for the +5 volts is built into U1. The error sense and +5 volt adjustment is from voltage divider R25, R26, and R27 which is connected from the regulated +5 volts to ground. C12 and C13 are bypass capacitors and R24 is a current limit resistor. The output of U1, pin 8, controls the base of the +5 volt regulator transistor, Q6.

5-37. **-18 VOLT REGULATOR.** The -18 volt regulator consists of Q1 on the rear chassis with its base controlled at a constant level by zener diode VR1 through R1 on the power supply regulator board. To regulate, VR1 must have a source voltage higher than its zener voltage. This is obtained by rectifying the voltage from T1 secondary, pins 10 and 11, and placing it in series with the unregulated -21 volts from bridge rectifier CR1. This boost voltage is filtered by C1, C2, and C3; and applied to VR1 through R2, R4, and R3.

5-38. +18 AND +24 VOLT REGULATORS. Q3 on the rear chassis, is the regulator transistor for the +18 volt supply, and Q5 is the regulator transistor for the +24 volt supply. The base reference voltage for Q3 and Q5 is obtained from VR2 and VR3 on the power supply pc board. VR2 and VR3 are connected to the +30 volt supply through resistor R7 and R8. VR2 is an 18 volt zener and VR3 is a 6.2 volt zener. The +18 volt reference is taken from across VR2 and connected to the base of Q3 through R5. The +24 volt reference is taken from across both VR2 and VR3 and connected to the base of Q5 through R6.

5-39. +21 AND +30 UNREGULATED POWER. The +21 unregulated power is taken from the + side of CR1 (the +18 volt regulator source). The +21 volts is filtered by C1. The +30 unregulated power is taken from CR3 (the +24 volt regulator source). It is filtered by C4.

5-40. END-OF-TAPE. Any time that the tape path is broken (tape runout or tape breakage), the end-of-tape sensor is activated. This is a phototransistor and lamp located in the head area. When light from the sensor lamp strikes the phototransistor, it conducts and applies a positive voltage to the base of emitter follower Q3 on the power supply pc board. R11 is a sensitivity adjustment, and C1 is a noise filter. When Q3 is biased on by the end-of-tape sensor, it applies a positive signal to the base of Q19 on the logic pc board. See figure 6-3. This forward biases Q19 which applies a low to pin 12 of the standby latch. This causes U33-11 to change state, dropping out the system logic and placing the recorder in the fail-safe mode. This applies a high (+5 volts) to Q4 of the fail-safe brake drive on the power supply pc board; and if the system is in the rewind mode, will cause the logic to activate the reel revolution counter reset solenoid driver, also on the power supply pc board.

5-41. REEL REVOLUTION COUNTER RESET SOLENOID DRIVER. The reel revolution counter reset solenoid driver consists of Q1 and Q2 on the power supply pc board. When the recorder is in the rewind mode and runs out of tape, a +5 volt command from U33-6 on the logic pc board will be applied through R9 to the base of Q1. This biases Q1 on which biases Q2 on, and provides a path to ground for the counter reset solenoid. The other side of the counter reset solenoid is connected to the +24 volts. When the standby mode is reestablished, or power removed, the reset solenoid will be deenergized. When the holding current is removed from the solenoid, the field will collapse. This back emf is suppressed by CR5 to protect Q2 from the resulting reverse voltage.

5-42. FAIL-SAFE BRAKE SOLENOID DRIVER. The fail-safe brakes are disengaged when power is applied to the brake solenoid, and engaged when power is removed. In standby and all operating modes, U33-11, the standby latch on the logic pc board supplies a low to Q4 on the power supply pc board. This low signal keeps Q4 cut off which makes its collector high (+5 volts) and turns Q5 on. This provides a ground path for the brake solenoid; the other end of the solenoid is connected to the +24 volts supply. CR9 is the back emf suppression diode for the brake solenoid. If the end-of-tape sensor is activated, the logic supplies a high to Q4 which turns it on and causes its collector to go low, turning off Q5, deenergizing the brake solenoid, and applying the fail-safe brakes. Anytime that the recorder power is turned off, the solenoid will be deenergized and the fail-safe brakes will be applied.

5-43. TAKE-UP REEL MOTOR CONTROL AND DRIVER. The take-up reel motor control consists of control transistor Q16 on the power supply pc board, and motor driver transistor Q8 on the rear chassis. The control signal is a voltage level from the logic pc board. This level is determined by the mode the recorder is in and applied to the base of the take-up motor control stage, Q16, through XA7A-DD. Q16 controls the base of Q8 through XA7B-A. Q8 is in series with the reel motor and +21 volts supply (unregulated +18 volt supply). It controls the current through the reel motor, and therefore, the torque of the motor. Resistors R4 and R2, on the rear chassis, are in series with the reel motor to ground. Zener diodes VR6 and VR8 are connected across the reel motor. VR6 limits the voltage across the reel motor; thus the maximum motor speed. VR8 provides reverse braking in the forward mode. Capacitor C26 is a bypass capacitor and resistors R48 and R54 and thermistor R55 form the input divider network.

5-44. SUPPLY REEL MOTOR CONTROL AND DRIVER. The supply reel motor control is Q15 on the power supply pc board, and the

motor driver transistor is Q2 on the rear chassis. The operation of the supply reel motor control and driver is the same as the take-up reel motor control and driver, previously described.

5-45. PLAY ACCELERATE AND PLAY CAPSTAN IDLER SOLENOID DRIVER. When the play mode is selected, a positive signal is applied at XA7A-E. This activates the capstan idler solenoid driver, and the run accelerate stage. The run accelerate stage is Q14. The positive play command from XA7A-E is applied to C23 which charges through R40 to ground. This produces a positive signal across R40 which is applied through R43 to the base of Q14 turning it on and applying a positive signal through R44 to the base of take-up motor control transistor, Q16. This causes the take-up motor to accelerate at increased torque for a period of time determined by the time constant of C23 and R40. When C23 is charged, Q14 cuts off and is not a factor until the play mode is initiated again. CR14 and R42 provide a quick discharge path for C23 when the play mode is removed. This is necessary in the event the play mode is immediately reselected.

5-46. The play capstan idler solenoid driver consists of Q12 and Q13 on the power supply pc board. The positive play command at XA7A-E is applied through R37 and CR12 to the base of emitter follower Q12. This forward biases Q12 causing its emitter to go positive, turning on Q13. Q13 provides a ground path for the run capstan idler solenoid. The other end of the solenoid is connected to the +30 volt supply. CR13 is the back emf suppression diode for the solenoid. R1 on the run capstan provides reduced holding current after the solenoid pulls in.

5-47. RUN CAPSTAN MOTOR CONTROL AND DRIVER. The run capstan motor control consists of complementary amplifier stage Q6 and Q7, and motor drivers, complementary pair Q4 and Q7. The capstan motor speed is controlled by a tachometer and servo system described under the logic pc board description. The run capstan servo provides an error signal to the motor control at XA7B-EE. This signal is connected directly to the base of Q6 and through diode CR10 to the base of Q7. Q6 on the power supply pc board and Q4 on the rear chassis provides capstan motor acceleration. Q7 on the power supply pc board, and Q7 on the rear chassis provides capstan motor deceleration. Motor driver transistor Q4 is in series with the motor and the +30 volt supply, and Q7 is in parallel with the capstan motor. When a positive going error signal is applied to the base of Q6, its collector moves in a negative direction and forward biases Q4, causing the motor to accelerate. If the error goes negative, the collector of Q6 will move in a positive direction and reduce the bias at the base of Q4, reducing the accelerating current for the motor. If the error signal goes further negative, Q7 on the power supply board will be forward biased, in turn forward biasing Q7 on the rear chassis. When Q7 conducts it acts as a short across the motor, causing it to decelerate rapidly. C10 is a frequency limiting capacitor to eliminate any carrier frequency from the capstan servo, and C9 is for amplifier stabilization. R21, R22, and R23 determine the gain of the output stages.

5-48. BIAS AND RECORD ENABLE, BIAS AND ERASE OSCILLATOR. The record command from the logic pc board is a positive signal at XA7A-K. This signal turns on Q10, which turns on Q11. Q11 provides a ground path for the bias oscillator, Q8 and Q9; and, a ground path through R32 to the record enable bus, XA7A-X. This is connected through pin 4 on each record/reproduce pc board to the gate of the record enable FET, Q10.

5-49. When the ground path through Q11 is supplied to the bias and erase oscillator, Q8 and Q9, it provides a 250 kHz signal to the erase head from J19, and to each of the record/reproduce pc boards through capacitors C19 through C22. The oscillator is a free running flip-flop. The frequency is determined by T1, and C14 and C15. The output is transformer coupled by T1, and fine tuned by C15 which is variable.

5-50. MONITOR PC BOARD ASSEMBLY

5-51. The monitor pc board assembly contains the signal monitoring electronics, tachometer amplifiers for the backspace and direction sense tachometers, direction sensing logic, search servo and some search logic, the repeat up-down counter and comparators. From the -18 volts supply, R69, zener diode VR1, and C29 form a -9 volt supply.

5-52. **MONITOR ELECTRONICS.** See figure 6-6. The monitor electronics consists of input switches; a summing amplifier (U13), tone control amplifiers (Q16, Q17, and Q18; and Q28, Q29, and Q30), a summing network and tone control, an FET source follower (Q20), squelch (U11 and Q21, Q31), amplifier and emitter follower (Q22 and Q23, respectively), and an output complementary emitter follower (Q24 and Q25).

5-53. The record signal and the reproduce signal from each record/reproduce pc board is connected to the monitor switches, S1 through S4. These switches may be set in any combination. The record and/or reproduce signal of the four tracks may be mixed. From the monitor switches, the signals are summed into amplifier U13. C48 and R80 control the gain of U13, and R82 is a terminating resistor. The output from U13 is connected to the bass boost circuit, Q28, Q29, and Q30; the treble boost circuit, Q16, Q17, and Q18, and emitter follower Q19. Q19 has a flat frequency response. The monitor signal from Q19 is connected through R84 and C30 to the center-tap, OFF position of the TONE control, R87. R84 and R86 provide attenuation to match the losses in the high pass and low pass filters. There is no frequency contouring when the TONE control is in the center, OFF, position.

5-54. Both the treble and bass circuits consist of a phase splitter and two emitter followers. The output of the treble boost circuit is connected to the cw end of the TONE control, R87, through C31, and the output of the bass boost circuit is connected to ccw end of the TONE control through C32. When the TONE control is maximum ccw, at B, the monitor output signal will have 200 Hz boost and 3.2 kHz cut with a 1 kHz crossover. When the TONE control is maximum cw, at T, the monitor signal will have 200 Hz cut, and 3.2 kHz boost with a 1 kHz crossover.

5-55. Note that the phase splitter for the bass control, Q28, and the treble control, Q16 are of opposite phasing; that is, the capacitor for the base phase splitter, C41, is connected to the emitter of Q28, and the capacitor for the treble phase splitter, C22, is connected to the collector of Q16. These are all pass networks. This compensates for the phase shift in the low pass filters in the base boost circuit (R113 and C42, and R115 and C43), and the high pass filters in the treble boost circuit (C23 and R63, and C24 and R65).

5-56. From the TONE control, the monitor signal is applied to the gate of FET source follower, Q20. From Q20, the signal is applied to the VOLUME control, R92, through squelch control gate, FET Q21, and capacitor C33. The squelch function is controlled from the logic pc board. When the recorder is in the run mode, run portion of the repeat mode; or the search mode, U23-6 on the logic pc board will provide a high logic level, monitor enable, to XA6-EE on the monitor pc board. When monitor is not enabled, a low at XA6-EE, U11-6 is high, turning on Q31 and making its collector low. This back biases CR7 causing this circuit to have no effect on the squelch gate Q21. Q21 is gated off by R91, disabling the monitor output. When the monitor enable signal at XA6-EE goes high, it is inverted by U11, applying a low to the base of Q31. This cuts off Q31, causing its collector to go high. This high signal forward biases CR7 applying the high to the gate of Q21, enabling the monitor amplifier.

5-57. The signal from VOLUME control, R92, is coupled through C34 to the base of amplifier Q22 which drives emitter follower Q23. Feedback resistor R143 determines the gain of Q22. C49 and R142 form an ac emitter bypass. C50 is an in-phase, bootstrap feedback, which increases the signal amplitude range of the amplifier.

5-58. Emitter follower Q23 drives the output complementary emitter followers, Q24 and Q25. The monitor signal from Q24 and Q25 is coupled through C36 to PHONES jacks on the front panel. R102 is the output terminating resistor.

5-59. **BACKSPACE (AND DIRECTION SENSE) TACHOMETERS.** See figures 6-6 and 7-8. The backspace tachometer consists of two, photoelectric tachometers. One tachometer (no. 1) is used for the repeat up-down counter, and the search servo; and both tachometers (no. 1 and 2) are used for direction sensing. Tachometers no. 1 and 2 are identical circuits. Tachometer no. 1 consists of phototransistor Q1 and lamp DS1 on the backspace tachometer assembly; and Q1, U1, and Q2 on the monitor and repeat control pc board. Tachometer no.

2 consists of phototransistor Q2, and lamp DS2 on the backspace tachometer assembly; and Q13, U2, and Q14 on the monitor and repeat control pc board assembly.

NOTE

The circuits for both tachometers are identical. Therefore, only the no. 1 tachometer circuit is described in detail.

5-60. The backspace tachometer consists of a tachometer disc and reticles between two lamps and phototransistors. As the tachometer disc turns with tape movement, it modulates light from the lamps which hits the phototransistors and causes their conduction to increase and decrease. The tachometer phototransistor, Q1, is connected as a feedback complementary amplifier with Q1 on the monitor and repeat control pc board. The base of the phototransistor is connected between R1 and R2 from the emitter of Q1 providing dc feedback. The signal from the collector of Q1 is coupled through C3 to U1, a saturated amplifier which functions as a Schmitt trigger. R9 and R11 provide positive feedback. CR1 is an unlatching diode to the base of Q2. The output from U1 is a square wave. CR1 will conduct until the signal reaches a positive level of about +5 volts. It will then be biased off by the +5 volt supply through R13. This +5 volt square wave on the base and emitter of emitter follower Q2 does three things: (1) It goes to U3-12, where after being counted down for the proper tape speed, it drives the repeat control up-down counter; (2) it is connected to U23-2 and 3, and U24-1, the direction sense logic; (3) it is coupled through C6 to the search servo.

5-61. Backspace tachometer no. 2 (Q13, U2, and Q14) is the same as tachometer no. 1 through Q14. The tachometer reticles are spaced so that the signals will be phased 90 degrees apart. This is important for direction sensing as will be explained later. From Q14, the no. 2 tachometer square wave is divided by two in U3. The output of U3 is differentiated by C21 through R58. This produces a positive pulse from Q15 which is connected to U24-2 of the direction sense logic. Refer to the direction sense description for details of the direction sense logic.

5-62. **SEARCH SERVO.** The search servo is a velocity servo that controls the velocity of the tape by varying the amplitude of the take-up reel motor voltage. Square waves from the no. 1 tachometer are differentiated on the leading and trailing edges (C7 and R17, and C8 and R20, respectively). The leading edge is used as a reference to begin charging C9 which develops a sawtooth. The rate at which C9 charges is determined by the SRCH SPEED control. At the trailing edge of the tachometer pulse, the charge on C9 is sampled and integrated by C10. The level on C10 is compared with a fixed reference and error is amplified by U1, and provides a control signal to the take-up reel motor driver. If the charging rate of C9 changes (SRCH SPEED control) or the tachometer rate changes (tachometer pulse width), the charge on C10 will change and change the drive on the take-up reel motor.

5-63. The +5 volts square wave at the emitter of Q2 is coupled through C6 to the base of Q3. Q3 amplifies the signal providing about an 18 volt signal swing between ground and the +18 volts. When the signal goes positive it will be differentiated by C7 through R17. This will provide a positive pulse on the base of Q4, turning it on, and shorting C9 to ground, dumping the charge on C9. When Q4 turns off, C9 will begin to charge to the +18 volt supply through R18, high speed trim control R146, and the SRCH SPEED control, R113, on the logic pc board.

NOTE

If the SRCH SPEED control is in the REMOTE position, the charge path of C9 will be through a resistor in the remote control instead of R113.

5-64. As C9 charges, the base and emitter of Q5 will follow the charge. Since Q6 is cutoff, except during the negative swing of the tachometer signal; CR3 will conduct through R22 and R23, holding the base of Q7 near ground. This cuts off Q7, and back biases CR2 so that the signal on the emitter of Q5 is blocked. When the tachometer signal goes negative, it is differentiated by C8 and R20 to the +18 volt supply. This negative pulse momentarily turns on Q6 which causes its collector to go positive. This momentarily back biases CR3

which allows the signal level on the emitter of Q5 (corresponding to the charge on C9) to pass through CR2 to the base of Q7. Q7 momentarily conducts according to amplitude of this signal. Also, when Q6 turns on, it turns on Q8 which is in the emitter circuit of Q7. The signal at the emitter of Q7 is a pulse the width of the negative tachometer signal differentiation, and corresponding in amplitude to the charge on C9. The charge on C9 is a function of its charging rate (SRCH SPEED control setting) and charging time (tachometer pulse rate).

5-65. The pulse at the emitter of Q7 determines the charge on C10. Q8 is cut off except during the sampling period, preventing C10 from discharging to ground, except during the sampling period and according to the pulse level. If the tape speed is too slow, the pulse amplitude will increase and increase the charge on C10. If the tape speed is too high, the pulse will be lower in amplitude than the charge on C10, and the charge on C10 will be reduced through R24 and Q8 to ground, accordingly.

5-66. The charge level on C10 is coupled through Darlington pair Q9 and Q10 to U1-9, the loop amplifier input. This level is compared with a level set by voltage divider network R27, offset control R28, and R31. R32, R33, R147, and C12 form a gain network. C11 and R34 are for frequency compensation of U1. U1-11 connects through CR12 to the collector of Q32. When not in the search mode, Q32 conducts causing U1-11 to go low and inhibits the loop amplifier and search servo. When the search mode is selected, Q32 is off, its collector is high, CR12 is back biased and the search servo enabled.

5-67. The output of the loop amplifier, U1, is clamped by CR13 to limit negative excursion. Emitter follower Q12 is the output stage. It is connected through R72 and CR13 (in the take-up reel motor control network) on the logic pc board to the take-up reel motor drive control on the power supply pc board.

5-68. SEARCH CONTROL (Q32 AND Q33). When the search mode is selected, the logic pc board provides a logic high at XA6-11 on the monitor. This forward biases Q33 providing a ground to the 15 ips bus through XA6-12. This selects the 15 ips tape speed equalizers. Also, when Q33 conducts, it turns off Q32 causing its collector to go high. This enables the search servo and disables the SPEED select switch. When not in the search mode, Q32 conducts and provides a ground for the SPEED select switch through CR10, XA6-9, and J15-10.

5-69. DIRECTION SENSE LOGIC. The direction sense logic uses the signals from backspace tachometers no. 1 and no. 2. The two tachometer signals are phased 90 degrees apart. The signal from tachometer no. 2 is divided by 2 in flip-flop U3 to desensitize the direction sense circuitry. The output from U3 is differentiated and Q15 produces a positive pulse corresponding to the leading edge of every other no. 2 tachometer pulse. Tachometer no. 1 signal from the emitter of Q2 is a symmetrical square wave and is connected to AND gate U24-1, and through inverter U23-1, 2, and 3 to AND gate U24-5. The divided signal from the collector of Q15 tachometer no. 2, is connected to AND gates U24-2 and U24-4.

5-70. Tachometer no. 1 produces a continuous square wave; that is, symmetrically high and low. Tachometer no. 2 produces a positive pulse corresponding to every second leading (positive going) edge. Since the two tachometers are 90 degrees out of phase, the leading edge of tachometer no. 2 (positive pulse) will occur when the tachometer no. 1 signal is high in one direction and when it is low in the other direction. As previously described, the signal from tachometer no. 1 is connected to pin 1 of AND gate U24, and through inverter U23 (pins 1, 2, and 3) to pin 5 of AND gate U24. This will result in the tachometer no. 1 signal at either U24-1 or U24-5 being high and the other low. When the tachometer changes direction, the logic levels will reverse. Assume that the tachometer no. 1 signal is high at the time the tachometer no. 2 pulse occurs. Since both U24-1 and U24-2 are high, the output, U24-3 goes high which causes flip-flop U23-13 to go low. The low from U23-13 goes to U26-8, and also to direction change delay stage Q35. The output of Q35 during the delay period will be high causing U25-10 to be low and U25-13 to be high. This will produce highs on both direction sense lines when changing direction for the period determined by C46 and R37. When C46 is charged, Q35 conducts providing a low

at U25-9, and since U25-8 is low, U25-10 becomes high producing a low at U25-13. U23-13 feeds back to U23-9 and maintains this condition until a direction change occurs. The other half of the direction sense logic is just the opposite with a high at U25-1.

5-71. If the tachometer no. 2 pulse occurs with the tachometer no. 1 signal low, indicating tape moving in the forward direction, the same events will occur only in the other half of the logic and U25-1 will be low and U25-13 will be high.

5-72. The direction sense output goes to the logic pc board where it is used by the logic in all tape handling modes. It is also used on the monitor and repeat control pc board to control the direction of the repeat up-down counter. When tape is moving in the reverse direction (take-up reel to supply), flip-flop U23-10 is low enabling the count up bus. When tape is moving in the forward (play) direction, U23-13 is low enabling the count down bus.

5-73. **REPEAT CONTROL LOGIC.** The repeat control logic on the monitor and repeat control pc board uses tachometer no. 1 signal and divides them down according to tape speed (U21). The outputs of the divider, U21, provides the input for the up-down counter. By means of a ladder network (R70 through R79, and R119 through R130), the up-down counter provides a voltage level corresponding to the pulses counted. This level is one of the inputs to each of the scan segment comparators (U14). The two comparators detect the scan segment begin and the scan segment end. The reference for the comparators are the BEGIN ○ and END • controls, respectively, on the logic pc board. The output of each comparator is coupled through an interface stage to the repeat logic on the logic pc board.

5-74. Tachometer no. 1 signals are connected to U3-12 of the tape speed dividing logic. This consists of five, divide by 2 flip-flops, part of U3 and all of U21. The output of each of the flip-flops is connected to one of the five tape speed AND gates, U22 and U7-12. The other inputs to the AND gates are the tape speed select lines from the SPEED switch. The tape speed selected will have a high on that line, the rest will be low. Note that the higher speeds are divided down more, and the low speeds are divided down proportionally less. This results in the scan segment being the same in time, regardless of the tape speed. The length of scan segment may be varied by the SCAN SEGMENT controls from near zero to a maximum of at least 10 seconds at any fixed tape speed.

NOTE

Because the repeat up-down counter operates from tachometer signals, representing actual tape movement, changing the play tape speed by the capstan SPEED VERNIER control, will change the time of the scan segment accordingly; although, the length of tape scanned will remain the same.

5-75. When the signals from the tape speed divide logic goes high at the tape speed AND gate enabled by the speed line; the output of that gate will go low causing one of the inputs to U26 to go low, and U26-8 to go high for the duration of that divided tachometer signal. The high pulse from U26-8 is connected to the first pair of AND gates in the up-down counter U4-2 and U4-13.

5-76. When the repeat mode is selected, the repeat logic on the logic pc board causes the clear bus to go low, having previously been high to reset all of the counter flip-flops. Note that the Q output of all the counter flip-flops connect into the comparator ladder network, except U19-3. In this flip-flop $\overline{Q}$, U19-2, connects to the voltage divider network. When the counter is reset, all Q's are low and all $\overline{Q}$'s are high. This results in a count always being in the voltage divider network so that regardless of where the BEGIN ○ control is set at the start of the repeat mode, no later setting of it can cause the counter to go below zero.

5-77. To understand the counter, note that it consists of a series of two, three input, inverting AND gates (except for the first pair which has two inputs), a single inverting AND gate which performs an inverting OR function, and a flip-flop connected so that it changes state with each tachometer signal applied to the clock

input, C. Note that one of the inputs of one AND gate is connected to the count up bus, and $\overline{Q}$ of the flip-flop; that one of the inputs of the other AND gate is connected to the count down bus, and Q of the flip-flop; and that the tachometer signal from the previous set of gates is connected to both AND gates. When the count up bus is high (see note below), the tachometer signals will pass through each set of gates where Q is high (and $\overline{Q}$ is low), toggling each flip-flop along the way, until it comes to a flip-flop where $\overline{Q}$ is high. It will toggle this flip-flop, but will not proceed to the next flip-flop because the count up gate must be enabled by Q being high. This decreases the count with each tachometer signal and lowers the ladder network output voltage.

NOTE

The counter counts up when the count up bus is low, and the count down bus is high. It counts down when the opposite is true.

5-78. If the count down bus is high, the tachometer signal will pass to the next flip-flop only if $\overline{Q}$ is high and Q is low. This will increase the count and raise the ladder network output voltage.

5-79. The tape backspaces first; therefore, the direction sensor flip-flop U23-10 is low and U23-13 is high. This will make U4-12 high and when the tachometer signal at U4-13 goes high, U4-11 will go low causing U4-6 to go high. This will cause U5 to change state and U5-3 (Q) to go high. The high at U5-3 is applied through R71 into the ladder network and increases the voltage to the comparators, U14, one step. U6-13 is high from the count down bus. The next high tachometer signal causes U6-1 to go high, U5 to toggle, making U5-3 low, U5-2 (U6-2) high, causing U6-12 to go low, and U7-3 to go high. This toggles U5 causing U5-5 to go high, and applies a high through R73 into the comparator ladder network, stepping it a step higher. The level through R71 is now low. The next high tachometer signal will cause U5-3 to go high, U5-5 to go low, and U9-5 to go high. This will increase the comparator voltage another step. This sequence will continue until the voltage on the ladder network reaches a level determined by the setting of the SCAN SEGMENT BEGIN ○ control R107 on the logic pc board. U14-13 will go high at this point. The BEGIN ○ control is connected through R145 to U14-8.

5-80. Comparator U14-13 is the begin control and U14-1 is the end control. U14-13 is configured to produce a high output when the voltage divider network goes above the level set by the BEGIN ○ control, and U14-1 is configured to go high when the voltage on the ladder network goes below the level set by the END • control. Therefore, the comparator outputs will be low except during command and execution of a direction change. The low outputs from the comparators, through diode CR5 and CR6 will bias transistors Q26 or Q27 on, producing low outputs to the repeat logic on the logic pc board. When one of the comparator outputs goes high, for example, the begin comparator U14-13, CR5 will be back-biased causing Q26 to be biased off through R104, producing a high output to the logic pc board. This will cause the recorder to go from the backspace mode through dynamic braking and into the play mode. When the tape changes direction, the direction sense logic, U23-13, will cause the count down bus to go low and the count up bus to high. The counter will start counting down and both comparator outputs will be low until the count reaches the level set by the END • control, R111. At this point, the end comparator, U14-1, will go high, causing the emitter of Q27 to supply a high to the logic pc board. This causes the recorder to go from the play mode through dynamic braking and into the backspace mode. This sequence continues until another mode is selected.

5-81. LOGIC PC BOARD ASSEMBLY

5-82. The logic pc board assembly contains the capstan servo circuitry and the system control logic and controls.

5-83. **CAPSTAN SERVO.** The capstan servo consists of a tachometer and tachometer electronics (U26 and Q1), tape speed circuitry and logic (Q2, Q3, Q4, Q5, U10, U17, and U18B), phase comparator (U1, U2, and U9), reference oscillator and logic (Q9, Q10, and U18A), and servo loop amplifier and associated circuitry (U25, Q7, and Q8). See figure 6-3, sheet 1.

5-84. **Capstan Tachometer.** The capstan tachometer is a magnetic tachometer located in the capstan assembly. It consists of magnetic poles in the capstan flywheel and a stationary printed circuit pickup. This produces a signal corresponding in rate to the rotational speed of the capstan (tape speed).

NOTE

The signal amplitude from the tachometer also increases with speed; however, only the signal rate (frequency) is used in the servo system.

5-85. **Tachometer Amplifier.** The tachometer amplifier consists of U26A, U26B, and Q1 on the monitor pc board.

5-86. The signal from the tachometer is connected to A5-W and A5-19 on the logic pc board. It is connected through R2 and R3 to tachometer amplifier U26A with R1 and R4 providing ground reference. C2 and C4 is for power supply decoupling. R5, R6, and C3 form a gain network, and C1 and R7 are for frequency compensation of U26A. The tachometer signal is connected from U26A-1 through R9 to squaring amplifier (Schmitt trigger) U26B. R11 is a dc offset adjustment. Positive feedback is through R13. Negative pulse from U16B-13 will cause diode CR1 to conduct and turn on emitter follower Q1. This causes the emitter of Q1 to go to near ground. When the tachometer pulse goes positive it back-biases CR1 biasing Q1 off through R15. This causes the emitter of Q1 to swing between zero and +5 volts with the tachometer signal. This signal is applied to the tape speed logic; U18B-9 for tape speeds, 3-3/4, 7-1/2, and 15 ips; and through VR1 to Q2 for tape speeds 15/16 and 1-7/8 ips.

5-87. **Tape Speed Logic.** The tape speed logic multiplies or divides the tachometer frequency for comparison with the reference frequency, U18A-3. At 15/16 ips, the tachometer frequency is doubled (X2), at 1-7/8 ips, it is X1, at 3-3/4 ips it is ÷ 2, at 7-1/2 ips it is ÷ 4, and at 15 ips it is ÷ 8.

5-88. For 15/16 ips and 1-7/8 ips the tachometer signal is coupled through level shifting diode VR1 to the base of phase splitter Q2. The signals at the emitter and collector of Q2, 180 degrees apart, are differentiated by C6 and R20 (emitter), and C5 and R21 (collector) and applied to the bases of parallel transistors Q3 and Q5, respectively. Assuming Q4 is biased off, the positive spikes from the differentiating networks will momentarily turn on one transistor and then the other (Q3, and Q5). Since the positive spikes represent the positive going and negative going edges of the tachometer pulse, they will occur at 2 times the tachometer rate. With both Q3 and Q5 operating, this will result in pulses across R22 at 2 times the tachometer rate. If Q4 is turned on, it will ground the base of Q5 holding it off. In this case, the differentiated pulse from the collector of Q2 will have no effect, the pulse from the emitter of Q2 will turn on Q3, only. This will result in a pulse across R22 at 1 times the tachometer rate. The pulses from R22 are applied to tape speed logic gate U10D-10. U10D and Q4 are controlled by 15/16 and 1-7/8 ips tape speed lines. The five tape speed lines are controlled by the SPEED switch, S1, on the tape transport which applies +5 volts to the selected line.

5-89. When 15/16 ips is selected, Q5-AA will be high (+5 volts). This high is applied through CR4 to U10D-9 which enables the gate and allows it to pass the tachometer pulses at U10D-10. CR3 blocks the high from CR4 which allows Q4 to be turned off through R23 to ground. This allows both Q3 and Q5 to conduct making the pulses being passed by U10D, 2 times the tachometer frequency.

5-90. When 1-7/8 ips is selected, Q5-22 is high. This high is applied through CR3 to U10D-9, enabling the gate, and through CR2 and R24 to the base of Q4. This turns on Q4 which grounds the base of Q5 holding it off. As previously described, only Q3 will be activated, resulting in the pulse rate at U10D-10 being the same as the tachometer frequency (1 times). When either 15/16 or 1-7/8 ips is selected, U10D-9 will be high and U10D will pass the tachometer pulses to U10E. In all other tape speeds U10D-9 is low through R28 which will inhibit it from passing the tachometer pulses.

5-91. For tape speeds 3-3/4, 7-1/2, and 15 ips, the tachometer signal from the emitter of Q2 is applied to binary divider chain U18B, then to U17A, and then to U17B. This results in U18B-5 being at 1/2 the tachometer frequency, U17A-3 being 1/4 the tachometer frequency, and U17B-5 being 1/8 the tachometer frequency. The divided signals are applied to AND gates U10A-13 (3-3/4 ips), U10B-2 (7-1/2 ips), and U10C-4 (15 ips). Whenever one of these tape speed lines is high, it will enable the corresponding AND gate which will pass the divided tachometer pulses to OR gate U10E.

5-92. Depending upon the tape speed selected, one of the inputs to U10E will be receiving tachometer pulses multiplied or divided in frequency to correspond to the reference oscillator frequency from U18A-3, when the capstan is at the correct speed. The output of U10E is applied to the base of Q6, which provides the tachometer pulse for the phase comparator.

5-93. Reference Oscillator. The reference oscillator consists of Q9, the oscillator, and U18, a ÷2 flip-flop. Q9 is a programmable unijunction transistor (PUJT) whose trigger point is determined by the voltage level on its gate. Q9 will conduct when the anode voltage reaches a level determined by the level at the gate. The gate voltage may either be fixed or variable by the SPEED VERNIER control, R67. In all modes except record, a high is supplied to the base of Q10 biasing it on and providing a ground path for K1. The high side of K1 is connected through the SPEED VERNIER switch to the +18 volt supply. Except when in the record mode or when the SPEED VERNIER switch is set to OFF, K1 is energized and the oscillator frequency, and capstan speed, is variable by R67. This controls the gate voltage of Q9. When in the record mode, or the SPEED VERNIER switch is OFF, K1 is de-energized and the gate voltage is determined by voltage divider R63 and R62.

5-94. The anode voltage of Q9 is determined by the charge on capacitors C21, C22, C23, and C70; and, the charging rate of the capacitors is the time constant of their total capacitance and the value of R66. This is trimmable by C23. The higher the voltage at the gate the longer the time required for the capacitors to charge to that voltage and therefore, the lower the frequency of the oscillator, and vice versa. When the anode reaches the level determined by the gate, Q9 conducts and dumps the charge on the capacitors through R65 to ground. This produces a positive pulse at the cathode of Q9 and to the clock input of the ÷2 flip-flop, U18A-12. U18A is a J-K flip-flop with the J and K inputs high. With each pulse to its clock input it will toggle, resulting in a symmetrical square wave at half the oscillator frequency at the $\overline{Q}$ output, U18A-3.

5-95. Phase Comparator. The phase comparator compares the reference oscillator signal and the tachometer signal and produces an error signal used by the servo loop amplifier to control the capstan motor; and thus, the capstan and tape speeds. The comparator consists of J-K flip-flops U1A and U1B, and inverting OR gates U2 and U9. The output of the phase comparator is U1B-6, $\overline{Q}$. When the capstan is at the proper speed, the output of the phase comparator (U1B-6) is a square wave 180 degrees out of phase with the reference oscillator (U18A-3). The position of the leading edge of the comparator output pulse is determined by the reference signal and the position of the trailing edge is determined by the tachometer signal. When power is first applied, the reference oscillator will start, but there is no tachometer signal until the capstan begins to turn. This will cause the output of the comparator, U1B-6, to go high and stay high until the capstan is up to speed.

5-96. The reference input to the phase comparator is through differentiators C7 and R35, and C8 and R37. Note that the time constant of C8 and R37 is larger than C7 and R35. This will result in a longer pulse to U9B-6 than to U2C-8. Note that these points are normally high through R35 and R37, and that the pulse is a negative (low) pulse resulting from the negative transition of the reference pulse. The short pulse is a clock pulse and the long pulse is the K control for U1B.

5-97. U2C-9 is low during normal operation. On the negative transition of the reference signal U2C-8 will go low making U2C-10 and U2A-2 high. This causes U2A-1 to go low which makes U2D-13 go high for the duration of the short pulse. U2D-13 is the clock signal to flip-flops U1A and U1B. The flip-flops toggle on the positive to negative transition of the clock pulse. Both the J and K inputs to U1A are wired high to the +5 volt bus; therefore U1A will toggle with each negative going clock pulse making Q and $\overline{Q}$ alternately high and low. When the reference and tachometer signals are in sync (180 degrees apart) U1A and U1B will be 180 degrees out of phase; and toggling with each

clock pulse; that is U1A–Q and U1B-$\overline{Q}$ high, and U1A-Q and U1B-$\overline{Q}$ low, and vice versa with the next clock pulse.

NOTE

The outputs of J-K flip-flops, Q and $\overline{Q}$, are controlled by the condition of the J and K input, respectively, at the clock time. For U1, the clock time is a positive to negative transition at C. If J is high and K is low at the clock time, Q will be high and $\overline{Q}$ will be low. If J is low and K is high, at the clock time, $\overline{Q}$ will be low and Q will be high. If both J and K are high, Q and $\overline{Q}$ will change state with each clock pulse. If both J and K are low, both Q and $\overline{Q}$ will remain as they were before the clock; one high and one low.

5-98. The long pulse from the reference signal differentiation results in a low at U9B-6 which causes its output, U9B-4, to go high which makes U1B-K high. (In normal operation, U9B-5 is low.) Except when there is a tachometer pulse, U9C-10 and U1B-J are low. Therefore, at the clock time (end of the short pulse), U1B-$\overline{Q}$ will go low, and U1B-Q will go high. Note that the long pulse will last about 4 times as long as the shorter clock pulse therefore, U1B-K will remain high during the clock transition.

5-99. The tachometer portion of the phase comparator operates the same as the reference. A positive pulse signal at the base of Q6 turns Q6 on and causes its collector to go low. There are two differentiating networks connected to the collector of Q6, C10 and R36 (short), and C9 and R38 (long). These are negative pulses; the short pulse from C10 to U2B-5 is the clock, and the long pulse to U9C-9 is the control signal to U1B-J. The low at U9C-9 causes its output to go high for the duration of the long pulse (U9C-8 is low) making U1B-J high.

5-100. The short clock pulse causes the output of U2B-4 to go high (U2B-6 is low) making U2A-1 low and U2D-13 high for the duration of the pulse. As described previously, the clock occurs at the positive to negative transition of U2D-13 at the end of the short pulse. At the clock time U1A will toggle making U1A-Q low and U1A-$\overline{Q}$ high. Also, since U1B-J is high because of the long tachometer pulse differentiation, and U1B-K is low, U1B-Q will go high and U1B-$\overline{Q}$ will go low at the clock time.

5-101. This sequence of reference pulse and tachometer pulse controlling and toggling U1B will continue as long as both signals are alternately received. U1B-$\overline{Q}$ is the phase comparator output signal to the servo loop amplifier. The reference signal determines the position of the positive going edge of the signal and the tachometer signal. determines the position of the negative going edge.

5-102. If for some reason either the reference or tachometer signal is not present (for example, there will be no tachometer signal when power is first applied) the phase comparator will lock up one condition. This is accomplished by U9A if there are no tachometer pulses, or U9D if there are no reference pulses. As described previously, U1A and U1B are normally out of phase, and that each clock pulse will toggle U1A but that control signals are required at U1B-J and K for U1B to toggle. If U1B-J and K do not alternately receive a high at the clock time, U1A and U1B will become in phase, which will inhibit highest frequency clock pulse inputs and prevent U1B from toggling. When this happens, both the inputs to U9A or U9D will be low making the output of that gate high. Both inputs to the other gate will be high making its output low. Assume that the tachometer pulse is absent and that reference pulse is present, as when power is first applied. This will result in U1B-Q being low because without a tachometer signal, U9C-9 will be high, and U9C-10 and U1B-J will be low. When the clock pulse from a reference signal causes U1A to toggle to where U1A-Q is low, it will make both inputs to U9A low and its output high. This high does two things:

1. It is applied to U2C-9 where it inhibits U2C from passing anymore short reference pulses to the clock circuit. This prevents U1A from toggling.

2. The high from U9A-1 is also applied to U9C-8 where it will keep U9C-10 and U1B-J low and inhibit U9C from passing the first long tachometer pulse.

5-103. When a tachometer pulse is received, the short pulse will produce a clock pulse through U2B, U2A, and U2D and toggle U1A, making U1A-$\overline{Q}$ low and U1A-Q high, removing the inhibit from U2C and U9C. However, since at the clock time both U1B-J and U1B-K were low, U1B will not change state and U1B-$\overline{Q}$ will remain high and U1B-Q will remain low. The next reference pulse will produce

a clock pulse toggling U1A and since U1B-K will be high and U1B-J low, U1B will remain in the same state. Since U1A toggled, that reestablishes the inhibit on U2C and U9C, blocking the long tachometer control pulse. This condition will remain with U1B-$\overline{Q}$ high, commanding the servo loop amplifier to accelerate until the tachometer frequency increases beyond the reference frequency and two tachometer pulses are received between reference pulses (a slight overspeed). The first tachometer short pulse will produce a clock pulse which will toggle U1A but not U1B because both its J and K inputs are low. This will put U1A and U1B out of phase which removes the inhibit from U2C and U9C. The next tachometer signal will produce both a clock signal and a long control high to U1B-J at the clock time (U1B-K is low). This will toggle both flip-flops; they are still out of phase which keeps the output of both inhibit gates low, U9A and U9D. The next reference pulse will toggle both flip-flops and the phase comparator will be operating normally, toggling with each reference and tachometer pulse. The reference pulse determines the positive going transition of the output signal, and the tachometer pulse determines the negative going transition of the output signal. The duty cycle and phase relative to the reference oscillator signal represent the capstan speed error.

5-104. If the reference oscillator signal were to fail, U9D would lockup the circuit as described for no tachometer pulse except in this case U1A-$\overline{Q}$ and U1B-$\overline{Q}$ will be low making U9D-13 high. This will inhibit short tachometer clock pulses through U2B, and long reference control pulses through U9B. This keeps the phase comparator output low, which commands the servo loop amplifier to decelerate the capstan. This condition will continue until the tachometer signals slow to where the two reference signals are received between tachometer signals. As previously described, this will unlock the logic and the normal toggling with each negative transition of the tachometer and reference pulse will resume.

5-105. Servo Loop Amplifier. The output of the phase comparator is summed through R58 with the reference signal through R57. As previously described, the reference signal and tachometer signal are 180 degrees out of phase when the capstan is in sync at the proper speed. Any variation in capstan speed results in a phase shift of the negative going edge or more accurately, a change in the duty cycle, of the comparator output. At the junction of R57 and R58 these two signals are summed, providing digital concellation of the carrier, and integrated by C20 and C19. The resulting signal is the servo error signal. This signal is conditioned by lead network R55 and C18, and lag network R54 and C17, and applied to U25-3, the servo loop amplifier.

5-106. U25 is a differential amplifier. The signal input is to U25-3 and gain and frequency compensation is to U25-2. R52 is the offset adjustment. Feedback network R47, R48, R49, C14, and C15 is a secondary lead/lag network; and R46, and C12 and C13 is a very low frequency lag network. The gain of the amplifier is changed to compensate for different capstan motor speeds by Q7 and Q8 which are controlled by the tape speed control lines. At 15/16 and 1-7/8 ips, both Q7 and Q8 are off and servo loop amplifier is operating at minimum gain. At 3-3/4 and 7-1/2 ips, Q8 is turned on through CR6 or CR5, respectively, through R43 from the high on the tape speed line, A5-Z or A5-21. When Q8 turns on, it places R42 in the output circuit to ground which increases the amplifier gain by decreasing the amount of feedback to U25-2. When 15 ips is selected, Q7 is biased on through R41, and R40 is placed in the output circuit to ground which again increases the amplifier gain.

5-107. The output from U25-6 (A5-X) is the amplified and conditioned error signal from the capstan servo to the capstan motor control and driver on the power supply pc board. (See the rear chassis and power supply pc board assembly description.)

5-108. SYSTEM CONTROL LOGIC. The system logic is best understood by first learning the concept of the logic and knowing what is to be accomplished in each mode. All of the modes and what the recorder actions are in each mode has already been explained in the system description in this section.

NOTE

In this description, selected means a mode control button is pressed. Initiate means the recorder is actually placed in a mode. The forward and rewind modes are initiated when the mode control button is pressed so in these two modes, there is no real difference. The play (and record), repeat, search, and standby modes are initiated only when tape movement is stopped. Therefore, when these mode buttons are pressed, and the recorder is

in a tape motion mode, a memory flip-flop changes state and the recorder goes into the stop (braking) mode. The mode selected is not actually initiated until tape motion stops at which time the associated memory flip-flop initiates the selected mode.

5-109. **Braking and Stop Logic.** (See figure 6-3, sheet 2.) Braking logic becomes active when stopping from any mode (STOP button pressed), or when changing from one tape motion mode to another except when going to the rewind or forward modes from any other mode. Since the forward and rewind modes are used by the logic for dynamic braking when it is necessary to stop the tape motion, it is not necessary to go through the stop sequence when entering either of these modes because the braking effect will be automatic. If rewind or forward is selected when tape is moving in the same direction as the mode selected, the result will be acceleration of the tape; therefore, it is not necessary to go through stop.

5-110. When the recorder is in a tape motion mode, the braking logic is enabled by a low from the mode logic (U3C-repeat, U3A-search, U32B-play, or U24B-forward/rewind). This low is applied to the search, repeat, and/or play braking enabling gate, U14B, U14C, and/or U15A, respectively. This will cause the outputs of the braking enabling gates to go high except for the enabling gate of the mode the recorder is in. These highs are applied to one input of the search, repeat, and play braking initiate AND gate U5B, U5C, and U5D, respectively. When another mode is selected, a high from the mode memory flip-flop (U4B-repeat, U4D-search, or U21D-play) will be applied to U5B, U5C, or U5D, causing the output of that gate to go high and causing U5E to go low. This low is applied to U15B-3, the stop initiate and latch-up gate, placing the recorder in the stop mode until tape passes through zero speed.

NOTE

The output of the braking logic (U5, U14B, U14C, and U15A) will only be low when the recorder is in one mode and another mode requiring braking is selected. The output, U5E, will then go low momentarily, initiating stop, until the stop logic knocks down the previous mode, then it will go high. However, by this time, the stop initiate and latch-up gate, U15B, will be latched up by a low from U8A.

5-111. The stop initiate and latch-up gate, U15B, is activated by a low at any one of its three inputs. One input is from the braking logic U5E, another from the STOP switch, S3, through inverter U13C, and the other input is from U8A, the stop knock-down gate. The output of the stop knock-down gate, U8A, is low when the recorder is not in any mode (all inputs high); that is, the period of time between when a mode control button is pressed and the tape comes to a stop, and the selected mode is initiated. Note that forward and rewind go directly into the mode without braking, and that play, repeat, and search modes have memory flip-flops that retain the mode command until all tape motion stops before actually initiating the mode.

5-112. When any input of U15B goes low, its output to stop knock-down gate U16A goes high, causing the output of U16A to go low. This is bussed to all of the mode knock-down gates and inhibits all modes controlled by knock-down gates; that is, play, forward, rewind, and standby. It also resets the search and repeat latches through U14A. This causes all inputs to U8A to be high and its output to be low, which latches the stop mode through U15B, U16A, and U8A. Also, the low from U8A goes through inverter U13B (now high) to braking control AND gates U23C and U23D. The other inputs to U23C and U23D are the direction sense lines. When there is tape motion, one line will be high and the other line will be low, depending upon the direction of the tape motion. For example, if tape is moving in the forward direction, A5-18 will be high. When the stop logic is activated, this will cause both inputs to U23C to be high and its output to be low. This low will cause the rewind mode output gate, U23B, to go high which will torque the reels, and light the REWIND indicator as though the recorder were actually in the rewind mode.

5-113. This condition will remain until tape motion passes through zero speed allowing the selected mode to be initiated by the logic. When another mode is initiated, one of the inputs to U8A will go low and its output goes high. This will dropout the stop logic and remove the high from the inputs of U23C and U23D, removing the rewind (or forward) braking torque. All inputs to U15B are now high, its output low which makes U16A's output high removing the stop knock-down.

5-114. **Reset Logic.** Whenever any mode is selected, all other mode flip-flops (both memories and latches) are reset. Play, repeat, and search have memory flip-flops. This is necessary because the tape must come to a stop before the mode is actually initiated. Since the forward and rewind modes do not go through a braking cycle, but go directly into the mode, they do not require a memory and the mode is removed by the knock-down logic when another mode is selected. When forward or rewind is selected, they initiate reset of all mode flip-flops (both memories and latches).

5-115. The gates involved in initiating reset are: U21A (stop and play), U21B (forward and rewind), U24D (stop and repeat), U24C (search), and U16A and U16B (stop and standby knock-down gates, respectively). The gates that do the resetting are: U32C (play memory and record latch, through U31D and U31A, respectively). U14A (repeat and search latches), U20A (repeat memory), and U20B (search memory).

5-116. When forward or rewind is selected, a high from the mode control switch (S2 or S6) will be applied to one of the inputs of U21B. This will produce a low output to: U20A which will reset the repeat memory, U4A and U4B; U20B which will reset the search memory, U4C and U4D; U32C which will reset the play memory and record latch, U21C and U21D, and U12C and U12D, through U31D and U31A, respectively; U14A which will reset the repeat latch, U3C and U3D, and the search latch, U3A and U3B; U20A which will reset the repeat memory, U4A and U4B; and U20B which will reset the search memory, U4C and U4D.

5-117. Assuming that the recorder is in a tape motion mode when the STOP button is pressed (standby mode select), the repeat and search memories are reset through U21A,and U20A and U20B, respectively. The play memory and record latch are reset through U24D and U32C (and U31D and U31A, respectively). U24D provides another path for resetting the search memory through U20B. When the STOP button is pressed it causes inverter U13C to go low; which causes the output of U16A, the stop knock-down and reset gate, to go low. This will reset the repeat and search latches through U14A.

5-118. When tape motion stops and the standby mode is obtained, U16A goes high and the standby knock-down and reset gate, U16B, goes low. The low output of U16B knocks down all modes, except standby, and resets all mode control flip-flops. The repeat and search latches are reset by a high output from U14A (U14A-1 is low). The play memory is reset by a high output from U31D (U31D-12 is low). The record latch is reset by a high output from U31A (U31A-1 is low). The repeat memory is reset by a high output from U20A (U20A-1 is low). The repeat memory is reset by a high output from U20A (U20A-1 is low) and the search memory is reset by a high output from U20B (U20B-12 is low). This condition is maintained as long as the recorder is in the standby mode. This condition also exists during fail-safe, insuring that all mode control flip-flops are reset. A high at U16B-6 in fail-safe makes its output low.

5-119. When the play (or record) mode is selected, the repeat and search memory reset is initiated by U21A and the repeat and search latch reset is initiated by U16A through the braking logic. When repeat is selected, U24D initiates the reset of the play memory and record latch through U32C and the search memory (through U20B). During braking U16A resets the repeat and search latches through U14A.

NOTE

Even though the repeat mode was selected, the repeat latch, U3C and U3D, will be held in reset by the stop logic until tape motion stops. When tape motion stops, the latch reset will be removed; and the repeat memory, U4A and U4B; and the direction sense logic (through U30A) will toggle the repeat latch, initiating the repeat mode. When search is selected, U24C resets the play memory and record latch through U32C (and U31D and U31A, respectively), and the repeat memory through U20A. Both the repeat and search latches are reset by the stop logic the same as when the repeat mode was selected.

5-120. **Direction Sense.** There are two direction sense lines that come from the direction sense logic on the monitor pc board, A5-N and A5-18. When tape is moving in the forward direction A5-18 is high, and A5-N is low. When tape is moving in the reverse direction A5-N is high, and A5-18 is low. When tape motion changes direction, both A5-N and A5-18 are momentarily high.

5-121. The direction sense performs three basic functions: (1) when braking, the direction sense determines how the reel motors will be torqued;

that is, rewind when stopping from a forward mode (U23C), or forward when stopping from a reverse mode (U23D), (2) the direction sense determines when tape motion has stopped (both lines momentarily high), and allows the new mode selected to be initiated by the logic; U30A for repeat, U30B for play, U30C for search, and U6A for standby and (3) the direction sense logic determines the braking in the repeat mode, U19A and U29A; and initiates the next mode (backspace or play) when the tape has stopped, U19C (backspace) and U29C (play).

5-122. **Reel Motor Control Logic and Mode Control Indicators.** The reel motor control circuitry (reel motor torque) is controlled by the logic through diode OR gates, and series resistors for fixed torques, the tape tension sensor for the supply reel in search, play (and record), and the search servo for the take-up reel in search. The output from the take-up reel OR gate to the take-up reel motor control and driver is A5-P, and the output to the supply reel motor control and driver is A5-10.

5-123. Both the take-up and supply reel outputs from the OR gates are connected to the REEL SIZE switch (S3 on the tape transport) through 1K resistors R84 and R85, respectively and blocking diodes CR25, CR26, CR27, and CR28. When the REEL SIZE switch is in the 10-1/2 position, the circuit is open and has no effect on the outputs. When the REEL SIZE switch is in the 4-7 position, it provides a ground for R84 and R85, through the diodes, which reduces the reel motor control signals; and therefore, the reel motor torques to compensate for the smaller size reel.

5-124. The reel motors are always controlled through the OR gates by a high from the mode control logic; except in fail-safe when the reels are secured by the mechanical fail-safe brakes. The tape tension sensor and search servo are also enabled by highs from the mode control logic and their control signals are returned to the logic pc board and routed through the OR gates.

5-125. The high from the mode control logic to the OR gates is also routed in parallel to the mode control indicators. This high turns on a transistor in the ground path of the indicator causing it to light. This gives a true indication of waht is happening in the recorder. For example, when a mode is selected, the mode indicator will not light until the logic has actually initiated that mode. If the tape is in motion and a mode requiring braking (play, search, or repeat) is selected, the FWD or REWIND indicator will light, indicating dynamic braking. When tape motion stops, the mode selected will be initiated and that indicator will light. In the repeat mode, the REPEAT indicator will be lighted continuously, and the FWD or REWIND indicator will light during braking, and the PLAY indicator will light during the play portion of the mode.

5-126. **Fail-Safe Logic.** Fail-safe is the condition the recorder goes into when power is first applied, or if tape breaks, or at end-of-reel. In fail-safe mode there is no reel motor torque and the mechanical fail-safe brakes are applied securing the reels. Before any tape motion mode can be entered into, the standby mode must be obtained first.

5-127. The key elements in determining the fail-safe mode are Q19, C71, U33D and U28C, and the end-of-tape sensor. When power is first applied, the fail-safe flip-flop will latch-up with U33D high and U28C low. This is determined by a high from the end-of-tape sensor at pin 15, and/or C71. C71 charges through the base-emitter of Q19 when power is first applied momentarily making its collector and U33D-19 low. If there is no tape on the recorder (through the tape sensor) when power is on, A5-15 is high, forward biasing Q19 causing its collector to be low. This causes the output of U33D to be high which does four things:

1. It is applied to the input of U28, and together with the high through R99 causes the output U28C to go low, latching up the fail-safe flip-flop.

2. It is applied through A5-S to the power supply pc board where it releases the fail-safe solenoid so that the brakes may be engaged by spring tension. (See the power supply pc board description.)

3. It is applied to one input of the counter reset gate, U33A-2. If end-of-tape occurs when the recorder is in the rewind mode (U33A-1 is high in rewind), U33A-3 will go low causing the counter reset flip-flop U33B and U33C, to change state providing a high to A5-U, and resetting the reel revolution counter. (See the power supply pc board description.) The counter reset flip-flop will remain in this state until the fail-safe mode is removed or power is turned

off. If the recorder is not in the rewind mode, the high at U33A-2 will have no effect because U33A-1 will be low.

4. The high from U33D also knocks down, inhibits, and resets all mode logic through stop knock-down and reset gate U16A, standby knockdown and reset gate U16B. The high input to inverting OR gates U16A and U16B causes a low output to the stop and standby knock-down and reset busses which knocks down and resets all logic, and inhibits selection of any mode.

5-128. If the recorder is in any other mode, and tape runout or breakage occurs, pin 15 will go high causing the fail-safe flip-flop to change state, knocking down all the logic and immediately establishing the fail-safe condition.

5-129. **Standby Logic.** The standby mode is initiated by pressing the STOP button. To enter the standby mode, tape must be properly threaded on the recorder, breaking the light path in the end-of-tape sensor. The standby mode may be initiated from either the fail-safe condition or when the recorder is in a tape motion mode. The logic that initiates standby is different for the two conditions, but the end result is the same. The STOP switch, S3, which initiates standby is a two section switch. S3B initiates standby when the recorder is in fail-safe, and S3A when the recorder is in a tape motion mode.

5-130. When the recorder is in the fail-safe condition, U33D of the fail-safe flip-flop is high which knocks down and inhibits all logic. This high, along with the high through R99, keeps the output of U28C low. Assuming the end-of-tape sensor input, A5-15, is low, which it must be to establish standby; pressing the STOP button, S3B, applies a low (ground) to U28C-9 and -11. This causes its output to go high, and with the high from Q19, through R97, causes the output of U33D to go low. The fail-safe control signal is now removed allowing the stop knock-down and reset gate, U16A, to go high. When U16A goes high, it makes all inputs to the standby knock-down gate, U8B, high, and its output low. The low output of U8B does two things:

1. Through inverter U13A it powers the STOP indicator and the reel motor control circuitry through the OR gate diodes CR21 and CR22. Note that the two reel motor control resistors (R80 and R81), are of the same value. This provides an equal torque on each reel motor. The value of the resistors are comparatively large resulting in the reel motor torque being small.

2. The low from U8B is also applied to U15C making its output high. This high does two things:

   a. Applied to the input of U16B, it keeps its output low. The output of U16B is the standby knock-down and reset bus. It is applied to all mode knock-down gates except the standby gate, U8B. It also resets all mode control flip-flops.

NOTE

There are five mode knock-down gates: U6B for rewind, U7A for play, U7B for forward, U8A for stop (braking), and U8B for standby. The search and repeat modes use the forward and rewind knock-down logic for knocking down other modes which is explained in the description of those modes. Search and repeat do not have knock-down gates but are reset by the stop (braking), standby, and/or reset logic. The knock-down gates are arranged so that if any of their inputs are low, their outputs will be high and this will knock down the logic of that mode. For the recorder to latch-up in a mode, all inputs to that mode knock-down gate must be high and its output low.

   b. When the play (or record), repeat, or search mode is selected, with the recorder in a tape motion mode, it must first go through the stop (braking) mode, and tape must come to a complete stop before the mode is initiated. When these are selected from the standby mode, there is no tape motion and the mode is initiated immediately. This is accomplished by the high from U16C, which is

applied to play initiate gate U31C, repeat initiate gate U11B, and search initiate gate U11C. This high enables the mode initiate gates so that when the mode select button is pressed, that mode is immediately latched up.

5-131. When the recorder is in standby and another mode is initiated, one of the inputs to U8B will go low, making its output high. This will remove the standby reel motor torque through U13A, and provide a high to the standby knock-down and latch-up gate, U15C-11. U15-9 is high from U6A whenever there is tape motion because one of the direction sense lines will be low, U6A-5 or U6A-4. U15-9 will also be high whenever the recorder is in a tape motion mode because U6A-1 will be low when in forward or rewind, and U6A-2 will be low when in play, repeat, or search. Whenever either the play, repeat or search memory is activated, it will provide a low to AND gate U22C which will supply the low to U6A-2. When either the forward or rewind mode is selected, one of the inputs to U29D will be low, and its output will supply the low to U6A-1. Therefore, U6A-6 will be high making all of U15C's inputs high, its output low, removing the high from U16B-5, and making its output high. This allows the selected mode to latch up.

5-132. Forward Mode Logic. The forward mode may be initiated at any time from any tape motion mode, or standby. When the forward mode is selected, it is not necessary for the recorder to go through the stop (braking) cycle. Therefore, the logic immediately knocks down the previous mode and latches up the forward mode.

5-133. Pressing the FWD button, S6, does two things:

1. It applies a high (momentarily while the FWD button is pressed) to the input of reset initiate gate U21B. This resets all mode control flip-flops (see the reset logic description).
2. It applies a high (momentarily while the FWD button is pressed) to the forward mode initiate gate U24A.

5-134. The high input to U24A causes its output to go low momentarily. This low is applied to forward mode knock-down and latch-up gate U22A, causing its output to go low. The output of U22A is the forward mode knock-down bus and provides a low to all knock-down gates except U7B, the forward knock-down gate. This knocks down all other modes and makes all inputs to U7B high, making its output low. This low does two things:

1. It is applied to U22A-1 which latches the forward mode by keeping the output of U22A low after the FWD button is released. This condition will remain until one of the inputs to U7B goes low, because another mode has been selected.
2. It is applied to U23A, making its output high. The output of U23A does two things:
   a. Through CR29 powers the reel motor control OR gates and turns on the FWD indicator transistor, Q15.
   b. The high from U23A causes the output of the forward and rewind mode braking logic enable gate, U24B, to go low. This enables the braking logic by causing the outputs of U14B, U14C, and U15A, to go high. When either play, repeat, or search are selected, a high will be applied to U5D, U5C, or U5B, respectively, which will initiate the stop (braking) mode.

NOTE

As previously described, when the forward or rewind mode is initiated, it does not go through the stop (braking) mode.

5-135. Rewind Mode Logic. The rewind mode may be selected from any tape motion mode or standby. Since it is not necessary to go through the stop (braking) mode when the rewind mode is initiated, the previous mode is immediately knocked down and the rewind mode latches up.

5-136. Pressing the REWIND button, S5, momentarily (while S5 is pressed) applies a high to rewind initiate gate, U16D, and to reset gate U21B. U21B resets all mode control flip-flops. (See the reset logic description.)

5-137. The momentary high input to U16D causes its output to go low, making the output of the rewind

knock-down and latch-up gate U22B, low. The output of U22B is the rewind knock-down bus and provides the low to all mode knock-down gates except the rewind gate, U6B. All inputs to U6B are now high, making its output low. This low does two things:

1. Applied to U22-4, it keeps the output of U22B low, which keeps other modes knocked down, until another mode is selected. When another mode is selected, one of U22B's inputs will go low and its output high, unlatching the rewind mode.

2. The low output of U6B is also applied to U23B, making its output high. This high does three things:

   a. Through CR32 it powers the reel motor control OR gates and turns on the REWIND indicator transistor, Q16.

   b. The high from U23B-6 is also applied to U24B, the forward and rewind mode braking logic enable gate. This is the same as described for the forward mode.

   c. The high from U23B-6 is applied to the base of counter reset enabling transistor Q18. This turns on Q18 which makes U31A-1 high which enables the counter reset logic. If tape runout occurs while the recorder is in the rewind mode, this signal will cause the counter to reset automatically. See the fail-safe description.

5-138. Play Mode Logic. The play mode may be initiated from any tape motion mode, or standby; however, the logic sequence for establishing the play mode is different, depending upon whether the recorder is in a tape motion mode or in standby. Once in the play mode, the logic is the same.

5-139. When the PLAY button, S2, is pressed, it does three or four things, depending upon whether the recorder is in standby or a tape motion mode:

1. It provides a high (+5 volts) to the RECORD switch, S4. This enables the RECORD switch while the PLAY button is pressed.

NOTE

This alone will not allow the record mode to be initiated by pressing the RECORD button at the same time as the PLAY button is pressed. The tape must come to a stop if in a tape motion mode, and the play logic must actually be latched-up with the output of U31B-6 high before the record mode can be initiated. This is explained later.

2. It applies a high to U21A-2 which resets the repeat and search memory flip-flops. (See the reset logic description.)

3. If the recorder is in standby, U31C-10 will be high; the high from the PLAY switch will cause the output of U31C-8 to go low. This low is applied to U32B-6, the play knock-down and latch-up gate. Its output will go low, knocking down the standby mode through U8B. This makes all inputs to U7A high and its output low which will latch-up the play mode through U32B-3, If the recorder was not in standby, U31C-10 will be low and U31C will perform no function in initiating the play mode.

4. The high from the PLAY switch is also applied to U21C-9 of the play memory flip-flop, U21C and U21D. This high will cause the flip-flop to change state, making the output of U21C low, and U21D high. The low output of U21C through U22C, to U6A inhibits the recorder from going into standby. The high from U21D does two things:

   a. It is applied to the play initiate-tape motion stopped gate, U30B-5. The other two inputs to U30B are the direction sense lines. As long as there is tape motion, one will be high and one will be low. When all tape motion stops, both direction sense lines will be momentarily high making all inputs to U30B high, and its output will go low. This low output is applied to U32B-4, the

play knock-down and latch-up gate. This will make the output of U32B low, knocking down the other tape mode, making all inputs to U7A high and its output low. The output of U7A-6 will latch up the play mode through U32B-3 until another mode is selected, causing one of the inputs to U7A to go low and its output to go high.

NOTE

When another mode is selected, the play flip-flop, U21C and U21D, is reset by the reset logic through U31D. (See the reset logic description.)

b. The high from U21D is also applied to braking logic gate U5D-9. Since this assumes the recorder was in a tape motion mode other than play, the output of U15A will also be high. This will cause the output of U5D to be high, making the output of U5E low. The low from U5E is applied to U15B-3, initiating the stop (braking) logic. (See braking and stop logic description.)

5-140. In review, when the PLAY button is pressed with the recorder in standby, U31C immediately initiates the play mode. When the recorder is in a tape motion mode, the play memory flip-flop initiates the stop (braking and reset) mode, and when the tape motion stops, it initiates the play mode through U30B.

5-141. As previously described, when the play mode latches up, the output of U7A is low, In addition to latching the play mode through U32B, it does two other things:

1. The low from U7A-6 is applied to the monitor enable gate U28B-5. This low causes the output of U28B to go high, which enables the monitor electronics. (See the monitor pc board description.)

2. The low from U7A-6 is applied to U31B-4, the play output and record enable gate. This causes the output of U31B-6 to go high which does four things:

a. It turns on Q14, the PLAY indicator transistor.

b. It powers the take-up reel motor control through control resistor R82 and OR gate diode CR23; and the supply reel motor control through CR14, the tape tension sensor which is returned through R83, and OR gate diode CR24.

NOTE

The tape tension sensor consists of a light source and a photoresistor with a movable mask between the two. In play and search modes, the photoresistor is powered by the high from the logic and the resulting signal, determined by the amount of light hitting the photoresistor, is returned to the logic pc board and through R83 and supply reel OR gate diode CR24 to control the supply reel motor torque.

c. The high from U31B-6 enables record initiate gate U19D.

d. The high from U31B-6 is applied through A5-6 to A7A-E on the power supply pc board, where it activates the play accelerate circuitry, and play capstan idler solenoid driver. This causes the take-up reel to accelerate rapidly for an instant, and the capstan idler to press the tape to the run capstan. Tape speed is now under capstan control.

NOTE

The capstan is rotating at the selected speed whenever power is on. The tape speed is controlled in the play and record modes (including repeat play) by pressing the tape to the capstan with the capstan idler.

5-142. **Record Mode Logic.** For the record mode to be initiated, the recorder must first be in

the play mode, and then the PLAY and RECORD buttons must both be pressed at the same time. In actual practice, if the recorder is in standby, pressing the PLAY and RECORD buttons simultaneously will put the recorder in the record mode because of the speed of the logic; however, if the recorder is in a tape motion mode, tape must be least come to a complete stop before pressing the PLAY and RECORD buttons will put the recorder in the record mode. If the buttons are released before the play and record modes latch-up, the result will be the play mode only. This is because the output of the play output and record enable gate, U31B-6 must be high for U19D will go high when the RECORD button is pressed. If U31B-6 is high when RECORD button S4 is pressed, and PLAY button S2 is pressed; both inputs to record initiate gate U19D will be high causing its output to go high, and changing the state of the record flip-flop, U12C and U12D. When in the record mode, U12C-10 will be high and U12D-13 will be low. This does three things:

1. The low from U12D-10 turns off Q10, which deenergizes K1. (See the capstan servo description.) This disables the SPEED VERNIER control, R67, in the capstan servo reference oscillator circuit.

2. The high from U12C-10 turns on the RECORD indicator transistor Q13.

3. The high from U12C-10 also enables the bias and erase oscillator, and record electronics. This is through A5-R to A7A-K on the power supply pc board. (See the power supply pc board description.)

5-143. As previously stated, the recorder is also in the play mode when it is in the record mode. All tape handling logic and functions are controlled by the play logic. When another mode is selected, the play mode is knocked down as described and the record flip-flop, U12C and U12D is reset by the reset logic through U31A. (See the reset logic description.)

5-144. Search Mode Logic. The search mode is initiated in two different ways, depending upon whether the recorder is in standby or a tape motion mode when the SEARCH button is pressed. U4C and U4D is the search memory flip-flop, and U3A and U3B is the search latch flip-flop. When search is selected from standby, both the memory and latch flip-flops will change state and the recorder will immediately go into the search mode. If the recorder is in a tape motion mode when search is selected, only the memory flip-flop will change state until tape motion comes to a complete stop. Then the latch flip-flop will change state and the recorder will be in the search mode.

5-145. Pressing the SEARCH button, S7, does two things if the recorder is in a tape motion mode; three things if the recorder is in standby:

1. The high from the SEARCH switch causes the search memory flip-flop to change state making the output of U4C-10 low; and U4D-13 high. This does three things:

   a. The low output from U4C-10 will inhibit the standby mode through U22C to U6A.

   b. The high from U4D-13 is applied to U5B-2 which initiates the stop (braking) mode if the recorder is in a tape motion mode. It is assumed that the recorder would be in some mode other than search; in which case, one of the inputs to U14B will be low and its output high. (See the braking and logic description.)

   c. The high from U4D-13 also enables search initiate-tape motion stopped gate U30C-9. The other two inputs to U30C are the direction sense lines. When there is tape motion, one of the lines will be high and the other line will be low. When tape motion stops, both lines will be momentarily high, and the output of U30C-8 will go low. The low output from U30C-8 will cause the output of U11D to go high which will cause the search latch, U3A and U3B, to change state, placing the recorder in the search mode. The high from U30C-8 is also applied to U28A-2 which knocks down the other modes. This is explained in 3b, below. This is how the search mode is initiated from a tape motion mode.

2. The high from the SEARCH switch initiates reset of all mode control flip-flops,

except search flip-flops, through U24C-10. (See the reset logic description.)

NOTE

When the search mode is selected, and there is tape motion, the search latch, U3A and U3B, is reset by U14A-12 from the stop and braking logic. When the recorder is in standby, the standby logic maintains the search latch in a reset condition through U14A-12. The only mode control flip-flop not reset when the search mode is initiated is the search memory, U4C and U4D, which changes state because the search mode was selected.

3. The high from the SEARCH switch is applied to search initiate gate U11C-9. When the recorder is in the standby mode, U11C-10 will be high; when not in standby, U11C-10 is low, and pressing the SEARCH button will have no effect on the output of U11C. If the recorder is in standby, the high from the SEARCH switch will cause the output of U11C-8 to go low. This low will do two things:

   a. The low output from U11C-8 is applied to U11D-12. This will cause the output of U11D to go high which will cause the search latch, U3A and U3B, to change state, placing the recorder in the search mode. This is how the search mode is initiated from standby.

   b. It will cause the output of U28A to go high which will knock-down the other modes through U24A and U16D. This high is applied to the forward mode initiate gate, U24A-3 and the rewind mode initiate gate U16D-12. This makes the output of U24A and U16D low which makes the outputs of the forward and rewind knock-down and latch-up gates low, U22A and U22B, respectively. The low output of U22A will knock-down all mode knock-down gates except forward, and U22B will knock-down all mode knock-down gates except rewind (see note below). The forward and rewind busses will knock-down each other,preventing them from latching up. This condition will remain while the recorder is in the search mode because the output of U28A will remain high, because of the low from the search latch, U3A-1 to U28A-1.

NOTE

The knock-down busses control all mode controls except the flip-flops. These are reset by the reset logic.

5-146. As previously described, the search latch may be toggled in either of two ways to place the recorder in search; by a low from U11C through U11D when in standby, or by a low from U30C through U11D when in a tape motion mode. A low from either initiate gate, U11C or U30C, will cause U28A's output to go high knocking down the knock-down logic; and will cause the output of U11D to go high, toggling the search latch; initiating the search mode. When the search latch changes state to the search condition, U3A will be low and U3B will be high. The low from U3A does three things:

1. It sustains high output of U28A since the other inputs, from U11C and/or U30C, are only momentary.

2. It supplies the low to monitor enable gate U28B-3; making its output high and enabling the monitor electronics.

3. It sets up the braking logic by applying the low to the repeat mode braking enabling gate, U14C-9, and to the play mode braking enabling gate, U15A-1.

5-147. The high output from search latch U3B does three things:

1. It turns on SEARCH indicator transistor, Q12.

2. It supplies a high through A5-6 to A6-11 on the monitor pc board. This selects the 15 ips tape speed equalizer for all four signal electronic channels, and

enables the search servo. (See the monitor pc board description.) The search servo control signal from the monitor pc board is returned through the REEL SIZE switch, S3 on the tape transport, to A5-17 on the logic pc board; where, through R72, take-up reel OR gate diode CR13, and A5-P, it controls the take-up reel motor control circuitry on the power supply pc board.

3. The high from U3B also enables the tape tension sensor through CR35 to pin A5-H. The control signal from the tape tension sensor is returned to A5-K on the logic pc board. Through R83, supply reel OR gate diode CR24 and A5-10 it controls the supply reel motor control circuitry on the power supply pc board.

NOTE

The tape tension sensor consists of a light source and a photoresistor with a movable mask between the two. In play and search modes, the photoresistor is powered by the high from the logic and the resulting signal, determined by the amount of light hitting the photoresistor, is returned to the logic pc board, and through R83 and supply reel OR gate diode CR24, to control the supply reel motor torque.

5-148. The recorder will remain in the search mode until another mode is selected or tape runs out. While in the search mode, the tape speed is controlled by the search servo. (See the monitor pc board description.) When another mode is selected, or tape runs out (fail-safe), the search memory, U4C and U4D, will be reset by a high from U20B; and the search latch, U3A and U3B, will be reset by a high from U14A. (See the braking and stop, and the reset logic descriptions.)

5-149. Repeat Mode Logic. The logic to place the recorder in the repeat mode is very similar to the search mode logic. It consists basically of a memory flip-flop, U4A and U4B; and a latch flip-flop, U3C and U3D. If the recorder is in standby when the REPEAT button is pressed, both the memory and latch will change state and the repeat mode will be immediately initiated. If the recorder is in a tape motion mode, only the memory will change state when the REPEAT button is pressed, and the latch will change state initiating repeat when tape motion comes to a stop. In all other modes, when the selected mode logic latches up, the logic remains in a static state until another mode is selected, or end-of-tape is reached. In the repeat mode, this is true of the repeat memory and latch; however, when the repeat latch changes state, it enables the repeat shuttle logic. This logic is controlled by the repeat control logic (up-down counter) and direction sense logic on the monitor pc board. (See the monitor pc board description.) The repeat control logic causes the tape to backspace a specific amount, brake, play the tape, brake, and backspace again; continuing this cycle until another mode is selected.

5-150. Pressing the REPEAT button does two things if the recorder is in a tape motion mode, three things if the recorder is in standby:

1. It applies a high to the stop and repeat reset initiate gate U24D-11. This resets the search, and play memory flip-flops, and the record flip-flop. (See the reset logic description.)

2. The high from the REPEAT switch is applied to U4A-2, causing the repeat memory flip-flop to change state. This will make the output of U4A-1 low, and U4B-4 high. This does three things:

   a. The high from U4B-4 is applied to U5C-4, the repeat mode braking initiate gate. This will initiate the stop (braking) mode. (See the braking and stop logic description.)

   b. The high from U4B-4 is also applied to the repeat initiate-tape motion stopped gate U30A-13. As long as there is any tape motion, one of the other two inputs to U30A (connected to the direction sense lines) will be low. When tape motion stops, they will both be momentarily high, and the output of U30A will go low. This low will cause the output of U11A to go high and toggle the repeat latch flip-flop, initiating repeat. It will also cause the output of U32A to go low knocking down the logic of other modes (see 5-151, 1 below). This is how the repeat

mode is initiated from a tape motion mode.

c. The low from U4A-1 is applied to U22C-10 inhibiting the standby mode.

3. When the recorder is in the standby mode, U11B-5 is high from U15C. When the REPEAT button is pressed, both inputs to U11B will be high, and its output will go low. This will cause the output of U11A to go high and toggle the repeat latch, and will cause the output of U32A to go low knocking down the logic of other modes. This is how repeat is initiated from the standby mode.

5-151. When the output of either repeat mode initiate gate, U11B or U30A, goes low it does two things:

1. This low is applied to U32A-2 or U32A-13, depending upon which initiate gate is active. It causes the output of U32A-12 to go low. This low is applied to forward and rewind knock-down and latch-up gates, U22A-2 and U22B-3, respectively. This causes the outputs of U22A and U22B to go low, knocking down and inhibiting all modes controlled by knock-down gates.

NOTE

Mode control flip-flops are not effected. They are controlled by the reset logic.

NOTE

The low inputs to U32A, are only momentary signals; however, the input signal will cause the repeat latch to change state. When it does, a low output from U3C-10 will maintain the output of U32A low, keeping the logic for other modes knocked down as described above.

2. The low output of either repeat initiate gate, U30A or U11B, will also toggle the repeat latch, U3C and U3D, by causing one of the inputs to U11A to go low. This will cause its output to go high, toggling the latch. The output of U3C-10 will now be low and U3D-13 will be high. This does six things:

a. The low from U3C-10 is applied to repeat knock-down gate U32A-1. This sustains the knock-down logic.

b. The low from U3C-10 is applied to U14B-3, the search mode braking enable gate; and U15A-2, the play mode braking enable gate. This sets up the braking logic for selection of other modes requiring dynamic braking.

c. When U3C-10 goes from high to low, it removes the inhibiting signal, through diodes CR9 and CR12, to the repeat shuttle logic. This will be covered in detail later.

d. The high from U3D-13 turns on the REPEAT indicator transistor, Q11.

e. The high from U3D-13 is applied through A5-12 to A6-AA on the monitor pc board where it enables the repeat up-down counter.

f. The high from U3D-13 enables repeat backspace initiate gate U19B, and repeat play initiate gate U29B. The gates are part of the repeat shuttle logic which is explained later.

5-152. Repeat Shuttle Logic. The repeat shuttle logic, along with the repeat control logic on the monitor pc board, controls motion of the tape in the repeat mode. Before the repeat mode is initiated, repeat latch U3C will be high and U3D will be low. The low from U3D-13 inhibits repeat play and backspace initiate gates, U29B and U19B, respectively. The high from U3C-10 is applied through diodes CR9 and CR12 to repeat flip-flop, U12A and U12B. This holds both outputs low which inhibits the backspace and play control gates; U19C and U29C, respectively; and the play and backspace braking gate, U29A and U19A, respectively. This prevents the repeat logic from having any control over the tape motion.

5-153. When the repeat mode is initiated, repeat latch U3C and U3D changes state. This makes U3C-10 low, and U3D-13 high. The high from U3D-13 enables the repeat play and backspace initiate gates, U29B and U19B, respectively, allowing them to be controlled by the repeat control logic from the monitor pc board through A5-M and A5-20. The low from U3C-10 removes the inhibit signal from the repeat flip-flop, U12A and U12B allowing it to be controlled by the repeat play and backspace initiate gates, U29B and U19B, respectively.

NOTE

When backspace is commanded, and while the recorder is braking and changing direction, A5-20 will be high. When play is commanded, and while braking and changing direction, A5-M will be high. During the remainder of the repeat cycle, both A5-20 and A5-M will be low.

5-154. When the repeat latch changes state, U3D-13 goes high, enabling the repeat up-down counter on the monitor pc board through A5-12. The counter has a built-in count so that when reset (enabled), the repeat control logic will always command backspace, A5-20 high. This will make both inputs to U19B high and its output high. The high from U19B-6 is applied through CR11 to repeat flip-flop U12B-6, making its output, U12B-4 low; and, since A5-M is low, U29B-6 will be low. This makes both inputs to U12A low and its output to U19C-9 and U19A-2 high. The high from A5-20 also resets repeat play latch, U27C and U27D.

NOTE

As previously described, when the repeat mode is selected, all tape motion must stop before it is initiated. Therefore, the first backspace operation begins with tape motion stopped and does not require braking.

5-155. If tape motion was stopped when repeat was initiated (standby mode), either direction sense line may be high. If A5-18 is high, U29A will momentarily torque the reel motor as in rewind (explained later). When tape begins to move in the reverse direction, A5-N will go high and A5-18 will go low. If A5-N was high to begin with, this high and the high from U12A-1 will cause the output of U19C-8 to go high. This powers the reel motor control circuit through control resistors R74 (take-up) and R75 (supply) and diode OR gates CR15 and CR16, respectively. Note that R75 is a smaller value than R74. This will produce a larger torque on the supply reel than on the take-up reel, causing the tape to move rapidly in a reverse direction.

NOTE

The reverse direction sense line, A5-N will remain high as long as tape is moving in the reverse direction. This, and the high from repeat flip-flop U12A-1, will maintain the backspace mode until the repeat play command is received from the repeat control logic (A5-M high), causing U12A and U12B to change state.

5-156. While the tape is backspacing, the up-down counter in the repeat control logic is counting pulses from the backspace tachometer. When the count reaches a level determined by the setting of the SCAN SEGMENT, BEGIN ✪ control, A5-M will go high. This will cause the output of U29B to go high, and through CR10, will cause the repeat flip-flop to change state making U12A-1 low and U12B-4 high. When U12A-1 goes low, it removes the high from U19C-9, causing its output to go low and removing the backspace motor control.

5-157. The high from U12B-4 is applied to backspace braking gate U19A, and repeat play control U29C-9. Since at the moment, tape motion is in the reverse direction A5-N is high and forward direction sense line, A5-18, is low. As long as there is reverse direction, tape movement U29C-10 will be low inhibiting initiation of repeat play. However, the high from the reverse direction sense line, and the high from U12B-4 will make both inputs to backspace braking gate U19A high. This will cause its output to go high. This high (U19A-3) is applied through diode CR30, to the forward mode motor control and indicator circuit. This will provide dynamic braking by temporarily torqueing the reel motors as in the forward mode. It also lights the FWD indicator.

5-158. When tape motion stops (actually it just passes through zero speed), the forward direction sense line, U5-18, goes high. This makes U29C-10 high, its output goes high and toggles the repeat play latch, U27C and U27D, making U27C high

and U27D low. The low from U27D-13 is applied to monitor enable gate U28B-4 making its output high, enabling the monitor electronics; and to play output gate U31B-5, making its output high, initiating the play mode and lighting the PLAY indicator. (See the play mode logic description.) For an instant, both the PLAY and FWD indicators (and, of course, the REPEAT indicator) will be lighted. This is because the output of the backspace braking gate U19A-3 will remain high, applying forward mode torque, until tape begins to move in the forward direction causing the reverse direction sense line to go low and making U19A-2 low. U19A-3 now goes low removing the forward mode torque and tape is controlled as in the play mode.

5-159. The play mode continues with the up-down counter on the monitor pc board counting backspace tachometer pulses until the count reaches a level determined by the SCAN SEGMENT, END • control. The repeat control logic will then cause A5-20 to go high. This high is applied to U27C-9 and to backspace initiate gate U19B-5. This causes the output of U19B-6 to go high and toggle the repeat flip-flop to backspace, U12A-1 high and U12B-4 low. With the output of U12B-4 low, the output of U29C goes low, and the high from A5-20 (to U27C-9) will cause the repeat play latch to toggle, removing the play mode command to U31B-5, and removing the monitor enable, U28B-4.

5-160. The high from U12A-1 is applied to backspace control gate U19C-9, and to repeat play braking gate U29A-2. The reverse direction sense line is low because tape is still moving in the forward direction; therefore, U19C-8 will remain low until tape motion changes direction and A5-N goes high. Since the forward direction sense line is high, U29A-1 will be high, and the high from U12A-1 will cause the output of U29A-3 to go high. Through diode CR31, this high powers the rewind motor control circuit and lights the REWIND indicator. This provides dynamic braking for the tape motion and will continue until tape comes to a stop and begins moving in the reverse direction causing the forward direction sense line, A5-18, to go low. This will cause U29A-1 to go low removing the rewind torque.

5-161. When the rewind torque causes tape to change direction, the reverse direction sense line will go high. This high and the high from U12A-1 will cause the output of U19C-8 to go high and power the backspace reel motor control circuit (previously described). This condition will remain until the repeat control logic on the monitor pc board commands the play portion of the repeat cycle.

NOTE

As described, when braking from backspace to play, the repeat play mode is initiated, and the PLAY indicator lights an instant before the forward braking torque is removed and the FWD indicator goes out. The same is true when braking from repeat play to backspace; however, there is no backspace indicator so it is not visually noticeable. This occurs because a high on one direction sense line is part of the control that causes the braking and a high on the other line initiates the next mode. When tape motion passes through stops, both direction sense lines will be momentarily high. This will initiate the next mode, but until tape begins moving in that direction, the braking torque is not removed. Since the braking torque and the next mode are in the same direction, this overlap will provide a small amount of acceleration and continuity of reel motor torque when changing direction.

5-162. This cycle of backspace, forward mode braking torque, play, rewind mode braking,and backspace will continue until another mode is selected. When another mode is selected, braking will be through the braking logic, and the reset logic will reset the repeat latch, U3C and U3D. This will inhibit the repeat shuttle logic, ending the repeat mode, and resetting the up-down counter on the monitor pc board through A5-12.

5-163. SRCH SPEED and SCAN SEGMENT Control. The SRCH SPEED control and SCAN SEGMENT controls are physically located on the logic pc board for operating convenience. These controls are part of the related circuits on the monitor pc board, and are included in the description of those circuits.

5-164. REMOTE CONTROLS AND INDICATIONS. Four modes are wired for external remote control and indication to REMOTE connector J103. Also the remote position of the SRCH SPEED control/ switch, R113, is wired to the REMOTE connector. All remote controls and indications parallel the corresponding control or indicator on the logic board. Figure 2-5 is a typical remote control circuit.

SECTION VI
SCHEMATICS AND WIRING DIAGRAMS

6-1. GENERAL

6-2. This section contains the major schematics and wiring diagrams for the AN/TNH-21, Flexible Voice Transcription Recorder/Reproducer. All of the schematics are listed in table 6-1. Some of the schematics for the smaller electromechanical assemblies are contained on the mechanical assembly drawing in Section VII. Schematics and wiring diagrams are listed numerically according to part number.

Table 6-1. Schematic and Wiring Diagrams

DESCRIPTION	PART NUMBER	FIGURE	PAGE
Run Capstan*	67-01-00, Sht 2	7-2	7-7/7-8
Run Capstan Tachometer*	67-01-15	7-3	7-11/7-12
Tape Transport Schematic	E67-03-00	6-1	6-3/6-4
Reel Motor Assembly *	67-04-00	7-7	7-19/7-20
Backspace Tachometer*	67-05-00	7-8	7-21/7-22
Run Motor Assembly*	67-07-00	7-11	7-27/7-28
Erase Head Assembly*	67-10-10	7-12	7-29/7-30
Record Head Assembly*	67-10-20	7-13	7-31/7-32
Reproduce Head Assembly*	67-10-30	7-14	7-33/7-34
Counter Assembly*	67-11-00	7-15	7-35/7-36
Fail-Safe Brake Assembly*	67-12-00	7-16	7-37/7-38
End-of-Tape Sensor Assembly*	67-14-00	7-17	7-39/7-40
Rear Chassis Schematic, Sheet 1	E67-16-00	6-2	6-5/6-6
Rear Chassis Schematic, Sheet 2	E67-16-00	6-2	6-7/6-8
Rear Chassis Schematic, Sheet 3	E67-16-00	6-2	6-9/6-10
Tension Sensor Assembly*	67-20-00	7-19	7-47/7-48
Logic PC Board Assembly Schematic (Capstan Servo), Sheet 1	E67-21-00	6-3	6-11/6-12
Logic PC Board Assembly Schematic (Control Logic), Sheet 2	E67-21-00	6-3	6-13/6-14
Reproduce Head Preamplifier Schematic	E67-22-00	6-4	6-15/6-16
Record/Reproduce PC Board Assembly Schematic	E67-23-00	6-5	6-17/6-18
Monitor PC Board Assembly Schematic (Sheet 1)	E67-24-00	6-6	6-19/6-20
Monitor PC Board Assembly Schematic (Sheet 2)	E67-24-00	6-6	6-21/6-22
Monitor PC Board Assembly Schematic (Sheet 3)	E67-24-00	6-6	6-23/6-24
Power Supply PC Board Assembly Schematic	E67-25-00	6-7	6-25/6-26
Integrated Circuit Diagrams		6-8	6-27/6-28

*Shown on the mechanical assembly drawing in Section VII.

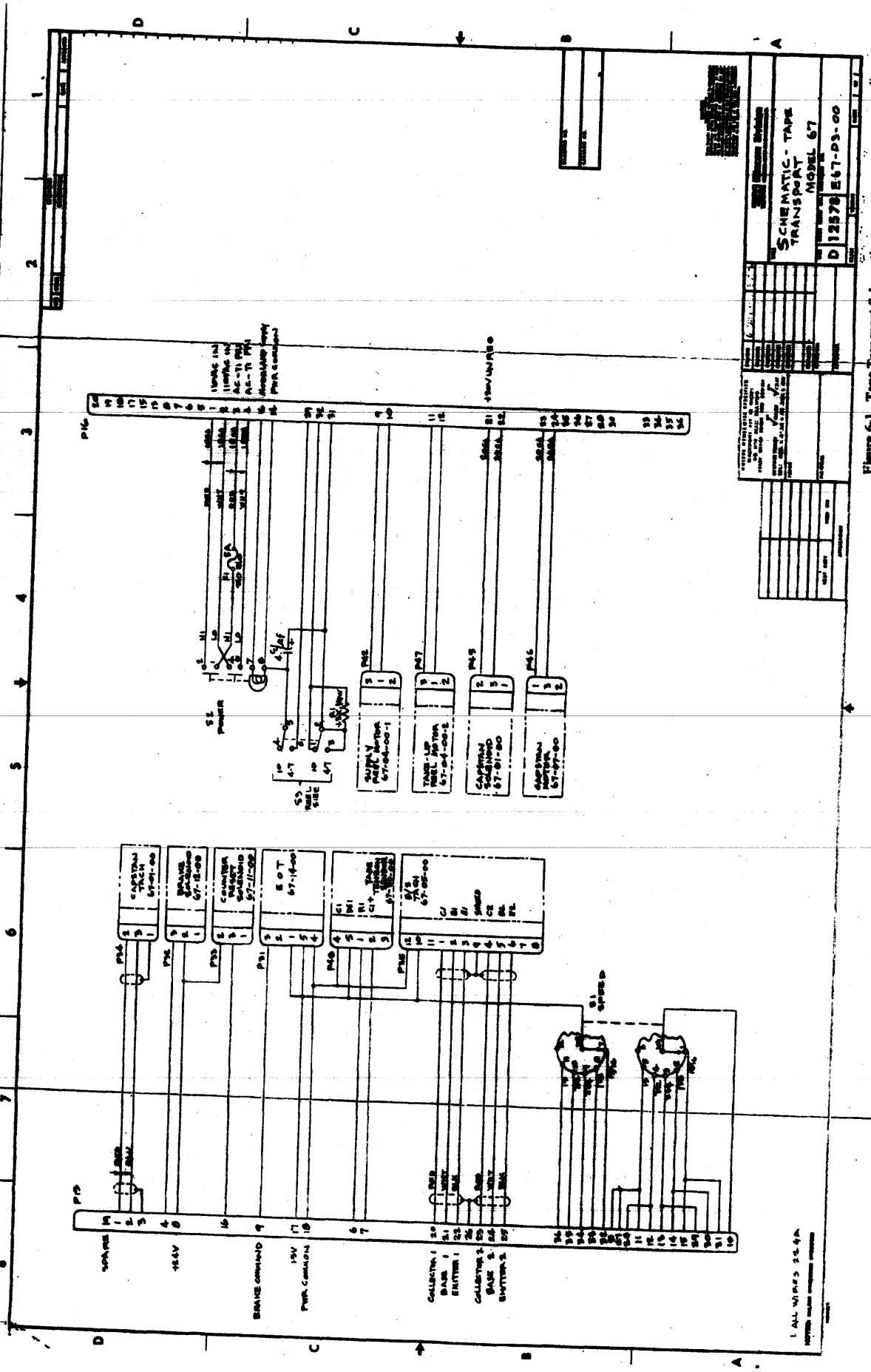


Figure 6-1. Tape Transport Schematic

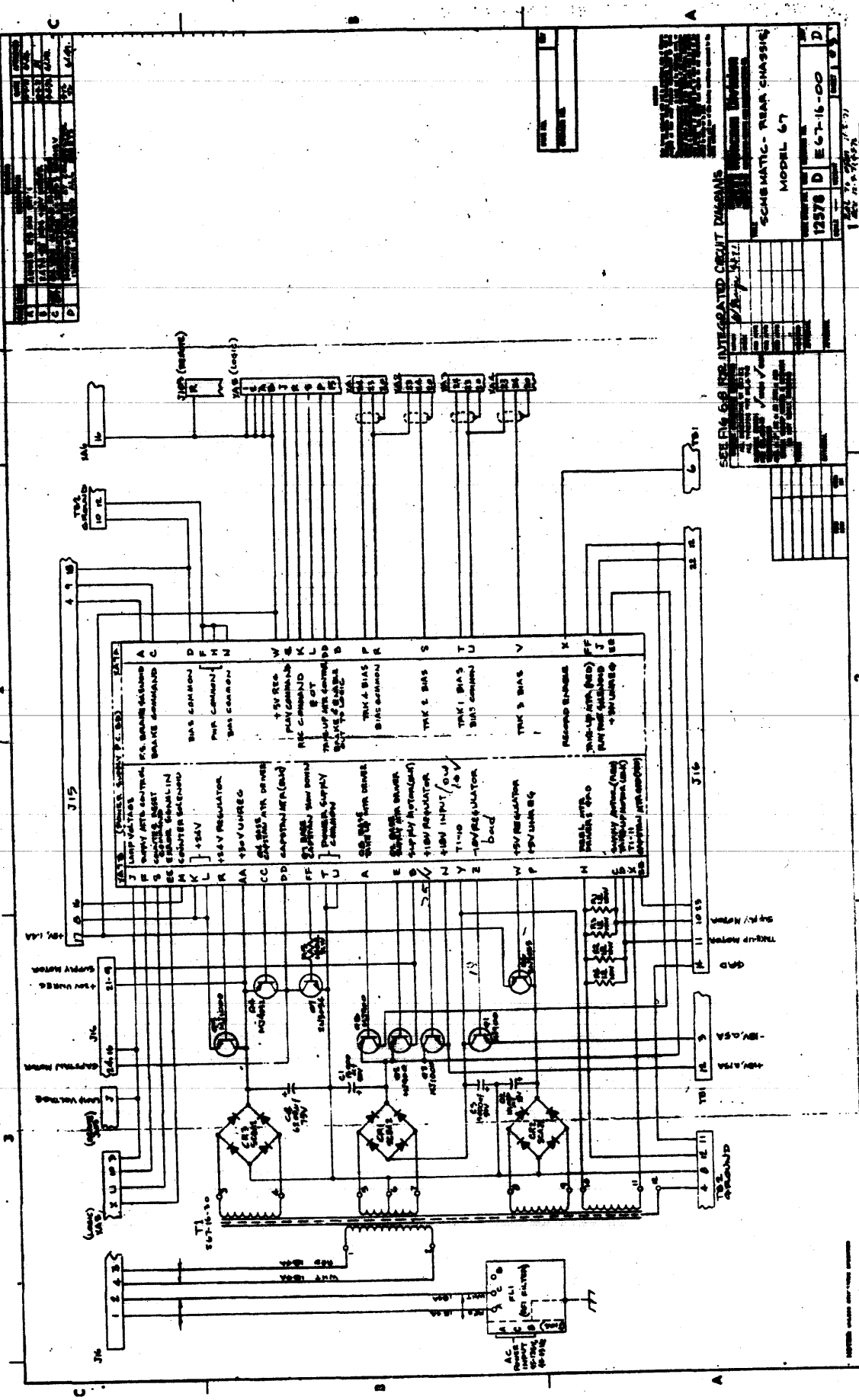


Figure 6-2. Rear Chassis Schematic, Sheet 1

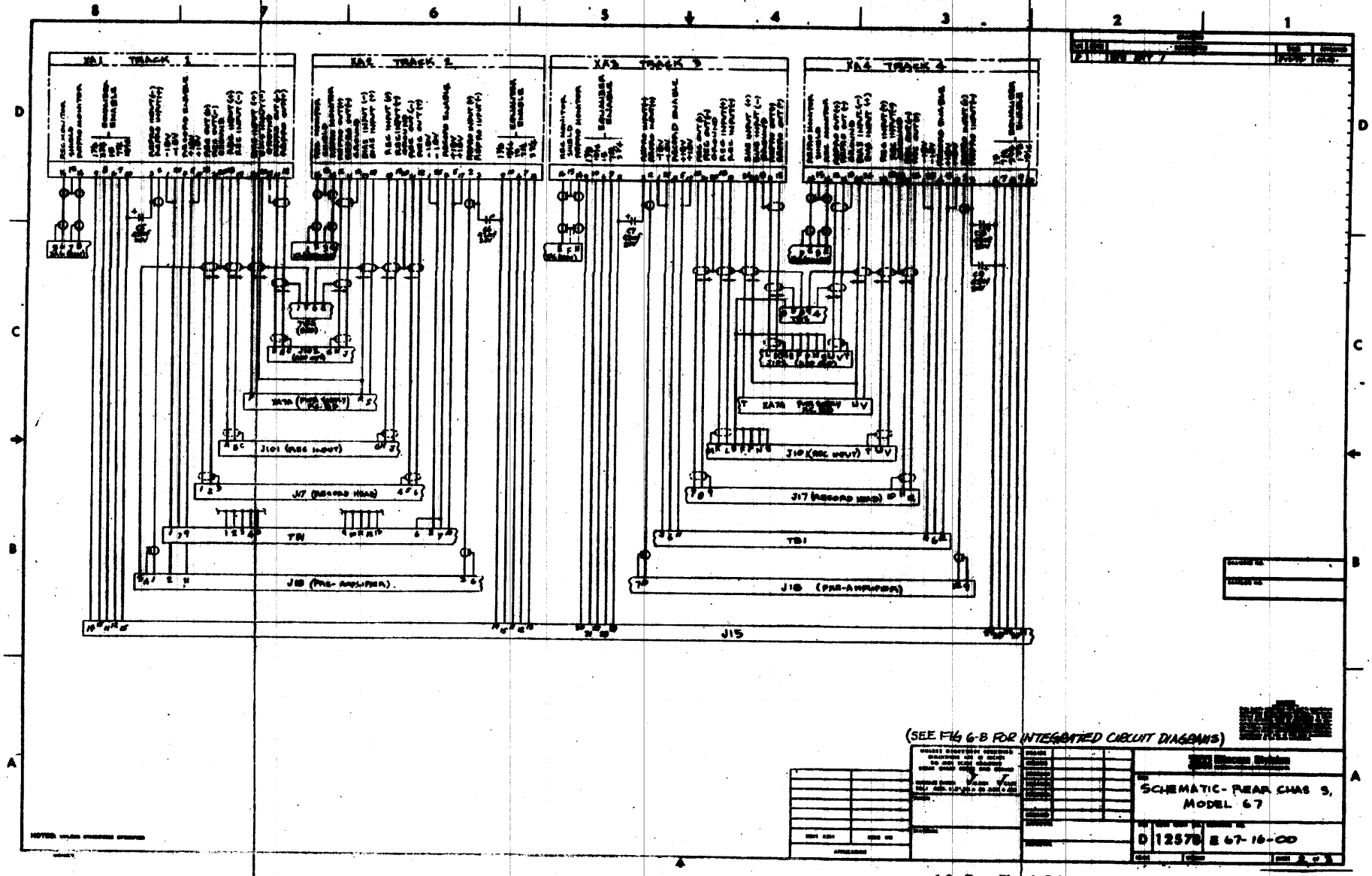


Figure 6-2. Rear Chassis Schematic, Sheet 2

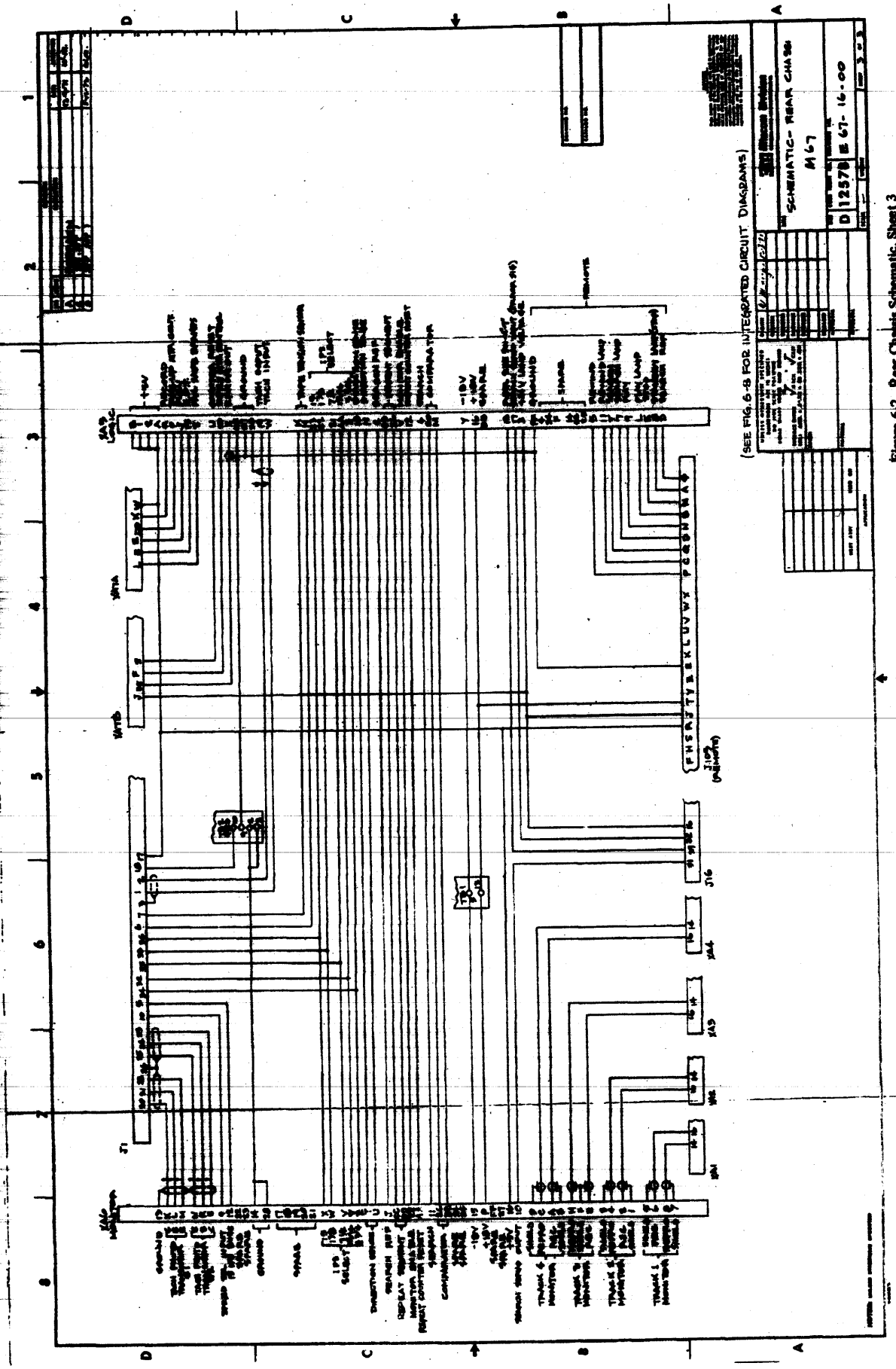


Figure 6-2. Rear Chassis Schematic, Sheet 3

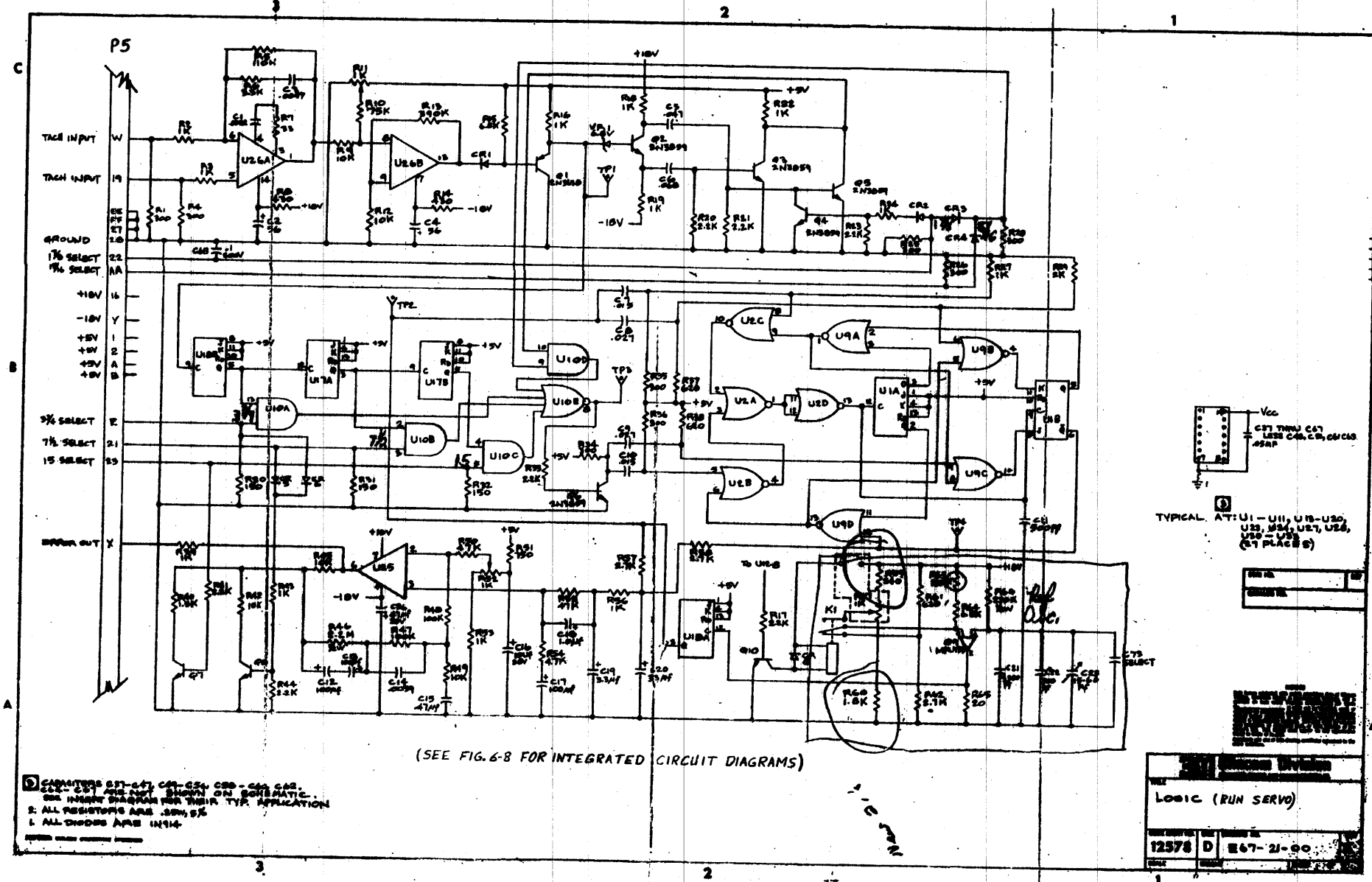


Figure 6-3. Logic PC Board Assembly Schematic (Capstan Servo), Sheet 1

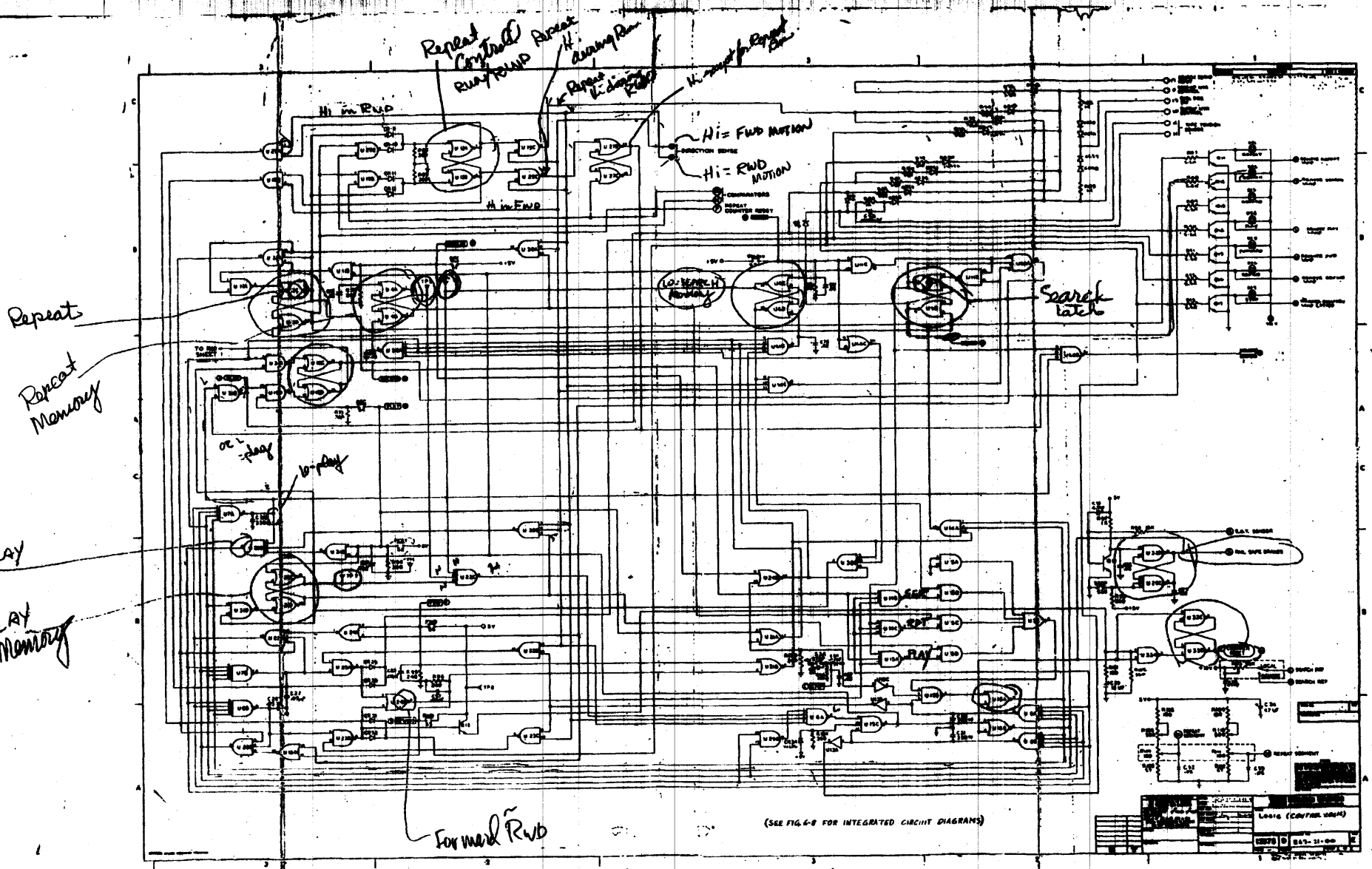


Figure 6-3. Logic PC Board Assembly Schematic (Control Logic), Sheet 2

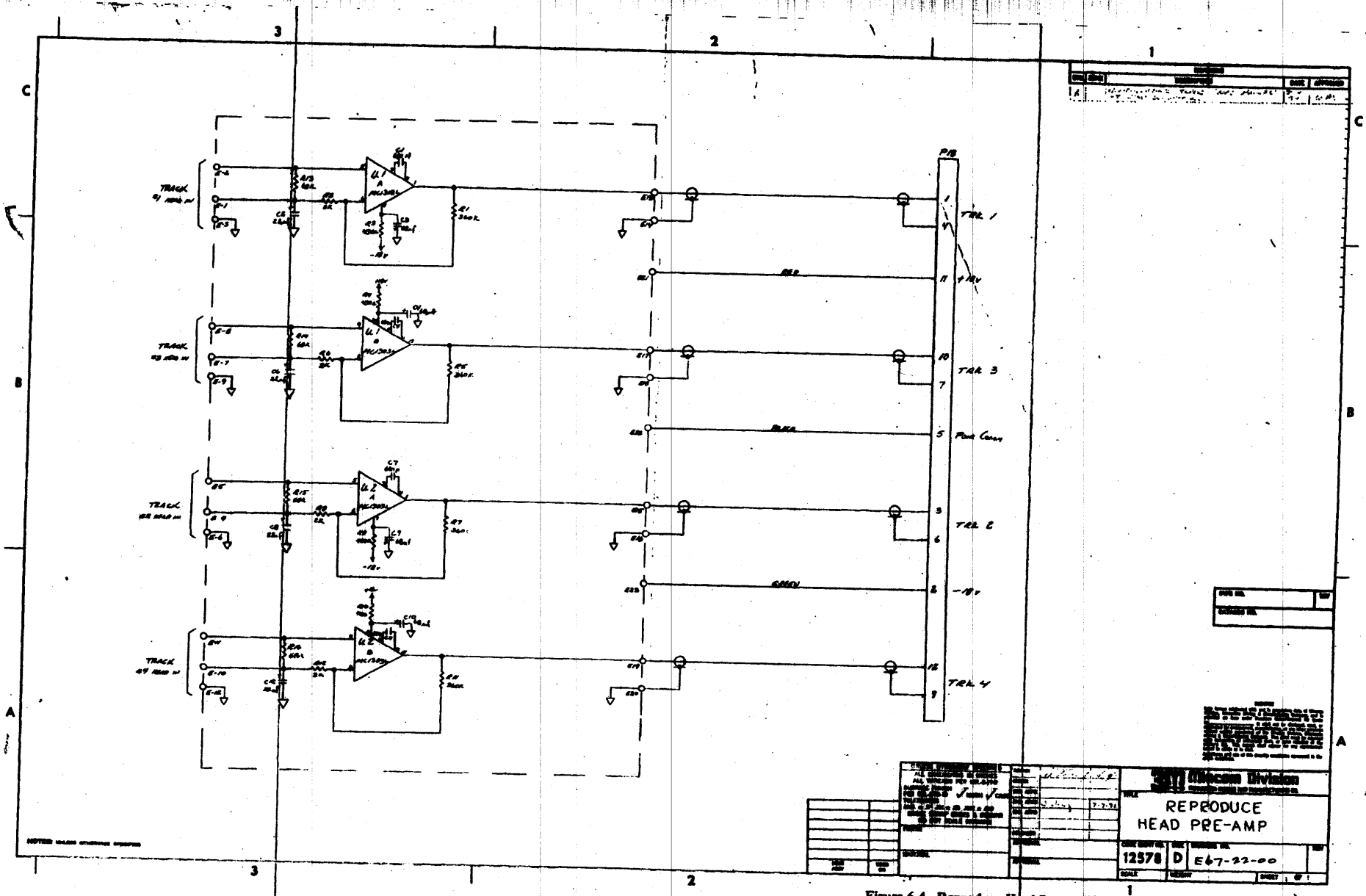


Figure 6-4. Reproduce Head Preamplifier Schematic

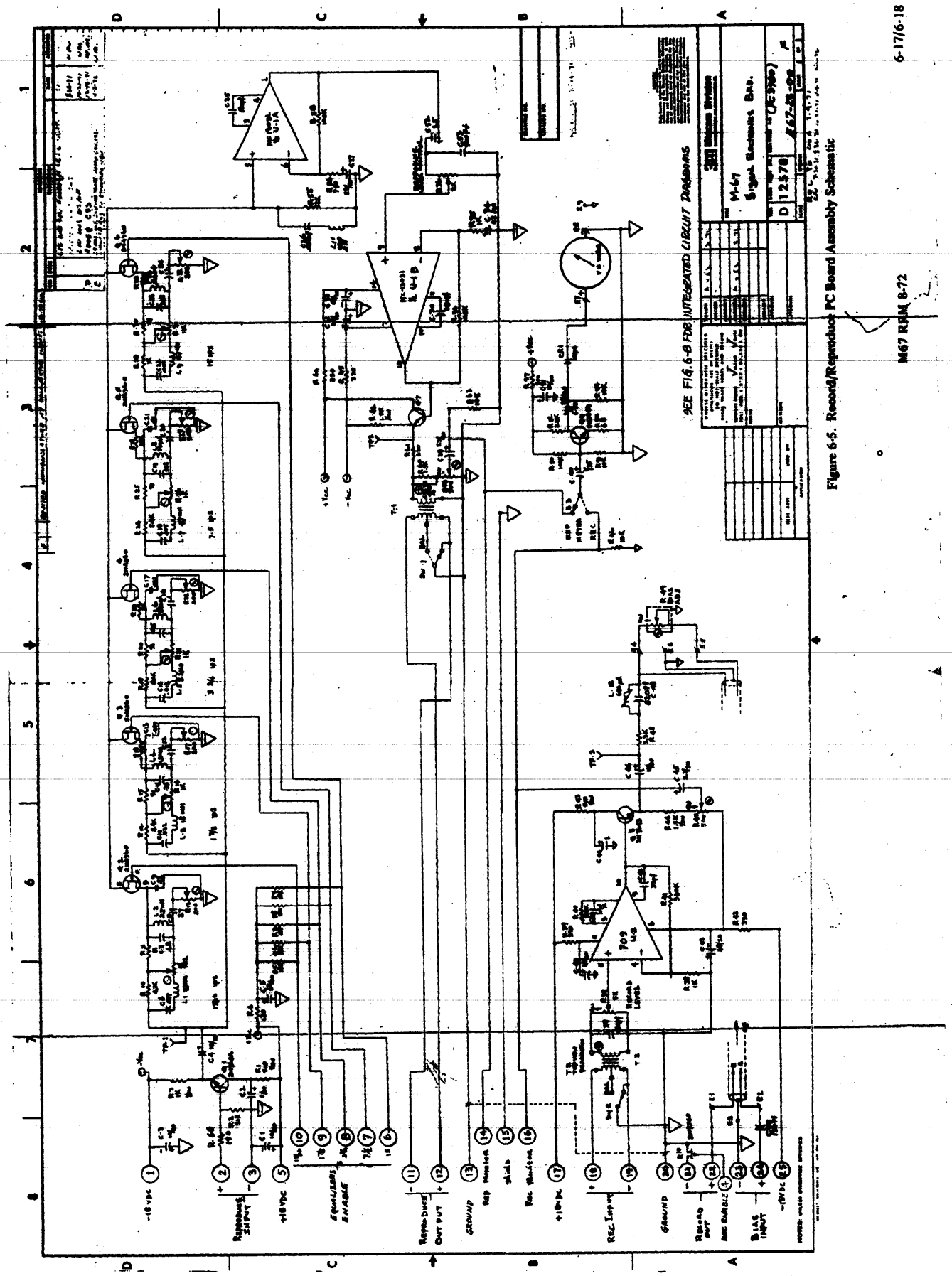


Figure 6-5. Record/Reproduce PC Board Assembly Schematic

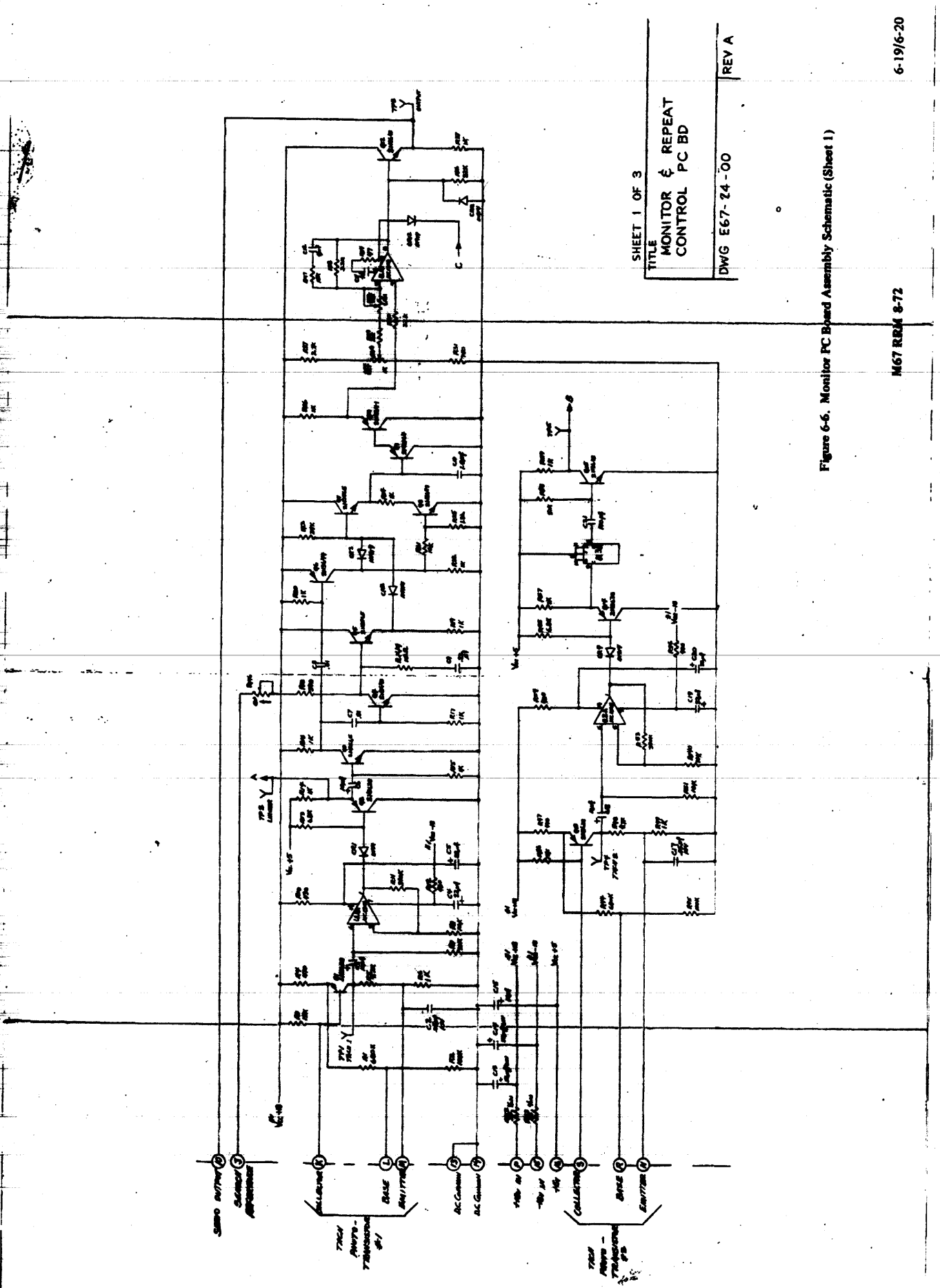


Figure 6-6. Monitor PC Board Assembly Schematic (Sheet 1)

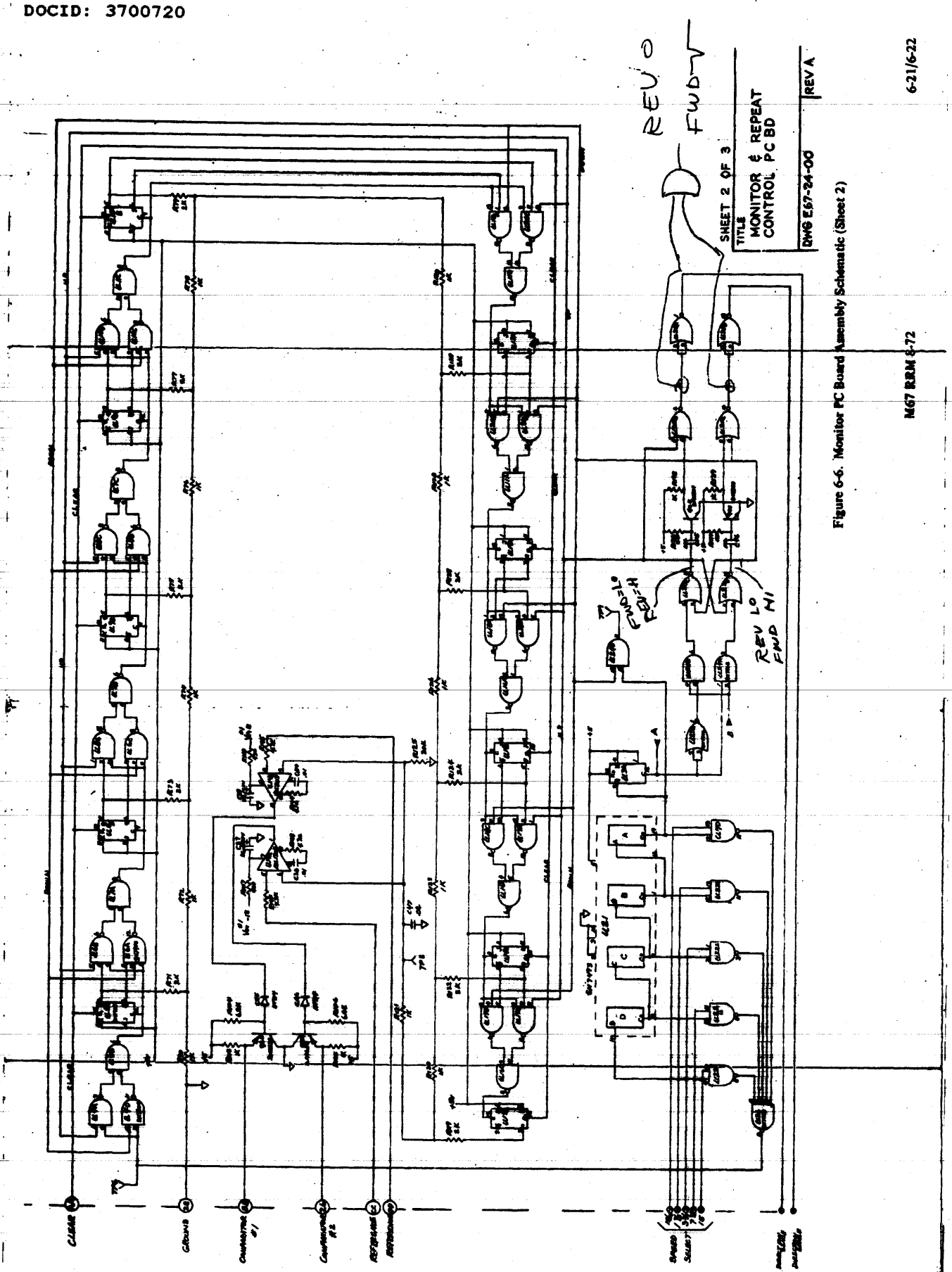


Figure 6-6. Monitor PC Board Assembly Schematic (Sheet 2)

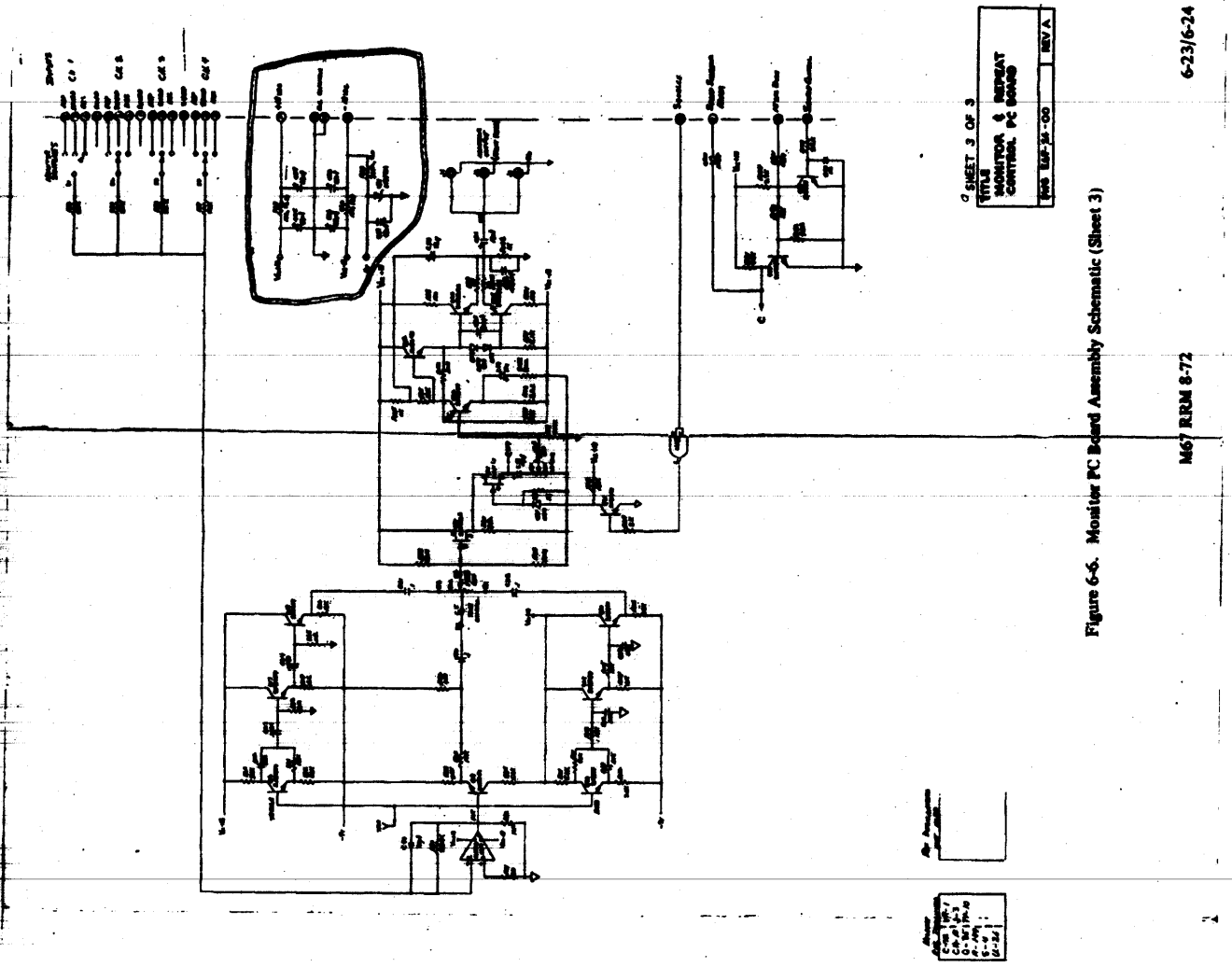


Figure 6-6. Monitor PC Board Assembly Schematic (Sheet 3)

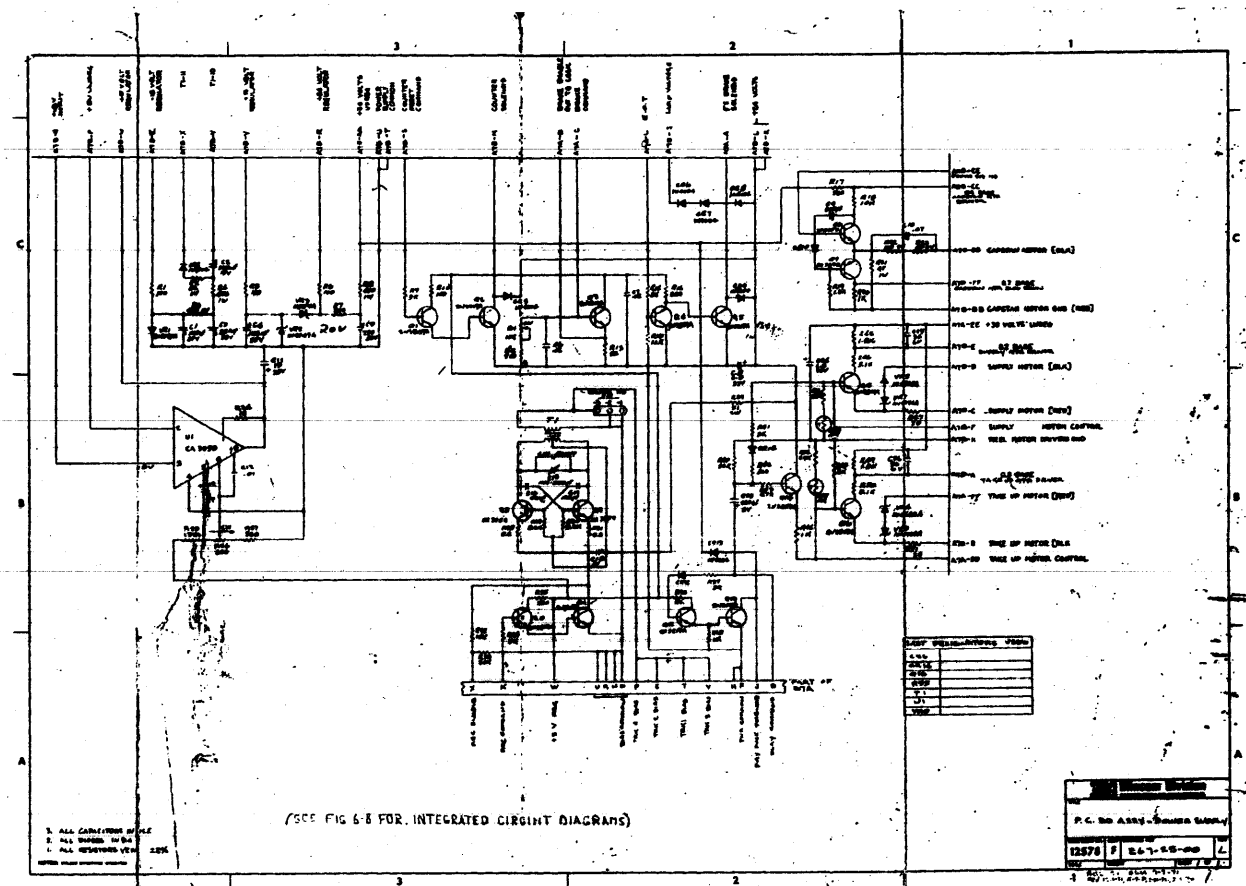


Figure 6-7. Power Supply PC Board Assembly Schematic

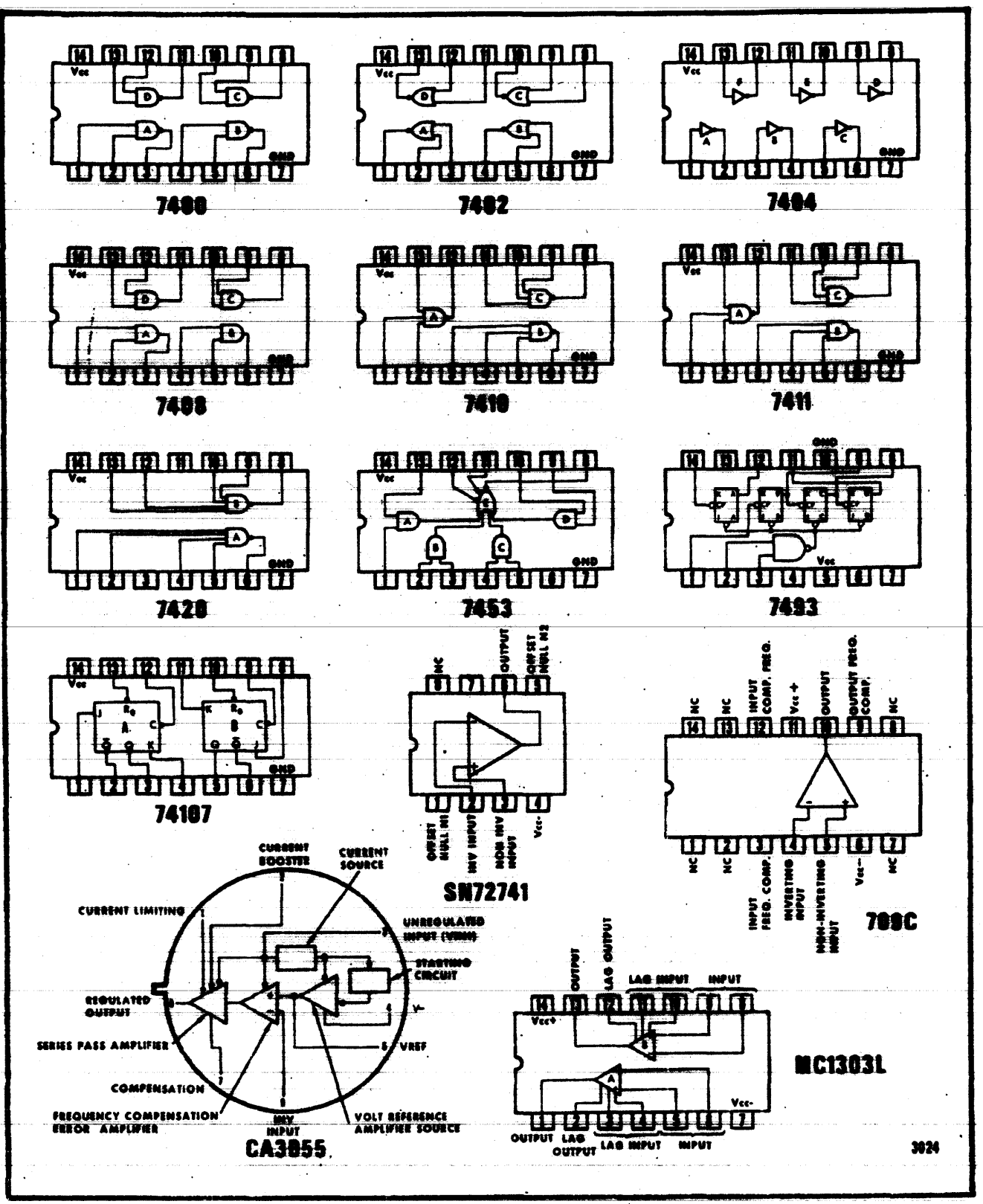


Figure 6-8. Integrated Circuit Diagrams

SECTION VII
DRAWINGS AND PARTS LISTS

7-1. GENERAL

7-2. This section contains the assembly drawings and parts lists for the AN/TNH-21, Flexible Voice Transcription Recorder/Reproducer. The drawing and parts list are arranged in numerical order, and the assembly drawing precedes the parts list when the parts list is contained on separate sheets. To locate parts for an assembly, find the assembly by name or number in table 7-1 and turn to the indicated parts list or assembly drawing. Use the assembly drawing to make positive identification of the part, and then obtain the description, and part number and/or catalog number (preferably both) from the parts list.

7-3. ORDERING REPLACEMENT PARTS

7-4. Parts should be ordered through one of the 3M Company, Mincom Division, Field Engineering Offices listed in the front of this manual. Whenever a recorder is used in a critical application, it is recommended that the user maintain a minimum stock of spare parts. The 3M Company has specialized personnel ready to assist the user in making a selection of spare parts. When ordering parts, the following information should be supplied:

1. The description of the part obtained from the parts list.
2. The 3M Company catalog number.
3. The manufacturer's part number.
4. If an electrical part, the reference designator from the parts list or schematic.
5. The part number of the major assembly and its serial number, if applicable.

Table 7-1. Drawings and Parts Lists

Table 7-1. Drawings and Parts Lists (Cont.)

DESCRIPTION	PART NUMBER	FIGURE	PAGE
Logic PC Board Assembly	67-21-00	7-20	7-49/7-50
Reproduce Head Preamplifier Assembly	67-22-00	7-21	7-65/7-66
Record/Reproduce PC Board Assembly	67-23-00	7-22	7-69/7-70
Monitor PC Board Assembly	67-24-00	7-23	7-79/7-80
Power Supply PC Board Assembly	67-25-00	7-24	7-95/7-96
Accessory Kit	PL67-29-00		7-103/7-104

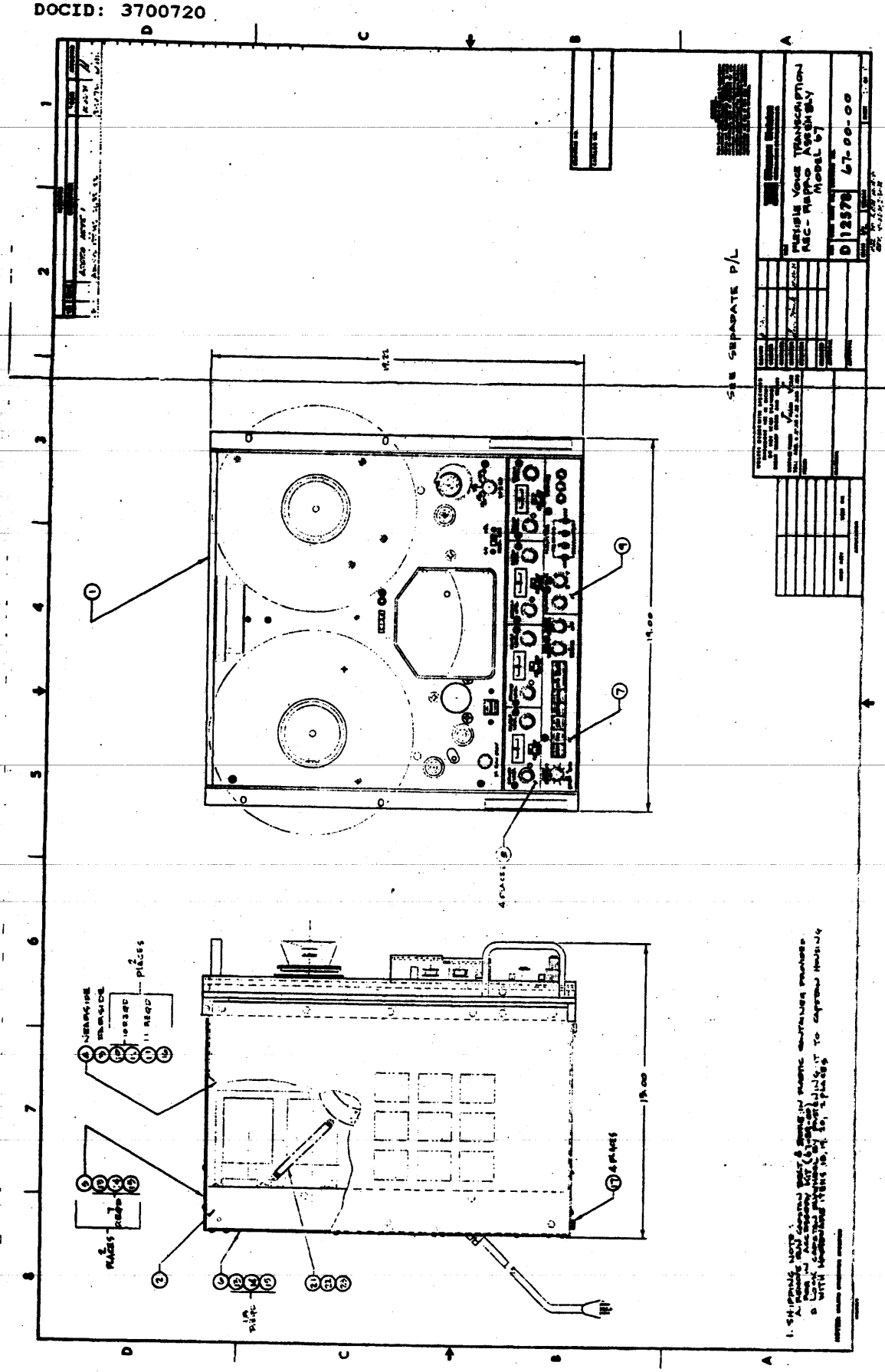


Figure 7-1. Flexible Voice Transcription Recorder/Reproducer Assembly, AN/TNH-21 (XR-3-128)

DOC ID: 3700720

3M Mincom Division (MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-00-00 SHEET 1 OF 1	B REV
	TITLE FLEXIBLE VOICE TRANSCRIPTION RECORDER/REPRODUCER ASSEMBLY, AN/TNH-21		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	TY
1		67-03-00	TOP PLATE ASSY		1
2		67-16-00	CHASSIS ASSY		1
3		67-16-09-1	PANEL-SIDE, RIGHT		1
4		67-16-09-2	PANEL-SIDE, LEFT		1
5		67-16-08	COVER, TOP AND BOTTOM		2
6		67-16-07	COVER, REAR		1
7		67-21-00	PC BD ASSY, LOGIC		1
8		67-23-00	PC BD ASSY, SIGNAL ELEC		4
9		67-24-00	PC BD ASSY, MONITOR		1
10			SCREW, PH, 8-32 X 7/16	83-9260-4550	20
11			WASHER, SP LOCK NO. 8	83-9261-4306	22
12			WASHER, FLAT NO. 8	83-9261-4005	20
13			SCREW, PH, 6-32 X 3/8	83-9260-4531	32
14			WASHER, SP LOCK NO. 6	83-9261-4305	32
15			WASHER, FLAT NO. 6	83-9261-4004	32
16			SCREW, CAP 8-32 X 7/16	83-9261-2149	2
17			BUMPER	83-1230-0449	4
18			SCREW, SOCKET HEAD 10-32 X 2"	83-9261-2109	2
19			WASHER, FLAT NO. 10	83-9261-4006	2
20			WASHER, LOCK NO. 10	83-9261-4307	2
21		1414-6	LUG	83-9630-0086	1
22			SPRING-EXT	83-7280-0236	1
23		TY-24M	TYRAP	83-7650-0597	1

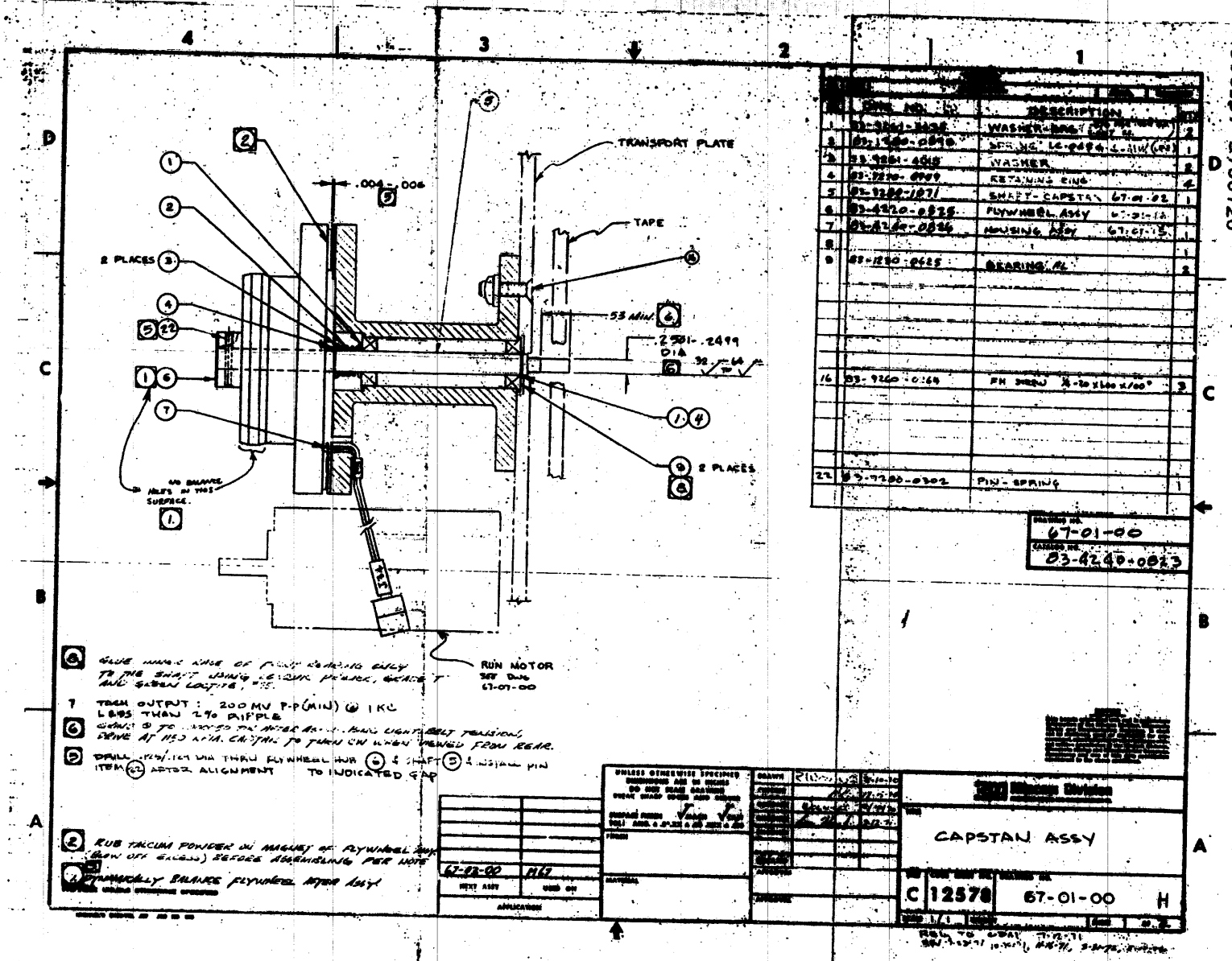


Figure 7-2. Run Capstan (Sheet 1 of 2)

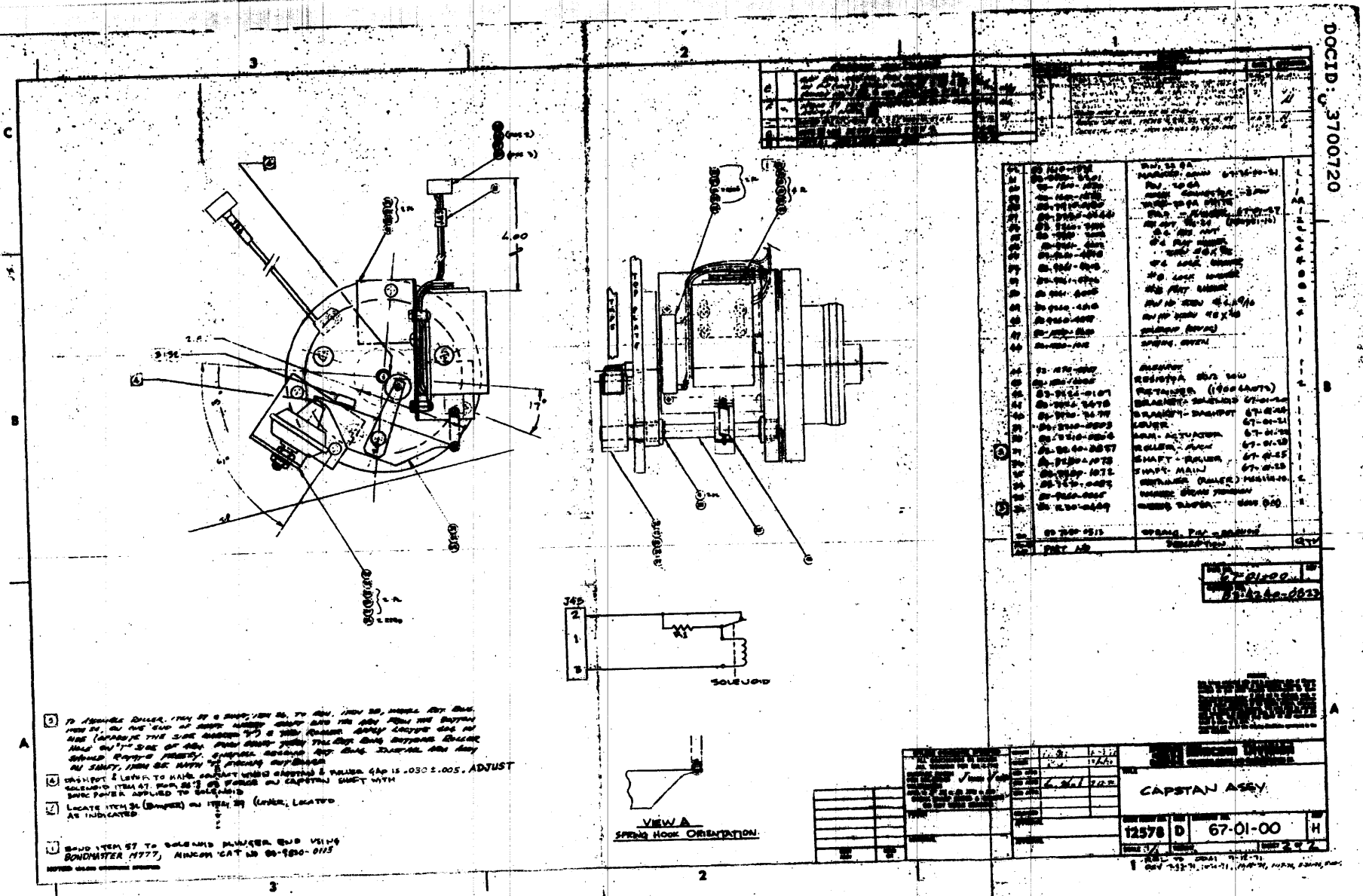
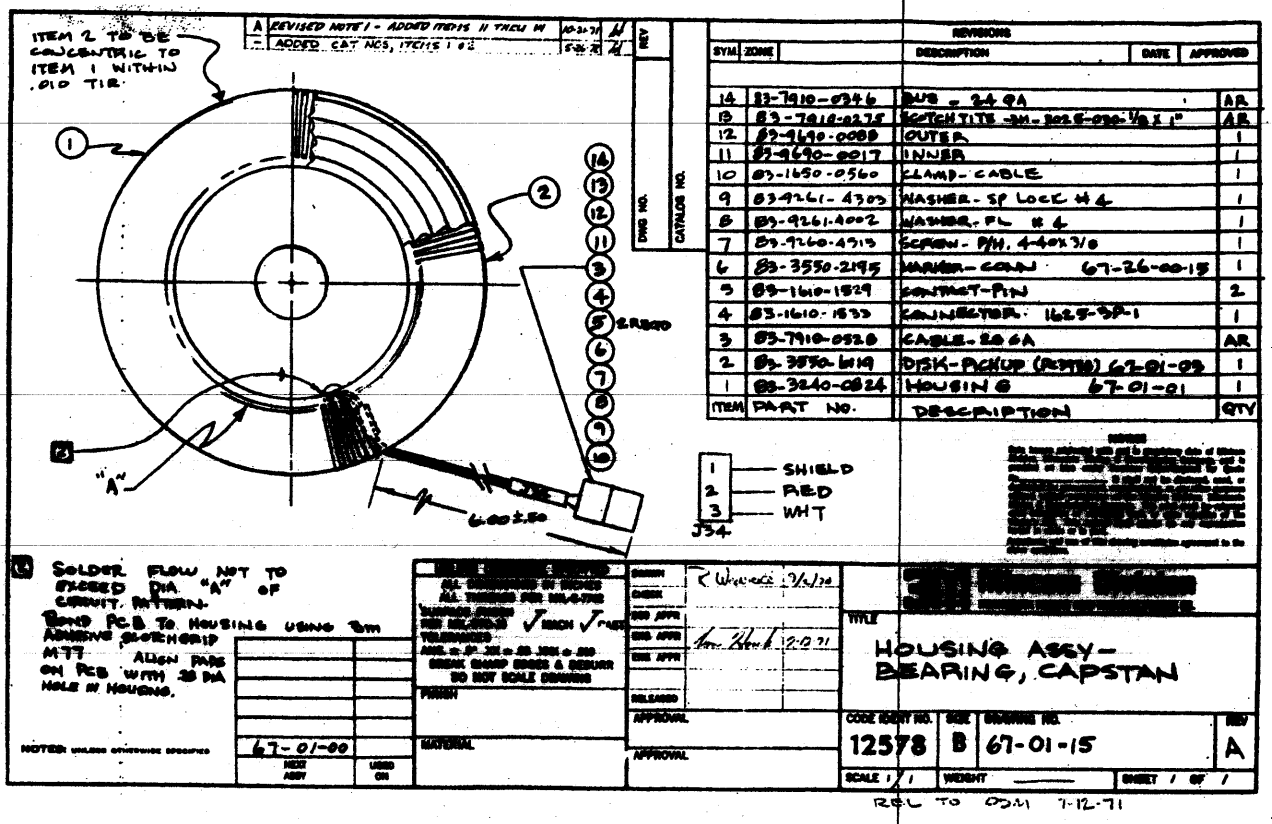


Figure 7-2. Run Capstan (Sheet 2 of 2)

DOCID: 3700720



SYM	ZONE	DESCRIPTION	DATE	APPROVED
A		REVISED NOTE 1 - ADDED ITEMS 11 THRU 14	10-21-71	
-		ADDED CAT NOS, ITEMS 1 & 2	5-26-71	

ITEM	PART NO.	DESCRIPTION	QTY
14	83-7910-0346	BUS - 24 GA	AR
13	83-7910-0275	SCOTCH TITE -3M- 3005-050-1/2 X 1"	AR
12	83-9690-0008	OUTER	1
11	83-9690-0017	INNER	1
10	83-1650-0560	CLAMP - CABLE	1
9	83-9261-4303	WASHER - SP LOCK #4	1
8	83-9261-4002	WASHER - FL #4	1
7	83-9260-4313	SCREW - P/H, 4-40 X 3/8	1
6	83-3550-2195	MARKER - CORN 67-26-00-15	1
5	83-1610-1529	CONTACT-PIN	2
4	83-1610-1532	CONNECTOR - 1625-3P-1	1
3	83-7910-0320	CABLE - 28 GA	AR
2	83-3850-1119	DISK-PICKUP (REF) 67-01-02	1
1	83-3240-0824	HOUSING 67-01-01	1

Figure 7-3. Run Capstan Tachometer, PC Board and Housing

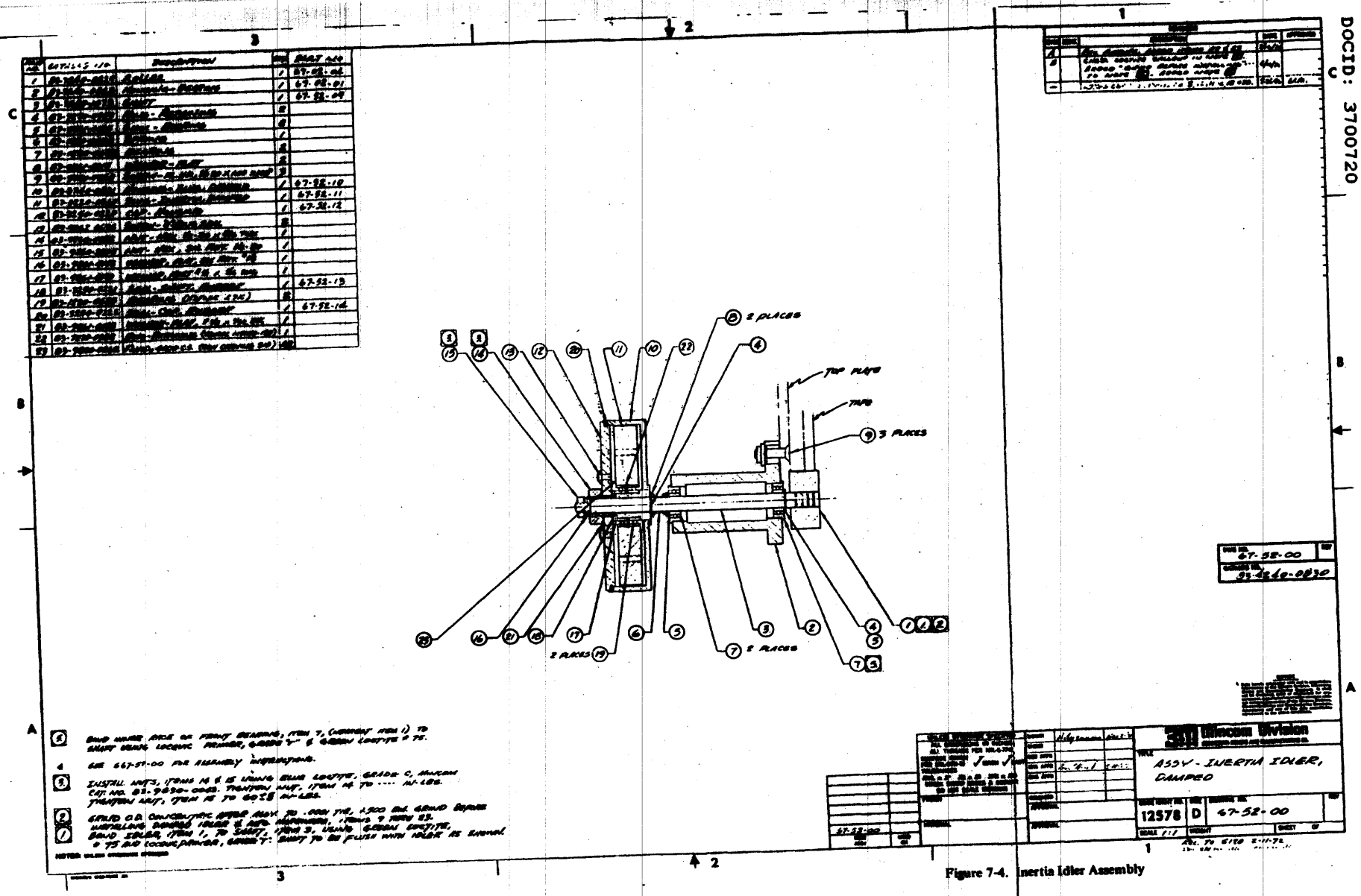


Figure 7-4. Inertia Idler Assembly

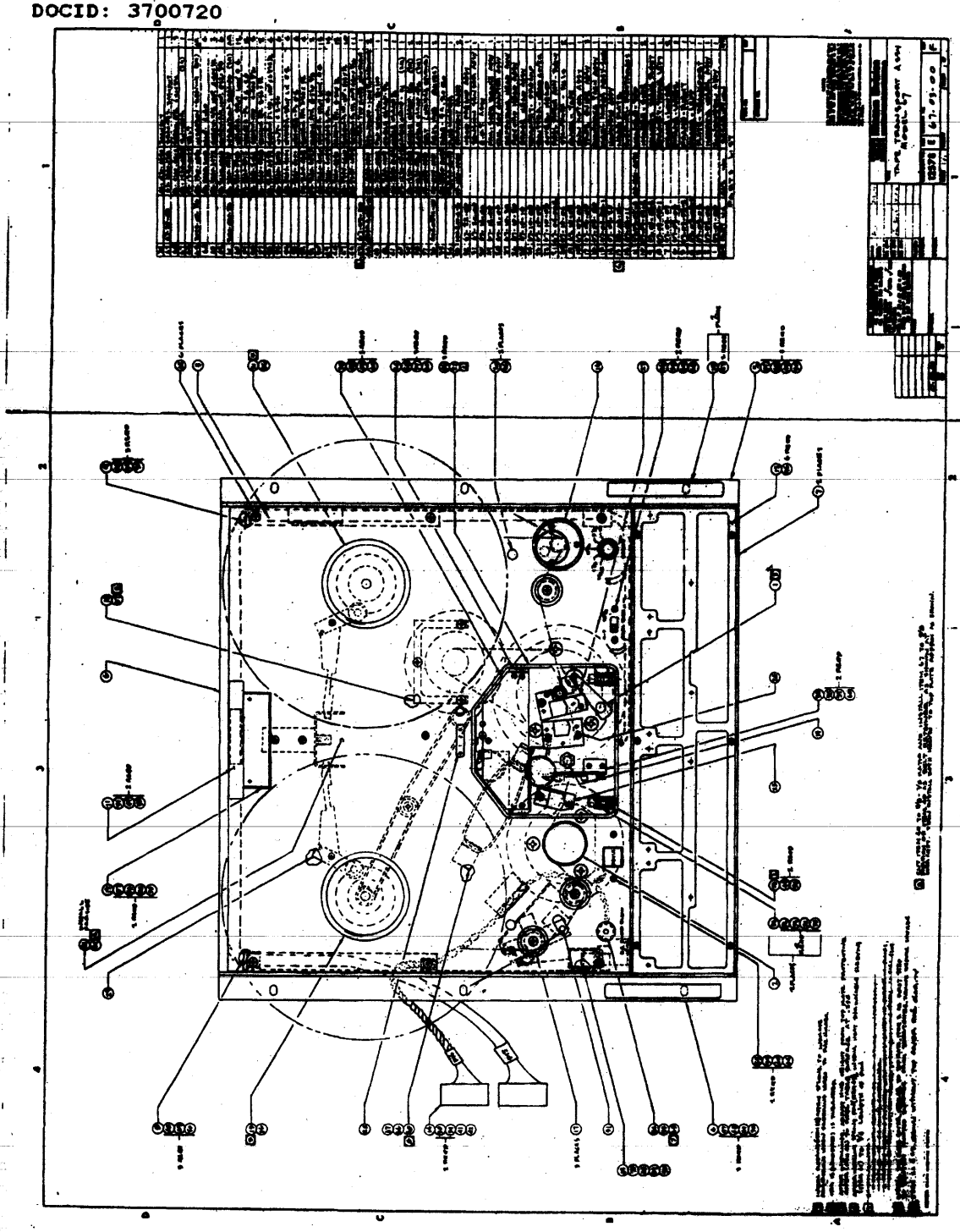


Figure 7-5. Tape Transport Assembly

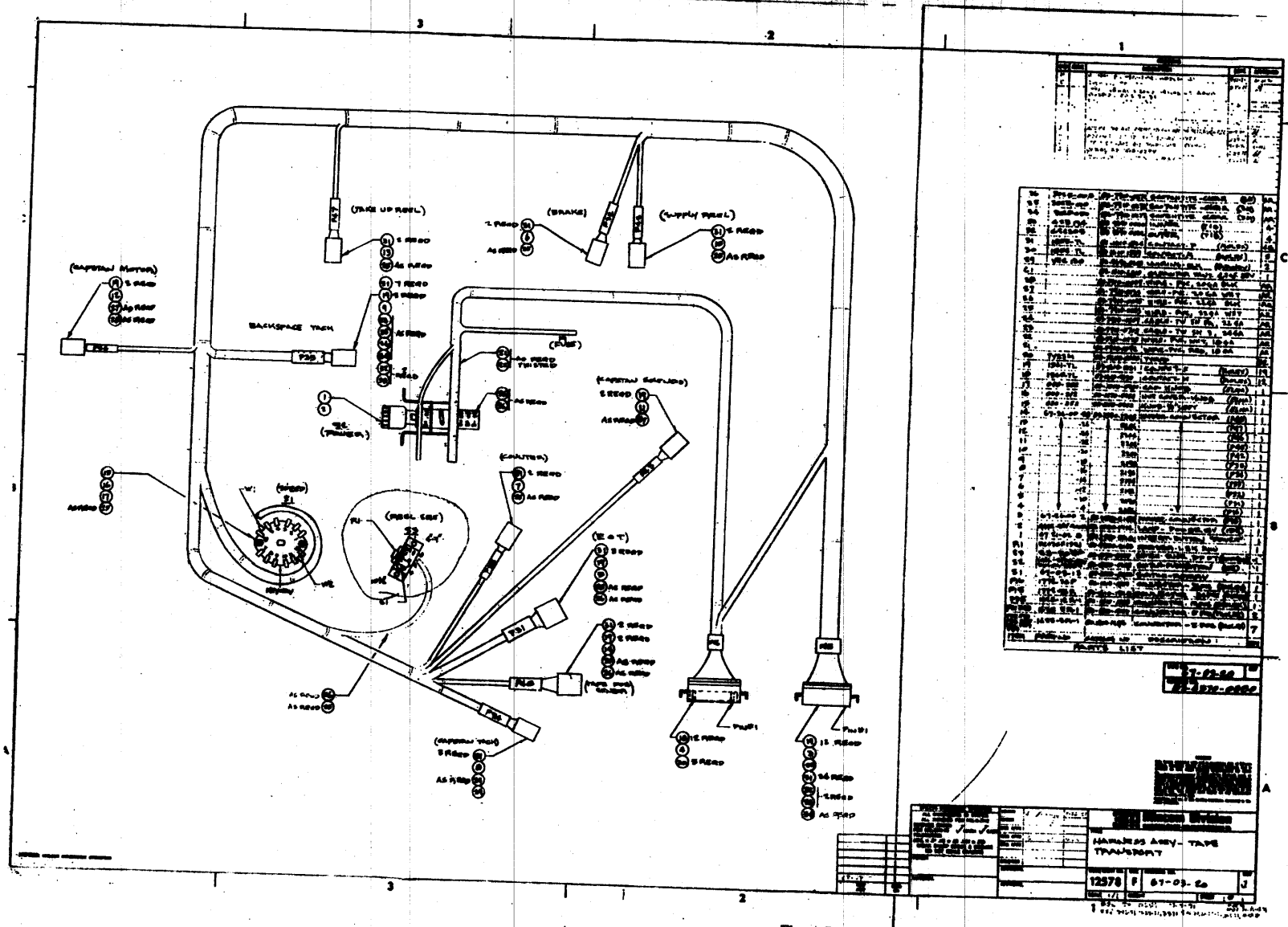


Figure 7-6. Tape Transport Harness Assembly

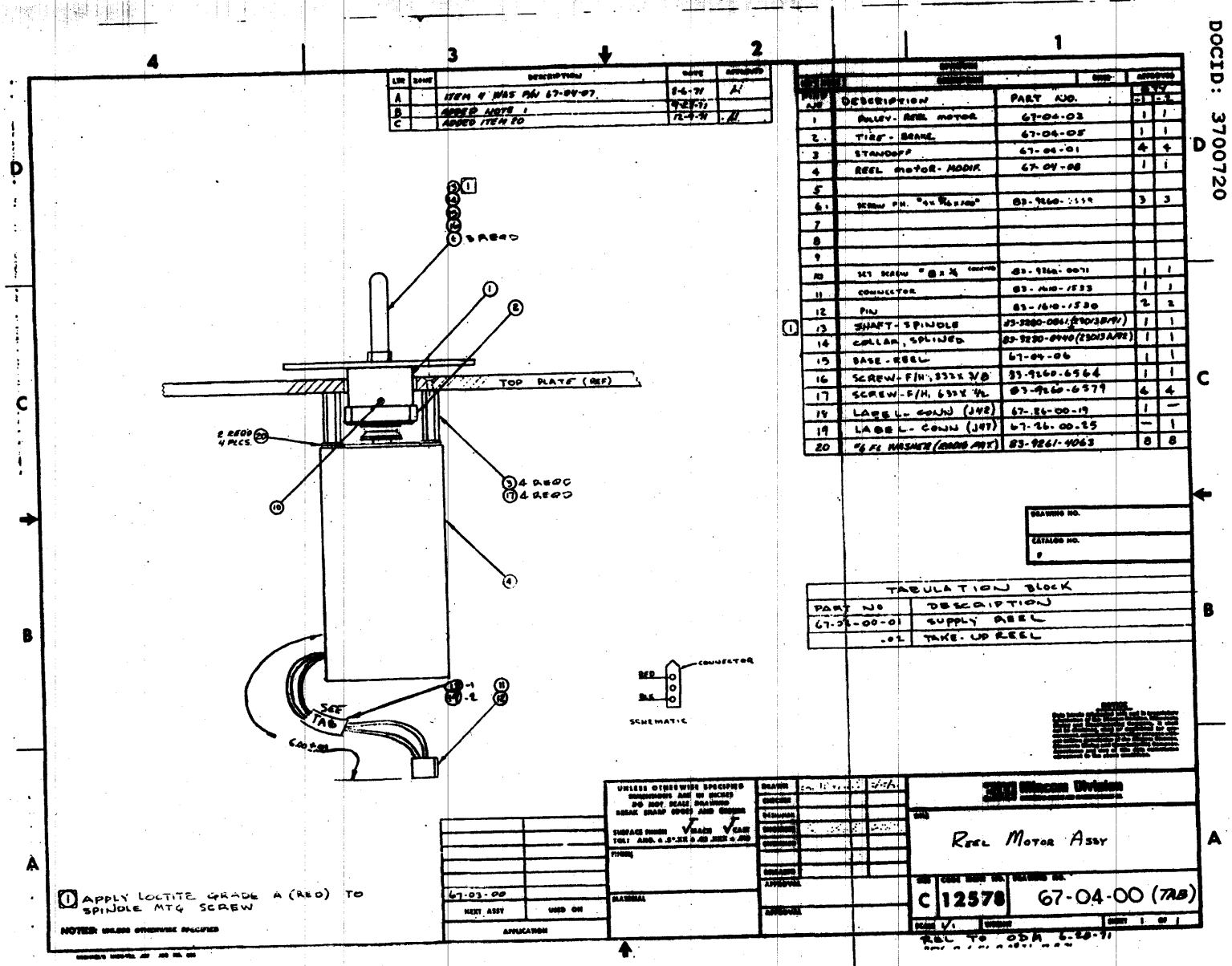


Figure 7-7. Reel Motor Assembly

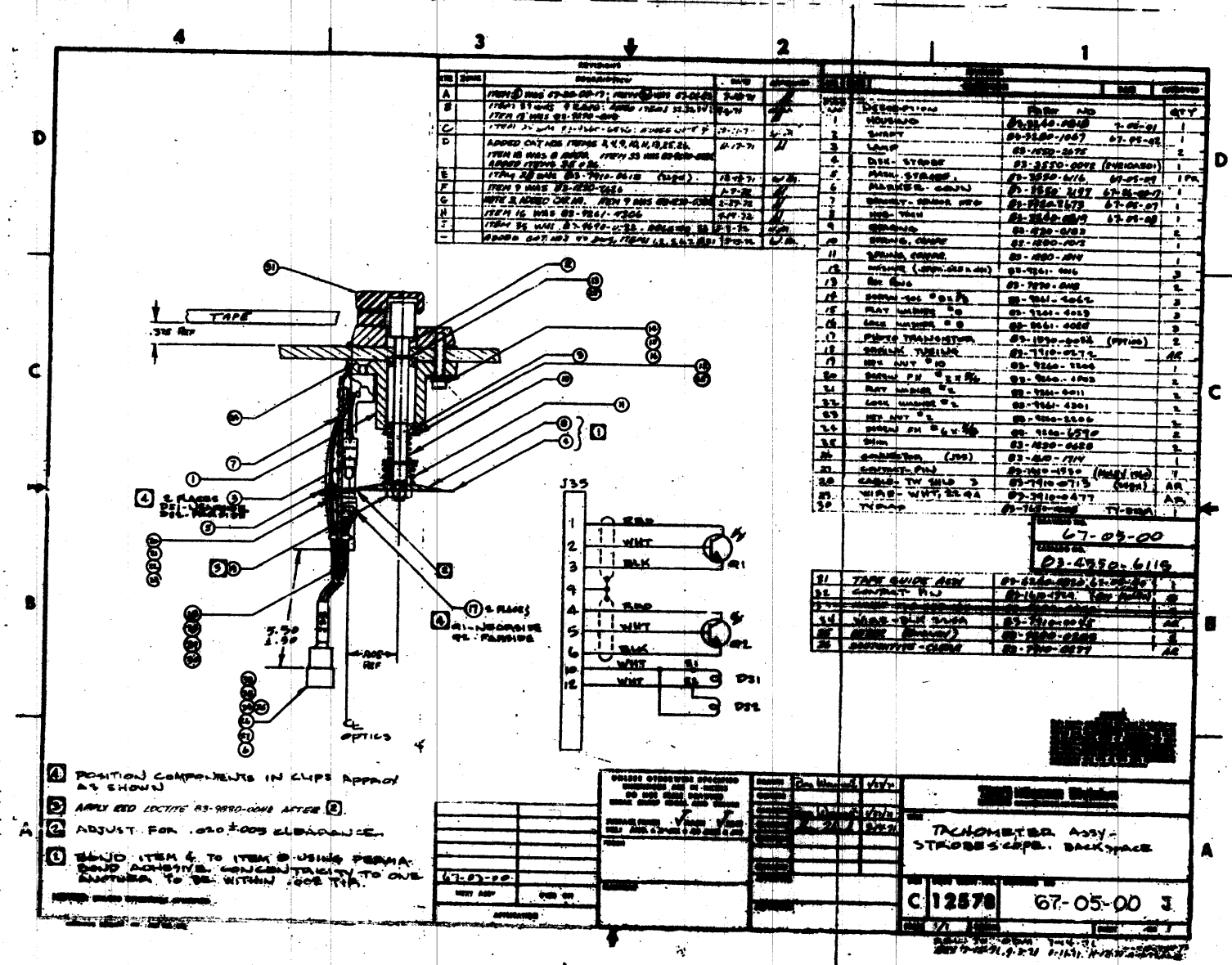


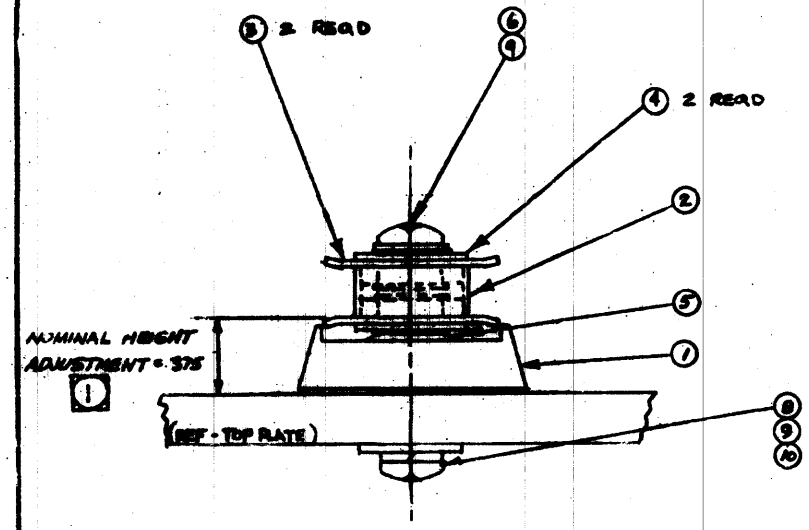
Figure 7-8. Backspace Tachometer Assembly

REVISIONS		
A	ITEM 10 WAS 83-9261-4306. ADDED NOTE 1	5-16-71 W.M.
B	ITEM 8 WAS 83-9260-4552	5-17-71 W.M.
C	ITEM 9 WAS 83-9261-4003	5-17-71 W.M.
D	ITEM 9 WAS 83-9261-4021	4-14-72 W
—	ADDED CAT. NO.'S TO PART ITEMS 1,2	5-5-72 W.M.

DWG NO. 67-06-00

CATALOG NO. 83-4240-0816

FIND NO.	DESCRIPTION	PART NO.	QTY
1	BASE	83-9240-0817, 67-06-05	1
2	SLEEVE	83-9240-0649, 67-06-04	1
3	FLANGE	83-9240-0864	2
4	BEARING	83-1830-0291	2
5	HEAVY WASHER	83-9262-0435	1
6	SCREW, [illegible]	83-9262-0423	1
7			
8	SCREW, PH [illegible]	83-9260-4553	1
9	FLAT WASHER #8	83-9261-4029	2
10	LOCK WASHER #8	83-9261-4020	1



NOTICE

[illegible]

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS IN INCHES
ALL THREADS PER MIL-S-7742
SURFACE FINISH PER MIL-STD-10 √ MACH √ CAST
TOLERANCES
ANG. ± .5° .XX ± .03 .XXX ± .010
BREAK SHARP EDGES & DEBURR
DO NOT SCALE DRAWING

FINISH

MATERIAL

	DRAWN	CHECK	ENG APPR	ENG APPR	ENG APPR	RELEASED	APPROVAL	APPROVAL
	[illegible]			[illegible]				
	6-25-71							

Minneapolis Division

TITLE: ROLLER ASSY— TAPE GUIDE

CODE IDENT NO.	SIZE	DRAWING NO.	REV.
12578	B	67-06-00	D

SCALE 2/1 WEIGHT 2 SHEET 1 OF 1

NEXT ASSY	USED ON
67-03-00	

1 USE ADJUSTMENT TOOL NO. 67-06-00-01

NOTES: UNLESS OTHERWISE SPECIFIED

REL TO PROD. 6-25-71
5-16-71, 9-23-71, 10-27-71, 4-14-72

Figure 7-9. Roller Tape Guide

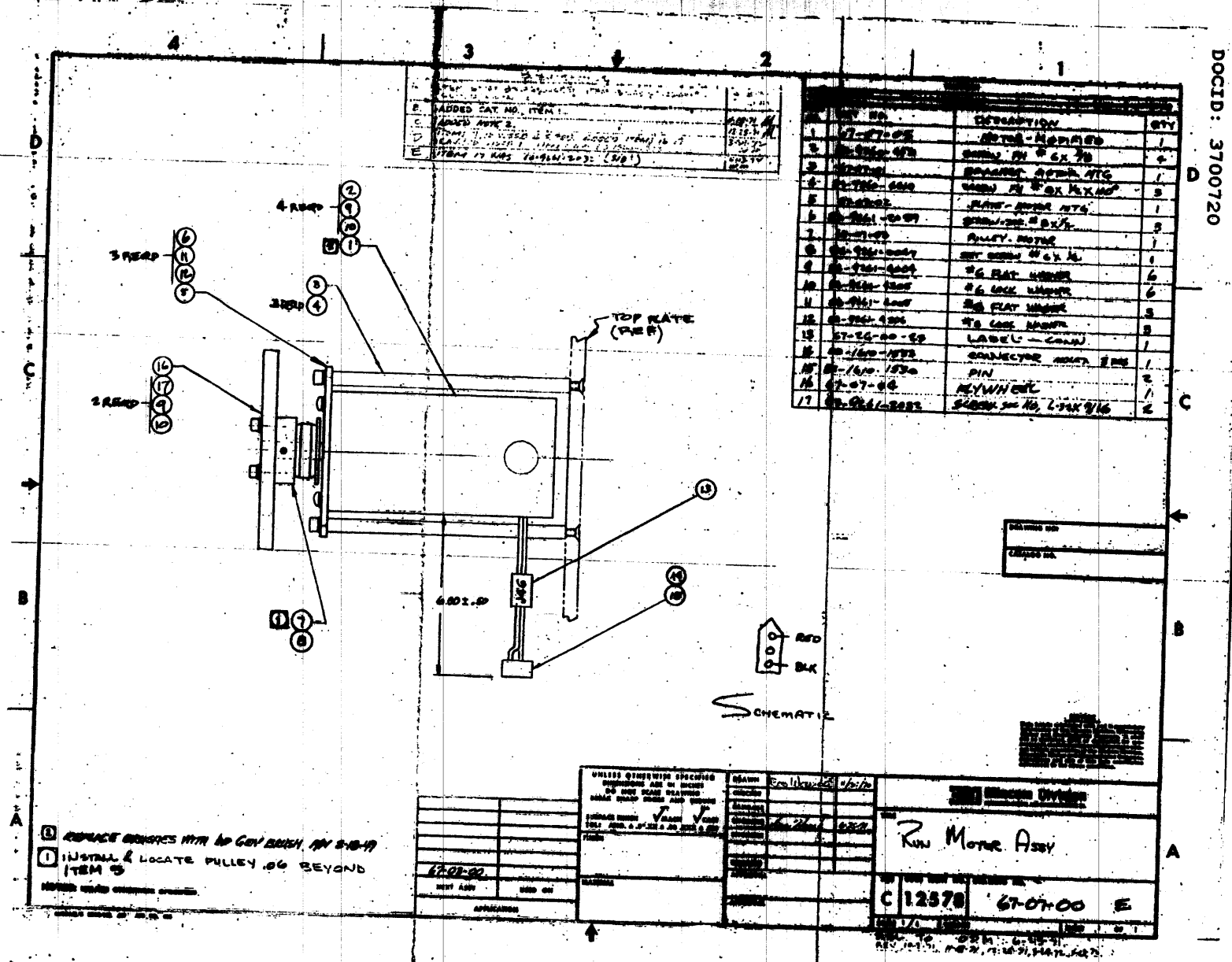


Figure 7-10. Run Motor Assembly

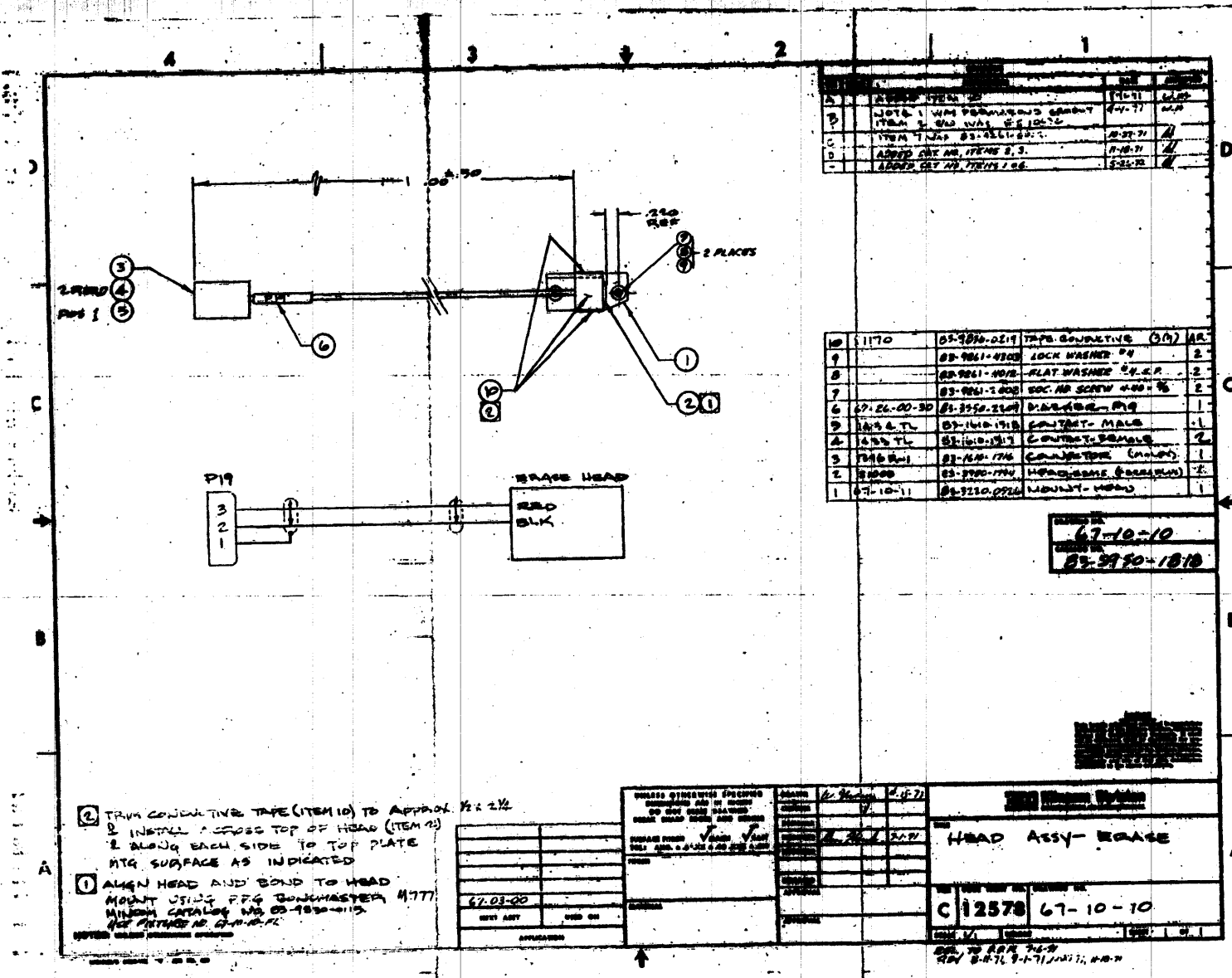


Figure 7-11. Erase Head Assembly

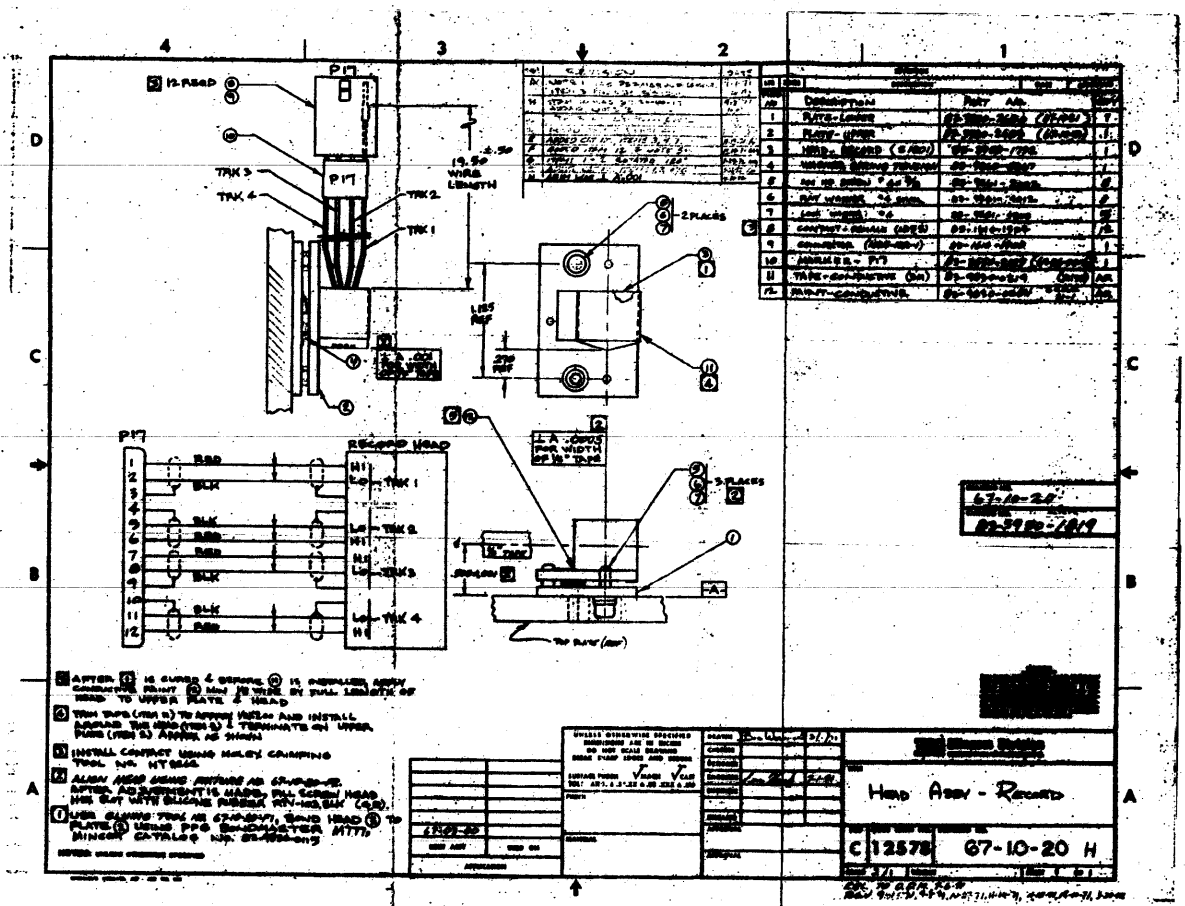


Figure 7-12. Record Head Assembly

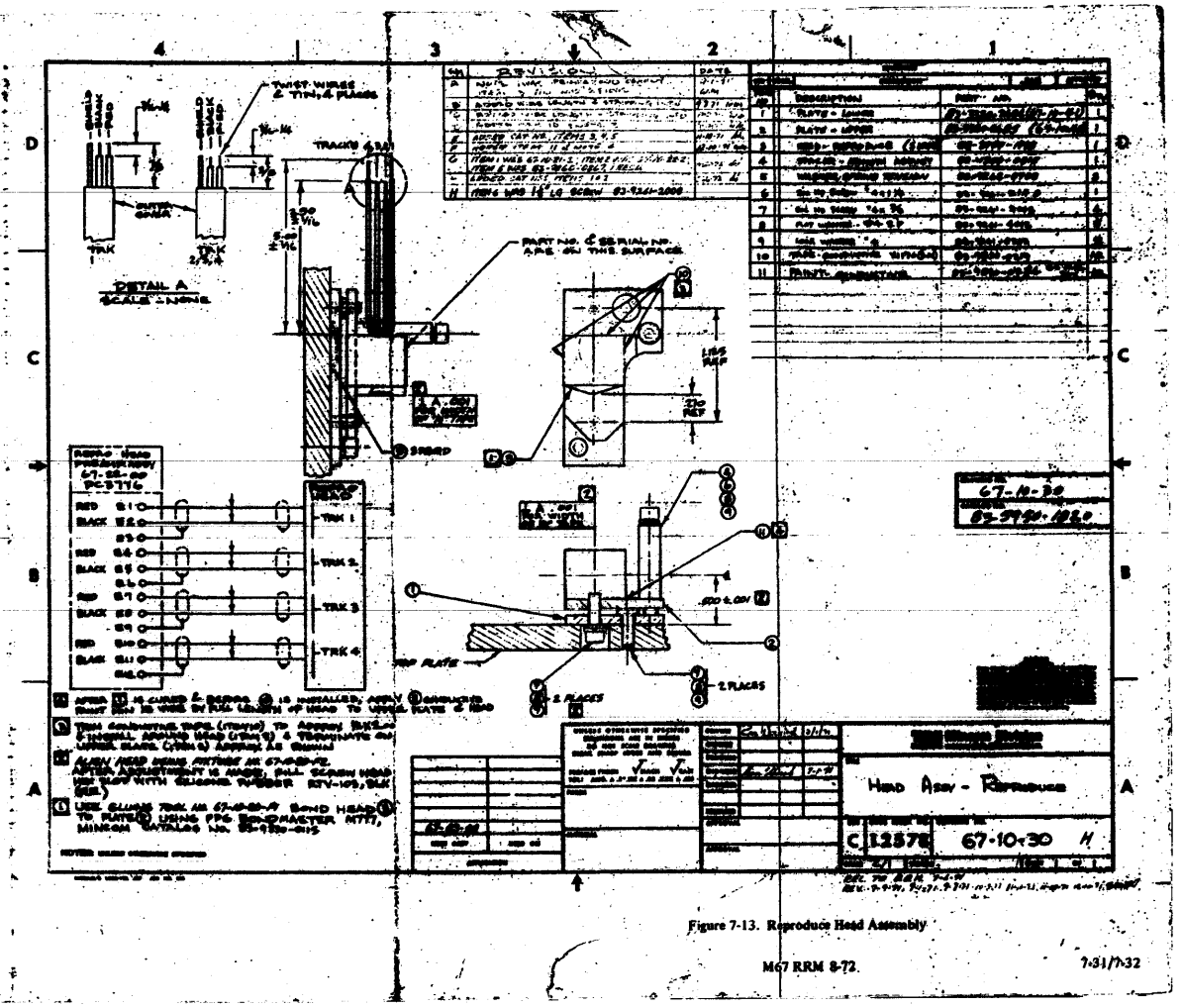


Figure 7-13. Reproduce Head Assembly

DOCID: 3700720

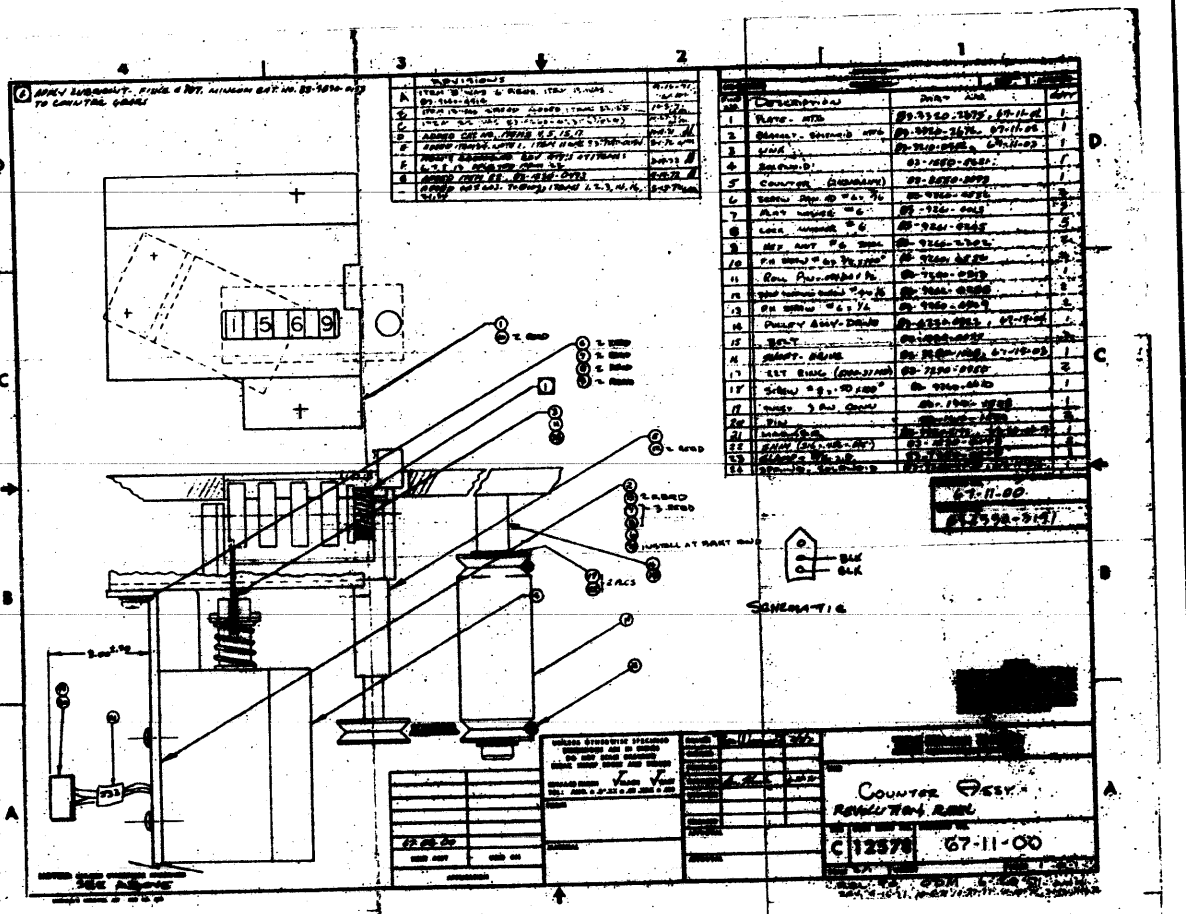


Figure 7-14. Counter Assembly

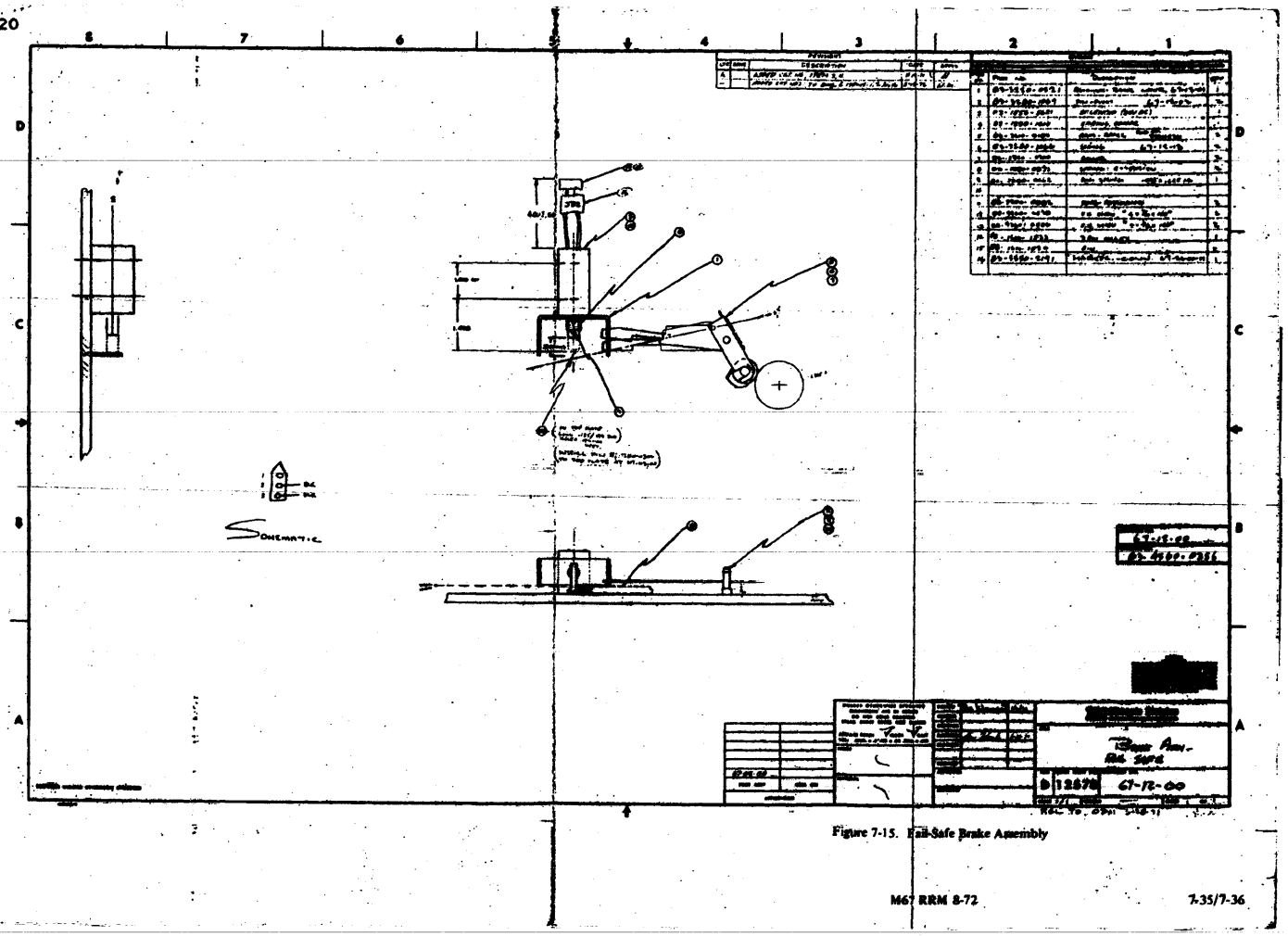


Figure 7-15. Fail-Safe Brake Assembly

DOCID: 3700720

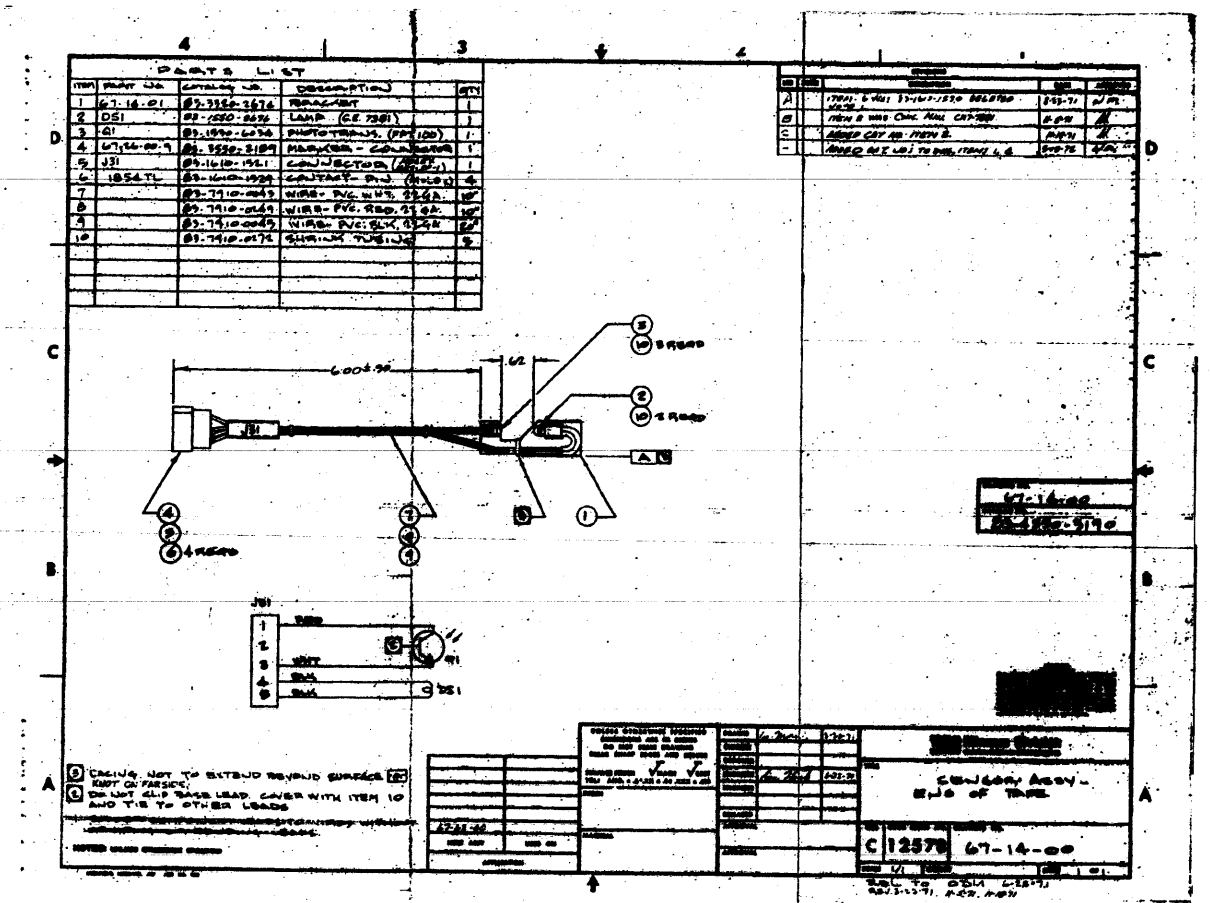


Figure 7-16. End-of-Tape Assembly

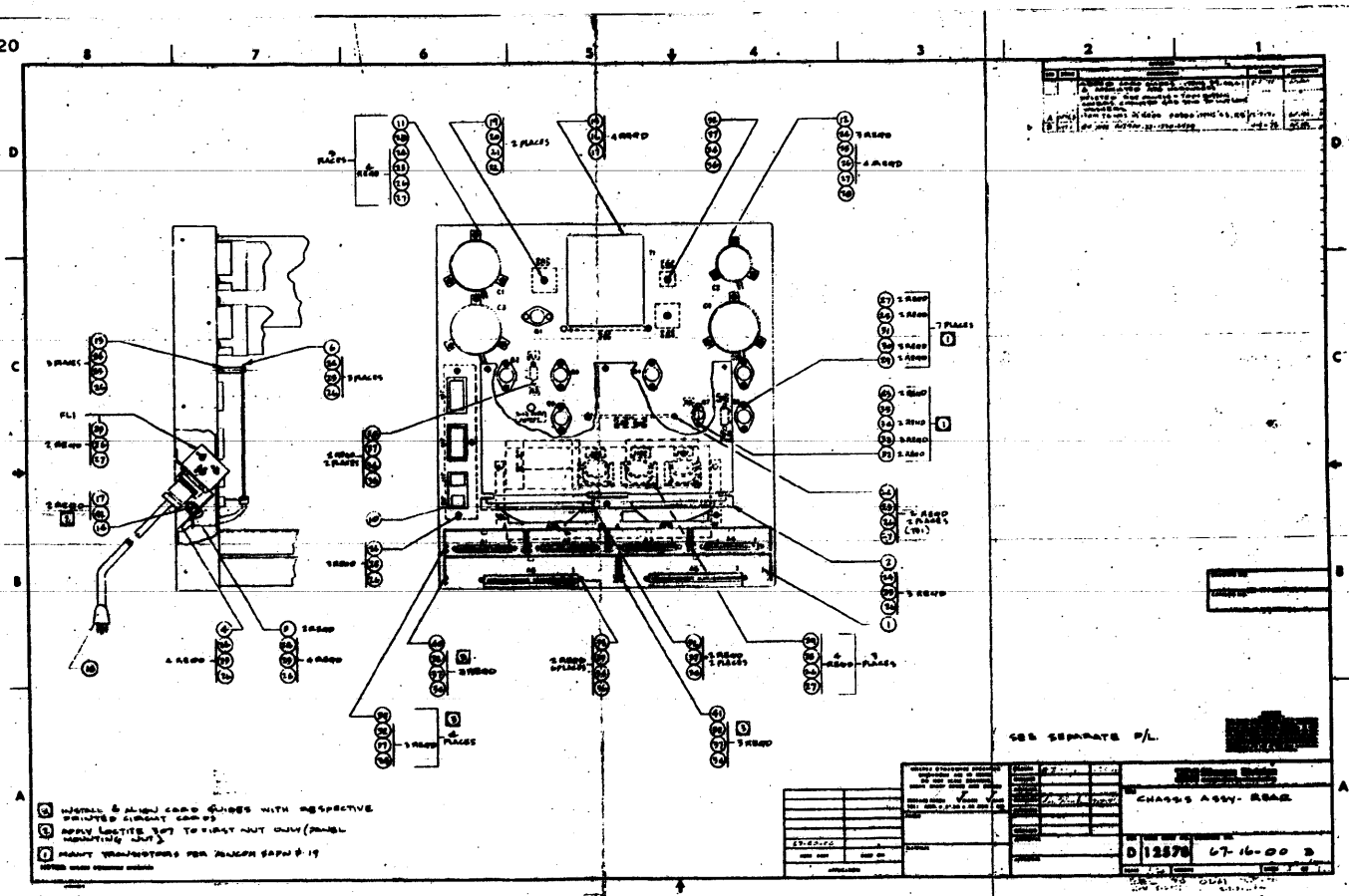


Figure 7-17. Rear Chassis Assembly

3M Mincom Division (MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-16-00 SHEET 1 OF 3	B REV
	TITLE REAR CHASSIS ASSEMBLY		CAT. NO.	

FIND NO.	DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
	C1			CAPACITOR, 15,000UF, 50V	83-1510-2170	1
	C2			CAPACITOR, 10,000UF, 15V	83-1510-2157	1
	C3			CAPACITOR, 15,000UF, 50V	83-1510-2170	1
	C4			CAPACITOR, 6200UF, 75V	83-1510-2129	1
	CR1	SEM TECH		DIODE, SCBA-2	83-1530-8028	1
	CR2	SEM TECH		DIODE, SCAJ2	83-1530-0523	1
	CR3	SEM TECH		DIODE, SCBA-2	83-1530-8028	
	Q1			TRANSISTOR, MJ900	83-1530-2469	1
	Q2			TRANSISTOR, MJ900	83-1530-2469	1
	Q3			TRANSISTOR, MJ1000	83-1530-2480	1
	Q4			TRANSISTOR, MJ4032	83-1530-2478	1
	Q5			TRANSISTOR, MJ1000	83-1530-2480	1
	Q6			TRANSISTOR, 2N3055	83-1530-2157	1
	Q7			TRANSISTOR, 2N3054	83-1530-2227	1
	Q8			TRANSISTOR, MJ900	83-1530-2469	1
	R1			RESISTOR, F101	83-1520-8324	1
	R2			RESISTOR, F101	83-1520-8324	1
	R3			RESISTOR, F101	83-1520-8324	1
	R4			RESISTOR, F101	83-1520-8324	1
	R5			RESISTOR, 100 OHM, 1/2W	83-1520-7221	1
	T1	MINCOM	S67-16-30	TRANSFORMER	83-3540-1351	1
	FL1	GENISTRON	CGF20649	FILTER	83-1540-0659	1

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Mincom Division	PARTS LIST	12578 CODE IDENT.	PL 67-16-00 SHEET 2 OF 3	B REV.
	TITLE REAR CHASSIS ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
1		67-16-01	CHASSIS		1
2		67-16-03	BRKT, PC CONN		1
3		67-16-04	SURPORT, CONN BRKT		2
4		67-16-06	BRKT CONN, REAR		1
6		67-25-00	PC BD ASSY, POWER SUPPLY		1
10		67-16-20	HARNESS ASSY		1
11			CLAMP, CAPACITOR 19/16 DIA	83-1650-0224	3
12			CLAMP, CAPACITOR 1-13/16 DIA	83-1650-0389	1
13			STANDOFF, 1-1/4 LG X 6-32	83-1350-0222	3
14		MS35206-281	SCREW, 1/4-20 X 3/4	83-9260-4582	1
15			WASHER, FL NO. 1/4	83-9261-4008	14
16			WASHER, LOCK NO. 1/4	83-9261-4009	4
17			NUT, HEX 1/4-20	83-9260-2009	6
18		67-16-10	CABLE ASSY, POWER		1
19			SCREW, PH, 8-32 X 3/4	83-9260-4564	2
20			WASHER, FL NO. 8	83-9261-4006	2
21			WASHER, LOCK NO. 8	83-9261-4020	2
22			NUT, NO. 8	83-9260-2006	2
24			SCREW, PH 6-32 X 3/8	83-9260-4531	30
25			WASHER, FL NO. 6	83-9261-4004	68
26			WASHER, LOCK NO. 6	83-9261-4305	54
27			NUT, NO. 6	83-9260-2005	48
28			SCREW, PH 6-32 X 5/8	83-9260-4535	4

3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-16-00 SHEET 3 OF 3	B REV.
	TITLE REAR CHASSIS ASSEMBLY		CAT. NO.	

FIND NO. - DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
29			SCREW, PH 6-32 X 7/16	83-9260-4532	26
30			WASHER-INT LOCK NO. 6	83-9261-4206	21
31			LUG-GRD, INT LOCK NO. 6	83-9630-0086	7
32			SCREW, PH 4-40 X 7/16	83-9260-4516	37
33			WASHER, INT LOCK NO. 4	83-9261-4203	3
34			WASHER, FL NO. 4	83-9261-4002	41
35			LUG-GRD, INT LOCK NO. 4	83-9630-0085	1
36			NUT, NO. 4	83-9260-2003	17
37			WASHER, LOCK, SPLIT NO. 4	83-9261-4303	39
38			SCREW, PH, 4-40 X 7/8	83-9260-4521	4
39	MINCOM	67-16-05-1	BRACKET, CARD GUIDE, SIGNAL		4
40	MINCOM	67-16-05-2	BRACKET, CARD GUIDE, LOGIC		1
41	MINCOM	67-16-05-3	BRACKET, CARD GUIDE, MONITOR		1
42		MS35333-40	WASHER, INT LOCK 1/4	83-9261-4209	2
43			TERMINAL, INSULATED	83-9630-0322	2

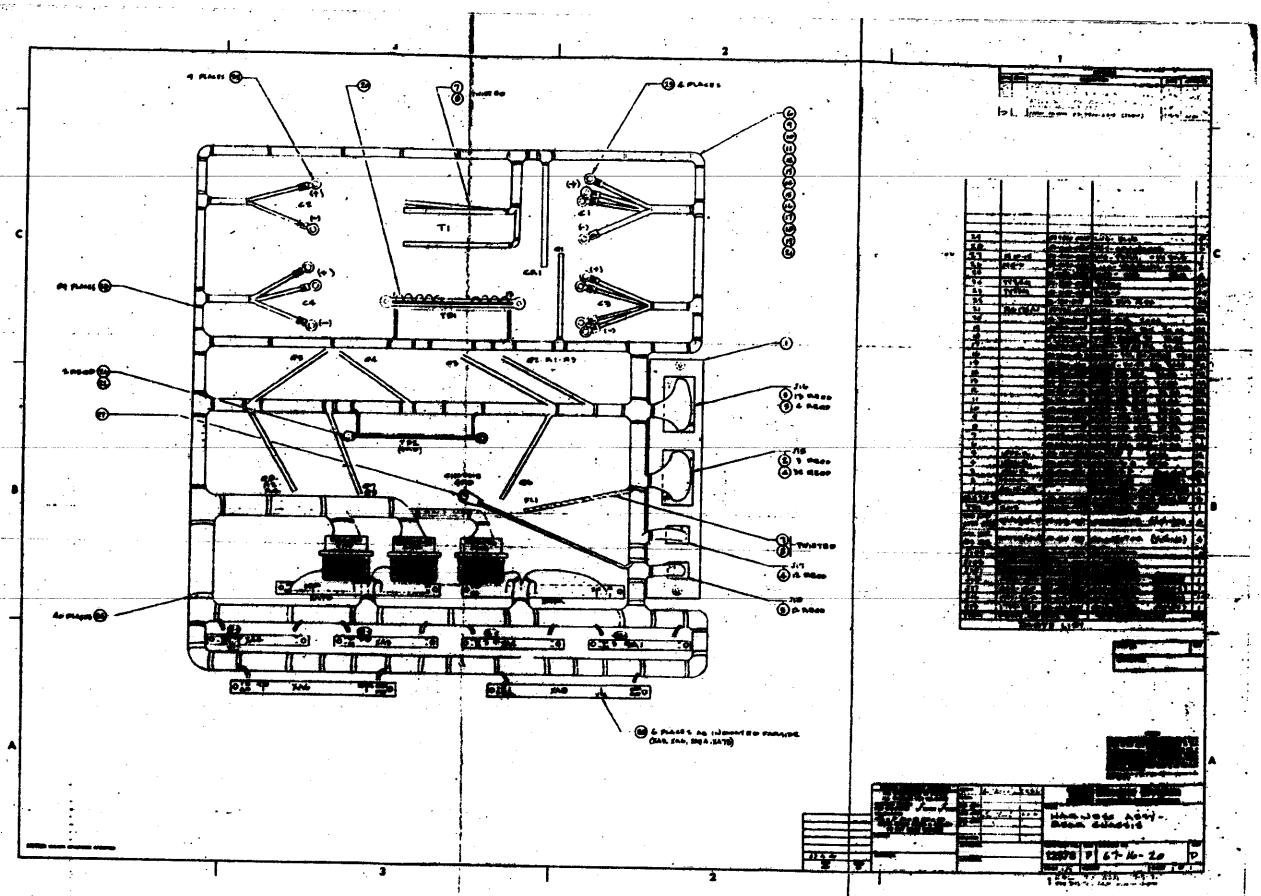

Figure 7-18. Rear Chassis Harness Assembly

DOCID: 3700720

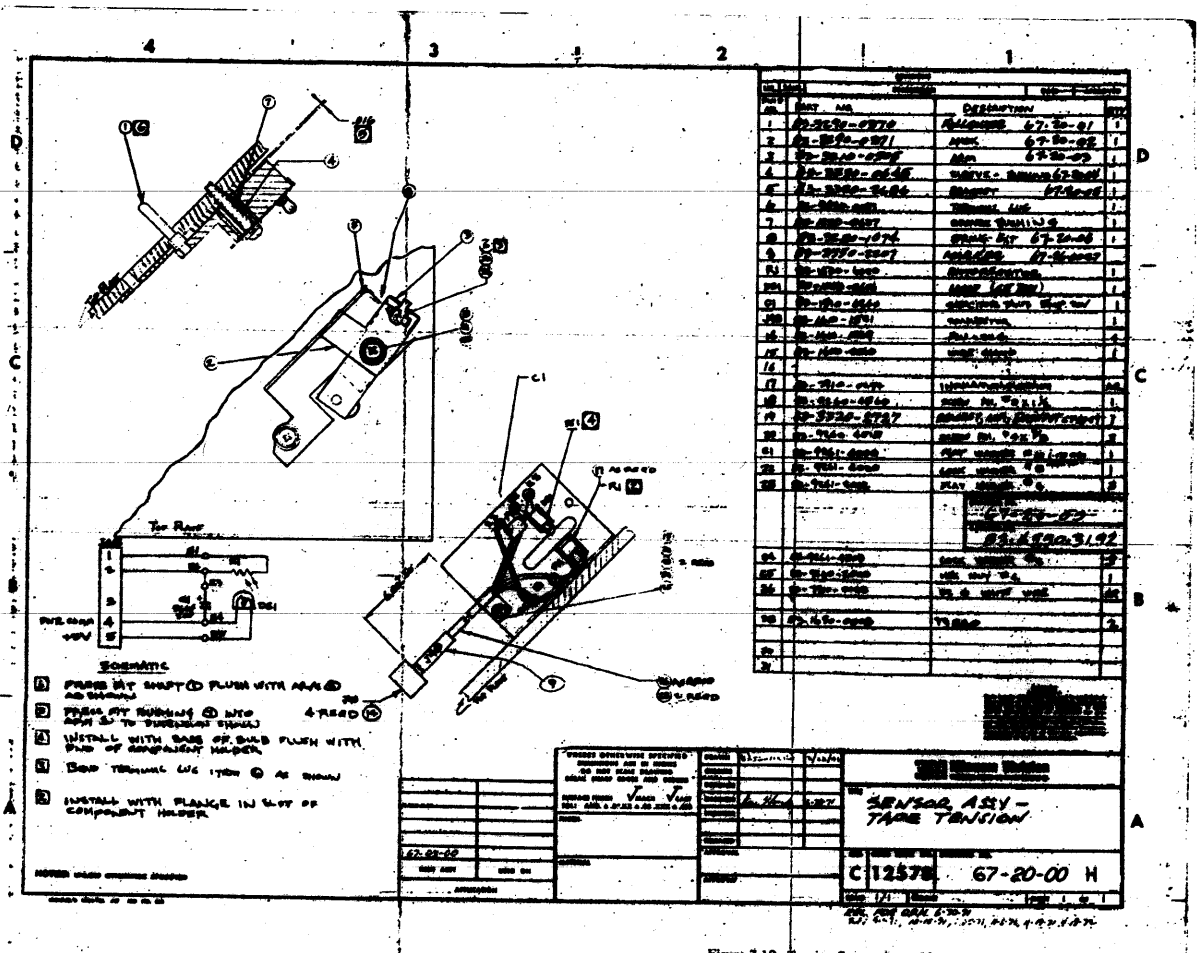

Figure 7-19. Tension Sensor Assembly

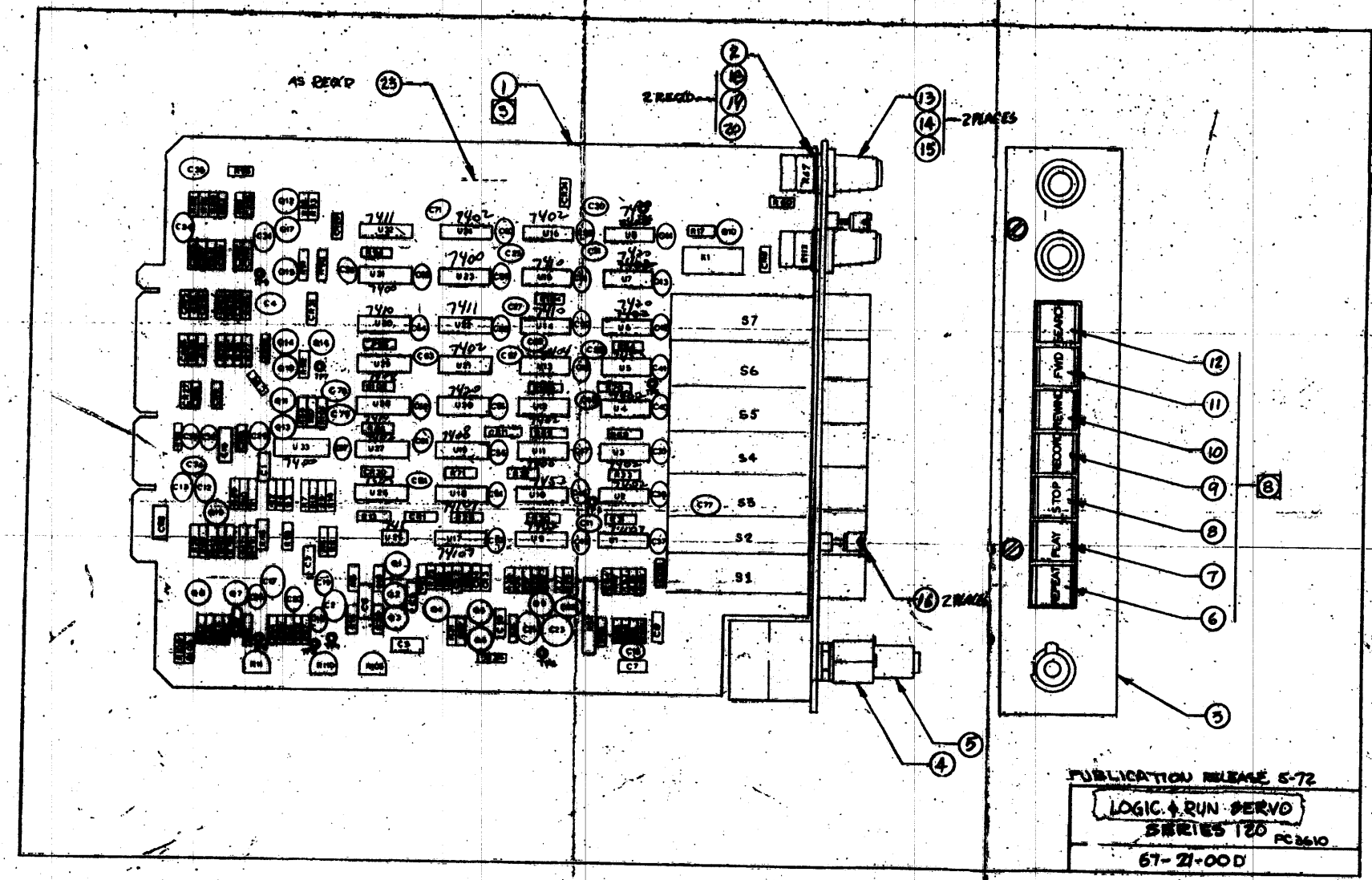

Figure 7-20. Logic PC Board Assembly

3M Mincom Division (MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 1 OF 14	D REV
	TITLE LOGIC PC BOARD ASSEMBLY		CAT. N .	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
1		67-21-00 (ITEM 1)	PC BD DETAIL PC3610		1
2		67-21-04	BRACKET, MTG		1
3		67-21-03	FRONT PANEL		1
4		67-21-01	KNOB, MODIFIED		1
5	BUCKEYE	SS50PL-3 BLK	KNOB	83-1270-0958	1
6		67-21-02-1	INSERT, SWITCH "REPEAT"		1
7		67-21-02-2	INSERT, SWITCH "PLAY"		1
8		67-21-02-3	INSERT, SWITCH "STOP"		1
9		67-21-02-4	INSERT, SWITCH "RECORD"		1
10		67-21-02-5	INSERT, SWITCH "REWIND"		1
11		67-21-02-6	INSERT, SWITCH "FWD"		1
12		67-21-02-7	INSERT, SWITCH "SEARCH"		1
13	ELMA	020-322	KNOB	83-1270-0955	2
14	ELMA	044-312	NUT COVER	83-1270-0953	2
15	ELMA	040-302	CAP, KNOB, BLK	83-1270-0954	2
16	AMATOM	6103-B-0440-4	SCREW, CAPTIVE	83-9260-0305	2
17	AMP	583527-1	SOCKET, I.C. (14 PIN)	83-1620-0273	32
18			SCREW, PH 6-32 X 1/4	83-9260-4529	4
19			WASHER, LOCK NO. 6	83-9261-4305	4
20			WASHER, FLAT NO. 6	83-9261-4004	4
21	AMP	583640-1	SOCKET, I.C. (8 PIN)	83-1620-0281	1
22			TRANSISTOR CONVERSION PAD (Q2 thru Q19)	83-9690-0191	18
23			WIRE, 24 GA WHT	83-7910-0428	AR
24		67-21-06	STIFFENER BAR		1

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3M Mincom Division (3-M-C Minnesota Mining and Manufacturing Co.)	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 2 OF 14	D REV
	TITLE: LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	TY
25			FIBER, WASHER	83-9630-0064	6
26			SCREW, PH, 2-56 X 1/2	83-9260-4505	3
C1			CAPACITOR, .0022UF	83-1510-4171	1
C2			CAPACITOR, 56UF, 20V TANT	83-1510-6260	1
C3			CAPACITOR, .0047UF	83-1510-4584	1
C4			CAPACITOR, 56UF, 20V TANT	83-1510-6260	1
C5			CAPACITOR, .047UF	83-1510-6028	1
C6			CAPACITOR, .068UF	83-1510-6029	1
C7			CAPACITOR, .015UF	83-1510-4165	1
C8			CAPACITOR, .027UF	83-1510-6025	1
C9			CAPACITOR, .027UF	83-1510-6025	1
C10			CAPACITOR, .015UF	83-1510-4165	1
C11			CAPACITOR, 500PF	83-1510-5104	1
C12			CAPACITOR, 100UF, 6V TANT	83-1510-6402	1
C13			CAPACITOR, 100UF, 6V TANT	83-1510-6402	1
C14			CAPACITOR, .0039UF	83-1510-6020	1
C15			CAPACITOR, .47UF	83-1510-4197	1
C16			CAPACITOR, 10UF, 35V TANT	83-1510-6214	1
C17			CAPACITOR, 100UF TANT	83-1510-6200	1
C18			CAPACITOR, 1.0UF, 35V TANT	83-1510-6390	1
C19			CAPACITOR, 3.3UF, 35V TANT	83-1510-6393	1
C20			CAPACITOR, 3.3UF, 35V TANT	83-1510-6393	1
C21			CAPACITOR, 3300PF	83-1510-5134	1
C22			CAPACITOR, 300PF	83-1510-5104	1

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3M Mincom Division (MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 3 OF 14	D REV
	TITLE LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	TY
C23	ERIE	538-011-112F	CAPACITOR, VARIABLE 15 - 60PF	83-1510-6380	1
C24			CAPACITOR, 100UF, 6V	83-1510-6402	1
C25			CAPACITOR 330PF	83-1510-5103	1
C27			CAPACITOR, .05UF	83-1510-2307	1
C28			CAPACITOR, .05UF	83-1510-2307	1
C29			CAPACITOR, 10UF, 20V TANT	83-1510-6396	1
C30			CAPACITOR, 750PF	83-1510-5113	1
C31			CAPACITOR, 330PF	83-1510-5103	1
C32			CAPACITOR, .02UF	83-1510-1008	1
C33			CAPACITOR, .02UF	83-1510-1008	1
C34			CAPACITOR, 47UF, 15V TANT	83-1510-6400	1
C35			CAPACITOR, 47UF, 15V TANT	83-1510-6400	1
C36			CAPACITOR, 47UF, 20V TANT	83-1510-6199	1
C68			CAPACITOR, .1UF, 200V	83-1510-4499	1
CR1			DIODE, 1N914	83-1530-0083	1
CR2			DIODE, 1N914	83-1530-0083	1
CR3			DIODE, 1N914	83-1530-0083	1
CR4			DIODE, 1N914	83-1530-0083	1
CR5			DIODE, 1N914	83-1530-0083	1
CR6			DIODE, 1N914	83-1530-0083	1
CR8			DIODE, 1N914	83-1530-0083	1
CR9			DIODE, 1N914	83-1530-0083	1
CR10			DIODE, 1N914	83-1530-0083	1
CR11			DIODE, 1N914	83-1530-0083	1

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3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 4 OF 14	D REV
	TITLE LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
CR12			DIODE, 1N914	83-1530-0083	1
CR13			DIODE, 1N914	83-1530-0083	1
CR14			DIODE, 1N914	83-1530-0083	1
CR15			DIODE, 1N914	83-1530-0083	1
CR16			DIODE, 1N914	83-1530-0083	1
CR17			DIODE, 1N276	83-1530-0104	1
CR20			DIODE, 1N276	83-1530-0104	1
CR21			DIODE, 1N914	83-1530-0083	1
CR22			DIODE, 1N914	83-1530-0083	1
CR23			DIODE, 1N914	83-1530-0083	1
CR24			DIODE, 1N914	83-1530-0083	1
CR25			DIODE, 1N914	83-1530-0083	1
CR26			DIODE, 1N914	83-1530-0083	1
CR27			DIODE, 1N914	83-1530-0083	1
CR28			DIODE, 1N914	83-1530-0083	1
CR29			DIODE, 1N914	83-1530-0083	1
CR30			DIODE, 1N914	83-1530-0083	1
CR31			DIODE, 1N914	83-1530-0083	1
CR32			DIODE, 1N914	83-1530-0083	1
CR34			DIODE, 1N276	83-1530-0104	1
CR35			DIODE, 1N914	83-1530-0083	1
C69			CAPACITOR, .47UF, 35V	83-1510-6411	1
C71			CAPACITOR, 4.7UF, 35V	83-1510-6210	1
K1	ELECTRO	701-3A	RELAY, SPDT	83-1550-3620	1

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3M Mincom Division (MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 5 OF 14	D REV
	TITLE: LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R1			RESISTOR, 300 OHM	83-9520-2135	1
R2			RESISTOR, 1K	83-9520-2088	1
R3			RESISTOR, 1K	83-9520-2088	1
R4			RESISTOR, 300 OHM	83-9520-2135	1
R5			RESISTOR, 110K	83-9520-2174	1
R6			RESISTOR, 3.3K	83-9520-2095	1
R7			RESISTOR, 33 OHM	83-9520-2243	1
R8			RESISTOR, 430 OHM	83-9520-2138	1
R9			RESISTOR, 10K	83-9520-2112	1
R10			RESISTOR, 75K	83-9520-2171	1
R11	BOURNS	3359W-1-102	RESISTOR, VARIABLE, 1K	83-1520-1608	1
R12			RESISTOR, 10K	83-9520-2112	1
R13			RESISTOR, 390K	83-9520-2184	1
R14			RESISTOR, 430 OHM	83-9520-2138	1
R15			RESISTOR, 6.8K	83-9520-2097	1
R16			RESISTOR, 1K	83-9520-2088	1
R17			RESISTOR, 2.2K	83-9520-2110	1
R18			RESISTOR, 1K	83-9520-2088	1
R19			RESISTOR, 1K	83-9520-2088	1
R20			RESISTOR, 2.2K	83-9520-2110	1
R21			RESISTOR, 2.2K	83-9520-2110	1
R22			RESISTOR, 1K	83-9520-2088	1
R23			RESISTOR, 2.2K	83-9520-2110	1
R24			RESISTOR, 1K	83-9520-2088	1

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3M Mincom Division (MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 6 OF 14	D REV
	TITLE: LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R25			RESISTOR, 300 OHM	83-9520-2135	1
R26			RESISTOR, 300 OHM	83-9520-2135	1
R27			RESISTOR, 1K	83-9520-2088	1
R28			RESISTOR, 300 OHM	83-9520-2135	1
R29			RESISTOR, 2K	83-9520-2148	1
R30			RESISTOR, 150 OHM	83-9520-2105	1
R31			RESISTOR, 150 OHM	83-9520-2105	1
R32			RESISTOR, 150 OHM	83-9520-2105	1
R33			RESISTOR, 2.2K	83-9520-2110	1
R34			RESISTOR, 300 OHM	83-9520-2135	1
R35			RESISTOR, 300 OHM	83-9520-2135	1
R36			RESISTOR, 300 OHM	83-9520-2135	1
R37			RESISTOR, 620 OHM	83-9520-2141	1
R38			RESISTOR, 620 OHM	83-9520-2141	1
R39			RESISTOR, 1K	83-9520-2088	1
R40			RESISTOR, 1.5K	83-9520-2117	1
R41			RESISTOR, 2.2K	83-9520-2110	1
R42			RESISTOR, 10K	83-9520-2112	1
R43			RESISTOR, 1K	83-9520-2088	1
R44			RESISTOR, 2.2K	83-9520-2110	1
R45			RESISTOR, 10K	83-9520-2112	1
R46			RESISTOR, 2.2M OHM, 1/2W	83-9520-3229	1
R47			RESISTOR, 100K	83-9520-2119	1
R48			RESISTOR, 100K	83-9520-2119	1

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3M Mincom Division — 3-M-S MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 7 OF 14	D REV
	TITLE: LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R49			RESISTOR, 10K	83-9520-2112	1
R50			RESISTOR, 47K	83-9520-2090	1
R51			RESISTOR, 750 OHM	83-9520-2142	1
R52			RESISTOR, VARIABLE, 1K	83-1520-1349	1
R53			RESISTOR, 1K	83-9520-2088	1
R54			RESISTOR, 4.7K	83-9520-2111	1
R55			RESISTOR, 47K	83-9520-2090	1
R56			RESISTOR, 1K	83-9520-2088	1
R57			RESISTOR, 2.7K	83-9520-2098	1
R58			RESISTOR, 2.7K	83-9520-2098	1
R59			RESISTOR, 240 OHM	83-9520-2133	1
R60			RESISTOR, 1.8K	83-9520-2147	1
R61			RESISTOR, 620 OHM	83-9520-2141	1
R62			RESISTOR, 2.7K	83-9520-2098	1
R63			RESISTOR, 20K	83-1520-8501	1
R64			RESISTOR, 6.8K	83-9520-2097	1
R65			RESISTOR, 20 OHM	83-9520-2233	1
R66			RESISTOR, 270K, 1/2W	83-9520-7393	1
R67	CTS	S67-21-05-1	RESISTOR, VARIABLE, 1K	83-3520-1609	1
R68			RESISTOR, 360 OHM	83-9520-2136	1
R69			RESISTOR, 360 OHM	83-9520-2136	1
R70			RESISTOR, 240 OHM	83-9520-2133	1
R71			RESISTOR, 360 OHM	83-9520-2136	1
R72			RESISTOR, 1.5K	83-9520-2117	1

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3M Mincom Division — Minnesota Mining and Manufacturing Co.	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 8 OF 14	D REV
	TITLE: LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R74			RESISTOR, 7.5K	83-9520-2156	1
R75			RESISTOR, 560 OHM	83-9520-2140	1
R76			RESISTOR, 820 OHM	83-9520-2115	1
R79			RESISTOR, 820 OHM	83-9520-2115	1
R80			RESISTOR, 6.8K	83-9520-2097	1
R81			RESISTOR, 6.8K	83-9520-2097	1
R82			RESISTOR, 3.9K	83-9520-2096	1
R83			RESISTOR, 1K	83-9520-2088	1
R84			RESISTOR, 1K	83-9520-2088	1
R85			RESISTOR, 1K	83-9520-2088	1
R86			RESISTOR, 240 OHM	83-9520-2133	1
R87			RESISTOR, 2.2K	83-9520-2110	1
R88			RESISTOR, 2.2K	83-9520-2110	1
R89			RESISTOR, 2.2K	83-9520-2110	1
R90			RESISTOR, 2.2K	83-9520-2110	1
R91			RESISTOR, 2.2K	83-9520-2110	1
R92			RESISTOR, 2.2K	83-9520-2110	1
R93			RESISTOR, 2.2K	83-9520-2110	1
R94			RESISTOR, 360 OHM	83-9520-2136	1
R95			RESISTOR, 240 OHM	83-9520-2133	1
R96			RESISTOR, 240 OHM	83-9520-2133	1
R97			RESISTOR, 1K	83-9520-2088	1
R98			RESISTOR, 10K	83-9520-2112	1
R99			RESISTOR, 360 OHM	83-9520-2136	1

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3M Mincom Division — 3M-3-8 MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 9 F 14	D REV
	TITLE LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R100			RESISTOR, 240 OHM	83-9520-2133	1
R101			RESISTOR, 100 OHM	83-9520-2094	1
R102			RESISTOR, 360 OHM	83-9520-2136	1
R104			RESISTOR, 360 OHM	83-9520-2136	1
R105			RESISTOR, 100 OHM	83-9520-2094	1
R106	BOURNS	3359W-1-501	RESISTOR, VARIABLE, 500OHM	83-1520-1610	1
R107, R111	CTS	C2-252	RESISTOR, VARIABLE 100 - 100 OHMS CONCENTRIC	83-1520-1611	1
R108			RESISTOR, 27 OHM	83-9520-2236	1
R109			RESISTOR, 100 OHM	83-9520-2094	1
R110	BOURNS	3359W-1-501	RESISTOR, VARIABLE, 500 OHMS	83-1520-1610	1
R112			RESISTOR, 27 OHM	83-9520-2236	1
R113	CTS	S67-21-05-2	RESISTOR, VARIABLE, 50K	83-3520-1612	1
R114			RESISTOR, 330 OHM	83-9520-2091	1
Q1			TRANSISTOR, 2N3638	83-1530-2155	1
Q2			TRANSISTOR, 2N3859A	83-1530-2261	1
Q3			TRANSISTOR, 2N3859A	83-1530-2261	1
Q4			TRANSISTOR, 2N3859A	83-1530-2261	1
Q5			TRANSISTOR, 2N3859A	83-1530-2261	1
Q6			TRANSISTOR, 2N3859A	83-1530-2261	1
Q7			TRANSISTOR, 2N3859A	83-1530-2261	1
Q8			TRANSISTOR, 2N3859A	83-1530-2261	1
Q9	MOTOROLA	MPU133	TRANSISTOR	83-1530-2455	1
Q10			TRANSISTOR, 2N3859A	83-1530-2261	1
Q11			TRANSISTOR, 2N3859A	83-1530-2261	1

3M Mincom Division (MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 10 OF 14	D REV
	TITLE: LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
Q12			TRANSISTOR, 2N3859A	83-1530-2261	1
Q13			TRANSISTOR, 2N3859A	83-1530-2261	1
Q14			TRANSISTOR, 2N3859A	83-1530-2261	1
Q15			TRANSISTOR, 2N3859A	83-1530-2261	1
Q16			TRANSISTOR, 2N3859A	83-1530-2261	1
Q17			TRANSISTOR, 2N3859A	83-1530-2261	1
Q18			TRANSISTOR, 2N3859A	83-1530-2261	1
Q19			TRANSISTOR, 2N3859A	83-1530-2261	1
S1	IEEC	IXCL-NON-CRBBL-240A	SWITCH, PUSHBUTTON	83-1550-5626	1
S2	IEEC	IXCL-NON-CRBBL-240A	SWITCH, PUSHBUTTON	83-1550-5626	1
S3	IEEC	IXCL-NON-CRBBL-240A	SWITCH, PUSHBUTTON	83-1550-5626	1
S4	IEEC	IXCL-NON-CRBBL-240A	SWITCH, PUSHBUTTON	83-1550-5626	1
S5	IEEC	IXCL-NON-CRBBL-240A	SWITCH, PUSHBUTTON	83-1550-5626	1
S6	IEEC	IXCL-NON-CRBBL-240A	SWITCH, PUSHBUTTON	83-1550-5626	1
S7	IEEC	IXCL-NON-CRBBL-240A	SWITCH, PUSHBUTTON	83-1550-5626	1
U1			INTEGRATED CIRCUIT, SN74107	83-1530-8163	1
U2			INTEGRATED CIRCUIT, SN7402	83-1530-8145	1
U3			INTEGRATED CIRCUIT, SN7402	83-1530-8145	1
U4			INTEGRATED CIRCUIT, SN7402	83-1530-8145	1

3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 11 OF 14	D REV
	TITLE LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
U5			INTEGRATED CIRCUIT, SN7453	83-1530-8149	1
U6			INTEGRATED CIRCUIT, SN7420	83-1530-8069	1
U7			INTEGRATED CIRCUIT, SN7420	83-1530-8069	1
U8			INTEGRATED CIRCUIT, SN7420	83-1530-8069	1
U9			INTEGRATED CIRCUIT, SN7402	83-1530-8145	1
U10			INTEGRATED CIRCUIT, SN7453	83-1530-8149	1
U11			INTEGRATED CIRCUIT, SN7400	83-1530-8060	1
U12			INTEGRATED CIRCUIT, SN7402	83-1530-8145	1
U13			INTEGRATED CIRCUIT, SN7404	83-1530-8142	1
U14			INTEGRATED CIRCUIT, SN7410	83-1530-8143	1
U15			INTEGRATED CIRCUIT, SN7410	83-1530-8143	1
U16			INTEGRATED CIRCUIT, SN7402	83-1530-8145	1
U17			INTEGRATED CIRCUIT, SN74107	83-1530-8163	1
U18			INTEGRATED CIRCUIT, SN74107	83-1530-8163	1
U19			INTEGRATED CIRCUIT, SN7408	83-1530-8147	1
U20			INTEGRATED CIRCUIT, SN7420	83-1530-8069	1
U21			INTEGRATED CIRCUIT, SN7402	83-1530-8145	1
U22			INTEGRATED CIRCUIT, SN7411	83-1530-8148	1
U23			INTEGRATED CIRCUIT, SN7400	83-1530-8060	1
U24			INTEGRATED CIRCUIT, SN7402	83-1530-8145	1
U25			INTEGRATED CIRCUIT, SN72741	83-1530-8159	1
U26			INTEGRATED CIRCUIT, MC1303	83-1530-8166	1
U27			INTEGRATED CIRCUIT, SN7402	83-1530-8145	1
U28			INTEGRATED CIRCUIT, SN7410	83-1530-8143	1

3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 12 OF 14	D REV
	TITLE LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	TY
U29			INTEGRATED CIRCUIT, SN7408	83-1530-8147	1
U30			INTEGRATED CIRCUIT, SN7410	83-1530-8143	1
U31			INTEGRATED CIRCUIT, SN7400	83-1530-8060	1
U32			INTEGRATED CIRCUIT, SN7411	83-1530-8148	1
U33			INTEGRATED CIRCUIT, SN7400	83-1530-8060	1
C37			CAPACITOR,.05UF,	83-1510-2307	1
C38			CAPACITOR, .05UF	83-1510-2307	1
C39			CAPACITOR, .05UF	83-1510-2307	1
C40			CAPACITOR, .05UF	83-1510-2307	1
C41			CAPACITOR, .05UF	83-1510-2307	1
C42			CAPACITOR, .05UF	83-1510-2307	1
C43			CAPACITOR, .05UF	83-1510-2307	1
C44			CAPACITOR, .05UF	83-1510-2307	1
C45			CAPACITOR, .05UF	83-1510-2307	1
C46			CAPACITOR, .05UF	83-1510-2307	1
C47			CAPACITOR, .05UF	83-1510-2307	1
C48			CAPACITOR, .05UF	83-1510-2307	1
C49			CAPACITOR, .05UF	83-1510-2307	1
C50			CAPACITOR, .05UF	83-1510-2307	1
C51			CAPACITOR, .05UF	83-1510-2307	1
C52			CAPACITOR, .05UF	83-1510-2307	1
C53			CAPACITOR, .05UF	83-1510-2307	1
C54			CAPACITOR, .05UF	83-1510-2307	1
C55			CAPACITOR, .05UF	83-1510-2307	1

3M Mincom Division (MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 13 OF 14	D REV
	TITLE: LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	TY
C56			CAPACITOR, .05UF	83-1510-2307	1
C57			CAPACITOR, .05UF	83-1510-2307	1
C58			CAPACITOR, .05UF	83-1510-2307	1
C59			CAPACITOR, .05UF	83-1510-2307	1
C60			CAPACITOR, .05UF	83-1510-2307	1
C61			CAPACITOR, .05UF	83-1510-2307	1
C62			CAPACITOR, .05UF	83-1510-2307	1
C63			CAPACITOR, .05UF	83-1510-2307	1
C64			CAPACITOR, .05UF	83-1510-2307	1
C65			CAPACITOR, .05UF	83-1510-2307	1
C66			CAPACITOR, .05UF	83-1510-2307	1
C67			CAPACITOR, .05UF	83-1510-2307	1
C76			CAPACITOR, .05UF	83-1510-2307	1
C77			CAPACITOR, .02UF	83-1510-1008	1
C78			CAPACITOR, .02UF	83-1510-1008	1
C79			CAPACITOR, .02UF	83-1510-1008	1
C80			CAPACITOR, .05UF	83-1510-2307	1
C81			CAPACITOR, .02UF	83-1510-1008	1
C82			CAPACITOR, .05UF	83-1510-2307	1
VR1			ZENER DIODE, 2N754A, 6.8V	83-1530-0097	1
DS1	IEEC	4622-24V-20MA	LAMP	83-1550-1914	1
DS2	IEEC	4622-24V20MA	LAMP	83-1550-1914	1
DS3	IEEC	4622-24V20MA	LAMP	83-1550-1914	1
DS4	IEEC	4622-24V-20MA	LAMP	83-1550-1914	1

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3M Mincom Division — 3-M-3 MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT	PL 67-21-00 SHEET 14 OF 14	D REV
	TITLE LOGIC PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
DS5	IEEC	4622-24V-20MA	LAMP	83-1550-1914	1
DS6	IEEC	4622-24V-20MA	LAMP	83-1550-1914	1
DS7	IEEC	4622-24V-20MA	LAMP	83-1550-1914	1

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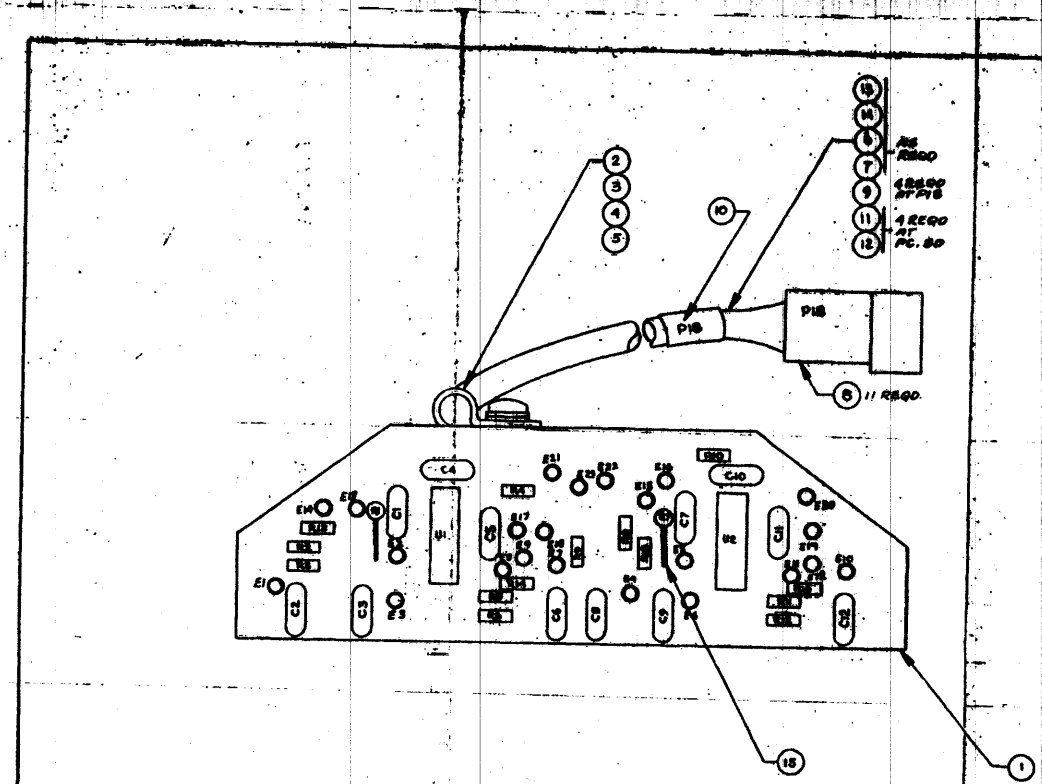

Figure 7-21. Reproduce Head Preamplifier Assembly

[redacted]CID: 37[redacted]72[redacted]

3M Mincom Division MINNESOTA MINING AND MANUFACTURING CO.

PARTS LIST	12578 CODE IDENT	PL 67-22-00 SHEET 1 OF 2	H REV
TITLE: REPRODUCE HEAD PREAMPLIFIER ASSEMBLY		CAT. NO.	

FIND NO.	DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
1			67-22-01	PC BD DETAIL, PC-3776		1
2		BIRNBACH	727	CLAMP	83-7650-0084	1
3				SCREW, PH, 6-32 X 7/16	83-9260-4532	1
4			MS15795-805	WASHER, FL NO. 6	83-9261-4375	1
5				WASHER, LOCK SPLIT NO. 6	83-9261-4305	1
6			RG174/U	CABLE, COAX	83-7910-0247	AR
7				WIRE, 22 GA, BLK	83-7910-0182	AR
8		MOLEX	1854	CONTACT, PIN	83-1610-1529	11
9		BURNDY	YEC110	FERRULE, BLUE (COAX SHIELD TERM.)	83-9090-0181	4
	R1		RC07GF364J	RESISTOR, 360K, 1/4W, 5%	83-9520-2183	1
	R2		RC07GF202J	RESISTOR, 2.0K, 1/4W, 5%	83-9520-2148	1
	R3		RC07GF431J	RESISTOR, 430 OHM, 1/4W, 5%	83-9520-2138	1
	R4		RC07GF431J	RESISTOR, 430 OHM, 1/4W, 5%	83-9520-2138	1
	R5		RC07GF364J	RESISTOR, 360K, 1/4W, 5%	83-9520-2183	1
	R6		RC07GF202J	RESISTOR, 2.0K, 1/4W, 5%	83-9520-2148	1
	R7		RC07GF364J	RESISTOR, 360K, 1/4W, 5%	83-9520-2183	1
	R8		RC07GF202J	RESISTOR, 2.0K, 1/4W, 5%	83-9520-2148	1
	R9		RC07GF431J	RESISTOR, 430 OHM, 1/4W, 5%	83-9520-2138	1
	R10		RC07GF431J	RESISTOR, 430 OHM, 1/4W, 5%	83-9520-2138	1
	R11		RC07GF364J	RESISTOR, 360K, 1/4W, 5%	83-9520-2183	1
	R12		RC07GF202J	RESISTOR, 2.0K, 1/4W, 5%	83-9520-2148	1
	R13			RESISTOR, 68K, 1/4W, 5%	83-9520-2118	1
	R14			RESISTOR, 68K, 1/4W, 5%	83-9520-2118	1
	R15			RESISTOR, 68K, 1/4W, 5%	83-9520-2118	1

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DOCID: 3700720

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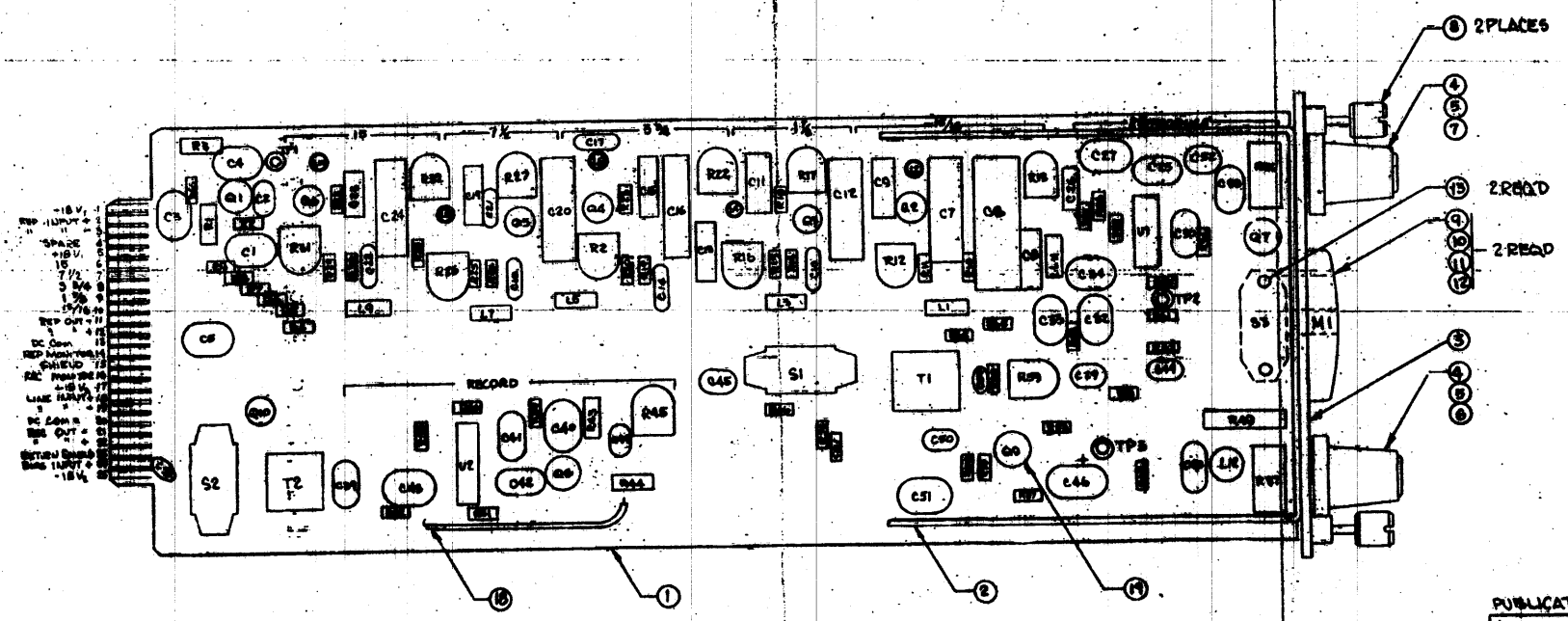
3M Mincom Division (MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-22-00 SHEET 2 OF 2	H REV
	TITLE: REPRODUCE HEAD PREAMPLIFIER ASSEMBLY		CAT. NO.	

FIND. NO. - DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R16			RESISTOR, 68K, 1/4W, 5%	83-9520-2118	1
C1		OA8365200	CAPACITOR, 680PF	83-1510-5200	1
C2	COMPONENTS	TSD4-20-226	CAPACITOR, 22UF, 20V	83-1510-6203	1
C3	COMPONENTS	TSD5-20-686	CAPACITOR, 68UF, 20V	83-1510-6211	1
C4	COMPONENTS	TSD5-20-686	CAPACITOR, 68UF, 20V	83-1510-6211	1
C5		OA8365200	CAPACITOR, 680PF	83-1510-5200	1
C6	COMPONENTS	TSD4-20-226	CAPACITOR, 22UF, 20V	83-1510-6203	1
C7		OA8365200	CAPACITOR, 680PF	83-1510-5200	1
C8	COMPONENTS	TSD4-20-226	CAPACITOR, 22UF, 20V	83-1510-6203	1
C9	COMPONENTS	TSD5-20-686	CAPACITOR, 68UF, 20V	83-1510-6211	1
C10	COMPONENTS	TSD5-20-686	CAPACITOR, 68UF, 20V	83-1510-6211	1
C11		OA8365200	CAPACITOR, 680PF	83-1510-5200	1
C12	COMPONENTS	TSD4-20-226	CAPACITOR, 22UF, 20V	83-1510-6203	1
U1	MOTOROLA	MC1303L	INTEGRATED CIRCUIT, 14 PIN	83-1530-8166	1
U2	MOTOROLA	MC1303L	INTEGRATED CIRCUIT, 14 PIN	83-1530-8166	1
P18	MOLEX	1625-12P-1	CONNECTOR	83-1610-1714	1
10		67-26-00-8	MARKER, P18		1
11		GSB-071	INNER-071 GREEN	83-9690-0091	4
12		GSC-128	OUTER-128 BLUE	83-9690-0157	4
13			WIRE, 22 GA, RED	83-7910-0187	AR
14			WIRE, 22 GA, GREEN	83-7910-0168	AR
15			SLEEVING, INSULATION, 22GA TEFLON	83-7910-0389	AR



PUBLICATION RELEASE 5-72

TITLE SIGNAL ELECTRONICS MODEL 67 (67-25-00)

DRAWING NO PC 5780 K

Figure 7-22. Record/Reproduce PC Board Assembly

3M Mincom Division (3-M-C-O MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-23-00 SHEET 1 OF 8	K REV
	TITLE: RECORD/REPRODUCE PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
C1			CAPACITOR, 10UF, 20V	83-1510-6396	1
C2			CAPACITOR, 1.0UF, 35V	83-1510-6390	1
C3			CAPACITOR, 10UF, 20V	83-1510-6396	1
C4			CAPACITOR, 10UF, 20V	83-1510-6396	1
C5			CAPACITOR, 68UF, 20V	83-1510-6211	1
C6			CAPACITOR, .047UF, 150V, 5%	83-1510-4249	1
C7			CAPACITOR, .68UF, 50V, 10%	83-1510-4368	1
C8			CAPACITOR, 2.7UF, 50V, 20%	83-1510-4385	1
C9			CAPACITOR, .22UF	83-1510-4336	1
C10			CAPACITOR, .022UF, 200V, 10%	83-1510-4237	1
C11			CAPACITOR, .33UF, 50V, 5%	83-1510-4369	1
C12			CAPACITOR, 2UF, 50V, 5%	83-1510-4200	1
C13			CAPACITOR, .047UF, 50V, 5%	83-1510-4249	1
C14			CAPACITOR, .012UF, 200V, 5%	83-1510-4234	1
C15			CAPACITOR, .1UF, 50V, 5%	83-1510-4310	1
C16			CAPACITOR, 1UF, 50V, 10%	83-1510-4270	1
C17			CAPACITOR, .022UF, 200V, 10%	83-1510-4237	1
C18			CAPACITOR, .005UF, 200V, 5%	83-1510-4244	1
C19			CAPACITOR, .068UF, 100V, 10%	83-1510-4332	1
C20			CAPACITOR, 1UF, 50V, 10%	83-1510-4270	1
C21			CAPACITOR, .01UF, 200V, 5%	83-1510-4233	1
C22			CAPACITOR, .002UF, 200V, 5%	83-1510-4362	1
C23			CAPACITOR, .068UF, 100V, 10%	83-1510-4332	1

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3M Mincom Division — MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT	PL 67-23-00 SHEET 2 OF 8	K REV
	TITLE: RECORD/REPRODUCE PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
C24			CAPACITOR, 1UF, 50V, 10%	83-1510-4270	1
C25			CAPACITOR, 680PF	83-1510-5200	1
C26			CAPACITOR, .0018UF, 200V	83-1510-6005	1
C27			CAPACITOR, 22UF, 20V	83-1510-6398	1
C29			CAPACITOR, 3.3UF, 25V	83-1510-6393	1
C30			CAPACITOR, 680PF	83-1510-5200	1
C32			CAPACITOR, 68UF, 20V	83-1510-6211	1
C33			CAPACITOR, 68UF, 20V	83-1510-6211	1
C34			CAPACITOR, 22UF, 20V	83-1510-6398	1
C39			CAPACITOR, 180PF	83-1510-5131	1
C40			CAPACITOR, 68UF, 20V	83-1510-6211	1
C41			CAPACITOR, 10PF	83-1510-5180	1
C42			CAPACITOR, 33PF	83-1510-5105	1
C43			CAPACITOR, 68UF, 20V	83-1510-6211	1
C44			CAPACITOR, 1.0UF, 35V	83-1510-6390	1
C45			CAPACITOR, 3.3UF, 25V	83-1510-6393	1
C46			CAPACITOR, 10UF, 20V	83-1510-6396	1
C48			CAPACITOR, 820PF	83-1510-5124	1
C49			CAPACITOR, 1.0UF, 35V	83-1510-6390	1
C50			CAPACITOR, 3.3UF, 25V	83-1510-6393	1
C51			CAPACITOR, 10UF, 20V	83-1510-6396	1
C52			CAPACITOR, 1.5UF, 35V	83-1510-6391	1
C53			CAPACITOR, 500PF, 500V	83-1510-5120	1

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3M Mincom Division — 3-M-C MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT	PL 67-23-00 SHEET 3 OF 8	K REV
	TITLE RECORD/REPRODUCE PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
C54			CAPACITOR, .0018UF	83-1510-6006	1
C55			CAPC ITOR, 130PF	83-1510-5274	1
CR1			DIODE, 1N914	83-1530-6083	1
L1	NYTRONICS	WEE-33000	INDUCTOR, 33MH	83-1540-0659	1
L2			INDUCTOR, 2.2MH	83-1540-0605	1
L3			INDUCTOR, 18MH	83-1540-0604	1
L4			INDUCTOR, 1.2MH	83-1540-0608	1
L5			INDUCTOR, 8.2MH	83-1540-0601	1
L6			INDUCTOR, 820UH	83-1540-0546	1
L7			INDUCTOR, 4.7MH	83-1540-0597	1
L8			INDUCTOR, 330UH	83-1540-0541	1
L9			INDUCTOR, 4.7MH	83-1540-0597	1
L10			INDUCTOR, 100UH	83-1540-0535	1
L11			INDUCTOR, 220UH	83-1540-0539	1
L12			INDUCTOR, 680UH (VAR.)	83-1540-0539	1
M1			METER-VU	83-1550-3074	1
Q1			TRANSISTOR, 2N3643	83-1530-2234	1
Q2			TRANSISTOR, 2N4360	83-1530-2294	1
Q3			TRANSISTOR, 2N4360	83-1530-2294	1
Q4			TRANSISTOR, 2N4360	83-1530-2294	1
Q5			TRANSISTOR, 2N4360	83-1530-2294	1

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3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-23-00 SHEET 4 OF 8	K REV
	TITLE RECORD/REPRODUCE PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
Q6			TRANSISTOR, 2N4360	83-1530-2294	1
Q7			TRANSISTOR, 2N3643	83-1530-2234	1
Q8			TRANSISTOR, 2N3643	83-1530-2234	1
Q9			TRANSISTOR, 2N3859	83-1530-2094	1
Q10			TRANSISTOR, 2N4360	83-1530-2294	1
R1			RESISTOR, 510 OHM, 1/2W, 2%	83-1520-7354	1
R2			RESISTOR, 51K, 1/4W, 5%	83-9520-2169	1
R3			RESISTOR, 1K, 1/2W, 2%	83-1520-7175	1
R4			RESISTOR, 120 OHM, 1/4W, 5%	83-9520-2103	1
R5			RESISTOR, 18K, 1/4W, 5%	83-9520-2114	1
R6			RESISTOR, 18K, 1/4W, 5%	83-9520-2114	1
R7			RESISTOR, 18K, 1/4W, 5%	83-9520-2114	1
R8			RESISTOR, 18K, 1/4W, 5%	83-9520-2114	1
R9			RESISTOR, 18K, 1/4W, 5%	83-9520-2114	1
R10			RESISTOR, 2.7K, 1/4W, 5%	83-9520-2111	1
R11			RESISTOR, 51 OHM, 1/4W, 5%	83-9520-2126	1
R12	BOURNS		RESISTOR, 1K TRIMPOT, 1/4W, 5%	83-1520-1584	1
R13	BOURNS		RESISTOR, 200 OHM TRIMPOT, 1/4W, 5%	83-1520-1582	1
R14			RESISTOR; 2.4K, 1/4W, 5%	83-9520-2149	1
R15			RESISTOR, 51 OHM, 1/4W, 5%	83-9520-2126	1
R16	BOURNS		RESISTOR, 1K TRIMPOT, 1/4W, 5%	83-1520-1584	1
R17	BOURNS		RESISTOR, 200 OHM, TRIMPOT, 1/4W, 5%	83-1520-1582	1
R18			RESISTOR, 3.9K, 1/4W, 5%	83-9520-2096	1

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3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-23-00 SHEET 5 OF 8	K REV
	TITLE RECORD/REPRODUCE PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	TY
R19			RESISTOR, 2.4K, 1/4W, 5%	83-9520-2149	1
R20			RESISTOR, 51 OHM, 1/4W, 5%	83-9520-2126	1
R21	BOURNS		RESISTOR, 1K TRIMPOT, 1/4W, 5%	83-1520-1584	1
R22	BOURNS		RESISTOR, 200 OHM, TRIMPOT, 1/4W, 5%	83-1520-1582	1
R24			RESISTOR, 2.4K, 1/4W, 5%	83-9520-2149	1
R25			RESISTOR, 51 OHM, 1/4W, 5%	83-9520-2126	1
R26	BOURNS		RESISTOR, 1K TRIMPOT, 1/4W, 5%	83-1520-1584	1
R27	BOURNS		RESISTOR, 200 OHM TRIMPOT, 1/4W, 5%	83-1520-1582	1
R28			RESISTOR, 12K, 1/4W, 5%	83-9520-2159	1
R29			RESISTOR, 1K, 1/4W, 5%	83-9520-2088	1
R30			RESISTOR, 51 OHM, 1/4W, 5%	83-9520-2126	1
R31	BOURNS		RESISTOR, 1K TRIMPOT, 1/4W, 5%	83-1520-1584	1
R32	BOURNS		RESISTOR, 200 OHM, TRIMPOT, 1/4W, 5%	83-1520-1582	1
R33			RESISTOR, 36K, 1/4W, 5%	83-9520-2166	1
R34			RESISTOR, 100K, 1/4W, 5%	83-9520-2119	1
R35			RESISTOR, 1K, 1/4W, 5%	83-9520-2088	1
R36	CTS	WA1066-62716	RESISTOR, 2K POT, 1/4W, 5%	83-1520-1613	1
R37	CTS	WA1065-62715	RESISTOR, 5K POT, 1/4W, 5%	83-1520-1614	1
R38			RESISTOR, 1K, 1/4W, 5%	83-9520-2088	1
R39			RESISTOR, 330 OHM, 1/4W, 5%	83-9520-2091	1
R40			RESISTOR, 510K, 1/4W, 5%	83-9520-2186	1
R41			RESISTOR, 330K, 1/4W, 5%	83-9520-2124	1
R42			RESISTOR, 330 OHM, 1/4W, 5%	83-9520-2091	1

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3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-23-00 SHEET 6 OF 8	K REV
	TITLE RECORD/REPRODUCE PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	TY
R43			RESISTOR, 510 OHM, 1/2W, 2%	83-1520-7354	1
R44			RESISTOR, 1.5K, 1/2W, 2%	83-1520-7217	1
R45			RESISTOR, 500 OHM TRIMPOT, 1/4W, 5%	83-1520-1583	1
R46			RESISTOR, 10K, 1/4W, 5%	83-9520-2112	1
R48			RESISTOR, 3.3K, 1/4W, 5%	83-9520-2095	1
R49			RESISTOR, 100K POT, 1/4W, 5%	83-1520-1539	1
R50			RESISTOR, 100K, 1/4W, 5%	83-9520-2119	1
R51			RESISTOR, 10K, 1/4W, 5%	83-9520-2112	1
R52			RESISTOR, 2.2K, 1/4W, 5%	83-9520-2110	1
R53			RESISTOR, 68 OHM, 1/4W, 5%	83-9520-2128	1
R54			RESISTOR, 10K, 1/4W, 5%	83-9520-2112	1
R55			RESISTOR, 2K, 1/4W, 5%	83-9520-2148	1
R56			RESISTOR, 750 OHM, 1/4W, 5%	83-9520-2142	1
R57			RESISTOR, 510 OHM, 1/4W, 5%	83-9520-2139	1
R58			RESISTOR, 100K, 1/4W, 5%	83-9520-2119	1
R59			RESISTOR, 500 OHM TRIMPOT, 1/4W, 5%	83-1520-1583	1
R60			RESISTOR, 1.5K, 1/4W, 5%	83-9520-2117	1
R61			RESISTOR, 620 OHM, 1/4W, 5%	83-9520-2141	1
R62			RESISTOR, 1.5K, 1/2W, 2%	83-1520-7217	1
R63			RESISTOR, 10K, 1/4W, 5%	83-9520-2112	1
R64			RESISTOR, 330 OHM, 1/4W, 5%	83-9520-2091	1
R65			RESISTOR, 330 OHM, 1/4W, 5%	83-9520-2091	1
R66			RESISTOR, 150 OHM, 1/4W, 5%	83-9520-2105	1

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3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-23-00 SHEET 7 OF 8	K REV
	TITLE RECORD/REPRODUCE PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
S1	CONTINENTAL	GF-124-PC	SWITCH, SLIDE	83-1550-5624	1
S2	CONTINENTAL	GF-124-PC	SWITCH, SLIDE	83-1550-5624	1
S3	CONTINENTAL	GI-141-PC-SPDT	SLIDE SWITCH, SYDEWYNDER, METER	83-1550-5625	1
T1	MINCOM	67-23-10-2	MATCHING TRANSFORMER, 600 OHM - 600 OHM	83-3540-1349	1
T2	MINCOM	67-23-10-1	MATCHING TRANSFORMER 10K - 2.5K	83-3540-1350	1
U1	MOTOROLA		INTEGRATED CIRCUIT, MC1303L DUAL PREAMPLIFIER	83-1530-8166	1
U2	FAIRCHILD	U6E7709393	INTEGRATED CIRCUIT, UA709, OP AMPLIFIER	83-1530-8074	1
1			PC BOARD DETAIL, PC3780		1
2		67-23-02	BRACKET		1
3		67-23-03	FRONT PANEL		1
4	ELMA	020-322	KNOB	83-1270-0955	2
5	ELMA	044-302	NUT COVER	83-1270-0956	2
6	ELMA	040-302	CAP-KNOB, BLACK	83-1270-0954	1
7	ELMA	040-301	CAP-KNOB, GRAY	83-1270-0957	1
8	AMATOM	6103-B-0440-4	CAPTIVE SCREW	83-9260-0305	2
9			SCREW-100°, 2-56 X 3/8	83-9260-0261	2
10		NAS620-2	WASHER, FL, NO. 2	83-9261-4001	2
11		MS35338-39	WASHER, LOCK	83-9261-4301	2
12		NAS671-2	NUT, 2-56	83-9260-2206	2
13		MS35206-204	SCREW, PH, 2-56 X 3/16	83-9260-4501	2
14			CABLE-TW SHIELDED PAIR, 22"	83-7910-0528	AR
15			FERRULE, INNER	83-9690-0017	3
16			FERRULE, OUTER	83-9690-0088	3

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3M Mincom Division (3-M-3 MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-23-00 SHEET 8 OF 8	K REV
	TITLE RECORD/REPRODUCE PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
17			SCOTCHTITE - 1" LG	83-7910-0275	AR
18			WIRE, 24 GA WHT 3"	83-7910-0392	AR
19			TRANSISTOR CONVERSION PAD - Q9	83-9690-0191	1

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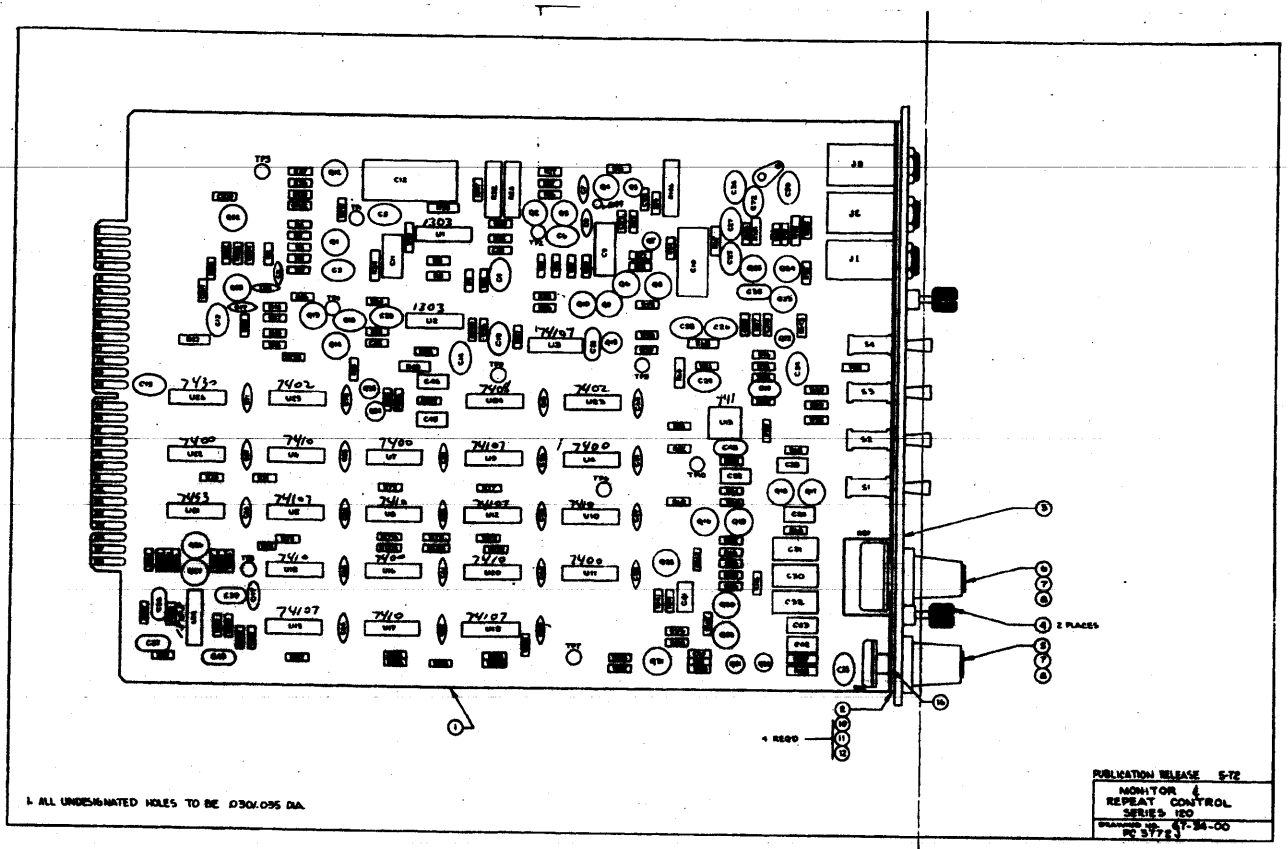

Figure 7-23. Monitor PC Board Assembly

3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 1 OF 14	I REV
	TITLE MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
C2			CAPACITOR, .05UF, 10V	83-1510-2307	1
C3			CAPACITOR, 10UF, 20V	83-1510-6396	1
C4			CAPACITOR, 22UF, 20V	83-1510-6398	1
C5			CAPACITOR, 22UF, 20V	83-1510-6398	1
C6			CAPACITOR, 10UF, 20V	83-1510-6396	1
C7			CAPACITOR, .01UF	83-1510-1048	1
C8			CAPACITOR, .01UF	83-1510-1048	1
C9			CAPACITOR, .22UF	83-1510-6004	1
C10			CAPACITOR, 1.0UF	83-1510-4486	1
C11			CAPACITOR, .1UF	83-1510-4469	1
C12			CAPACITOR, 5UF	83-1510-4298	1
C13			CAPACITOR, 56UF, 20V	83-1510-6260	1
C14			CAPACITOR, 56UF, 20V	83-1510-6260	1
C15			CAPACITOR, 10UF, 20V	83-1510-6396	1
C17			CAPACITOR, .05UF, 10V	83-1510-2307	1
C18			CAPACITOR, 10UF, 20V	83-1510-6396	1
C19			CAPACITOR, 22UF, 20V	83-1510-6398	1
C20			CAPACITOR, 22UF, 20V	83-1510-6398	1
C21			CAPACITOR, 100PF	83-1510-5155	1
C22			CAPACITOR, .022UF	83-1510-4459	1
C23			CAPACITOR, .0039UF	83-1510-6020	1
C24			CAPACITOR, .0039UF	83-1510-6020	1
C25			CAPACITOR, 68UF, 20V	83-1510-6211	1
C26			CAPACITOR, 68UF, 20V	83-1510-6211	1

3M Mincom Division — MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 2 OF 14	1 REV
	TITLE: MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
C27			CAPACITOR, 68UF, 20V	83-1510-6211	1
C28			CAPACITOR, 68UF, 20V	83-1510-6211	1
C29			CAPACITOR, 47UF, 20V	83-1510-6199	1
C30			CAPACITOR, .1UF	83-1510-4499	1
C31			CAPACITOR, .1UF	83-1510-4499	1
C32			CAPACITOR, .1UF	83-1510-4499	1
C33			CAPACITOR, 15UF, 20V	83-1510-6397	1
C34			CAPACITOR, 15UF, 20V	83-1510-6397	1
C35			CAPACITOR, 820PF	83-1510-5124	1
C36			CAPACITOR, 10UF, 20V	83-1510-6396	1
C37			CAPACITOR, 56UF, 20V	83-1510-6260	1
C38			CAPACITOR, .01UF	83-1510-1048	1
C39			CAPACITOR, 56UF, 20V	83-1510-6260	1
C40			CAPACITOR, .01UF	83-1510-1048	1
C41			CAPACITOR, .015UF	83-1510-4165	1
C42			CAPACITOR, .056UF	83-1510-4002	1
C43			CAPACITOR, .056UF	83-1510-4002	1
C44			CAPACITOR, .02UF	83-1510-1008	1
C45			CAPACITOR, .022UF	83-1510-4459	1
C46			CAPACITOR, .022UF	83-1510-4459	1
C47			CAPACITOR, .02UF	83-1510-1008	1
C48			CAPACITOR, 75PF	83-1510-5273	1
C49			CAPACITOR, 10UF, 20V	83-1510-6396	1

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3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 3 OF 14	1 REV
	TITLE MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
C50			CAPACITOR, 56UF, 20V	83-1510-6260	1
C51			CAPACITOR, .05UF, 10V	83-1510-2307	1
C52			CAPACITOR, .05UF, 10V	83-1510-2307	1
C53			CAPACITOR, .05UF, 10V	83-1510-2307	1
C54			CAPACITOR, .05UF, 10V	83-1510-2307	1
C55			CAPACITOR, .05UF, 10V	83-1510-2307	1
C56			CAPACITOR, .05UF, 10V	83-1510-2307	1
C57			CAPACITOR, .05UF, 10V	83-1510-2307	1
C58			CAPACITOR, .05UF, 10V	83-1510-2307	1
C59			CAPACITOR, .05UF, 10V	83-1510-2307	1
C60			CAPACITOR, .05UF, 10V	83-1510-2307	1
C61			CAPACITOR, .05UF, 10V	83-1510-2307	1
C62			CAPACITOR, .05UF, 10V	83-1510-2307	1
C63			CAPACITOR, .05UF, 10V	83-1510-2307	1
C64			CAPACITOR, .05UF, 10V	83-1510-2307	1
C65			CAPACITOR, .05UF, 10V	83-1510-2307	1
C66			CAPACITOR, .05UF, 10V	83-1510-2307	1
C67			CAPACITOR, .05UF, 10V	83-1510-2307	1
C68			CAPACITOR, .05UF, 10V	83-1510-2307	1
C69			CAPACITOR, .05UF, 10V	83-1510-2307	1
C70			CAPACITOR, .05UF, 10V	83-1510-2307	1
C71			CAPACITOR, .05UF, 10V	83-1510-2307	1
C72			CAPACITOR, .022UF, 200V	83-1510-4237	1

3M Mincom Division — MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT.	PL 67-24-00 SHEET 4 OF 14	1 REV
	TITLE MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
CR1			DIODE, 1N914	83-1530-0083	1
CR2			DIODE, 1N914	83-1530-0083	1
CR3			DIODE, 1N914	83-1530-0083	1
CR4			DIODE, 1N914	83-1530-0083	1
CR5			DIODE, 1N914	83-1530-0083	1
CR6			DIODE, 1N914	83-1530-0083	1
CR7			DIODE, 1N914	83-1530-0083	1
CR8			DIODE, 1N914	83-1530-0083	1
CR9			DIODE, 1N914	83-1530-0083	1
CR10			DIODE, 1N914	83-1530-0083	1
CR11			DIODE, 1N914	83-1530-0083	1
CR12			DIODE, 1N914	83-1530-0083	1
CR13			DIODE, 1N914	83-1530-0083	1
Q1			TRANSISTOR, 2N3638	83-1530-2155	1
Q2			TRANSISTOR, 2N3638	83-1530-2155	1
Q3			TRANSISTOR, 2N3565	83-1530-2149	1
Q4			TRANSISTOR, 2N3643	83-1530-2234	1
Q5			TRANSISTOR, 2N3565	83-1530-2149	1
Q6			TRANSISTOR, 2N3644	83-1530-2269	1
Q7			TRANSISTOR, 2N3565	83-1530-2149	1
Q8			TRANSISTOR, 2N3643	83-1530-2234	1
Q9			TRANSISTOR, 2N3644	83-1530-2269	1
Q10			TRANSISTOR, 2N3644	83-1530-2269	1
Q12			TRANSISTOR, 2N3643	83-1530-2234	1

3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 5 OF 14	I REV
	TITLE MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
Q13			TRANSISTOR, 2N3638	83-1530-2155	1
Q14			TRANSISTOR, 2N3638	83-1530-2155	1
Q15			TRANSISTOR, 2N3643	83-1530-2234	1
Q16			TRANSISTOR, 2N3859	83-1530-2261	1
Q17			TRANSISTOR, 2N3859	83-1530-2261	1
Q18			TRANSISTOR, 2N3859	83-1530-2261	1
Q19			TRANSISTOR, 2N3859	83-1530-2261	1
Q20			TRANSISTOR, 2N5163	83-1530-2379	1
Q21			TRANSISTOR, 2N5163	83-1530-2379	1
Q22			TRANSISTOR, 2N3859	83-1530-2261	1
Q23			TRANSISTOR, 2N3643	83-1530-2234	1
Q24			TRANSISTOR, 2N2219A	83-1530-2154	1
Q25			TRANSISTOR, 2N2904A	83-1530-2113	1
Q26			TRANSISTOR, 2N3638	83-1530-2155	1
Q27			TRANSISTOR, 2N3638	83-1530-2155	1
Q28			TRANSISTOR, 2N3859	83-1530-2261	1
Q29			TRANSISTOR, 2N3859	83-1530-2261	1
Q30			TRANSISTOR, 2N3859	83-1530-2261	1
Q31			TRANSISTOR, 2N3643	83-1530-2234	1
Q32			TRANSISTOR, 2N3643	83-1530-2234	1
Q33			TRANSISTOR, 2N3643	83-1530-2234	1
Q34			TRANSISTOR, 2N3859	83-1530-2261	1
Q35			TRANSISTOR, 2N3859	83-1530-2261	1

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3M Mincom Division — 3-M-C MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 6 OF 14	I REV
	TITLE MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R1			RESISTOR, 680K	83-9520-2189	1
R2			RESISTOR, 100K	83-9520-2119	1
R3			RESISTOR, 15K	83-9520-2120	1
R4			RESISTOR, 470 OHM	83-9520-2116	1
R5			RESISTOR, 4.7K	83-9520-2111	1
R6			RESISTOR, 1K	83-9520-2088	1
R8			RESISTOR, 10K	83-9520-2112	1
R9			RESISTOR, 10K	83-9520-2112	1
R10			RESISTOR, 430 OHM	83-9520-2138	1
R11			RESISTOR, 390K	83-9520-2184	1
R12			RESISTOR, 430 OHM	83-9520-2138	1
R13			RESISTOR, 6.8K	83-9520-2097	1
R14			RESISTOR, 1K	83-9520-2088	1
R15			RESISTOR, 1K	83-9520-2088	1
R16			RESISTOR, 1K	83-9520-2088	1
R17			RESISTOR, 1K	83-9520-2088	1
R18			RESISTOR, 390 OHM	83-9520-2137	1
R19			RESISTOR, 1K	83-9520-2088	1
R20			RESISTOR, 1K	83-9520-2088	1
R21			RESISTOR, 10K	83-9520-2112	1
R22			RESISTOR, 1K	83-9520-2088	1
R23			RESISTOR, 27K	83-9520-2100	1
R24			RESISTOR, 1K	83-9520-2088	1

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3M Mincom Division — 3·M·C MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT	PL 67-24-000 SHEET 7 OF 14	I REV
	TITLE MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	TY
R25			RESISTOR, 1.8K	83-9520-2147	1
R26			RESISTOR, 1K	83-9520-2088	1
R27			RESISTOR, 2.7K	83-9520-2098	1
R28			RESISTOR, VARIABLE, 1K	83-1520-1533	1
R29			RESISTOR, 10K	83-9520-2112	1
R30			RESISTOR, 22K	83-9520-2163	1
R31			RESISTOR, 750 OHM	83-9520-2142	1
R32			RESISTOR, VARIABLE, 50K	83-1520-1538	
R33			RESISTOR, 3.3M OHM	83-9520-3233	1
R34			RESISTOR, 47 OHM	83-9520-2125	1
R36			RESISTOR, 22K	83-9520-2163	1
R37			RESISTOR, 1K	83-9520-2088	1
R38			RESISTOR, 22K	83-9520-2163	1
R39			RESISTOR, 22K	83-9520-2163	1
R40			RESISTOR, 22K	83-9520-2163	1
R41			RESISTOR, 22K	83-9520-2163	1
R42			RESISTOR, 33 OHM, 1/2W	83-1520-7333	1
R43			RESISTOR, 33 OHM, 1/2W	83-1520-7333	1
R44			RESISTOR, 680K	83-9520-2189	1
R45			RESISTOR, 100K	83-9520-2119	1
R46			RESISTOR, 15K	83-9520-2120	1
R47			RESISTOR, 470 OHM	83-9520-2116	1
R48			RESISTOR, 4.7K	83-9520-2111	1
R49			RESISTOR, 1K	83-9520-2088	1

3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 8 OF 14	1 REV
	TITLE MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R51			RESISTOR, 10K	83-9520-2112	1
R53			RESISTOR, 390K	83-9520-2184	1
R54			RESISTOR, 430 OHM	83-9520-2138	1
R55			RESISTOR, 6.8K	83-9520-2097	1
R56			RESISTOR, 430 OHM	83-9520-2138	1
R57			RESISTOR, 1K	83-9520-2088	1
R58			RESISTOR, 51K	83-9520-2169	1
R59			RESISTOR, 1K	83-9520-2088	1
R60			RESISTOR, 5.6K	83-9520-2154	1
R61			RESISTOR, 15K	83-9520-2120	1
R62			RESISTOR, 8.2K	83-9520-2099	1
R63			RESISTOR, 10K	83-9520-2112	1
R64			RESISTOR, 12K	83-9520-2159	1
R65			RESISTOR, 10K	83-9520-2112	1
R66			RESISTOR, 12K	83-9520-2159	1
R67			RESISTOR, 100 OHM, 1/2W	83-1520-7221	1
R68			RESISTOR, 100 OHM, 1/2W	83-1520-7221	1
R69			RESISTOR, 300 OHM, 1/2W	83-1520-7349	1
R70			RESISTOR, 1K	83-9520-2088	1
R71			RESISTOR, 2K	83-9520-2148	1
R72			RESISTOR, 1K	83-9520-2088	1
R73			RESISTOR, 2K	83-9520-2148	1
R74			RESISTOR, 1K	83-9520-2088	1
R75			RESISTOR, 2K	83-9520-2148	1

3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 9 OF 14	I REV
	TITLE MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	TY
R76			RESISTOR, 1K	83-9520-2088	1
R77			RESISTOR, 2K	83-9520-2148	1
R78			RESISTOR, 1K	83-9520-2088	1
R79			RESISTOR, 2K	83-9520-2148	1
R80			RESISTOR, 220K	83-9520-2121	1
R81			RESISTOR, 33 OHM	83-9520-2243	1
R82			RESISTOR, 10K	83-9520-2112	1
R83			RESISTOR, 5.6K	83-9520-2154	1
R84			RESISTOR, 10K	83-9520-2112	1
R85			RESISTOR, 5.6K	83-9520-2154	1
R86			RESISTOR, 430 OHM	83-9520-2138	1
R87	CTS	CD2452	RESISTOR, VARIABLE, 1M OHM	83-1520-1615	1
R88			RESISTOR, 10M OHM	83-9520-3250	1
R89			RESISTOR, 10M OHM	83-9520-3250	1
R90			RESISTOR, 4.7K	83-9520-2111	1
R91			RESISTOR, 1M OHM	83-9520-2123	1
R92		S67-21-05-3	RESISTOR, VARIABLE, 10K	83-3520-1617	1
R93			RESISTOR, 330K	83-9520-2124	1
R94			RESISTOR, 47K	83-9520-2090	1
R95			RESISTOR, 22K	83-9520-2163	1
R96			RESISTOR, 2.2K	83-9520-2110	1
R97			RESISTOR, 5.1K	83-9520-2153	1
R98			RESISTOR, 100 OHM	83-9520-2094	1
R99			RESISTOR, 10 OHM	83-9520-2232	1

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3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 10 OF 14	I REV
	TITLE MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. N .	TY
R100			RESISTOR, 10 OHM	83-9520-2232	1
R101			RESISTOR, 100 OHM	83-9520-2094	1
R102			RESISTOR, 1K	83-9520-2088	1
R103			RESISTOR, 1K	83-9520-2088	1
R104			RESISTOR, 6.8K	83-9520-2097	1
R105			RESISTOR, 1K	83-9520-2088	1
R106			RESISTOR, 6.8K	83-9520-2097	1
R107			RESISTOR, 430 OHM	83-9520-2138	1
R108			RESISTOR, 4.7 OHM, 1/2W	83-9520-3264	1
R109			RESISTOR, 4.7 OHM, 1/2W	83-9520-3264	1
R110			RESISTOR, 430 OHM	83-9520-2138	1
R111			RESISTOR, 5.6K	83-9520-2154	1
R112			RESISTOR, 3.6K	83-9520-2151	1
R113			RESISTOR, 10K	83-9520-2112	1
R114			RESISTOR, 12K	83-9520-2159	1
R115			RESISTOR, 10K	83-9520-2112	1
R116			RESISTOR, 12K	83-9520-2159	1
R117			RESISTOR, 1K	83-9520-2148	1
R118			RESISTOR, 18K	83-9520-2114	1
R119			RESISTOR, 2K	83-9520-2148	1
R120			RESISTOR, 1K	83-9520-2088	1
R121			RESISTOR, 1K	83-9520-2088	1
R122			RESISTOR, 2K	83-9520-2148	1
R123			RESISTOR, 1K	83-9520-2088	1

MS7 REM 8-72

3M Mincom Division (3-M-C Minnesota Mining and Manufacturing Co.)	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 11 OF 14	1 REV
	TITLE MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R124			RESISTOR, 2K	83-9520-2148	1
R125			RESISTOR, 20K	83-9520-2162	1
R126			RESISTOR, 1K	83-9520-2088	1
R127			RESISTOR, 2K	83-9520-2148	1
R128			RESISTOR, 1K	83-9520-2088	1
R129			RESISTOR, 2K	83-9520-2148	1
R130			RESISTOR, 1K	83-9520-2088	1
R131			RESISTOR, 4.7K	83-9520-2111	1
R132			RESISTOR, 4.3K	83-9520-2152	1
R133			RESISTOR, 12K	83-9520-2159	1
R134			RESISTOR, 3.9K	83-9520-2096	1
R135			RESISTOR, 1K	83-9520-2088	1
R136			RESISTOR, 4.3K	83-9520-2152	1
R137			RESISTOR, 4.3K	83-9520-2152	1
R138			RESISTOR, 1K	83-9520-2088	1
R139			RESISTOR, 1K	83-9520-2088	1
R140			RESISTOR, 10K	83-9520-2112	1
R141			RESISTOR, 4.7K	83-9520-2111	1
R142			RESISTOR, 470 OHM	83-9520-2116	1
R143			RESISTOR, 150K	83-9520-2177	1
R144			RESISTOR, 4.7K	83-9520-2111	1
R145			RESISTOR, 4.7K	83-9520-2111	1
R146			RESISTOR, VARIABLE, 2K	83-1520-1534	1

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3M Mincom Division (MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 12 OF 14	I REV
	TITLE: MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R147			RESISTOR, 15K	83-9520-2120	1
R148			RESISTOR, 2.2K	83-9520-2110	1
R149			RESISTOR, 10 OHM	83-9520-2232	1
S1	CONT. OF AMER	T8106 6910	SWITCH	83-1550-5627	1
S2	CONT. OF AMER	T8106 6910	SWITCH	83-1550-5627	1
S3	CONT. OF AMER	T8106 6910	SWITCH	83-1550-5627	1
S4	CONT. OF AMER	T8106 6910	SWITCH	83-1550-5627	1
J1			PHONE JACK	83-1610-0885	1
J2			PHONE JACK	83-1610-0885	1
J3			PHONE JACK	83-1610-0885	1
U1			INTEGRATED CIRCUIT, MC1303	83-1530-8166	1
U2			INTEGRATED CIRCUIT, MC1303	83-1530-8166	1
U3			INTEGRATED CIRCUIT, SN74107	83-1530-8163	1
U4			INTEGRATED CIRCUIT, SN7400	83-1530-8060	1
U5			INTEGRATED CIRCUIT, SN74107	83-1530-8163	1
U6			INTEGRATED CIRCUIT, SN7410	83-1530-8143	1
U7			INTEGRATED CIRCUIT, SN7400	83-1530-8060	1
U8			INTEGRATED CIRCUIT, SN7410	83-1530-8143	1
U9			INTEGRATED CIRCUIT, SN74107	83-1530-8163	1
U10			INTEGRATED CIRCUIT, SN7410	83-1530-8143	1
U11			INTEGRATED CIRCUIT, SN7400	83-1530-8060	1
U12			INTEGRATED CIRCUIT, SN74107	83-1530-8163	1
U13			INTEGRATED CIRCUIT, SN72741	83-1530-8159	1
U14			INTEGRATED CIRCUIT, MC1303	83-1530-8166	1

M67 REM 8-72

3M Mincom Division (3-M-C Minnesota Mining and Manufacturing Co.)	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 13 OF 14	1 REV
	TITLE: MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
U15			INTEGRATED CIRCUIT, SN74107	83-1530-8163	1
U16			INTEGRATED CIRCUIT, SN7400	83-1530-8060	1
U17			INTEGRATED CIRCUIT, SN7410	83-1530-8143	1
U18			INTEGRATED CIRCUIT, SN7410	83-1530-8143	1
U19			INTEGRATED CIRCUIT, SN74107	83-1530-8163	1
U20			INTEGRATED CIRCUIT, SN7410	83-1530-8143	1
U21			INTEGRATED CIRCUIT, SN7493	83-1530-8066	1
U22			INTEGRATED CIRCUIT, SN7400	83-1530-8060	1
U23			INTEGRATED CIRCUIT, SN7402	83-1530-8145	1
U24			INTEGRATED CIRCUIT, SN7408	83-1530-8147	1
U25			INTEGRATED CIRCUIT, SN7402	83-1530-8145	1
U26			INTEGRATED CIRCUIT, SN7430	83-1530-8061	1
VR1			ZENER DIODE	83-1530-0388	1
1		67-24-00 (ITEM 1)	PC BD DETAIL (PC3772)		1
2		67-24-03	BRACKET, MTG		1
3		67-24-02	FRONT PANEL		1
4	AMATOM	6103-B-0440-4	SCREW, CAPTIVE	83-9260-0305	2
5	ELMA	020-322	KNOB, 1/8	83-1270-0955	1
6	ELMA	020-352	KNOB, 1/4	83-1270-0952	1
7	ELMA	044-312	NUT COVER	83-1270-0953	2
8	ELMA	040-302	CAP, KNOB, BLK	83-1270-0954	2
9	AMP	583527-1	SOCKET, I.C. (14 PIN)	83-1620-0273	25
10			SCREW, PH, 6-32 X 1/4	83-9260-4529	4
11			WASHER, FL NO. 6	83-9261-4004	4

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3M Mincom Division — 3-M-3 MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT	PL 67-24-00 SHEET 14 OF 14	I REV
	TITLE MONITOR PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
12			WASHER, LOCK NO. 6	83-9261-4305	4
13	AMP	583640-1	SOCKET, I.C. (8 PIN)	83-1620-0281	1
14			PAD, TRANSISTOR (Q24, 25)	83-9690-0001	2
15			PAD-CONVERSION (Q16,17,18,19,22,28,29,30,34,35)	83-9690-0191	10
16			WASHER, 1/4	83-9262-0046	1
17			WIRE, 22 GA WHITE	83-7910-0180	AR
18			LUG, TERMINAL	83-9630-0062	1
19		67-24-04	STIFFENER		1
20			SCREW, PH 2-56 X 1/2	83-9260-4505	3
21			WASHER, FIBER, .110 X .250 X .06 THK	83-9630-0064	6

M67 REM 9-72

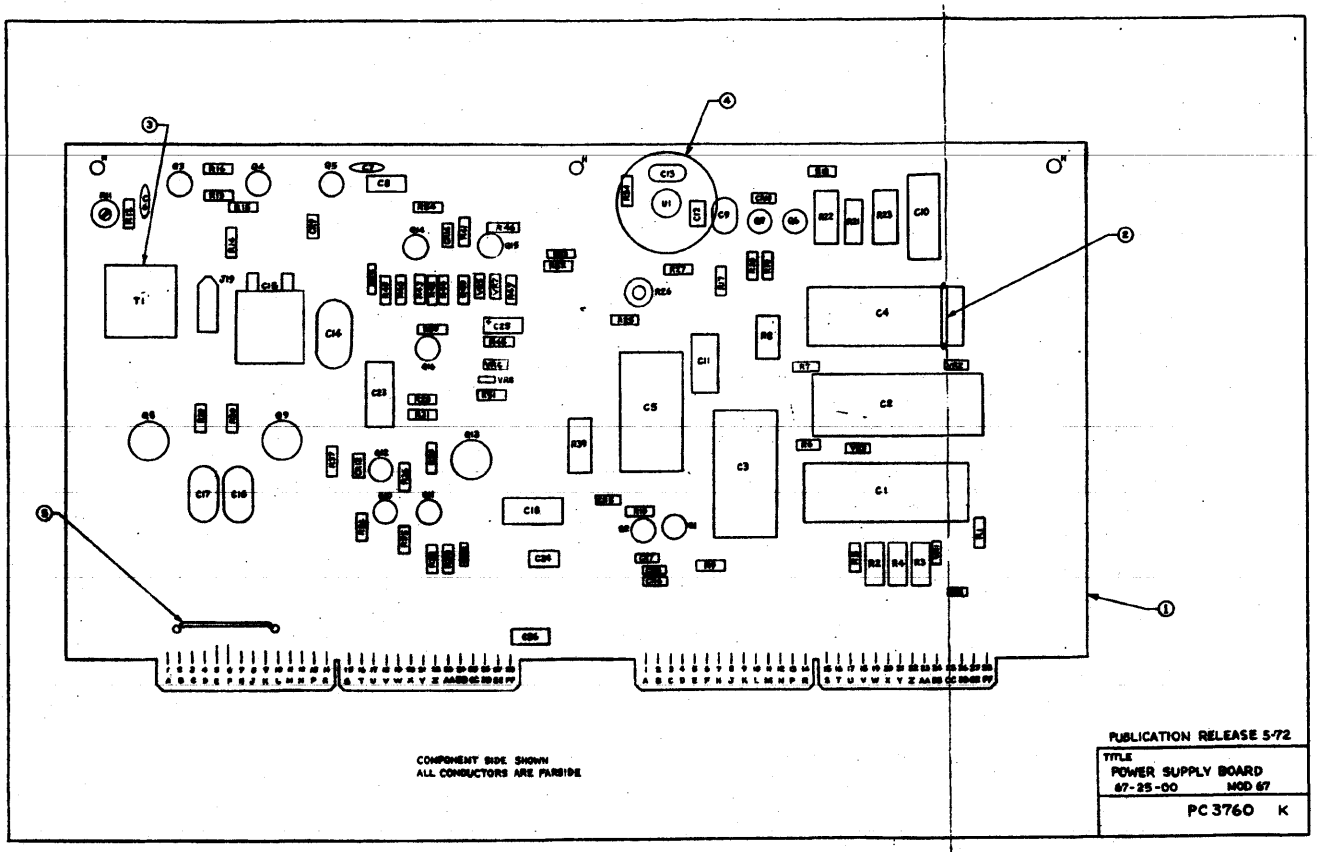

Figure 7-24. Power Supply PC Board Assembly

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3M Mincom Division — 3-M-C MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT	PL 67-25-00 SHEET 1 OF 5	K REV
	TITLE: POWER SUPPLY PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
C1			CAPACITOR, 1000UF, 25V	83-1510-2217	1
C1			CAPACITOR, 2000UF, 15V	83-1510-2151	1
C3			CAPACITOR, 250UF, 50V	83-1510-2031	1
C4			CAPACITOR, 1000UF, 25V	83-1510-2217	1
C5			CAPACITOR, 250UF, 50V	83-1510-2031	1
C6			CAPACITOR, CERA, .02UF	83-1510-1008	1
C7			CAPACITOR, CERA, .02UF	83-1510-1008	1
C8			CAPACITOR, 6.8UF, 35V	83-1510-6420	1
C9			CAPACITOR, 820PF	83-1510-5124	1
C10			CAPACITOR, .47UF	83-1510-2052	1
C11			CAPACITOR, 15UF, 35V	83-1510-6426	1
C12			CAPACITOR, 2.2UF, 35V, TANT.	83-1510-6415	1
C13			CAPACITOR, .01UF	83-1510-1048	1
C14			CAPACITOR, 5600PF	83-1510-5329	1
C15	ARCO	313-M	CAPACITOR, VARIABLE 1000-2155PF	83-1510-5001	1
C16			CAPACITOR, 1500PF	83-1510-5146	1
C17			CAPACITOR, 1500PF	83-1510-5146	1
C18			CAPACITOR, 4.7UF, 20V	83-1510-6438	1
C23			CAPACITOR, 220UV, 6V	83-1510-6445	1
C24			CAPACITOR, 6.8UF, 35V	83-1510-6420	1
C25			CAPACITOR, 56UF, 6V	83-1510-6439	1
C26			CAPACITOR, 56UF, 6V	83-1510-6439	1
CR2			DIODE, 1N4004	83-1530-0151	1
CR5			DIODE, 1N4004	83-1530-0151	1

MG7 REM 8-72

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3M Mincom Division (MINNESOTA MINING AND MANUFACTURING CO.)	PARTS LIST	12578 CODE IDENT	PL 67-25-00 SHEET 2 OF 5	K REV
	TITLE POWER SUPPLY PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
CR6			DIODE, 1N4004	83-1530-0151	1
CR7			DIODE, 1N4004	83-1530-0151	1
CR8			DIODE, 1N4004	83-1530-0151	1
CR9			DIODE, 1N4004	83-1530-0151	1
CR10			DIODE, 1N914	83-1530-0083	1
CR12			DIODE, 1N914	83-1530-0083	1
CR13			DIODE, 1N4004	83-1530-0151	1
CR14			DIODE, 1N914	83-1530-0083	1
J19	MOLEX	09-18-5031	CONNECTOR	83-1610-1666	1
Q1			TRANSISTOR, 2N3859A	83-1530-2261	1
Q2			TRANSISTOR, 2N2219A	83-1530-2154	1
Q3			TRANSISTOR, 2N2219A	83-1530-2154	1
Q4			TRANSISTOR, 2N3859A	83-1530-2261	1
Q5			TRANSISTOR, 2N2219A	83-1530-2154	1
Q6			TRANSISTOR, 2N3053	83-1530-2180	1
Q7			TRANSISTOR, 2N3638	83-1530-2155	1
Q8			TRANSISTOR, 2N3054	83-1530-2227	1
Q9			TRANSISTOR, 2N3054	83-1530-2227	1
Q10			TRANSISTOR, 2N3859A	83-1530-2261	1
Q11			TRANSISTOR, 2N2219A	83-1530-2154	1
Q12			TRANSISTOR, 2N2219A	83-1530-2154	1
Q13			TRANSISTOR, 2N3054	83-1530-2227	1
Q14			TRANSISTOR, 2N3859A	83-1530-2261	1
Q15			TRANSISTOR, 2N3859A	83-1530-2261	1

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3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-25-00 SHEET 3 OF 5	K REV
	TITLE POWER SUPPLY PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	TY
Q16			TRANSISTOR, 2N3859A	83-1530-2261	1
R1			RESISTOR, 100 OHM	83-1520-7221	1
R2			RESISTOR, 82 OHM, 1W	83-9520-4129	1
R3			RESISTOR, 470 OHM, 1W	83-9520-4087	1
R4			RESISTOR, 470 OHM, 1W	83-9520-4087	1
R5			RESISTOR, 100 OHM	83-1520-7221	1
R6			RESISTOR, 100 OHM	83-1520-7221	1
R7			RESISTOR, 220 OHM	83-1520-7220	1
R8			RESISTOR, 470 OHM, 1W	83-9520-4087	1
R9			RESISTOR, 3K	83-1520-7219	1
R10			RESISTOR, 100 OHM	83-1520-7221	1
R11	BOURNS	3359P-1-103	RESISTOR, VARIABLE, 10K	83-1520-1616	1
R12			RESISTOR, 510 OHM	83-1520-7354	1
R13			RESISTOR, 82 OHM	83-1520-7342	1
R14			RESISTOR, 2K	83-1520-7263	1
R15			RESISTOR, 10K	83-1520-7148	1
R16			RESISTOR, 200 OHM	83-1520-7346	1
R17			RESISTOR, 560 OHM	83-1520-7355	1
R18			RESISTOR, 10K	83-1520-7148	1
R19			RESISTOR, 1.8K	83-1520-7201	1
R20			RESISTOR, 1K	83-1520-7175	1
R21			RESISTOR, 47 OHM, 1W	83-9520-4124	1
R22			RESISTOR, 130 OHM, 2W	83-9520-5086	1
R23			RESISTOR, 130 OHM, 2W	83-9520-5086	1

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3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-25-00 SHEET 4 OF 5	K REV
	TITLE POWER SUPPLY PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R24			RESISTOR, 10 OHM	83-1520-7325	1
R25			RESISTOR, 1.3K	83-1520-0035	1
R26			RESISTOR, VARIABLE, 200 OHM	83-1520-1582	1
R27			RESISTOR, 560 OHM	83-1520-7355	1
R28			RESISTOR, 8.2 OHM	83-9520-3266	1
R29			RESISTOR, 8.2K	83-1520-7369	1
R30			RESISTOR, 8.2K	83-1520-7369	1
R31			RESISTOR, 8.2 OHM	83-9520-3266	1
R32			RESISTOR, 10K	83-1520-7148	1
R33			RESISTOR, 30K	83-1520-7374	1
R34			RESISTOR, 3K	83-1520-7219	1
R35			RESISTOR, 220 OHM	83-1520-7220	1
R36			RESISTOR, 82 OHM	83-1520-7342	1
R37			RESISTOR, 3K OHM	83-1520-7219	1
R38			RESISTOR, 1K OHM	83-1520-7175	
R39			RESISTOR, 51 OHM, 2W	83-9520-5099	1
R40			RESISTOR, 22K	83-1520-7372	1
R41			RESISTOR, 3K	83-1520-7219	1
R42			RESISTOR 620 OHM	83-1520-7356	1
R43			RESISTOR, 4.7K	83-1520-7147	1
R44			RESISTOR, 1K	83-1520-7175	1
R45			RESISTOR, 1.8K	83-1520-7201	1
R46			RESISTOR, 5.1K	83-1520-7142	1
R47			RESISTOR, 20 OHM	83-1520-7328	1

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3M Mincom Division	PARTS LIST	12578 CODE IDENT	PL 67-25-00 SHEET 5 OF 5	K REV
	TITLE POWER SUPPLY PC BOARD ASSEMBLY		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	QTY
R48			RESISTOR, 3K	83-1520-7219	1
R49			RESISTOR, 1.8K	83-1520-7201	1
R50			RESISTOR, 5.1K	83-1520-7142	1
R51			RESISTOR, 20 OHM	83-1520-7328	1
R52			RESISTOR, 2.4K	83-1520-7270	1
R53		41TD2	THERMISTOR, 10K	83-1520-8503	1
R54			RESISTOR, 2.4K	83-1520-7270	1
R55		41TD2	THERMISTOR, 10K	83-1520-8503	1
T1	WOLLENSAK	271-32480	TRANSFORMER,	83-1540-1376	1
U1	RCA	CA3055	INTEGRATED CIRCUIT,	83-1530-8195	1
VR1			ZENER DIODE, 1N4747A	83-1530-0437	1
VR2			ZENER DIODE, 1N4747A	83-1530-0437	1
VR3			ZENER DIODE, 1N754A	83-1530-0097	1
VR5			ZENER DIODE, 1N4748A	83-1530-0438	1
VR6			ZENER DIODE, 1N4748A	83-1530-0438	1
VR7			ZENER DIODE, 1N4734A	83-1530-0431	1
VR8			ZENER DIODE, 1N4734A	83-1530-0431	1
			WIRE, 22 GA WHITE	83-7910-0180	AR
1			PC BD DETAIL (PC3760)		1
2		TY-24M	TYRAP	83-7650-0597	10
3	WOLLENSAK	01172190	SHIELD, XMFR	83-1650-0676	1
4		00000A803	HEATSINK	83-3690-0356	1
5			TRANSISTOR CONVERSION PAD (Q1,4,10,14,15,16)	83-9690-0191	6

3M Mincom Division — 3-M-3 MINNESOTA MINING AND MANUFACTURING CO.	PARTS LIST	12578 CODE IDENT	PL 67-29-00 SHEET 1 OF 1	A REV
	TITLE ACCESSORY KIT		CAT. NO.	

FIND NO.- DESIG	MFG NAME	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CAT. NO.	TY
1		67-30-00	EXTENDER, PC BD, LOGIC AND MONITOR		1
2		67-31-00	EXTENDER, PC BD, SIGNAL ELEC		1
3			MANUAL.	83-5990-1277	2
4		MS3106B24-28S	CONNECTOR	83-1610-0898	1
5		MS3106A24-28PW	CONNECTOR	83-1610-1715	1
6		MS3106A24-28P	CONNECTOR	83-1610-0408	1
7			BOX, PLASTIC BELT CONTAINER	83-1130-0092	1
8		67-29-01	TAG, CAUTION		1
9	THOMAS&BETTS	TY-24M	STRAP, TYRAP	83-7650-0597	1
10		67-29-02	KEY-HEX, ALLEN, MODIFIED	83-3270-1001	1

NATIONAL SECURITY AGENCY
CENTRAL SECURITY SERVICE
FORT GEORGE G. MEADE, MARYLAND 20755-6000

FOIA Case: 60813A
27 May 2010

Mr. James N. England
811 Kenmore Road
Chapel Hill, NC 27514

Dear Mr. England:

This is the final response to your Freedom of Information Act (FOIA) request submitted via the Internet on 9 February 2010, which was received by this office on 16 February 2010, for a document titled, "AN/TNH-21 Recorder-Reproducer Set, Sound, Instruction Manual, National Security Agency, Fort G. Meade, Md., December, 1973". As previously stated in our initial response to you, dated 8 March 2010, since processing fees were minimal, we are not assessing fees for this request. A copy of your request is enclosed.

On 22 February 2010 you were advised during a telephone conversation with a member of my staff that we were unable to locate the 1973 version of the manual. However, we located a 1972 version, and you agreed that version would satisfy your request.

Your request has been processed under the provisions of the FOIA and the 1972 version of the AN/TNH-21 Instruction Manual is enclosed.

Sincerely,

Sally A. Nicholson
for

PAMELA N. PHILLIPS
Chief
FOIA/PA Office

Encls:
a/s

DOCID: 3659597

Jungerheld, James R

From:	webteam nsa.gov
Sent:	Tuesday, February 09, 2010 1:38 PM
To:	FOIANET
Cc:	nick@navy-radio.com
Subject:	England, James - FOIA Request (Web form submission)

Nam : James N England

Email: nick@navy-radio.com

Postal Address: 811 Kenmore Rd.

Postal City: Chapel Hill

P stal State-prov: NC

Zip Code: 27514

Country: United States of America

Home Phone: 919-929-4342

Work Phone: 919-361-2148

R cords Requested:
I am looking for only one document (presumably unclassified) "AN/TNH-21 Recorder-Reproducer Set, Sound, Instruction Manual, National Security Agency, Fort G.Meade, MD, December 1973."

I am restoring one of these recorders and would like to obtain a copy of the instruction manual - the usual sources for old manuals have nothing and the NSA historian suggested a FOIA request. If this will cost me more than $40 please cancel this request. Thank you.