ELI-200

12-Lead Interpretive
Electrocardiographs

SERVICE MANUAL

Mortara

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ELI-200 SPECIFICATIONS

Instrument Type: 12-lead interpretive electrocardiograph

Paper Type: Thermal sensitive, full grid, 215 mm x 75 mm

Recording Technique:Computer controlled Thermal Dot Array (200 dots/inch)

Writer Speeds: 5, 10, 25, 50 mm/sec., computer controlled

Recorder Time Resolution: 1 msec.

Sensitivity: 5, 10, and 20 mm/mV

Multiple Output Formats: User Selectable

Standard Leads Available: I, II, III, aVR, aVL, aVF, V1, V2, V3, V4, V5, V6

Input Channels: Simultaneous acquisition of all classical leads

Input Impedance: 47 megohm, defibrillator protected

Input Dynamic Range: 40 mV

Electrode Offset Tolerance: 320 mVDC

Common Mode Rejection: 130db, minimum, up to 210db with Digital Processing

Patient Leakage Current: Less than 10 microamperes with patient cable connected (meets AAMI standards SCL1278)

Chassis Leakage Current: Less than 100 microamperes (Meets AAMI Standards SCL1278)

Frequency Response: 0.05 to 160 Hz

A/D Conversion: 13 Bits (5 microvolt LSB)

Digital Sampling: 32,000 s/sec/channel, used for pacemaker artifact detection. 500 s/sec/channel, used for recording and analysis

Special Computer Functions: Arm Lead Reversal Detection, Lead-off and/or Artifact Detection, Drift Reduction, AC Interference Rejection

Power: 100-240 VAC 50/60 Hz

Weight: 17 pounds

Dimensions: 14" x 16 1/2" x 4 3/4"

Fuses: 250V 200 ma SLOW-BLOW at 120 VAC (3AG, UL)
250V 200 ma SLOW-BLOW at 240 VAC (5x20 mm, UL)
250V 3 AMP SLOW-BLOW for Battery (3AG, UL)

Design and specifications are subject to change without notice.

1.0 PERFORMANCE TESTING

1.1 Introduction:

This test procedure is based on the factory Quality Assurance Final Test Procedure, but it is not identical, and need not necessarily be performed in the exact order in which the tests are listed. However, the troubleshooting guide in section 2.0 corresponds sequentially to the performance tests as far as the type of trouble symptoms which may be encountered.

Sample traces of tests which include a writer print-out are provided in section 10.0 as an aid for diagnosis of problems. Some of these traces were derived using the 10-Lead Bio-Tek Model ECG-1 Simulator. If a different simulator is used for performance testing the operator must be familiar with the correct waveform output of the type used.

If it is necessary to perform the transmit/receive tests, then another ELI-200 which is fully functional is required. For the direct transmit/receive tests, this unit must be available at the servicing site, along with the proper interconnect cable. For the modem transmit/receive tests, however, the unit used for test may be located at a remote installation.

Leakage tests description and diagrams for class 1 category CF medical equipment are provided in section 11.0. These tests should be performed any time the writer, the circuit board assembly, the AC connector or the AC switch assembly are removed and replaced. Any AAMI and/or IEC approved Leakage tester may be used.

1.2 Equipment Required:

1.2.1 10-Lead Bio-Tek ECG-1 Simulator or Equivalent
1.2.2 Patient Data input shorting plug
1.2.3 Resting Patient Cable with American Marking (P/N 9293-010)
1.2.4 Roll of thermal 8" ECG Paper (P/N 9100-006)
1.2.5 Fully Functional ELI-200 with Baud Rate set at 9600 or 38400 for Direct Transmit/Receive
1.2.6 Test LCD Assembly (P/N 14000-004), for troubleshooting
1.2.7 Test Keyboard, for troubleshooting
1.2.8 Digital Multimeter and test leads, for troubleshooting
1.2.9 Oscilloscope and Probes, for troubleshooting printhead control circuits.

1.3 **Test Equipment Set-Up**:

1.3.1 Connect the ELI-200 to a mains power source (120V or 240V), making sure the 120V/240V switch, located on the rear of the unit, is set for 120V.

1.3.2 Connect the patient cable to the simulator.

1.3.3 Connect the shorting plug to the patient input port.

1.3.4 Install the roll of ECG paper.

1.4 **Initial Set-Up**:

Note: Insure a beep is heard every time a key is pressed during the Performance test.

1.4.1 Turn on the unit's main power switch, located at the rear. The message 'CHARGING' should appear on the LCD. Press the DC On key on the keyboard. The message 'SELF TEST' should appear momentarily on the LCD, followed by the first screen of the configuration parameters, indicating the following:

AC FILTER: 60Hz	STORAGE FORMAT: 2.5s	EX

Illustration 1

1.4.2 Toggle through each of the options and set the default parameters as follows:

AC Filter: 60Hz	Storage Format: 2.5s	press ENTER
Plot Format: INT	Interp Format: REA	press ENTER
Plot Freq: 100Hz	Plot Channels: 3	press ENTER
Units: LB/IN	Date Format: US	press ENTER
Baud Rate: 38400	Auto Delete: OFF	press ENTER
Auto Save: ON	Queueing: Off	press ENTER
Site #: Copies 0 Cart #: Retrieve Serials: 0		press ENTER four times
ID Format: LONG		press ENTER
Rhythm Lead Selection CH1/II, CH2/V1, CH3/V5		press ENTER
Site Name:		press ENTER

Table 1

1.4.3 After the sitename has been entered, the LCD advances to the following menu:

```
CURRENT DATE AND TIME:  00/00/00  00:00
NEW DATE AND TIME:      00/00/00  00:00
```

Illustration 2

1.4.4 Set the current date by entering the numbers in the mm/dd/yy format. Time should be entered using a 24 hour clock value. Then press ENTER to display the following screen:

```
NEW DATE AND TIME:   12/31/88  17:55
```

Illustration 3

1.4.5 Check the date and time for the correct reading, and press ENTER again to start the clock. The LCD returns to the main menu as shown here:

```
eli 200                                   Rate: ???
SPF      25mm/s     10mm/mV     100Hz         ID
```

Illustration 4

1.5 **Noise Test**:

1.5.1 Press the 'mm/mV' key to change the Gain to 20 mm/mV, and connect a shorting plug at the patient input connector.

1.5.2 Press the ECG key. The following screen appears:

```
New Patient?          YES     STAT          REQ
```

Illustration 5

1.5.3 Press YES. The following screen appears:

```
Last name: ▒
```

Illustration 6

1.5.4 Enter letters 'Q' to 'M' (e.g.,q, w, e, r,...) under the Last name; then press ENTER. Only the letters 'Q to Z' will appear on the LCD. Listen for the beep after each key press.

1.5.5 Press ENTER. The following screen appears:

First Name: ▒

Illustration 7

1.5.6 Press "ENTER". The following screen appears:

Patient ID: ▒

Illustration 8

1.5.7 Enter digits '0' to '9' in the Patient identification field, making sure all the digits are displayed on the LCD. Hold the backspace key to erase all the numbers and then enter the serial number from the back of the unit. Press ENTER. All the alpha and numeric keys are now tested.

1.5.8 Continue to press ENTER for Age, Ht(in), Wt(lb), Sex, Race, Medication 1, Medication 2, Location, Room, and Comment. The messages Acquiring ECG, Analyzing ECG, and Saving ECG appear followed by a printout of Trace 1.

1.5.9 Check Trace 1 for noise on all leads. Total peak to peak noise amplitude should not be more than 1.0 mm. Compare this to Sample Trace 1.

1.5.10 Check for drift on the same noise trace, from the start of the trace to the end of the trace. The total drift from time zero to time 10 seconds shall not exceed 1 mm.

1.5.11 Disconnect the shorting plug and connect the Patient Cable and ECG Simulator. Also, press EX to display the main menu.

1.6 **ECG, Keyboard and Cable Test:**

1.6.1 Press the 'mm/mV' key on the Main Menu, to display 20mm/mV.

1.6.2 Press the ECG key. Press NO to the 'New patient?' question.

1.6.3 Acquiring ECG, Analyzing ECG, Saving ECG, appear in sequence on the LCD followed by a printout of Trace 2. To insure that the printhead is aligned properly check the left edge of the 3 calibration pulses for variation of greater than 1 mm from the lower left edge of the top pulse to the lower left edge of the bottom pulse. Check the height of the calibration pulse. At 20mm/mV, it should be equal to exactly 4 large boxes. Specifically, check the ID number to see that it corresponds to the numbers entered. Look at the last name and first name to see that all of the letters are entered and check the HR value to see that it corresponds to the value set on the simulator (60 BPM); then check the ECG waveforms for all 12 leads against the Sample Trace 2. Noise between each complex should not exceed 1.5mm (1-1/2 small red box) from peak to peak amplitude. Check for correct date and time on the lower Left corner and check for the Printing Sequence number and Software version (i.e., v10/90) on the lower right corner. Do not tear off printout. The LCD displays the following:

```
Name:                                   ID:
CPY   3CH   25mm/s   10mm/mV  100Hz   INT   EX
```

Illustration 9

1.6.4 Press EX. The Main Menu appears.

1.7 **Rhythm Test**:

1.7.1 Press the RHY key. The following screen appears:

```
New Patient?          YES             STAT
```

Illustration 10

1.7.2 Press STAT. The rhythm strip starts printing leads II-V1-V5 and the following screen appears:

```
II-VI-V5                              Rate: 68
GRP        25mm/s    10mm/mV    100Hz
```

Illlustration 11

1.7.3 Press GRP after 2 QRS complexes are printed to toggle through the lead groups: I-II-III, aVR-aVL-aVF, V1-V2-V3 and V4-V5-V6. Look for noise. Watch for changing faded areas on the printout indicating a need for writer adjustment. Compare this to Sample Trace 3.

1.7.4 Press the 'mm/s' key and print 2 complexes at 50mm/s. Press the key again and print 3 complexes at 5mm/s.

1.7.5 Press the 'Hz' key and print 3 complexes at 40Hz.

1.7.6 Press the 'mm/mV' key and print 3 complexes at 20mm/mV.

1.7.7 Press STOP.

1.8 **Lead Fail Test**:

1.8.1 With the patient cable connected to the ELI-200, remove one lead at a time from the simulator and check Lead Fail messages on the Main Menu as follows:

Lead Removed	Message on LCD
LL	LL
RL	RL/RA/LA/LL/V?
LA	LA
RA	RL/RA/LA/LL/V?
V1	V1
V2	V2
V3	V3
V4	V4
V5	V5
V6	V6

Table 2

Note: If the two Limb Leads (LL and LA) are disconnected at the same time, then the message "RL/RA/LA/LL/V?" will appear.

1.9 **Directory Test**:

1.9.1 Press SPF. The following screen appears:

	LIST	BATCH				
DIR	DIR	PLT	RTV	RCV	REQ	EX

Illustration 12

1.9.2 Press LIST DIR to receive Trace 4 of the directory.

1.9.3 Press DIR. The following screen appears:

Name: Quertyuiopasclfghjkl		ID: Units S/N	
ERASE	LIST	SELECT	EX

Illustration 13

The demographic information of the most recently acquired ECG will automatically be displayed.

1.10 **Transmit/Receive Tests**:

1.10.0 Connect the unit under test to a fully functional ELI-200 via the serial ports using the direct Transmit/Receive cable, and set both units to the same baud rate.

1.10.1 Power up the functional unit from the keyboard and press "SPF". The following screen appears:

	LIST	BATCH					
DIR	DIR		PLT	RTV	RCV	REQ	EX

Illustration 14

1.10.2 Press "RCV". The following screen appears:

```
Receive ready
                                  EX
```

Illustration 15

1.10.3 The functional unit is now ready to receive ECGs.

1.10.4 In order to transmit with the unit under test, it is necessary to have acquired an ECG using the simulator. Acquire an ECG and enter the unit's serial no. as the patient ID. Then, from the directory, press the "XMT" key displayed under this latest ECG acquired. The following screen appears:

```
Transmit in progress
ID: Unit's S/N
```

Illustration 16

1.10.5 On the functional (Receiving) unit, press the "EX" key, then the DIR softkey. Next, press "DIR". The patient name of the last acquired ECG followed by the serial number of the unit under test should appear on the top line of the LCD.

1.10.6 DIRECT RECEIVE: On the unit under test, select "SPF" from the Main Menu. Then, press the "RCV" key. The LCD should display "RECEIVE READY".

1.10.7 On the functional unit, press the "XMT" key from the directory. The previously received ECG will be transmitted back to the unit under test.

1.10.8 On the unit under test, select "SPF" from the Main Menu. Then, select "LIST DIR" from the next screen. A printout of the directory will show the originally transmitted and then re-received ECG with an "X" under the "XMT" column. Compare this to Sample Trace 4.

1.10.9 Now delete each record on the unit under test. This is done by selecting each record individually, then pressing the DEL key . (This key label will change to RCR when it has been pressed.) Using the arrow keys, select each record and repeat the process until all records of the directory are deleted. Now press LIST DIR to obtain a printout of the directory. You will now see an "X" in the column labeled DEL.

1.10.10 MODEM TRANSMISSION: A fully functional unit must be available, either at the same location or at an outside location to do this test. Connect the unit under test to a phone line.

1.10.11 Press "ALT" and "SPF" to access the "CONF/CLOCK" screen. Press "CONF" and "ENTER" till the BAUD RATE selection field appears. Press "38400" and the baud rate should switch to "1200". Press "ENTER" twice and set the phone number of the unit being transmitted to by using the numeric keys.

Note: If a number is necessary to access a dial tone for an outside line, separate the numbers by the uppercase letter "W". (i.e. 9W3541600). Press "ENTER" until the "CONF/CLOCK" screen appears; then, press the "EX" key.

1.10.12 Press "SPF" from the Main Menu. Press "DIR". From the directory printout, select an ECG that has not been transmitted from the unit under test by pressing the appropriate arrow key on the display to access that record.

1.10.13 Connect the functional (Receiving) unit to a phone line and power up from the keyboard.

1.10.14 Press "ALT" and "SPF" to access the "CONF/CLOCK" screen. Press "CONF" and "ENTER" till the BAUD RATE selection field appears. Press "38400" and the baud rate should switch to "1200". Press "ENTER" twice and set the phone number of the unit under test. Press the "EX" key twice to return to the Main Menu.

1.10.15 Press the "SPF" key, then press the "RCV" key. The LCD should display "RECEIVE READY".

1.10.16 On the unit under test, press the "XMT" key to transmit the selected ECG. Listen for the dial tone and the phone number being dialed. Observe the receiving unit. The message: "RECEIVING ECG" should appear on the LCD.

1.10.17 After the message: "RECEIVE READY" appears on the LCD of the receiving unit, press the "STOP" key of the unit under test, followed by "SPF", then "RCV" to allow the unit under test to receive an ECG.

1.10.18 MODEM RECEIVE: On the functional unit, press the "STOP" key, followed by "SPF", then "DIR." Next, press SELECT twice. Press the "XMT" key to send the ECG to the unit under test. Listen for a dial tone, followed by the phone number being dialed. On the unit under test, observe the LCD displaying the message: "RECEIVING ECG".

1.10.19 When the message: "RECEIVE READY" appears on the unit under test, press the "STOP" key on the functional unit and turn it off.

1.10.20 Press the "STOP" key on the unit under test. Press the "SPF" key, followed by "LIST DIR". All ECGs that have been transmitted should have an "X" under the "XMT" column.

1.10.21 Reprogram the original phone number and baud rate as described in step 1.10.11. Remove power from both units.

1.11 **Writer Self Test:**

Note: The SELF TEST is a memory destructive test, which will erase the entire memory, since all RAM locations are subject to a write-read test.

1.11.0 Power up the unit from the keyboard and install a roll of thermal paper into the writer.

1.11.1 Press "ALT" and "0" simultaneously to access the "CONF" and "CLOCK" menu. Press "ALT" and "T" simultaneously to initiate the self test. The LCD will display:

```
SELF TESTS WILL ERASE DIRECTORY
     CONTINUE                        EX
```

Illustration 17

Press CONTINUE. The LCD will now display:

```
eli 200
SELF TEST MODE                              080000
```

Illustration 18

The number displayed in the lower right corner of the LCD corresponds to the end address of memory. (Normal size memory will be indicated by 080000; expanded memory is indicated by 140000).

If a faulty memory location is detected, the address number of that location will be displayed in the center of the lower LCD line.

After the end address of memory is displayed, a SELF TEST printout is generated.

The contrast test consists of a sequence of 6 squares having closely spaced vertical lines. In each square the lines should be placed further apart so that distinct lines begin to be visible in the third square when a system is printing at properly adjusted contrast.

The cal pulse at the bottom of the trace and the ramp should be of even darkness and there should be no gaps or light spots in the printing. Measure the line at the end of the printout in order to ascertain if the paper drive motor speed is within tolerance. It should be 100mm +/- 2mm. Compare this to Sample Trace 6.

Also compare the characters printed at the top of the printout, consisting of the message AMPLIFIER OK, date and time, and a list of alphanumeric characters (including special characters).

1.11.2 This concludes the writer self test. If the unit is left in the test mode, it will automatically generate a SELF TEST printout once an hour. During this time, no keys pressed except for the ON/OFF key will be acknowledged. The unit will beep when a key is pressed, but will not respond in the normal way. In order to leave the test mode, the unit must be turned off.

This concludes the Performance Tests.

2.0 TROUBLESHOOTING

2.1 Equipment Required:

See "Performance Testing," Section 1.0

Note: An Oscilloscope may be necessary to isolate between a faulty printhead or the circuit board.

2.2 Introduction:

Since repair of the ELI-200 is limited to replacement of subassemblies, including the entire circuit board, the troubleshooting guide does not extend to the circuit board component level. However, a hardware description, schematics, and an assembly drawing are provided in other parts of this manual in case of on-site modifications or emergency repairs.

In order to avoid confusion with regard to differences in display menus or messages, a current set of software should be installed in the circuit board during testing. Also, remove the battery fuse during any disassembly necessary for servicing.

2.3 Fault Isolation Table:

TROUBLE SYMPTOMS		DIAGNOSIS
2.3.1	AC On - Blank LCD, no pixels illuminated.	See Par. 2.4
2.3.2	AC On - Bar across top of LCD or faint illumination of pixels.	See Par. 2.5
2.3.3	AC On - "Charging" message appears but characters are missing with or without spaces between.	See Par. 2.5
2.3.4	AC On - Any other message is displayed other than "charging."	See Par. 2.5
2.3.5	DC On - "Battery Low" message appears on display.	See Par. 2.6
2.3.6	DC On - No response when key is pressed.	See Par. 2.7
2.3.7	DC On - Bar across top of LCD or faint illumination of pixels (unit stays on).	See Par. 2.5

2.3 **Fault Isolation Table (Continued):**

TROUBLE SYMPTOMS		DIAGNOSIS
2.3.8	DC On - Bar across top of LCD or faint illumination of pixels (unit shuts off).	Replace circuit board
2.3.9	Self test fail, error message, or unit locks up in any display mode.	Replace circuit board
2.3.10	Cannot access clock menu or change date and time.	Replace circuit board
2.3.11	Noise/drift test failure.	Replace circuit board
2.3.12	Keyboard test - No response to key press, no audio.	Install test key board. If it still fails, replace circuit board.
2.3.13	Keyboard test - Key press response on display, but no audio.	See Par. 2.8
2.3.14	ECG test - Will not recognize leads or excessive noise.	Replace circuit board
2.3.15	ECG test - Communication error.	Replace circuit board
2.3.16	ECG test - Locks up or will not complete analysis (no interpretation print-out).	Replace circuit board
2.3.17	Won't save ECG.	Directory full? Replace circuit board.
2.3.18	Fails calibration pulse alignment.	See 3.0, removal and replacement of printhead. Check writer motor.
2.3.19	Writer test - Printing too light or too dark, or uneven.	See Par. 2.9
2.3.20	Writer test - Gaps in printing, missing dots, or no printing at all.	See Par. 2.10

2.3 Fault Isolation Table (Continued):

TROUBLE SYMPTOMS	DIAGNOSIS
2.3.21 Writer test - Unit shuts down or motor drive stops when trying to print.	See Par. 2.10
2.3.22 Writer test - No motor drive.	See Par. 2.11
2.3.23 Writer test - Motor drive erratic or noisy; paper speed out of tolerance.	See Par. 2.11
2.3.24 Lead fail test - No fail indication or constant fail indication.	Check Patient Cable for corrosion or dried gel deposits. Check tightness of alligator clips; then replace circuit board.
2.3.25 Fails direct receive or transmit tests.	Check unit-to-unit cable. Check baud rates of each unit for matching rates; then replace circuit board.
2.3.26 Fails modem receive or transmit test.	Check phone line connections (multiline? dedicated line?), then replace circuit board.
2.3.27 No dial tone or touch-tone audio during modem tests.	See Par. 2.12

2.4 AC On - Blank LCD; No Pixels Illuminated:

2.4.0 Check both line fuses for continuity and verify that the voltage selector is at the proper setting for the line voltage.

2.4.1 Disconnect the violet wire from J5 and the blue wire from J6. Connect a multimeter set up for AC volts across the 2 wires. Turn on the AC power switch. The multimeter should read the line voltage. If it does not, check across the AC power switch terminals that the blue and violet wires connect to, then check across the black and red/yellow wires that plug into the other set of switch terminals. If the voltage is present at the black and red/yellow wires, replace the switch. If not, then replace the AC connector assembly. If the voltage is present across the blue and violet wires, continue.

2.4.2 Connect the negative lead of the multimeter. Set up for DC volts to the negative end of C24. Connect the positive lead first to the anode of D13, then D8. Approximately + 20 VDC should be present. If not, replace the circuit board.

2.4.3 Connect the positive lead of the meter to the cathode of D17. + 5 VDC +/-0.2 VDC should be present. If not, replace the circuit board.

2.4.4 Connect the meter to U29 pin 6. The voltage at that pin should be less than + 0.75 VDC. If not, then replace the circuit board. Otherwise, continue.

2.4.5 Remove power from the unit. Connect the test LCD to J15. Turn on the AC power again and verify whether or not the problem is the LCD or the circuit board. Replace the LCD or the circuit board.

2.5 **AC On - Bar Across Top of LCD or Faint Illumination of Pixels**:

2.5.0 With a multimeter set up for DC Volts, measure between the negative end of C24 (neg. lead) and the cathode of D17 (pos. lead). The voltage should be +5.0 +/-0.2 VDC. If not, then replace the circuit board.

2.5.1 Move the meter negative lead to isolated analog ground (right side of spark gap RL). Measure the voltage at the positive end of C100. It should be +5.0 +/-0.2 VDC. If not, then replace the circuit board.

2.5.2 Remove power from the unit. Connect the test LCD to J15, and turn on the AC power switch. If the "charging" message comes up, replace the unit's LCD assembly. If not, replace the circuit board.

2.6 **DC On - "Battery Low" Message Appears on Display**:

2.6.0 With a multimeter set up for DC Volts, measure across each individual set of battery terminals. The voltage should be +6.0 VDC minimum. If it is between +4.0 and +6.0 VDC, put the unit on charge, otherwise replace the low battery.

This step should be done under load.

2.6.1 Connect the negative lead from the meter to the negative end of C24 and positive lead to the cathode of D8. The voltage should be +18.0 VDC minimum. Disconnect one of the battery leads and connect a DC ammeter in series. The keep-alive current should be less than 300 µA. If it is greater, replace the circuit board.

Note: If the batteries are disconnected, any ECGS stored in memory or any special set-up parameters, including date and time, will be lost.

2.6.2 Press the keyboard DC On key. If the unit comes up in the set-up menu, exit to Main Menu. Check for the "battery low" message.

2.6.3 With a multimeter, measure the DC voltage at U14 pin 8. It should be approximately 8.6 VDC lower than the battery voltage. Measure the voltage at U14 pin 3. It should be about 0.08 times the battery voltage. Measure the voltage at U29 pin 4. It should be OV, if the batteries are above +16.0 VDC (measured across all three), and greater than +4 VDC if they are below +16.0 VDC. If the batteries are charged and any of these tests fail, replace the circuit board.

2.7 DC On - No Response When DC On Key is Pressed:

2.7.0 Refer to steps 7.3.0 and 7.3.1 for battery testing and keep-alive current measurement. If the batteries check out good and the current is below 300 µA, check the voltage at the cathode of D17. It should be approximately +4.4 VDC. Press the DC on Key on the keyboard. The voltage should rise to +5.0 VDC +/-0.2 VDC. If it does, but nothing is visible on the display, then substitute the test LCD to verify whether or not the LCD in the unit is working. If the test LCD remains blank, try pressing some of the keyboard keys and listen for the key click from the speaker.

2.7.1 If the +5V does not turn on, the LCD is blank, or if there is no key click, then disconnect the keyboard at J12 and plug in a test keyboard. If this fails, replace the Circuit Board. Otherwise, replace the Unit's Keyboard.

2.8 **Keyboard Test-Key Press Response on Display but No Audio:**

2.8.0 Disconnect the speaker assembly from the circuit board. Connect an AC Voltmeter across the speaker terminals on the circuit board and hold down one of the alphanumeric keys on the keyboard. The voltage should be between 3 and 4 VAC RMS. If it is not, replace the circuit board. Otherwise, replace the speaker assembly, as explained in section 3.11.

2.9 **Writer Test-Printing Too Light or Too Dark, or Uneven:**

2.9.0 The printing intensity is affected by three different factors:

A. Available power to the head (batteries)
B. The print strobe adjustment (R55) or component tolerances in the strobe circuit.
C. Mechanical alignment.

2.9.1 The print strobe duty cycle is factory adjusted on the circuit board using R55. The period of the strobe is approximately 1 MS. At 50 MM/Sec., the on time (active low) should be about 800 µsec.; at all other speeds it is 600 to 650 µsec. This can be observed if an oscilloscope is available by probing U13 pin 12.

2.9.2 Install a roll of thermal ECG paper into the writer. The unit should be powered up in the Main Menu. Select 50 MM/Sec. paper speed and 20 MM/MV sensitivity. Press "RHY," then "Stat." Examine the calibration pulses printed in all 3 channels. The rising and falling edges as well as the top should be smooth lines with no fading or strings of individual dots. They should also not be extremely dark or thick (uneven thickness or scorch marks). To increase darkness, adjust R55 1 or 2 turns at a time counterclockwise. Adjust clockwise to lighten printing. If the adjustment has no effect, check the battery voltage, then replace the circuit board.

2.9.3 For uneven printing, power up the unit and select the Main Menu. Simultaneously press "ALT" and "0," then "ALT" and "T." The writer selftest is initiated by pressing CONTINUE. Examine the ramp on the printout. It should be a smooth, 45 degree diagonal line which extends across the entire grid portion of the paper, without any gaps or uneven darkness areas. If there is a problem, check that all 4 of the printhead mounting screws are tightened evenly and that the front of the printhead is flush with the front of the mounting plate. If the problem persists, possible causes could be:

A. The printhead itself.
B. The platen or the mechanical alignment of the writer chassis (replace the entire writer).

Before replacing the entire writer, however, try varying the tightness of the Writer mounting screws on the underside of the tray individually. Replace printhead mounting screws with shoulder screws, Mortara part 6001-002-01.

2.10 Writer Test - Gaps in Printing, Missing Dots, or No Printing at All:

2.10.0 Refer to step 2.9.3 in order to check printing quality. If there are sizeable gaps in the ramp or no printing all, check the head power cable (P/N 25020-017) and the head signal cable (P/N 25018-014). These cables plug in between the circuit board and the thermal printhead. If the cables have no shorts, opens, or damaged connectors, then the problem could be caused equally by either the printhead or the circuit board. If there are individual dots missing, however, the printhead is at fault.

2.10.1 In order to isolate the problem to the printhead or the circuit board, an oscilloscope is necessary. First, check the batteries to verify that the combined voltage is greater than +18 VDC underload. Then, check both ends of R48 with a multimeter and verify that VH is present (greater than +18 VDC) when the writer is running. Next, using an oscilloscope, check U12 pins 12 through 18. Refer to the portion of the schematic that shows the printhead drive circuitry. U12 pins 12, 13, 14 (STB 1* - STB7*) should be varying duty cycle pulses of approximately 1 MS period at 25 MM/Sec. paper speed. U25 pin 15 (clock) should be bursts of 3MHZ clock pulses with the interval between bursts varying at the same rate as the strobes. U12 pin 16 (latch *) should be very narrow negative going pulses (less than 200 NSec.) spaced at wide intervals. U12 pin 17 (data) should be positive going pulses varying in interval. U12 pin 18 (enable) should go from 0V to +5V as soon as the writer starts running. If all these signals are present, the problem is the printhead or the ribbon cable. If not, replace the circuit board.

2.11 Writer Test - No Motor Drive:

2.11.0 This problem could be caused equally by either the writer or the circuit board. First, install a roll of thermal paper and close the writer lid. Gently pull on the protruding strip of paper and verify that there is sufficient tension and no slipping. The drive gears should turn smoothly. Do not pull too hard as this may damage the motor.

2.11.1 Measure the combined battery voltage. It should be greater than +18 VDC. Next, connect a voltmeter between 10Ω2W resistor IN L1 position side nearest Q4 marking on PCB (the transistor lead closest to J12) and return (the negative end of C14).

2.11.2 Power up the unit from the keyboard and select the Main Menu. Select 5 MM/Sec. paper speed. Press "RHY," then "Stat." Sequence through all of the paper speeds and note the DC voltage readings. They should be as follows:

Approximately +2.5 VDC to +5.0 VDC
at 5 MM/Sec.
" " +3.5 VDC to +5.5 VDC
at 10 MM/Sec
" " +6.0 VDC to +8.0 VDC
at 25 MM/Sec
" " +11.0 VDC to +13.0 VDC
at 50 MM/Sec

If the voltages are not present, replace the circuit board. If they are too high (+10 to +18 VDC at 5 MM/Sec.) the problem is most likely an open wire in the cable or the motor. Replace the writer motor assembly. If the voltages are normal, replace the writer motor assembly.

2.12 Modem Test - No Dial-Tone or Touch-Tone Audio:

2.12.0 Perform the modem test as described in the "minimum performance testing" section and refer to step 2.8.0 under "keyboard test - no audio" to fault isolate between the speaker and the circuit board.

3.0 SERVICE AND MAINTENANCE

Caution: Remove battery fuse at right rear of unit before attempting any disassembly. Also, removing the fuse at the right rear of the unit will cause the configuration parameters to reset to the default setting. In addition, all ECGs stored in memory will be lost.

3.1 Overview:

This section provides servicing and maintenance instructions for the ELI 200 interpretive electrocardiograph. Subsequent parts of this section are disassembly, inspection techniques, cleaning techniques, and installation.

3.2 Tools and Materials:

The following is a list of recommended materials, tools and chemicals to have available for maintenance.

3.3 List of Cleaning Materials:

3.3.0 Vacuum cleaner.

3.3.1 Nonmetallic, softbristle brush.

3.3.2 Clean, lint-free cloth.

3.3.3 **DRY,** low pressure compressed air (30 psi).

3.3.4 Cleaning solvents (isopropyl alcohol, 99% pure).

3.4 List of Repair Materials:

3.4.0 Screwdriver, philips #2.

3.4.1 Screwdriver, flatblade.

3.4.2 Nutdriver set, standard.

3.4.3 Multimeter.

3.4.4 O Scope.

Note: The equipment and solvent mentioned above are standard shop commodities that are available from commercial sources. If in the performance of normal maintenance or repair, the PCB assembly, AC connector assembly, AC switch assembly, or writer assembly are removed or replaced, a leakage test should be performed. See section 11.

3.5 Cleaning and Inspecting Techniques:

This section contains instructions for periodic cleaning and inspection of the instrument as preventative maintenance measures. It also contains specific cleaning procedures to be conducted after disassembly. Parts having identical cleaning procedures are grouped under common headings. No special tools are required.

3.5.0 Interior cleaning.

Note: Ventilate work area thoroughly when using solvents. Observe manufacturers' warnings on solvent containers with regard to personnel safety and emergency first aid. Be sure first aid equipment is available before using chemicals. Observe shop safety and fire precautions. Ventilate all work areas where solvents are used. Store solvents and solvent-soaked rags in approved containers. Refer to manufactures' instructions on containers for recommended fire-fighting procedures, and make sure that fire-fighting equipment is available.

3.5.1 Magnetic cleaning.

Clean transformers and inductors with a dry, nonmetallic, softbristle brush.

Note: Do not use solvents to clean transformers or inductors. The chemical action of solvents may remove the varnish from the wire coils, rendering the component useless. The solvent also neutralizes the adhesive of the cover tape, resulting in eventual tape separation from the windings.

3.5.2 Printed circuit board cleaning.

Note: The printed circuit board assemblies in the ELI-200 system contain static sensitive devices. Use special handling procedures.

Clean assembled parts with a vacuum cleaner or low pressure compressed air (30 psi).

Prior to soldering, clean surfaces with a nonmetallic, soft bristle brush dipped in solvent.

Dry with low pressure compressed air.

Take care when cleaning printed circuit boards that wires or component leads are not bent back and forth in such a manner as to weaken them and cause them to eventually break.

3.5.3 Metallic and plastic parts cleaning.

Brush all surfaces and parts with a nonmetallic, soft bristle brush.

Wipe metal surfaces with soft, nonabrasive cloth dampened with isopropyl alcohol.

Note: Do not wipe over surfaces of nameplates or labels with abrasive cleaners or materials, as this will eventually wear away the nameplate information. Do not use solvents to clean plastic parts.

Dry surfaces with clean cloth.

Wipe surfaces of nameplates and labels with clean dry cloth.

3.5.4 Exterior cleaning.

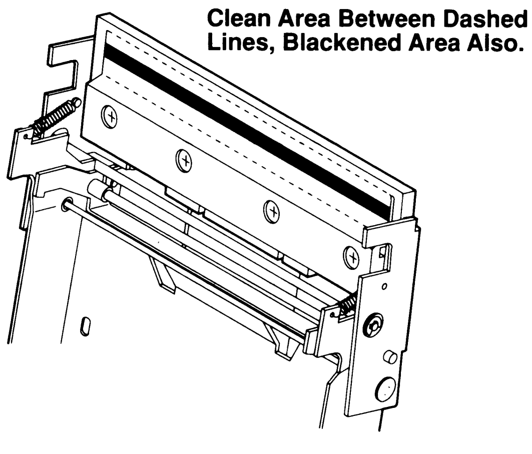
Use a damp cloth to clean external covers and the line cord. Do not use alcohol, solvents, or cleaning solutions. These cleaning agents may damage the surfaces of the instrument.

3.5.5 Printhead cleaning.

Open the writer cover as explained in section 3.7.

Apply isopropyl alcohol to a clean cloth, and wipe the writer printhead until all foreign matter is removed.

After cleaning is completed, inspect the unit using the techniques described in section 3.5.



After the inspection is complete, install the cover as explained in section 3.7.

3.5.6 Inspection of writer assembly harness.

Remove the cover, as explained in section 3.7.

Using the inspection techniques described in section 3.5.9, inspect the wire harness.

If no defects are found, install the cover and restore the unit to service. If a defect is found, refer to the following step.

If a defect is found in the cable, replace it with a new cable.

Note: The removal of the writer assembly as explained in section 3.7 may be necessary to replace the cable.

After a cable is replaced, install the cover as explained in section 3.7.

3.5.7 Printhead adjustment.

Refer to section 2.9.1 and 2.9.2.

3.5.8 Exterior inspection.

Visually inspect the entire instrument for wear, maintenance damage, corrosion, deterioration, and damage resulting from dropping.

3.5.9 Interior visual inspection.

Check components, wiring, solder joints and printed circuit conductor patterns.

Check all connectors for loose, bent or corroded contact points.

Check wires, harnesses and cables for signs of wear or deterioration.

Inspect sleeving and tubing for proper installation or evidence of damage.

Inspect components and their leads for security of mounting, deterioration or leakage.

Check terminals and connections for proper installation, failed soldering, and loss or wear.

Inspect PCB surfaces for charring, cracking or brittleness.

Note: Some degree of discoloration of the PCB surface may be expected due to continued exposure to the operating temperatures of some of the components.

Check the identification nameplate and other decals for legibility.

Inspect chassis, covers and brackets for warping, bending, surface damage, or missing captive hardware.

Check all screws and nuts for tightness or signs of stripped or crossed threads.

Check for damaged traces on PCBs. Look for lifted conductors and inspect for breaks, scratches, nicks, or pin holes.

Check for any other form of mechanical damage which may indicate a failure.

If, during the process of normal maintenance or repair, the PCB assembly, AC connector assembly, AC switch assembly, or writer assembly are removed and replaced, perform the leakage test as describe in Section 11.

3.6 Preventative Maintenance Schedule:

Maintenance to be Performed	Period	Notes
Clean and inspect unit.	6 mo.	Do every 3 mo. if unit is in heavy use.
Printhead cleaning.	80 hrs.	Do every 40 hrs. if unit is being used with ELI-XR.
Check printhead wire harness.	160 hrs.	-
Printhead adjustment.	-	Adjust printhead when print head is replaced.
Leakage tests.	-	-

Table 3

3.7 Cover Assembly Removal/Installation:

3.7.0 Open the writer cover and remove four screws that hold it on. Set the writer cover aside.

3.7.1 Remove the six panhead screws which attach the unit cover to the base of the unit. They are located on both sides of the unit.

3.7.2 Lift the cover assembly gently and tilt it towards the left side of the unit as seen from the front. Set the cover assembly on its left edge. Unplug the two keyboard cables (J19 of PCB) and the LCD cable (J15 of PCB).

Note: Position all cables to facilitate error free assembly of the unit.

3.7.3 Set the cover assembly aside with the top facing up. Reassemble in reverse order.

3.8 Writer Removal/Installation:

3.8.0 Unplug the printhead data cable (J13 of PCB), the paper drive motor cable (J12 of PCB), and the printhead data cable (J11 of PCB).

3.8.1 Before removing the writer assembly, scribe locating marks on the base floor (on all four corners). This will accurately align the writer upon reassembly.

3.8.2 Remove the four writer mounting screws from the underside of the base. The writer will now lift out of the base. Reassemble in reverse order.

3.9 Printhead Removal/Installation:

3.9.0 Remove the four printhead mounting screws. Slide the printhead out of the front of writer. Gently disconnect the cables from the head by pulling on the plastic housings (not the wires).

3.9.1 Reassemble in reverse order.

Note: When installing a new printhead, make sure that the front edge of the printhead lines up flush with the front of the lid before tightening the mounting screws. After the unit is reassembled, run the writer self test as described in section 1.11 of the performance tests. It may be necessary to loosen the screws and skew the printhead slightly at the top or bottom in order to get even printing across the entire trace.

3.10 **Paper Drive Motor Removal/Installation**:

3.10.0 Using a 1.3 mm allen wrench, loosen the set screw on the motor gear and slide the gear off the shaft.

3.10.1 Remove the two mounting screws which hold the motor to the chassis.

3.10.2 Remove the motor. Reassemble in reverse order.

Note: There are two different sets of threaded holes for the mounting screws. One is metric and one is English. Try the mounting screws on the motor first before attempting to install the motor.

3.11 **Printed Circuit Board Assembly Removal/Installation**:

3.11.0 Disconnect cable J15 and J19 from the printed circuit board. Set the cover assembly aside.

3.11.1 Remove the battery fuse F1 from the fuse holder located at the back of the printed circuit board.

Note: Removal of the battery fuse F1will cause a loss of all ECGs stored in memory or any special setup parameters, including date and time.

3.11.2 Unplug the cables located at the following jacks: J3, J4, J11, J12, J13, and J14.

3.11.3 Unplug the speaker assembly cable from SP1, the AC switch from J5 and J6, and the AC connector assembly from J7, J8, J9, and J10.

To reassemble all the removed cables refer to section 6.1, Interconnection List, and to Sheet 7 of the Schematics.

3.11.4 Remove the nine screws which mount the PC board to the chassis. Reassemble in the reverse order.

Note: When installing a new board, do not replace the battery fuse F1 until the cables and batteries have been connected to the board.

3.12 **Keyboard Removal/Installation**:

3.12.0 Remove the cover as explained in section 3.7.

3.12.1 Unplug the keyboard from J19 of the circuit. Note the position of the connectors.

3.12.2 Check the underside of the cover for four or five keyboard mounting nuts. If none are found, remove the keyboard following the steps in section 3.12.3. If mounting nuts are found, remove the keyboard following the steps in 3.12.4.

3.12.3 Pry one corner of the keyboard loose starting from the left side of the cover assembly, and lift it up to separate the keyboard from the cover.

3.12.4 Use a 5.5mm nut driver to remove the nuts from the threaded studs in the keyboard.

3.12.5 Remove the two connectors through the slot in the cover assembly.

3.12.6 Remove any large deposits of glue from the cover assembly, if needed.

3.12.7 When installing a new keyboard, check the LCD window for dust and lint. Clean with a soft cloth.

Note: Before reassembling in reverse order, contact the manufacturer to ensure the proper keyboard replacement part number.

3.12.8 When connecting plug J19 to the printed circuit board, note that the marking on flex circuit pin 1 and pin 9 is on the print circuit board and the flex circuit.

3.13 **LCD Removal/Installation**:

3.13.0 Unplug the LCD ribbon cable from the LCD assembly.

3.13.1 Remove the four screws which mount the LCD assembly to the inside of the cover.

3.13.2 Remove the LCD assembly. Reassemble in reverse order.

Note: The connector on cable for the LCD lead has one smooth side and one side with the key tab. When the connector is installed, the key tab side of the connector is toward the cover. The smooth side is toward the PC board.

3.13.3 When installing a new LCD assembly, inspect it first for scratches, smudges, lint, or dust. Clean with a soft cloth.

3.14 **AC Connector Assembly Removal/Inspection**:

3.14.0 Disconnect the AC connector assembly leads from

J7, J8, J9, and J10 of the circuit board.

3.14.1 Disconnect the red/yellow and black leads from the AC switch assembly. Remove the nut and washer attaching the ground wire to the safety ground lug.

3.14.2 Using a common screwdriver, push down on the locking tabs at the top of the AC connector assembly one at a time while pushing the assembly outwards from the rear panel. Then, do the same thing with the locking tabs at the bottom of the assembly.

3.14.3 Pull the leads through the panel. When reassembling, push the assembly into the panel until it snaps in place.

3.15 **AC Switch Removal/Installation**:

3.15.0 Disconnect the AC switch leads from J5 and J6 of the circuit board.

3.15.1 Disconnect the red/yellow and black leads from the switch.

3.15.2 Using a common screwdriver, push down on the locking tabs at the top of the switch one at a time while pushing the switch outwards from the side of the chassis. Then, do the same thing with the locking tabs at the bottom of the switch.

3.15.3 Pull the leads through the hole. When reassembling, push the switch into the hole until it snaps into place.

3.16 **Batteries Removal/Installation**:

Note: Removing the batteries or the fuse will cause a complete loss of stored memory.

3.16.0 Make sure that the battery fuse has been removed from F1 of the circuit board.

3.16.1 Disconnect the battery leads from J3 and J13 of the circuit board.

3.16.2 Remove the four screws which attach the battery bracket to the base of the unit. Remove the battery bracket.

3.16.3 Disconnect the battery interconnect leads. Remove the batteries.

Note: Be sure that the polarity of the batteries is correct. In addition, the batteries should be in series for a total voltage of 18 v or more.

3.16.4 Reassemble in reverse order.

Note: Use only Mortara replacement batteries, Mortara part #4800-003, 6 v, DC, 1 amp, gel cell.

3.17 **Speaker Removal/Installation**:

3.17.0 Disconnect the speaker (SP1) from the circuit board.

Note: A determination must be made as to the type of mounting method. If the speaker is mounted using RTV, go to section 3.17.2. If the speaker is held in place by a metal bracket, go to section 3.17.3.

3.17.1 Remove the speaker from the chassis as follows:

3.17.2 Pry the speaker loose from the bottom of the chassis, and remove the speaker.

3.17.3 Loosen the mounting bracket using a philips screwdriver. Move the mounting bracket to the side and remove the speaker.

Note: Remove battery fuse F1 prior to loosening the bracket. This will cause a loss of memory and any stored data. The writer assembly may need to be moved. If so, follow the writer assembly removal procedure, section 3.8

3.17.4 Install the new speaker, using one of the following methods.

3.17.5 Apply RTV or silicone adhesive compound to the bottom of the chassis and press the speaker on to it.

3.17.6 Position the speaker over the speaker hole in the bottom of the chassis. Then , position the bracket over the top of the speaker. Next, use a philips screw driver to tighten the screw to secure the bracket, and reposition the writer assembly if needed. Finally, reconnect the speaker to the printer circuit board at SP1.

4.0 BATTERY CHARGING

4.1 The ELI-200 operates on AC power or on an internal battery which can be charged by doing the following:

4.1.1 Connect the ELI-200 to AC power using the power cord provided. Turn the power switch located on the back of the ELI-200 to the ON position (1/0). The message: 'CHARGING' will appear on the LCD screen.

4.1.2 To fully charge an ELI-200, the unit should be plugged in for approximately 8 hours, and, when fully charged, the ELI-200 will operate continuously for approximately 4 hours.

4.2 When approximately 30 minutes of continuous operation remain in the unit, the message: 'BATTERY LOW' will appear on the LCD. When this message appears, printing is disabled to avoid total battery discharge. Connecting the unit to AC will make it possible to generate printouts. However, it is recommended that the unit be left in the CHARGING mode for some time before using it on battery power only. If a blank LCD screen appears when the ON/OFF, DC key is pressed, the battery is fully discharged. Please note the following:

4.2.1 Whenever possible, especially following extended use, the ELI-200 should be connected to AC Power and charged, when not in use.

Note: Removing the fuse, located on the back of the unit, will cause the configuration parameters to reset to the default setting. In addition, all ECGS stored in memory will be lost.

5.0 HARDWARE DESCRIPTION

5.1 **Introduction**:

The MORTARA ELI-200 is an advanced interpretive electrocardiograph system utilizing the latest electronic technology and software. The ELI-200 offers 12 lead patient ECG monitoring, a 2 line by 40 character display, a full function touchpad keyboard, a 8-inch thermal writer for outputting waveforms and interpretive data, a real-time electronic clock and calendar, a RS-232 communications port, a 1200 baud internal modem, internal power supply and battery recharge circuitry, and an exercise display output. The system utilizes CMOS digital components to minimize power consumption and enhance performance. The circuitry within the ELI-200 is contained on a single printed circuit board and a LCD display module.

This report is concerned with the basic operational theory of the ELI-200. The descriptions of circuit functions often make reference to specific electronic components on the circuit boards. A schematic is provided to allow the reader to follow the discussion. Note that signal and pin names which are 'active-low' on the schematic (shown with a bar above the name) are designated in this report by an asterisk (*) immediately after the name.

5.2 **Functional Overview**:

The block diagram of FIGURE 1 depicts each ELI-200 system component in relation to the others. The system controller is the heart of the machine, as it provides the interfacing for system components and contains the microprocessor and software necessary for I/O functions and ECG interpreting. The 68000 based system controller directs all interaction between the subsystems, the keyboard and its LCD display, the printhead and the writer motor, the modem, the RS-232 and exercise port, the front end, and the Real-Time clock.

The power supply provides the various voltage levels for the circuit board, the LCD, and the thermal writer. It is capable of operating on 120 VAC, 240 VAC, or internal battery power. The power supply also provides the battery recharge function and memory backup power. The ELI-200 can operate solely on battery power under normal use.

The analog amplifier section is responsible for receiving ECG lead potentials from the patient cables in analog form and converting this information into digital form for the system controller. The analog section provides protection to the unit from lead overvoltage and is isolated from the other system components for user and patient safety.

5.3 Power Supply Section:

The power supply for the ELI-200 is composed of five sections. The first section is used to generate a current-limited voltage source that supplies system power and/or charges the system batteries. The second section regulates the system power from either the first section or the batteries to produce keep-alive voltage source and to provide a low battery sense signal. The third section is a switching power supply which generates the needed five volts for the intermediate digital circuitry and the isolated five volts and plus and minus eight volts for the patient connected circuitry. The fourth section consists of three six volt sealed lead-acid batteries which are connected through a 1 Amp slow blow fuse. The batteries are used to provide a limited amount of stored energy for operation of the system when it is disconnected from the power mains. The fifth section supplies energy to the Thermal Printhead.

The first section uses an isolation transformer which has a two winding primary intended for serial/parallel connection to a 240/120 power main. The output from the secondary is rectified by a bridge rectifier (B1) and a DC voltage of 25-45 volts is obtained. This voltage is regulated to 20.6 volts by two nearly identical circuits. The first regulator, built around Q16 and Q7, delivers .6 amperes used either as system power or as a float charge supply for the sealed lead-acid batteries. When a momentary high current demand exists, such as during the writing of vertical lines on the writer, the supplied voltage will drop as low as 1.2 volts if the current limit is reached. For this reason a second regulator (Q13,Q14), current limited at .3 amperes, is included. This output is then merged with the output of the first regulator through diodes D7 and D13. The second regulator enables the system to operate without batteries on AC alone. If the output of the first regulator is current limited by printhead draw, the second regulator will supply the switching power supply with the needed voltage.

The second section provides three main functions. First, Q10, in conjunction with R30 and R31, will turn on the main system via D12 and supply it with a ACON signal. This occurs any time that the AC power is on, providing a voltage at the base of Q10.

The second and third function of this section is performed by U14 and its associated circuitry. The max666 chip regulates the battery voltage down to provide the "keep-alive" +5 volts to the system via D17. This chip (U14) also provides the low battery detect in conjunction with R49 and R50. The threshold for low battery sense is set for 16.8 volts which should permit at least thirty minutes of battery driven operation after the low battery condition is met, even if the unit is not powered from the mains.

The third section of the power system is a switching power supply (U6,Q18,T3) which may be turned on or off by the system controller. When turned on the supply runs at a fixed rate of forty kilohertz (KHz) in the flyback mode. During each cycle, energy is stored in the magnetic field of the transformer core and then extracted into the four secondary circuits during the collapse of that field. The secondary with the lowest voltage, as scaled by the number of winding turns, will start to draw energy first. Hence the four circuits are somewhat demand regulated. One circuit, the intermediate five volt supply (D14,L2,C40), is used to sense voltage and regulate all circuits. The other three circuits are isolated and used to supply power for the patient connected parts.

The fourth section provides storage for one ampere-hour of charge at a nominal eighteen volts. As long as the system is connected to the power mains and turned on the batteries are under a float charge. When the system is operated the power required is taken first from that delivered by the float charger, and second from the batteries if the required current exceeds that supplied by the linear regulators. The system should be left on float charge whenever possible since there is a small current drain that depletes the batteries when the charger is not active. A fully charged set of batteries has a shelf life of more than 6 months, at which time they would be totally discharged. The ELI-200 is shipped with the battery circuit fuse removed so that no discharge takes place before the unit is installed.

The fifth section of the power supply is used for the printhead power. This section uses a signal from the Digital board (HEADON) to control the 18V power to the printhead and its 6800 uF capacitor. The 6800 uF capacitor is utilized to meet peak current demands of the printhead without exceeding the current limits of the 1 amp fuse. The 3 ohm resistor (R48) is used to limit the current to the capacitor at initial turn on. Resistor R22 is used to bleed off the voltage in the quiescent state.

5.4 **Isolated Front End**:

The front end is divided into two subsections - the analog front end and the digital front end. The analog front end receives the analog patient lead signals and converts this information into binary form for the digital front end to process and send to the system controller section. The analog front end is powered by plus and minus eight volts, and the digital circuitry is provided a plus five volt supply.

The analog front end includes those parts that are used to obtain the electrode signals, digitize them, and preprocess the digital data. The operating principle upon which the circuitry is based is as follows: the difference between the current value of the selected signal and an estimate of its value at the last sample time is measured and then a new estimate is computed by adding the difference to the old estimate. A measurement consists of eight quick digitizations in succession on the same signal with a varying dither signal added to improve the quantization accuracy. Eight different signal channels are measured in succession and then the process is repeated. The time required for the eight measurements is about sixteen microseconds, and the time between beginning measurements sets is 31.25 microseconds. Thus the time delay between beginning measurements on the same channel is 250 microseconds, a four KHz sampling rate. A timing diagram showing the relationship of some of the pertinent signals is presented in FIGURE 2.

Signals from a conventional ten-lead patient cable are introduced at connector J15. Resistors in the patient cable on all leads except right leg, protect against excess voltage. The right leg lead is protected with a spark gap. The twelve lead electrocardiographic information is derived from the potentials appearing on nine of the ten electrodes. The remaining electrode, RL, provides a driven 'common' reference for the other nine electrodes. The signals from the nine signal electrodes are amplified, in groups of three, in the hybrids H1, H2, and H3. The amplification is by a factor of sixteen. Each of the hybrids includes a high impedance bias source connected to the inputs to facilitate lead fail detection, and also includes a fourth amplifier channel which provides an inverted output proportional to the average of the input signals. This output from H3, whose inputs are connected to the limb lead electrodes (RA, LA, and LL) is used to drive the RL electrode to aid in reducing the effects of common mode signals.

The three amplified limb lead signals from H3 are connected to hybrid H4 in which they are averaged and used as a reference value to be subtracted from the selected signal being measured. The output from H3 corresponding to RA is connected to a threshold detector consisting of Q19 and its associated discrete components which generates the right arm lead fail signal RAF. The other two outputs from H3 (corresponding to LA and LL) and the outputs of H1 and H3 are connected to the inputs of the multiplexer U21. The signals MUX0, MUX1, and MUX2 generated in the ANALOG CONTROL GATE ARRAY (U43) are used to determine which of the eight inputs to the multiplexer is selected for measurement and passed to H4 via a buffer amplifier, using half of U24.

The estimated signal value which is to be subtracted from the selected signal is generated with the aid of U30 and U31. U31 is a serial-to-parallel shift register which is used to hold the upper six bits of the binary value of the signal estimate, and its outputs are fed to a binary resistor ladder included in H4. This combination is called the coarse DAC. The LSB of this output is equivalent to ten millivolts at the input. U30 is a serial input A/D converter which, together with the other half of U24, converts the low order ten bits of the signal estimate to an analog value also fed to H5. This combination is called the fine DAC. The LSB of the data fed to the converter corresponds to forty microvolts at the input to the system. Both U30 and U31 incorporate separate shift and holding registers so that the outputs are not affected while data is being shifted in. Data is shifted to the outputs as a result of the signal LDDAC*.

Hybrid H4 contains the passive components which, in conjunction with op-amp U35, serves as the summing amplifier to generate the difference signal. The reference voltage is used as a signal input (R) to H4 to provide an offset which biases the input at the A/D converter to mid-range. The gain of the amplifier is 7.63.

Hybrid H5 contains the passive components which, together with the two halves of op-amp U32, performs two functions. One function takes the output of reference diode D46 and creates the five volt reference voltage for the system. The second combines the output of the summing amplifier with the three binary weighted dither signals, DTHR0-DTHR2 and amplifies the result by sixteen. The amplifier output is limited due to the effects of diodes D42-D44, both to protect the input to the ADC and to limit the effective signal difference to plus or minus one millivolt per sample referred to the input.

The ADC U42, under the control of the gate array U43, is used to digitize the difference signal. Eight conversions in rapid succession are performed on each difference with different values of dither for each. After the eighth conversion, the next channel is selected and some settling time is allowed. The signal presented to the input to the ADC starts at a base value and then has seven steps added with each step equal to approximately ninety millivolts. The digital output of the ADC is in offset binary form, i.e. the sign bit is inverted. Only the top six bits of the result are used and the sign is extended into bits AD5 and AD6.

Gate array U43 controls the channel selection and conversion operations, and provides for preprocessing of the digital data. The results of the eight conversions on the difference signals are added to each other and then added to the old estimate value to obtain the new estimate. After the new estimate is computed, a thirteen bit value corresponding in range to the fine DAC range is extracted as the signal value for the sample. The result is a twos complement binary number with a zero value corresponding in range to the center of the fine DAC range. The additional three bits are achieved as a result of the eight measurements with dither. Depending on the contents of a control register in the chip, either one sample or a sum of four or eight samples for each channel is accumulated and passed to the microprocessor as data. In addition, pacemaker pulse and lead fail indications are obtained and passed as status bytes.

If the results of computing the new estimate for a data channel caused the coarse DAC value to either overflow or underflow, a flag is set indicating lead fail for that channel, and the old estimate is not changed. A new signal value is computed, however, based on the old estimate. If the magnitude of the difference value exceeds 0.64 millivolts referred to the input and lead fail is not indicated for that channel, a flag is set indicating a possible pacemaker pulse. The pacemaker indicators for all channels are logically 'OR'ed to one bit for each 250 microsecond interval. The eight lead fail flags for the most recent samples are combined to one status byte, and the last eight pacemaker flags (LSB equals most recent) are combined as a second status byte accessible by the microprocessor.

The 8.192 Megahertz (MHz) system clock is used to provide timing for the gate array. The period associated with the acquisition of one data sample requires 256 clock cycles or 31.25 microseconds. One conversion and read cycle requires sixteen cycles and the eight conversions for one sample therefore requires 128 cycles. The remaining 128 cycles are used to compute the new estimate, serially output the DAC values for the next plus one channel, and compute the sign value. At the beginning of a channel read operation, the channel selected is changed, and the next values are strobed into the DACs to permit everything to settle before the next conversion is commanded. During the 256th clock cycle, conditions are tested to see if they correspond to the eighth clock of the last set needed to complete one data set for the microprocessor, and if so, an interrupt flag is set to signal the processor of the fact.

The digital front end consists of five main components; the microprocessor (U34), the ROM (U45), the RAM (U44), the ISO-LINK GATE ARRAY (U36), and the ANALOG CONTROL GATE ARRAY (U43). The microprocessor used in this section is a 63B03 running at 8.192 MHz (Y2) and operating in the non-multiplexed mode.

The signal which is connected to the non-maskable interrupt of the microprocessor originates at the ANALOG CONTROL GATE ARRAY (U43) and indicates that a conversion sequence has been completed and data is available to be read by the microprocessor. A block of eighteen bytes would normally be read in response to this interrupt including two status bytes followed by sixteen data bytes. The other interrupt input, IRQ1*, is connected to the ISO-LINK GATE ARRAY output signal RHF* (Receive FIFO Half Full). Signal RESET* is the low-true reset signal to the microprocessor.

The memory consists of one 8 Kilobyte PROM (U45) at address E000H-FFFFH that contains the operating program and one 32 Kilobyte RAM (U44). The two chips interface directly to the microprocessor through the 8 data lines (DO-7) and the 13 address lines (AO-A12). The control lines to these chips are generated by the ISO-LINK GATE ARRAY. Note that the RAM is selected by two different chip selects (CS02*,CS06*). If the Ram is addressed using CS02*(4000H-5FFFH), address line A11 is enabled and the ram is operated as a normal 32K byte chip. If the Ram is addressed using CS06*(C000H-DFFFH), address line A11 is disabled. The result is that by using CS06*, the 8K byte RAM may be converted into a 2K byte cyclic buffer.

In this section, the ISO-LINK handles both the serial communications and the address/control decoding. The gate array uses address lines A13-A15 to generate eight 8K chip selects (CSO*-CS7*). CS2* and CS6* are used for the RAM, and CS7* is used for the PROM. CSO* is used internally along with the signals E, A2-A7, and R/W* from the processor to generate 8 read strobes and 8 write strobes (R20*-R74* and W20*-W74*). Three read and write strobes are used internally by the gate array, and one read and one write strobe (R20* and W20*) are used externally for the analog control gate array. The address of the utilized strobes are 0020-23H, 0065-67H, 0070-73H and 0074-77H. The ISO-LINK GATE ARRAY also generates two signals, LRD* and LWT* that are used by the memory chips.

The ISO-LINK executes bi-directional serial communications to the non-isolated side of the system. The processor puts the gate array in transmit mode, and then writes byte wide data into a four deep transmit FIFO. The gate array then inserts a start and stop bit for each byte and transmits at a bit rate of 8.192 MHz. Every millisecond, the processor sends a bundle of data consisting of 10 bytes, one synch byte, followed by 9 data bytes. Upon completion of the transmission, the processor clears the transmit bit, and the gate array then sends a status byte reflecting the state of the two gate array status inputs (SINO and SIN1). The ISO-LINK is then in the receive mode, and can then receive data through the 16 deep receive FIFO. The processor can either pole the internal FIFO empty bit or wait until the FIFO is half full, and receives an interrupt via the RHF* signal.

5.5 **System Controller**:

The SYSTEM CONTROLLER is divided into eight main sections; the microprocessor and memory, motor control, Thermal printhead control, a Real-time clock, the keyboard, the display, the modem, and the RS-232 output control. The major components and basic operation of each section follows.

The microprocessor used in this section is a Motorola cmos 68000(U22). The 68000 has an address space of 16 megabyte which is only partially decoded in this application. The processor has 23 address lines and 16 data lines which connect directly to the memory and other system components. The 68000 is clocked by a signal SYSCLK supplied by a cmos crystal oscillator (Y3). This signal is also supplied to the ISO-LINK GATE ARRAYs and the TPH (thermal printhead) GATE ARRAY.

The 68000 outputs 4 signals (UDS*,LDS*,R/W*,AS*) that are used by the ISO-LINKs to facilitate memory transfers. The ISO-LINKS use these signals along with the address lines to generate the signal VPA* that is fed back to the microprocessor to complete memory cycles. The other signal used by the processor to complete memory cycles is DTACK*. This signal is generated by U23A. The DTACK* signal is normally low, allowing the processor to operate at full speed. The oneshot will pull the signal high if extended bus cycles are desired. Wait states are inserted in the bus cycle when ever an address with A23 high is used. The wait time is then determined by the timing of R60 and C69(3uS) or the timing of R71 and C117 (.5uS). The interrupts (IPL0-3*) and the RESET* signal are driven by sources discussed later.

The system memory consists of two 64K byte EPROMS (U11,U19) and up to eight 128K byte static RAMS (U7-10, U15-18). The EPROM chip selects and the read/write lines for these chips originate from the ISO-LINK (U27). The RAM sockets can be populated with either 32K byte or 128K byte chips. If the 32K chips are used, the resistor sip package RP3 is installed. The second ISO-link (U20) then uses CS1* along with A16 and A17 to generate four 64K chip selects (CSBO-4*) that are used to access the RAMs. If 128K byte RAMs are used, then RP4 is installed and the "B" chip selects become 256K selects mirroring those from the first ISO-LINK. Using the 128K byte chips, the system can contain up to 1 Mbyte of storage RAM. Since the RAMS and EPROMS have 150 ns or better access times, no memory wait cycles are generated, and the processor can run at full speed.

As in the digital front end, the address decoding is handled by the ISO-LINK GATE ARRAYs (U20,U27). The microprocessor addressing space is partitioned by the gate array (U27) into eight 256 Kbyte sections or chip selects (CS0*-CS7*) using the address bits A18-A20. RAM (U7-10, U15-18) is situated in one section at addresses 04-0000H to 07-FFFFH, or in four sections (04-0000H to 13-FFFFH). ROM (U11,U19) occupies the section at 00-0000H to 03-FFFFH. The internal control registers of the ISO-LINK are located at CS7* (1C-0000H to 1F-FFFFH) and use addresses A1, A6, A7, A8, A9, and A10 to generate eight read strobes

(R20*-R74*) and eight write strobes (W20*-W74*). Three of these read/write strobes are used internally and five are brought out to pins. Chip select six (CS6*) is used to address both the modem and the TPH gate array. The modem on the low half of the bus, and the TPH on the high half. U27 also generates the upper and lower read and write lines for the RAMs and ROMs (URD*, LRD*, UWT*, LWT*).

Internal to both ISO-LINK GATE ARRAYS are two 8-bit control registers (CONTROL REGISTER #0 and CONTROL REGISTER #1) located at addresses 1C-03C1H and 1C-03C3H respectively for U27 and 1F-0981H and 1F-0983H respectively for U20. CONTROL REGISTER #1 is used to latch control bits for internal circuitry (refer to the separate report titled 'ISO-LINK GATE ARRAY' for a more detailed description of internal ISO-LINK functions). Five bits of CONTROL REGISTER #0 are brought out on external pins BIT3-BIT8. BIT3-BIT5 are programmable as outputs while BIT7-BIT8 are programmable as inputs or outputs. U27 utilizes BIT8 and BIT5 to control the keyboard beeper. The speaker is driven by a simple feedback oscillator which oscillates at 4KHz when BIT8 is programmed as an input, and stops oscillating when BIT8 is programmed as an output. BIT5 is used to change the frequency of the oscillator to modify the speaker sound. The outputs BIT3 and BIT4 of U27 are used in controlling the LCD display. The use of the outputs on U20 will be discussed in the RS-232 section.

The ISO-LINK U27 is responsible for transmitting and receiving synchronous serial data between the front end and the system controller board. With the control bit UART cleared to '0', the receiver section of the ISO-LINK expects modulated data at the XDATA input, and uses the XCLK input as the data clock. The XCLK signal is sent from the front end board, and is used to synchronize the data, which is in phase with the clock when the data is '0' and out of phase when the data is '1'. All received data bytes are loaded into a 16 byte FIFO (First-In/First-Out buffer) which can be read from by the microprocessor accessing the internal R70* signal. The status of the receive FIFO is monitored by the Receive Half Full pin (RHF*), which goes low and triggers the IRQ2* Interrupt (NMI) line on the microprocessor. In the transmit mode, the outgoing data is modulated with the 10 MHz transmit clock and sent out the XDATA line. The transmit clock is sent out the XCLK line. The transmit section is equipped with a four byte FIFO, which is controlled by the internal W70* signal.

The main function of U20 is to transmit and receive asynchronous serial data to connector J2, directly for the ELI-XR, or through U1 for a RS-232 interface port. A control bit (UART) in the ISO-LINK is set to receive the RS-

232 data in an internal 16-bit receive FIFO via the XCLK pin. The ISO-LINK performs the serial-to-parallel conversion so that the information can be fetched via the data lines by the microprocessor. The receiver circuitry automatically loads all received bytes into the FIFO. The RHF* pin on U20 is a status line that goes active when the receive FIFO has received nine bytes of data and interrupts the processor via U46 and IRQ0*. The XDAT pin sends serial data that has been written to the internal transmit section of the ISO-LINK, equipped with a four byte FIFO. Data is loaded into the transmit FIFO by the W70* strobe and transmitted externally with the following protocol - one start bit, eight inverted data bits with D0 first, and one stop bit. The baud rate is determined by programming the internal 16-bit counter (discussed next).

The final section of the ISO-LINK GATE ARRAYS not previously discussed is the divide-by-N counter, which outputs on the 16X pin. This counter uses the system clock (CLK) as the timing reference. The counter is equipped with two 8-bit input registers to program in an initial count. These registers are located at address 1C-0340H for U27 and at address IF-0941H for U200. The counter is also equipped with an output port so that the count can be used externally for timing. The count is decremented by the leading edge of each input clock cycle. When the count reaches all ones (FFFFH), the counter is disabled. On the trailing edge of the next clock cycle, the 16X output goes to a low level for a cycle, unless a bit in CONTROL REGISTER # 1 (CLKL) is cleared, then 16X stays low until the counter is read from again. The 16X pin for this application is used on U27 to provide adjustable pulse widths for the motor control circuitry (discussed later). U11 uses the programmable counter internally to provide the 9600 baud communication timing for the RS-232 port or the 1.25 MHz baud rate for ELI-XR communication.

A real-time clock chip (U39) is provided in the system controller to maintain an accurate record of time and date. This information is used in documenting ECG records and, like the RAMs, is battery backed up when the ELI-200 is not in use. Current time and date can be accessed from U39 by selecting internal registers at address 81C-02C0H and read from or written to these registers at address 81C-0280H. Data is latched onto D0-D3 during each access. Because the clock chip access time is so long (3.0 microseconds), wait states in the bus cycle are generated in the microprocessor by a one-shot (U25A) which holds the DTACK* signal high for the necessary time, thus lengthening the read and write strobes the appropriate amount of time.

The system controller interfaces to the user through several devices; the keyboard, the liquid crystal display, and the thermal writer. The keyboard is strobed and tested by accessing address 1C-0200H (W20* and R20* from U27). Eight rows and ten columns comprise the keyboard character matrix: data lines D0 through D7 contain the keyboard status during these accesses. All key debounce is performed by software.

The liquid crystal display provided on the ELI-200 is a 2 line by 40 characters-per-line display powered from a single 5 volt source. Two resistors, R58 and R59, set the LCD contrast. The LCD registers are read from and written to by setting the appropriate levels on BIT3 and BIT4 of U27 and accessing the data on D0-D7. Characters are read from or written to the LCD at address 1C-0240H (R24* and W24*). Since the LCD has a long access time (0.5 microseconds), wait states are inserted into the microprocessor bus cycle by a one-shot holding the DTACK line low for the appropriate time.

The thermal writer, is controlled by two main components; the THERMAL PRINTHEAD GATE ARRAY (U37) and an 8K by 8-bit static RAM (U38). The microprocessor communicates with U37 via D8-D15 and control lines CS6*,R/W*, LDS*, A1, and SYSCLK. This gate array has a 12-bit data buffer located at address 18-0000H which is filled by first writing the upper 4 bits with A1 low and then writing the lower 8 bits with A1 high. The microprocessor sends a new line of data to the TPH gate array every 1 millisecond during printing by writing a low level to the 1KHz pin. The gate array then receives a 12-bit value defining the number of dots in a line followed by the dot information, which is two 12-bit numbers per displayed waveform. The microprocessor then follows this by any text that is to be printed. The gate array takes this information and translates it into a serial stream of bits on HDATA, the length of which is determined by the number of dot elements on the printhead. The gate array also supplies the printhead with a bit clock (HCLK) and, at the end of a line, a negative latch pulse (START*) which transfers the serial data to the printhead elements. The START* line is also used to derive strobes (STRB1*-STRB7*) to vary the length of time the head elements are to remain on, thereby providing control of print darkness and protecting the elements from overheating. The strobe length is determined by the one shot U9B and the timing is determined by the charge time of C39. The microprocessor can extend the strobe length by setting the "25mm" to a low level, which reduces the charge current to C39. The other factor determining strobe length is the printhead voltage. If the voltage at the printhead (VH) drops, the C39 charge current supplied through R2 is reduced, thus lengthening the strobes. The second part of the thermal writer is the paper motor and its control.

The motor control circuitry is at the top of the ELI-200 schematic 7.4, consisting of three FETs (Q2-4) and two logic gates. The motor is disabled when Q4 is "on" forming an electronic brake across the terminals of the motor. The brake is controlled by the "FWD" signal through the inverter U5B. When the motor is enabled, a variable width positive pulse drives the Gate of Q2 through U46D. The Drain of Q2 pulls the Gate of Q3 low and applies +18V to the motor via L1. The pulse length, or duty cycle, determines the delivered power, and thus the motor speed. When Q3 is turned off, combination of L1 and D4 keeps the motor turning till another pulse is applied to L1.

The "PULSE" signal originates at the 16X pin of ISO-LINK U27 and is varied by the microprocessor. The 68000 determines the desired pulse width by monitoring the speed of the motor. The motor supplies a "TACH" signal that is used to set the one shot U23B, which causes the IPL1* interrupt to the processor. The processor then acknowledges the tachometer pulse and clears U23B.

In addition to the operator interfaces just discussed, the ELI-200 contains two ports for communicating with external devices. The first of these ports is accessed on J2. This port serves both as a standard RS-232 interface and as a dedicated link to the Mortara Instrument ELI-XR exercise display. This port outputs both plus and minus 10V signals and also standard +5V digital signals.

The operation of this port is controlled by the ISO-LINK gate array U20. The gate array is operated in the asychronous mode with the internal 16 bit divide-by-N counter determining the baud rate. The serial data is outputed on the XDAT pin and serial data is inputed on the XCLK pin. For interfaces to the ELI-XR, the counter is set to zero which results in a 1.25 M baud rate. The ELI-XR accepts the digital levels found on pin 1 and pin 9 of the external connector J2. The level converter chip (U1) can not respond to the high data rate, so pins 3 and 2 of J2 should not be connected to.

For normal RS-232 operation, the connector pins 2 and 3 are used. The transmitted data (300-9600 baud) is outputed on J2 pin 3 via the +/-10V level translator U4. The receive data is accepted on pin 2 of J2 and translated to digital levels by U4. For RS-232 operation, pins 1 and 9 of J2 must be left open and dis connected. The RS-232 interface also supports 3 status lines, two input lines and one output line. The input lines are CLEAR-TO-SEND (CTS) found on J2-8 and DATA-READY (DSR) found on J2-6. These signals are level translated by resistors, and diodes internal to U20 and monitored by BIT8 and BIT7 respectively. The other status signal is generated by the BIT3 pin of U20 and is connected to both J2-4 and J2-7 via the level translator U1.

The second external port is for the internal 1200 baud modem. The ELI-200 makes use of the standard four pin telephone jack. The modem features tone or pulse dialing, and also auto-answer. The modem is made up of a one chip modem, U4, and its Data Access Arrangement (DAA). The modem chip is a Silicon Systems K222U with internal UART. The chip interfaces to the microprocessor as a standard eight bit parallel peripheral. In addition to the eight data lines, the chip also has four address bits A1-A4. The chip uses chip select CS6* from the ISO-LINK U27 and the LRD* and LWR* to interface with the data bus. The chip (U4) receives its reference frequencies from an internal oscillator and an external 11.0592MHz crystal Y1. The modem chip also supplies an interrupt signal to the processor via U47B and U46C. This interrupt is not normally used since the data rate is slow compared to the processor speed and polling services the chip fast enough.

The K222U interfaces to the phone line through 5 pins, Ring Interrupt (RI*), Off Hook(OH*), TXA1 and TXA2, and the receive input RXA. The OH* signal is an open drain output that is used to drive the on line relay under processor control. The RI* input is used to signal the processor that there is an incoming call. The AC ringing signal on the phone line is rectified by D1 and then is used to drive the input of an OPTO-ISOLATOR U3. The output of the isolator then drives the RI* input.

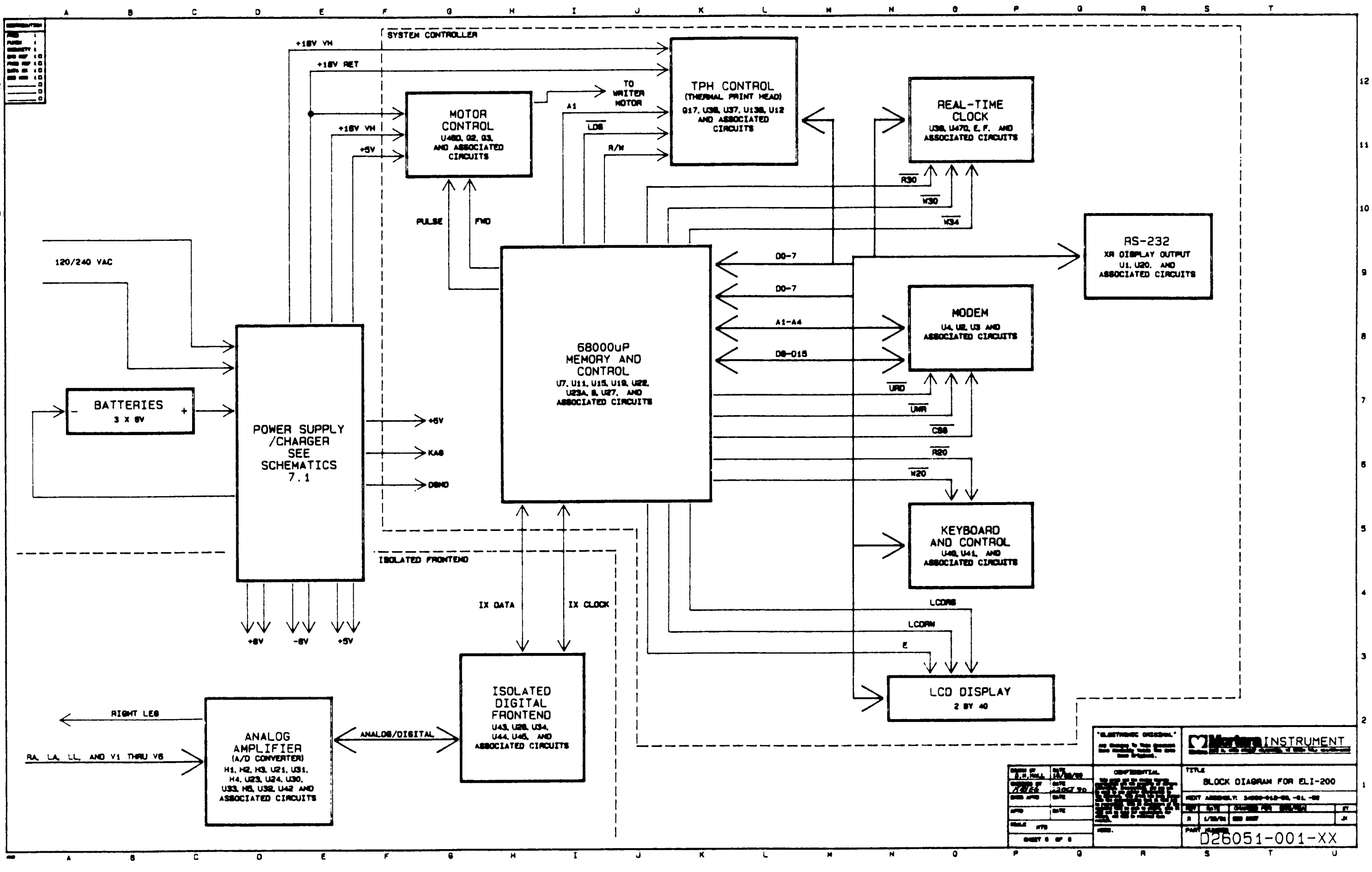
The final three signals are the analog signals to the phone line. TXA1 and TXA2 are used to drive the isolating transformer through R16 and C13. The resistor R16 is used as an impedance matching resistor so that the transmitted signal can be discerned from the receive signal. The line side of the transformer is protected from surges by MOV1 and R7.

The modem also supplies a high impedance signal used to drive a speaker. This signal is combined with the key-beep signal at U1 to drive an 8 ohm speaker SP2. This can then reflect the audio of the received phone signal along with audible feedback for the keyboard.

The only remaining circuitry to be discussed is the RESET* generation and the power on/off circuitry. This circuitry is located on page 2 of the schematic and includes a one-shot U13A and an inverter U5C. In the off state, the digital ground is removed from most of the system and it floats up to +5v. The one-shot U13 is kept powered by Keep Alive Ground (KAG). Upon a ON key press, a high level appears at the clock input pin 1 and triggers the one-shot. The one-shot has a time-out of approximately 2.2 seconds which is determined by R40 and C36. The one-shot will be retriggered by the 68000 reading the R34* location and pulsing pin 2.

When the one-shot is triggered at turn on, the POWEROFF signal goes low and turns off Q18 which allows the switcher to turn on. The POWEROFF signal is used to generate the RESET* signal using U5C and R18 and C15. The R-C combination is used to produce a 200 millisecond delay before the RESET* signal is allowed to return high. The processor can turn off its power by clearing the one-shot by writing to the W60* location. The W60* signal will pull down the cathode of D29 and discharge C38, clearing U13A.

5.6 Block Diagram



5.7 ELI-200 KEYBOARD MATRIX

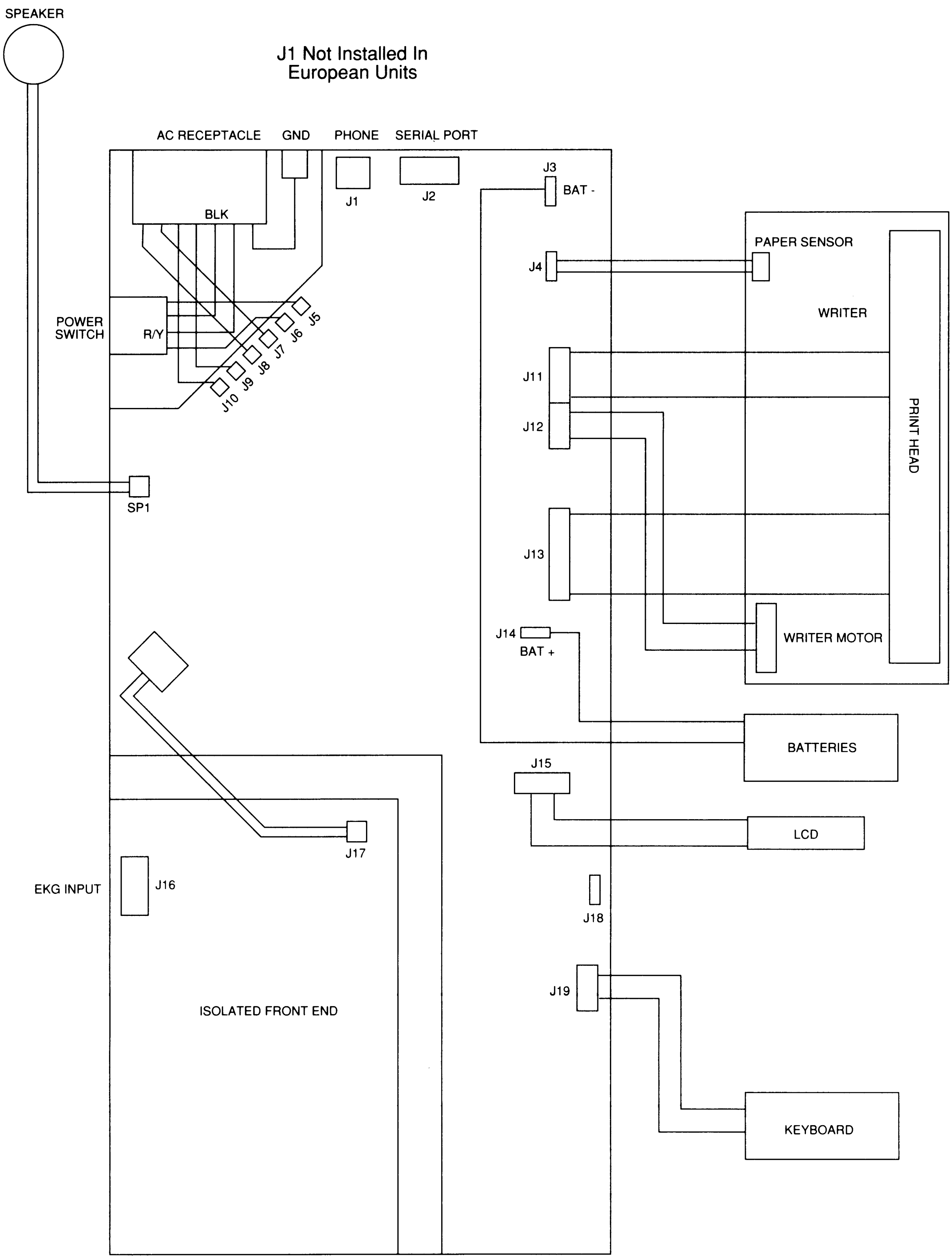
row / column

column \ row	1	2	3	4	5	6	7	8
1	SPF	Z	X	C	V	B	N	
2	ALT	0	3	4	7	8		
3		1	2	5	6	9		
4		E	R	U	I	⌫	ECG	
5	SHIFT	Q	W	T	Y	O	RHY	
6	ENT	D	F	J	K	P	XMT	
7	STOP	A	S	G	H	L	M	
8								DC ON OFF

COLUMN		ROW	
1	J19-1	1	J19-9
2	J19-2	2	J19-10
3	J19-3	3	J19-11
4	J19-4	4	J19-12
5	J19-5	5	J19-13
6	J19-6	6	J19-14
7	J19-7	7	J19-15
8	J19-8	8	J19-16

NOTE: J19 IS LOCATED ON ELI-200 PCB ASSEMBLY

6.0 INTERCONNECTION DIAGRAM



6.1 Interconnection List

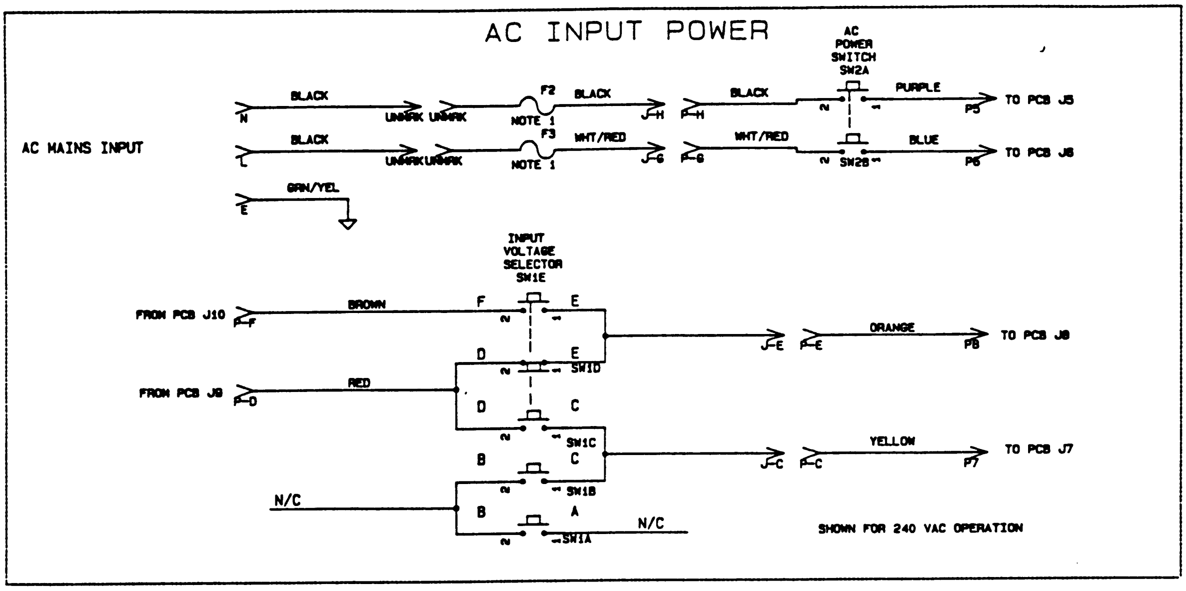
Connector	Pin #	Name	Description/Location
J1 (Modular Phone Jack)	1	-	Not Used
	2	-	TXA1 (Modem)
Not installed on European units.	3	-	TXA2 (Modem)
	4	-	Not Used
J2 (RS-232 PORT)	1	CD	XDAT (R3)
	2	RX	R1 in (Max 232)
	3	TX	T1 out (Max 232)
	4	DTR	T2 out (Max 232)
	5	GND	Circuit Ground
	6	DSR	Bit 7 (R14)
	7	RTS	T2 out (Max 232)
	8	CTS	Bit 8 (R15)
	9	RI	XCLK (R6)
SP1 (Speaker Connector)	1	Speaker High	C6(-)
	2	Speaker Low	18V Return
J3 (Battery Neg.)	-	-	F1 - 2
J14 (Battery Pos.)	-	-	D10 Anode
J12 (Writer Motor)	1	Motor Return	18V Return
	2	+5V	Digital +5V
	3	TACH	U23B Pin 9
	5	GND	Digital Ground
	6	Motor High	Q4 Drain, L1
	4,7,8	-	Not Used
	9,10	-	Not Used
J5 (Violet Wire)	-	AC in (Switch)	Line
J6 (Blue Wire)	-	AC in (Switch)	Neutral
J7 (Yellow Wire)	-	T2 Primary #2	High
J8 (Orange Wire)	-	T2 Primary #2	Low
J9 (Red Wire)	-	T2 Primary #1	High
J10 (Brown Wire)	-	T2 Primary #1	Low
J11 (Printhead Power/Data)	1 - 7	18V RET	18V Return
	8 - 14	VH	Head Voltage
J13 (Prinhead Data)	1	+5V	Q17 Drain
	2	BEO	RP1 Pin 4
	3	DATA	RP1 Pin 6
	4, 6, 20	KAG	Keep-alive Ground
	22, 24, 26	"	"
	5	STB1*	RP1 Pin 8
	7	STB2*	RP1 Pin 8
	8	-	Not Used
	9	STB3*	RP1 Pin 10
	11	STB4*	RP1 Pin 10
	13	STB5*	RP1 Pin 10
	10, 12, 14	-	Not Used
	15	STB6*	RP2 Pin 2
	17	STB7*	RP2 Pin 2
	19	STB8*	RP2 Pin 2
	16, 18	-	Not Used
	21	Latch *	RP2 Pin 4
	23	CLK	RP2 Pin 6
	25	-	Not Used
J4 (Cue Sensor)	1	Emitter+	R9
	2	Sensor+	U5D Pin 9, R8
	3	Emitter-	Circuit Ground
	4	Sensor-	Circuit Ground
J19 (Keyboard)	1	Column 1	RP1 Pin 2
	2	Column 2	RP9 Pin 10
	3	Column 3	RP9 Pin 8
	4	Column 4	RP6 Pin 8
	5	Column 5	RP6 Pin 10

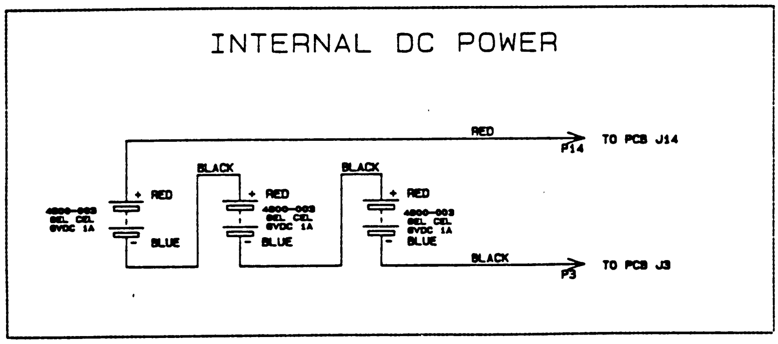
Table 4

Connector	Pin #	Name	Description/Location
J19 (Keyboard) Cont.	6	Column 6	RP6 Pin 4
	7	Column 7	RP6 Pin 6
	8	Column 8	RP6 Pin 2
	9	Row 1	RP9 Pin 1
	10	Row 2	RP9 Pin 3
	11	Row 3	RP9 Pin 5
	12	Row 4	RP8 Pin 7
	13	Row 5	RP8 Pin 9
	14	Row 6	RP8 Pin 3
	15	Row 7	RP8 Pin 5
	16	Row 8	RP8 Pin 1
J15 (LCD)	1	VSS	Digital Ground
	2	VDD	R58 - R59
	3	VA	+5V
	4	RS	LCDRS
	5	R/W*	LCDRW
	6	E	U5A - Pin 2
	7	DB0	D0 (Data Bus)
	8	DB1	D1 "
	9	DB2	D2 "
	10	DB3	D3 "
	11	DB4	D4 "
	12	DB5	D5 "
	13	DB6	D6 "
	14	DB7	D7 "
J16 (Patient Connector)	1	V2	ECG Input
	2	V3	"
	3	V4	"
	4	V5	
	5	V6	"
	6	GND	Analog Ground
	7	-	Not Used
	8	-	Not Used
	9	RA	ECG Input
	10	LA	"
	11	LL	"
	12	V1	"
	13	GND	Analog Ground
	14	RL	Right Leg Drive
J17 (Isolated Voltages)	1	+8V Pulse	ISO +8V (D38)
	2	+8V Return	Analog Ground
	3	-8V Return	Analog Ground
	4	-8V Pulse	ISO - 8V (D37)
	5	+5V Pulse	ISO +5V (D39)
	6	+5V Return	Digital Ground

Table 4 (continued)

6.2 Interconnection Diagram 2

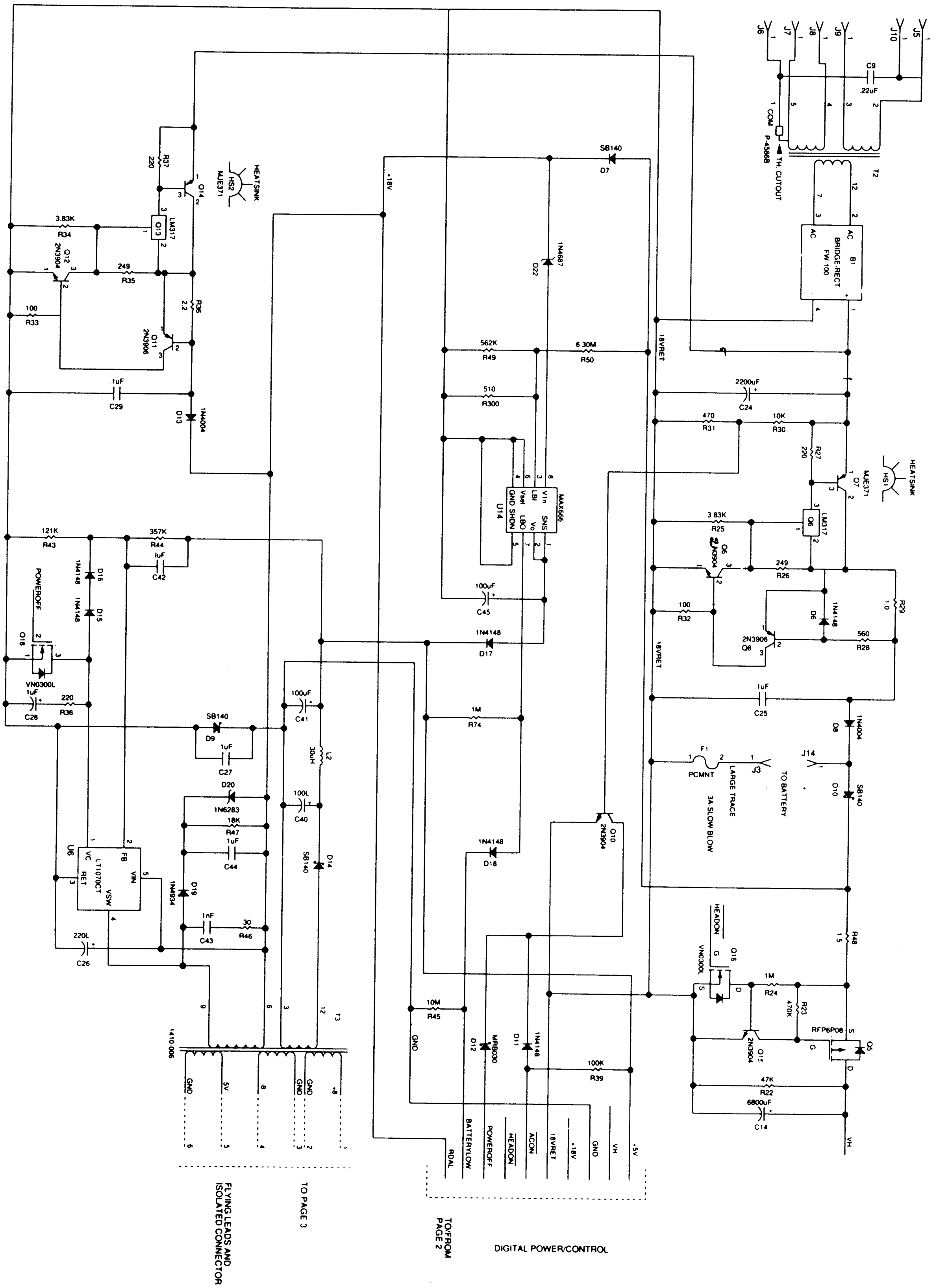




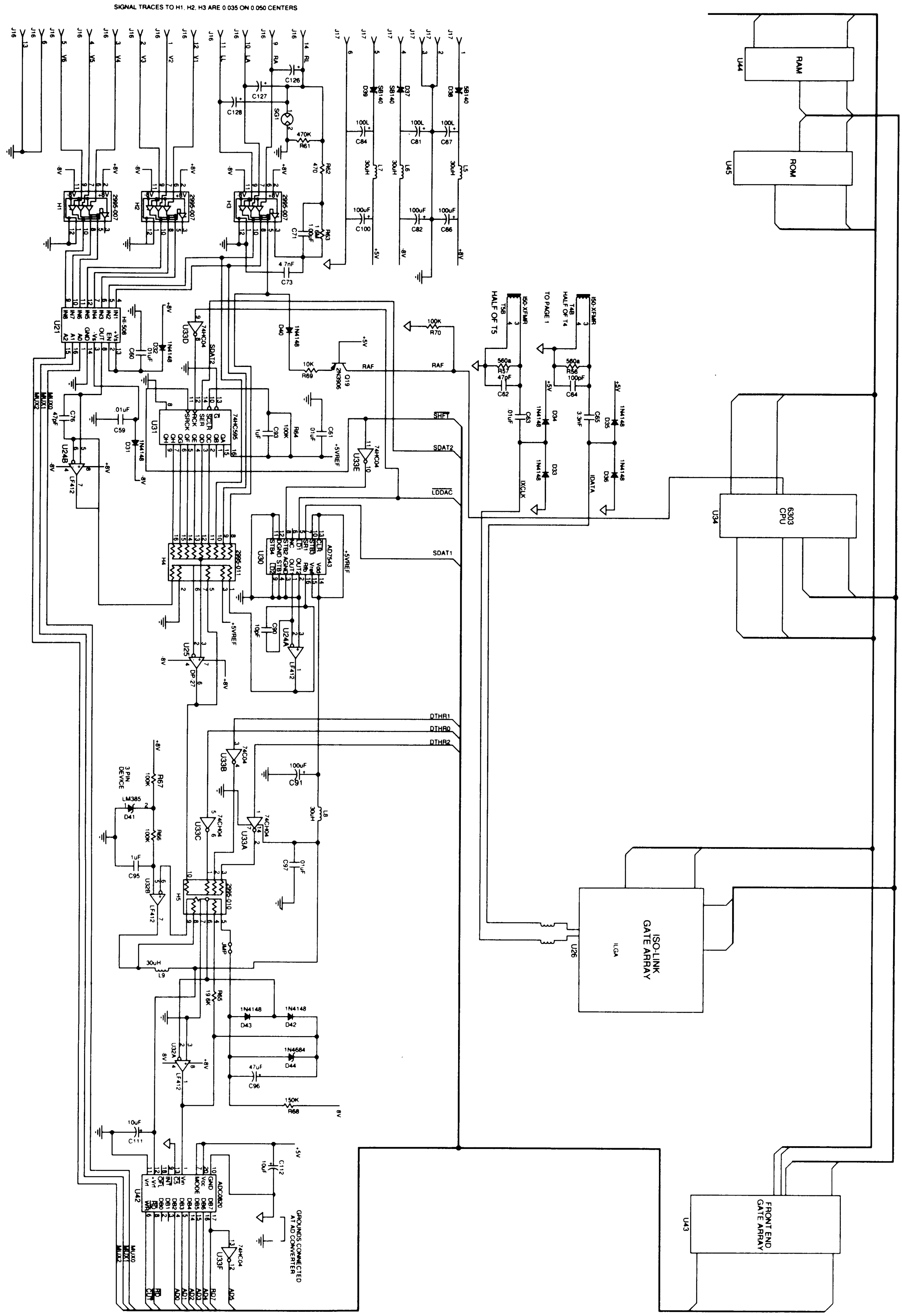
NOTES: 1) FUSE F2 AND F3 ARE 200MA SLOW BLOW (0.2 3AGSB)
FOR ALL INPUT VOLTAGES.

7.0 CIRCUIT BOARD ASSEMBLY

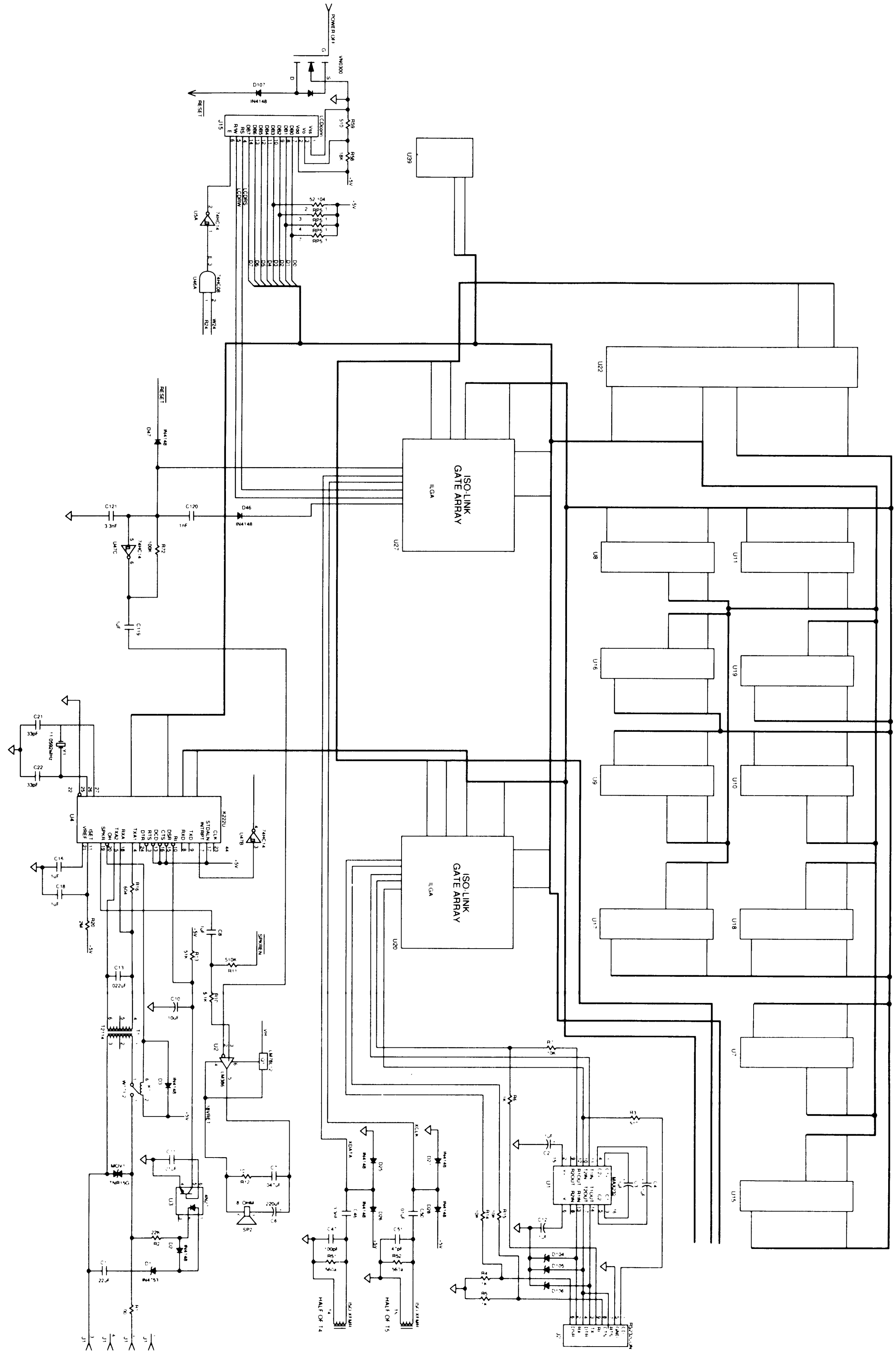
7.1 Battery Charger/Power Supply Schematic



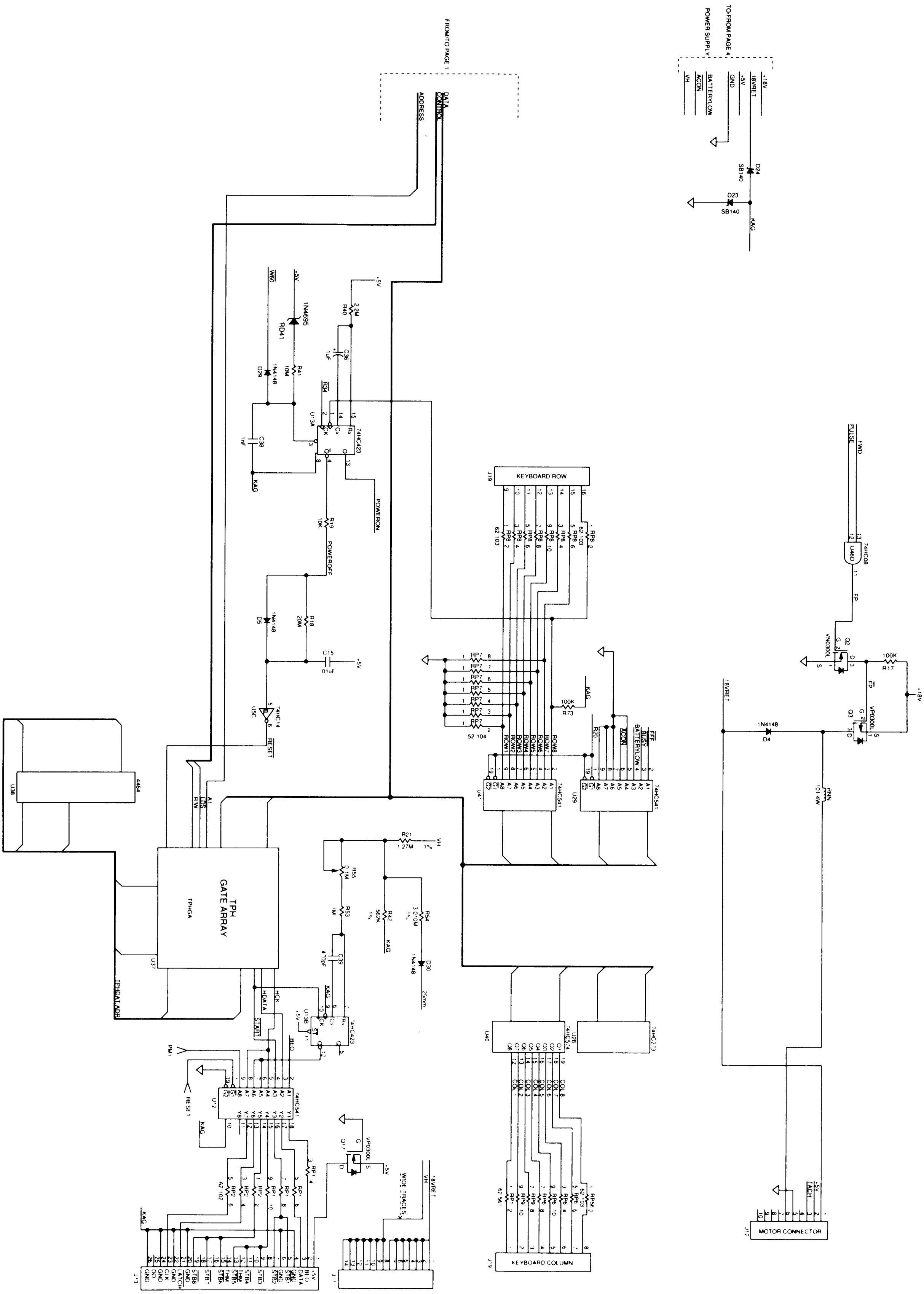
7.2 ECG Front End Schematic



7.3 System Controller Schematic

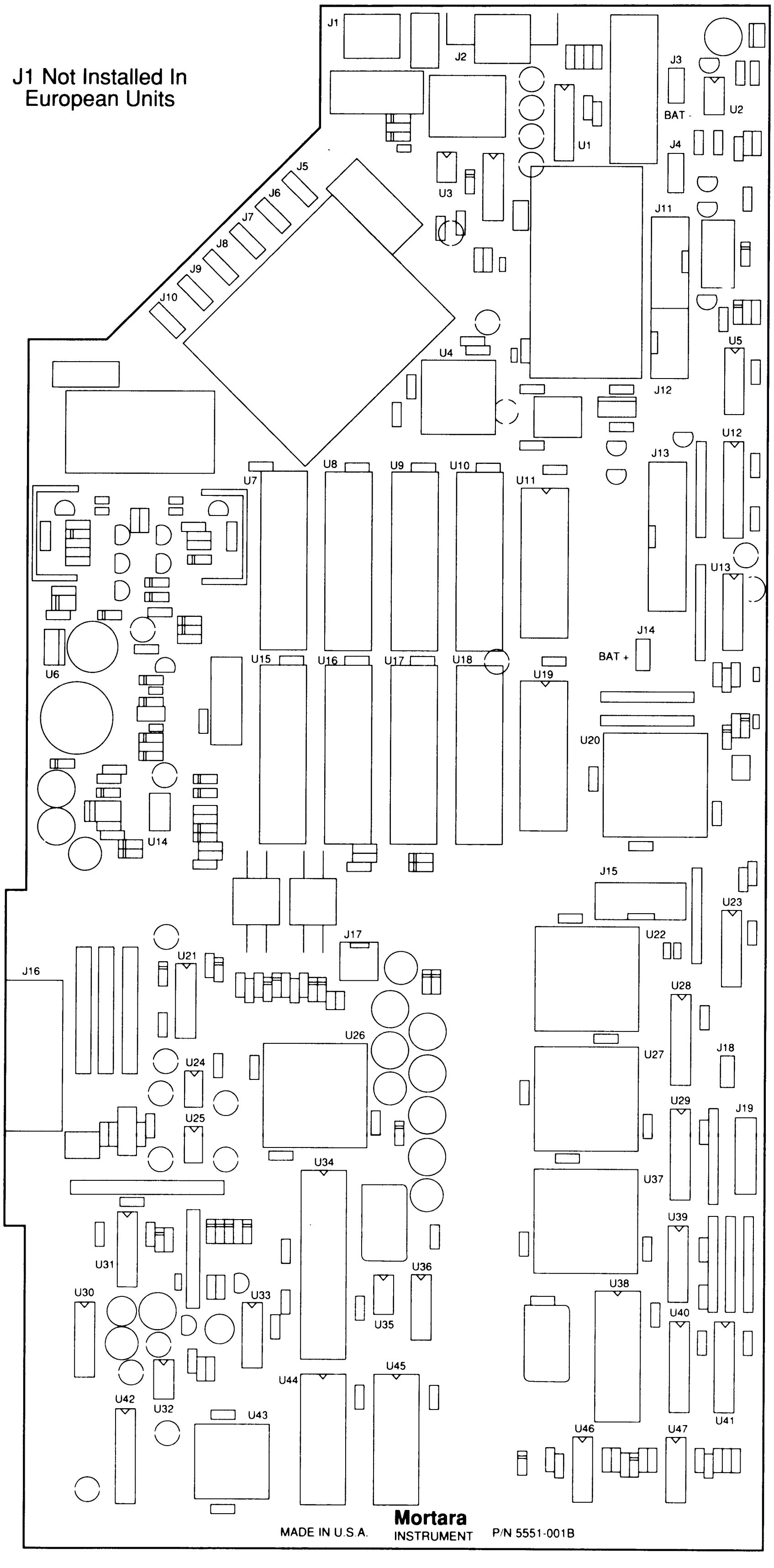


7.4 Main Control Schematic – 8.5 Inch Writer



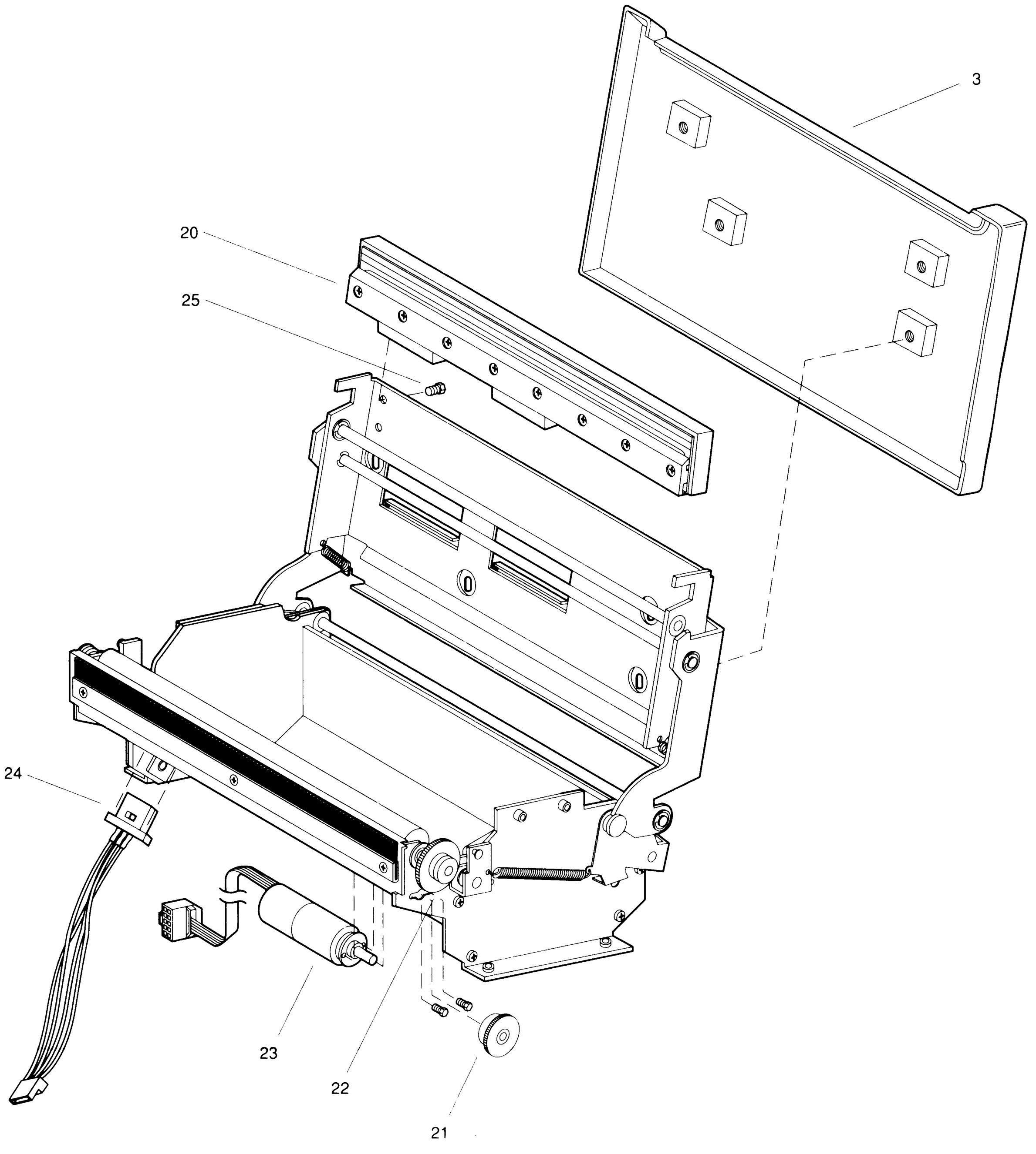
8.0 CIRCUIT BOARD ASSEMBLY DRAWING

J1 Not Installed In
European Units



9.0 PARTS LIST

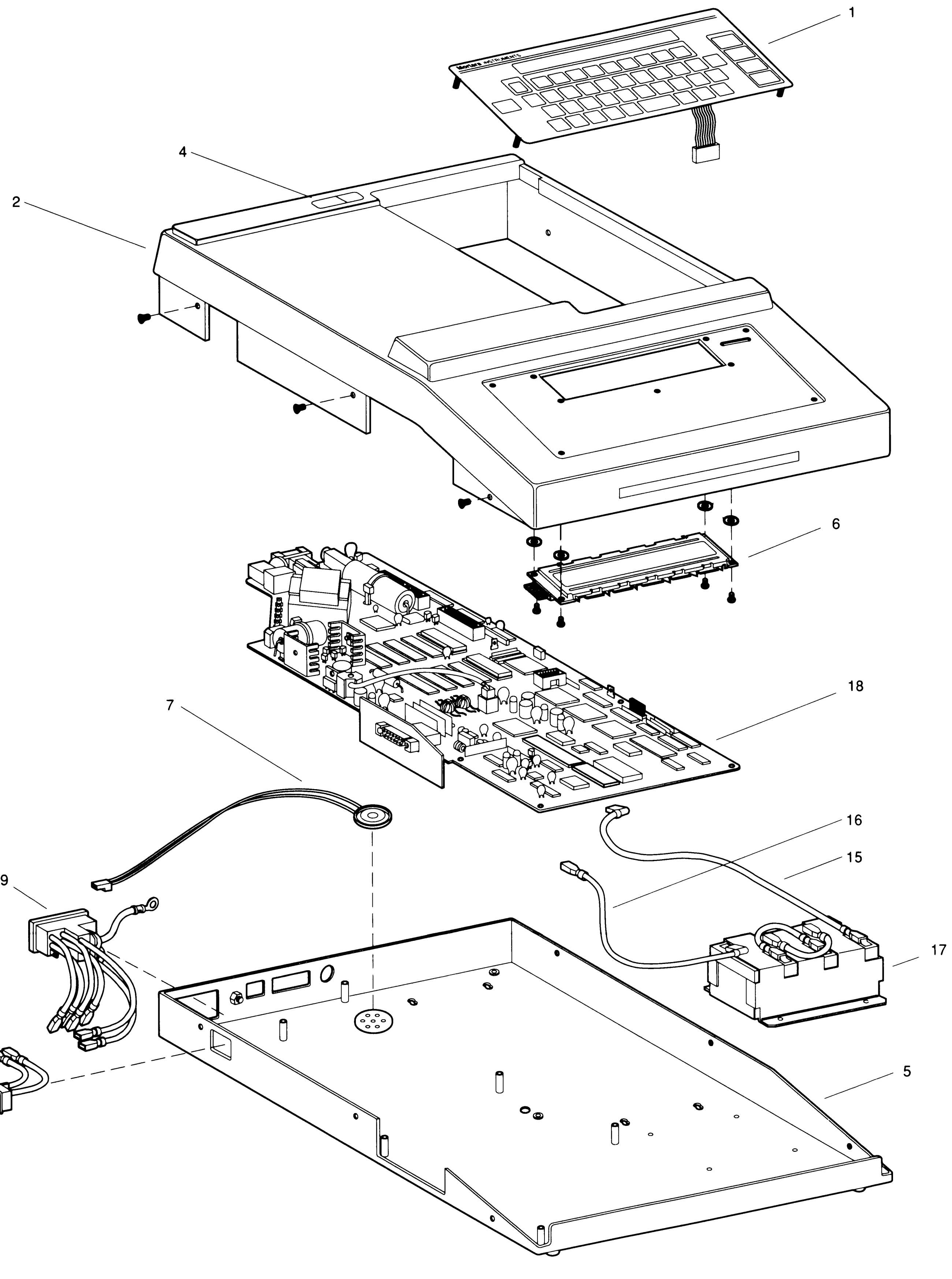
9.1 Writer Assembly



9.2 Writer Assembly Parts List

Illus. Ref.	P/N	Part Description	Quantity
19	22500-200	WRITER, THERMAL, ROLL, 8.5"	
20	5450-216	PRINTHEAD, THERMAL, 8.5"	1
21	6515-046	GEAR, PLASTIC, 46 TOOTH	1
22	6515-064	GEAR, PLASTIC, 64 TOOTH	1
23	6545-001	MOTOR, PRINTER DRIVE	1
24	25020-025	ASSEMBLY, PHOTO SENSOR, ELI-200	1
25	6001-002-01	SCREW, SHOULDER HEX M3 x 0.5	1

9.3 Chassis Assembly



9.4 Chassis Assembly Parts List

Parts List for 1 Units of Assembly: #33999-001-1000
Printed Date: February 1991
Assembly Part Description: BASE ASSY, ELI-200, ALL VOLTS-STANDARD

Illus. Ref.	P/N	Part Description	Quantity
	4000-003	FUSE, 3AG, 250V, 3A	1
	4115-003	FUSE CARRY, 3AG, GRY, (41010-002A)	1
	4800-003	BATTERY, GEL CELL, 1 AMP	3
	6020-430	SCREW, PHL, FLSTR, M3 x 6	15
	6020-830	SCREW, PHL, FLSTR, M3 x 8	12
	6105-030	WASHER, LOCK, SPLIT, M3	3
	6106-060	WASHER, FLAT M6	1
	6106-130	WASHER, FLAT M3 9MM O.D.	4
	6107-060	WASHER, LOCK, EXTERNAL, M6	2
	6150-432	NUT, HEX, STEEL, 1/4-32	2
	6152-001-01	NUT, W/CAPTIVE WASHER M3	5
	6191-003	GROUNDING POST, THUMB NUT, 1/4-32	1
	7450-002	BUMPER, RND, MNT W SCREW, 5/8X9/32	5
	7495-001	CABLE TIE, LOCKING, 3.8 x .10	3
	7495-004	CABLE TIE, SCR MTG, 4.5 x .10	1
	8484-202	PATIENT CONNECT SURROUND, ELI-200	1
	8551-07	SPEAKER RETAINER	1
5	8554-200	CHASSIS, MAIN, ELI-200	1
	8554-215	BATTERY BRACKET, ELI-200	1
	12000-049	LABEL, GROUP FOR ELI-200 (SERIES 9049)	1
7	14040-003	ASSY, SPKR-GRILL-CONN, ELI-200	1
8	14050-003	ASSY, AC SWITCH & LEADS, 100/200 STR	1
9	14050-005	ASSY, AC CONN & LEADS, ELI-200	1
19	22500-200	WRITER ASSY, 8" THERMAL ROLL PAPER	1
	25018-014	CABLE ASSY, RIBBON, SIG TO HEAD ELI-200 26C	1
	25020-017	CABLE ASSY, ELI-200, POWER-HEAD	1
15	25020-018	CABLE ASSY, RED, 18AWG, BAT (+), E200	1
16	25020-019	CABLE ASSY, BLK, 18AWG, BAT (-), E200	1
17	25020-020	CABLE ASSY, BLK, 18AWG, BAT-BAT, E200	2
	26051-001	ELI-200 PCB ASSEMBLY STANDARD	1

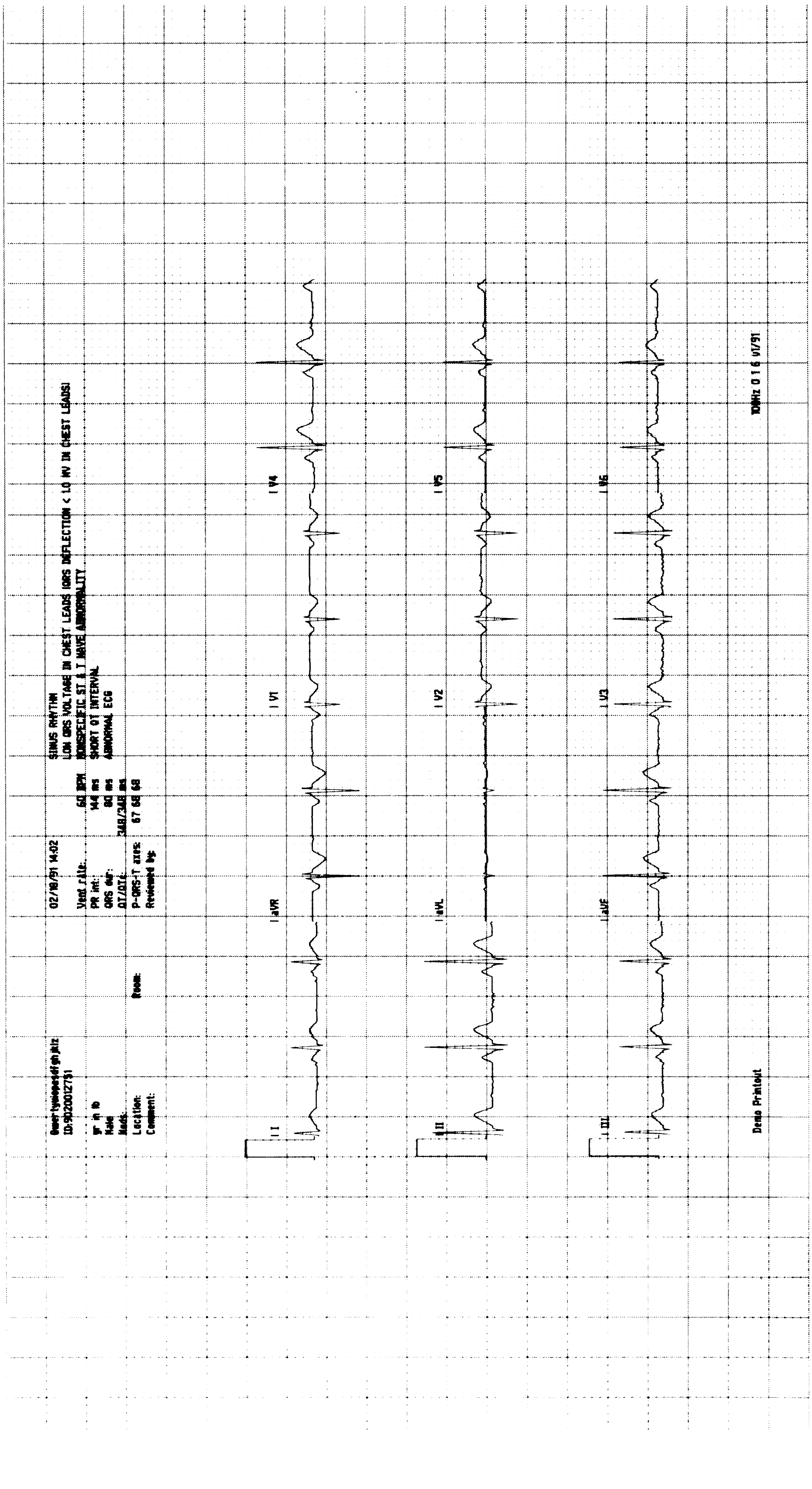
Parts List for 1 Units of Assembly: #34000-012-1000
Printed Date: February 1991
Assembly Part Description: ELI-200 12 LEAD 110V ECG 1/91

	3181-008	HOSPITAL POWER CORD 8'	1
	4000-006	FUSE, 0.2A 3AG 250V SLO-BLO	2
	4115-007	FUSE CARRY, 3AG, GREY, (3221-03XA)	2
1		KEYBOARD, 46 KEY ASSEM MORTARA INSTRUMENT	1
	6020-010	SCREW, PHL, FLAT, M3 x 10	2
	6020-430	SCREW, PHL, FLSTR, M3 x 6	9
	6020-830	SCREW, PHL, FLSTR, M3 x 8	7
	6105-030	WASHER, LOCK, SPLIT, M3	16
	6106-130	WASHER, FLAT M3 9MM O.D.	10
	6152-030	NUT, HEX, STEEL, M3	5
	6400-004	CABLE, TEL, 4 PIN MOD, 8', 4 PIN MOD	1
3	8484-201	DOOR FOR ELI-200 WRITER, WHITE	1
4	8484-203	BUTTON, ELI-200, WRITER	1
2	8484-210	COVER 12 LEAD ELECTROCARD (SAME 8484-200)	1
	8554-047-50	LATCH RELEASE BRACKET FOR ELI-200	1
	8554-048-50	ARM, LATCH RELEASE FOR ELI-200	1
	9025-015	LABLE, WARNING FOR FUSE	1
	9041-007	LABEL, U/L LISTED ELI-100/200 DEVICES	1
	9046-008-02	LABEL, ELI-100/200 AC FUSE RATING EUROPE	1

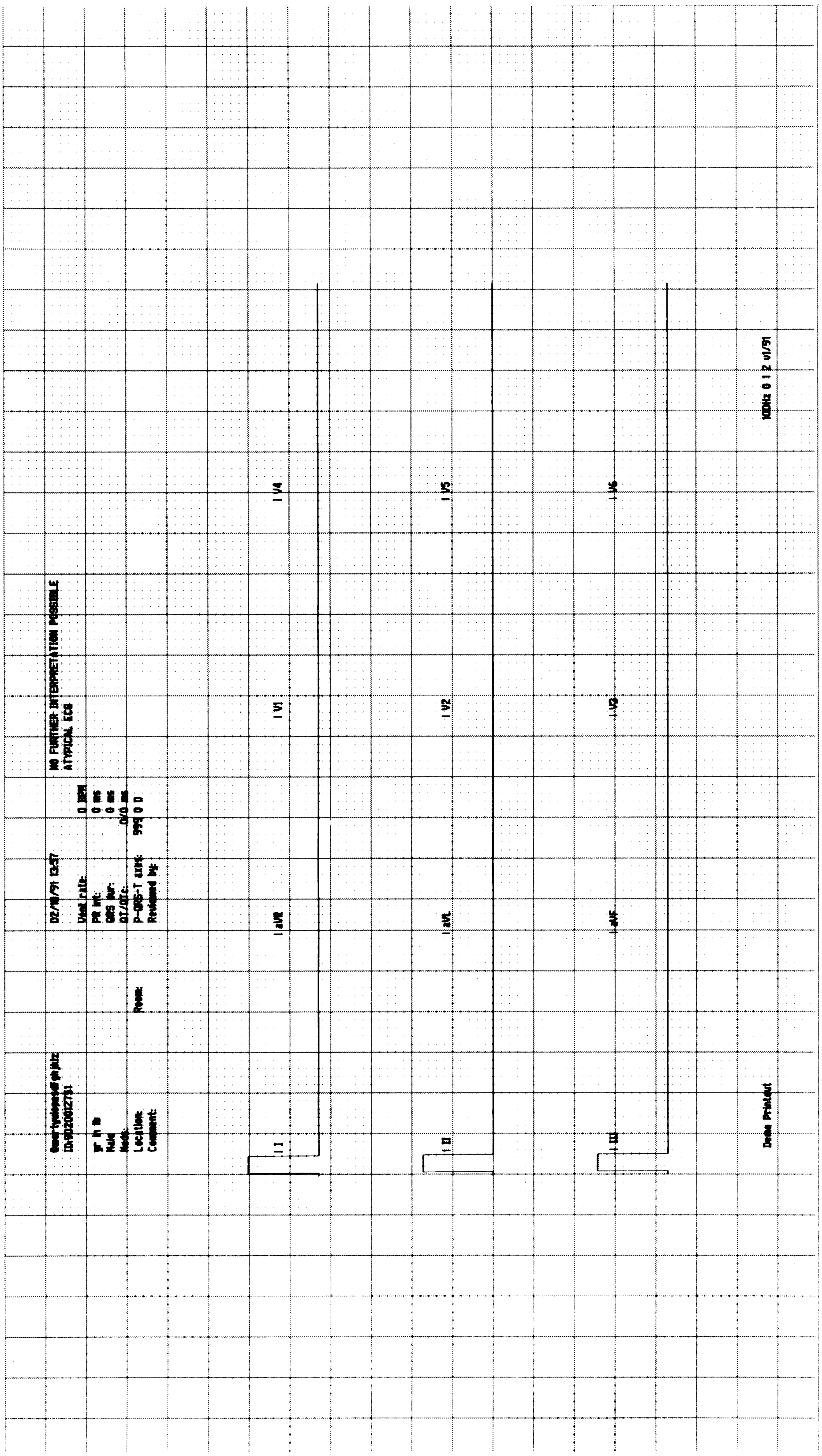
Illus. Ref.	P/N	Part Description	Quantity
	9100-006	CHART PAPER 8.5 ROLL PERF FULL GRID	1
	9100-008	CHART PAPER 8.5 ROLL PERF 200' W/HEADER	1
	9300-007	ELECTRODE, REST SENTRY 1020	500
	9325-001	4MM ALLIGATOR CLIP ADAPTOR	10
	9501-001	PHYSICIAN'S GUIDE TO ECG ANALYSIS	1
	9502-002-50	ELI-200 OPERATOR'S MANUAL-ASSEMBLED	1
	9503-002	ELI-200 SHORT FORM INSTRUCTION CARD	1
	9504-001	THERMAL PAPER WARNING NOTICE	1
	10100-6432	EPROM, ELI-100/200 & Q750 FE/U43 26JU90	1
	10200-0101	EPROM, ELI-200 LO/U19 20NOV90	1
	10200-0201	EPROM, ELI-200 HI/U11 20NOV90	1
6	14000-004	ASS, 2 x 40 LCD & 2 x 7 RA CONN	1
	25018-010	CABLE ASSY, RIBBON LCD TO BRD ELI-100/200	1
18	33999-001-1000	BASE ASSEMBLY, ELI-200 ALL VOLTS-STANDARD	1
	9293-010-50	RESTING PATIENT CABLE W/AMERICAN MARKING	1
	9300-024-50	RESTING TAB TYPE ELECTRODE-BOX OF 500	1

10.0 APPENDIX A - SAMPLE TRACES

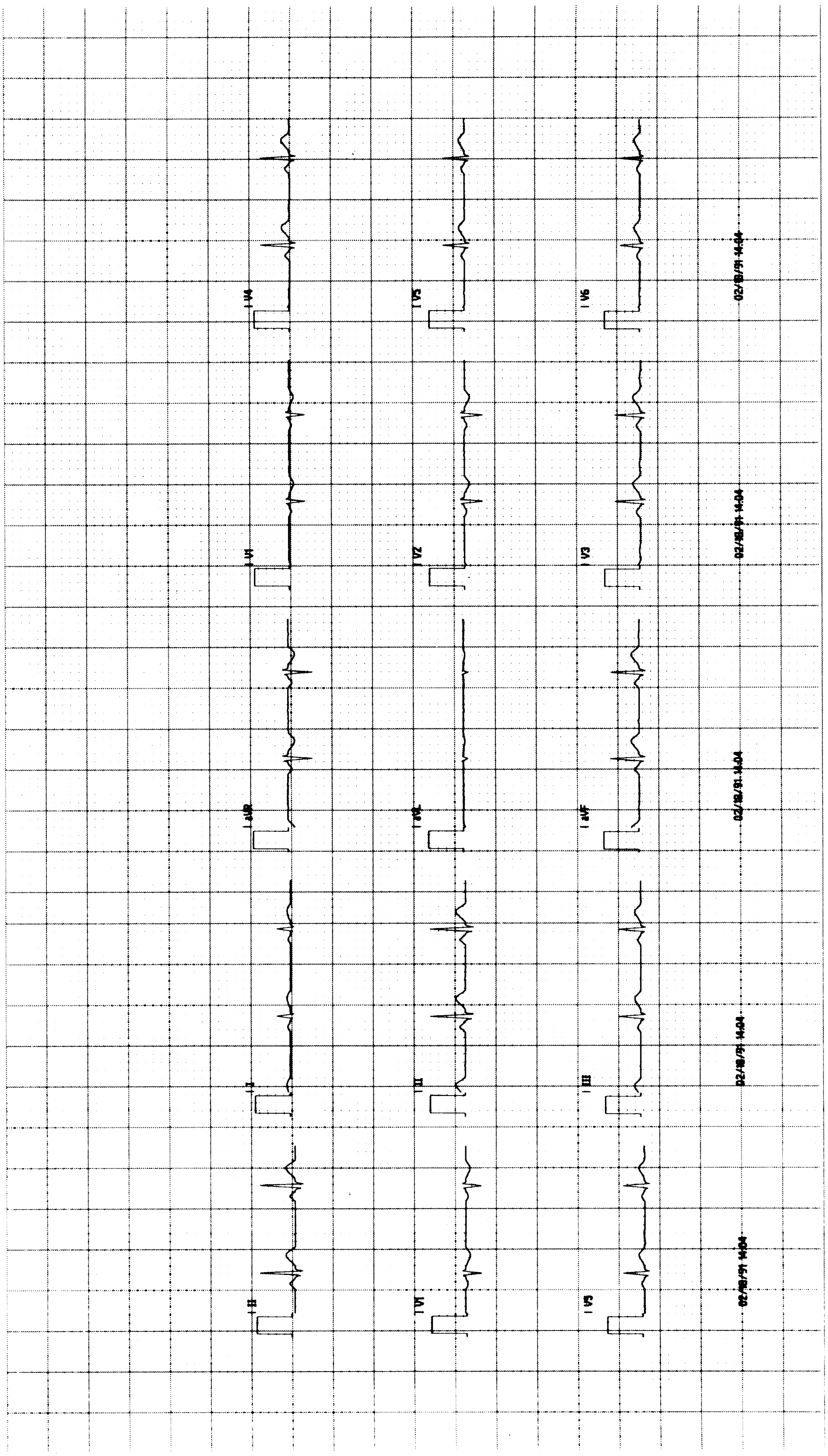
SAMPLE TRACE 1: NOISE/DRIFT TEST



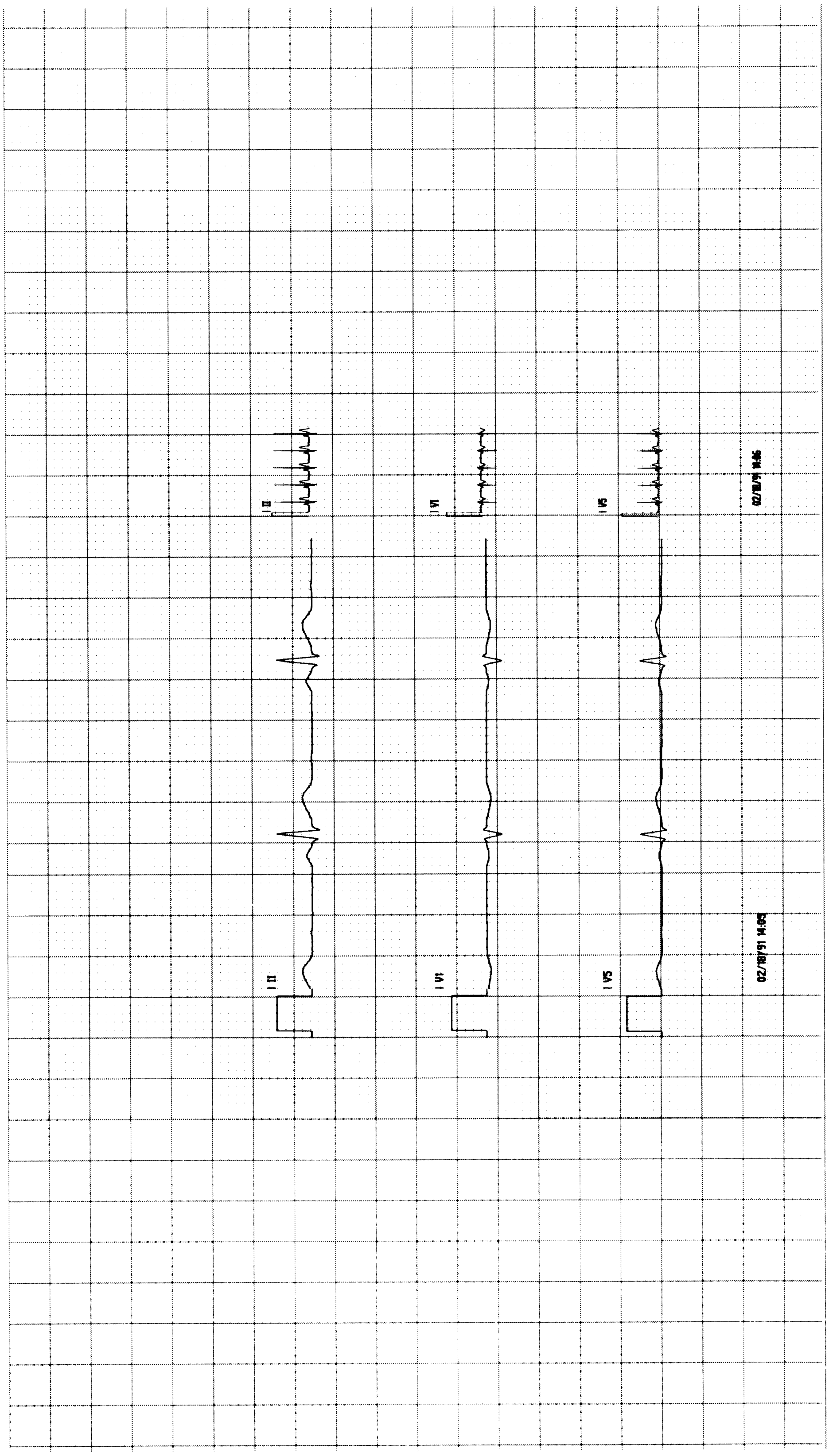
SAMPLE TRACE 2: 12-LEAD AUTO ECG



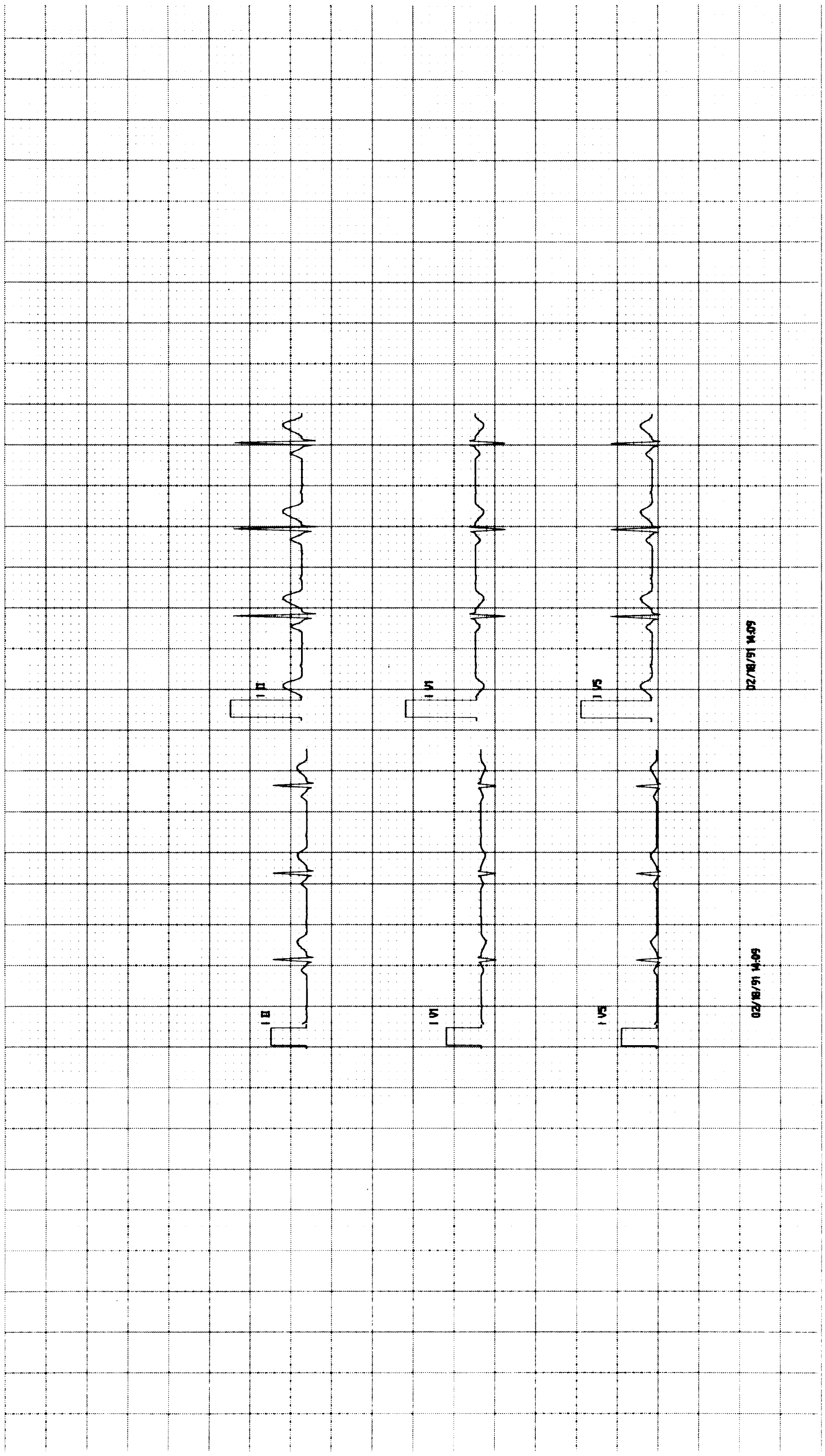
SAMPLE TRACE 3: RHYTHM STRIPS



SAMPLE TRACE 3: RHYTHM STRIPS (Continued)



SAMPLE TRACE 3: RHYTHM STRIPS (Continued)

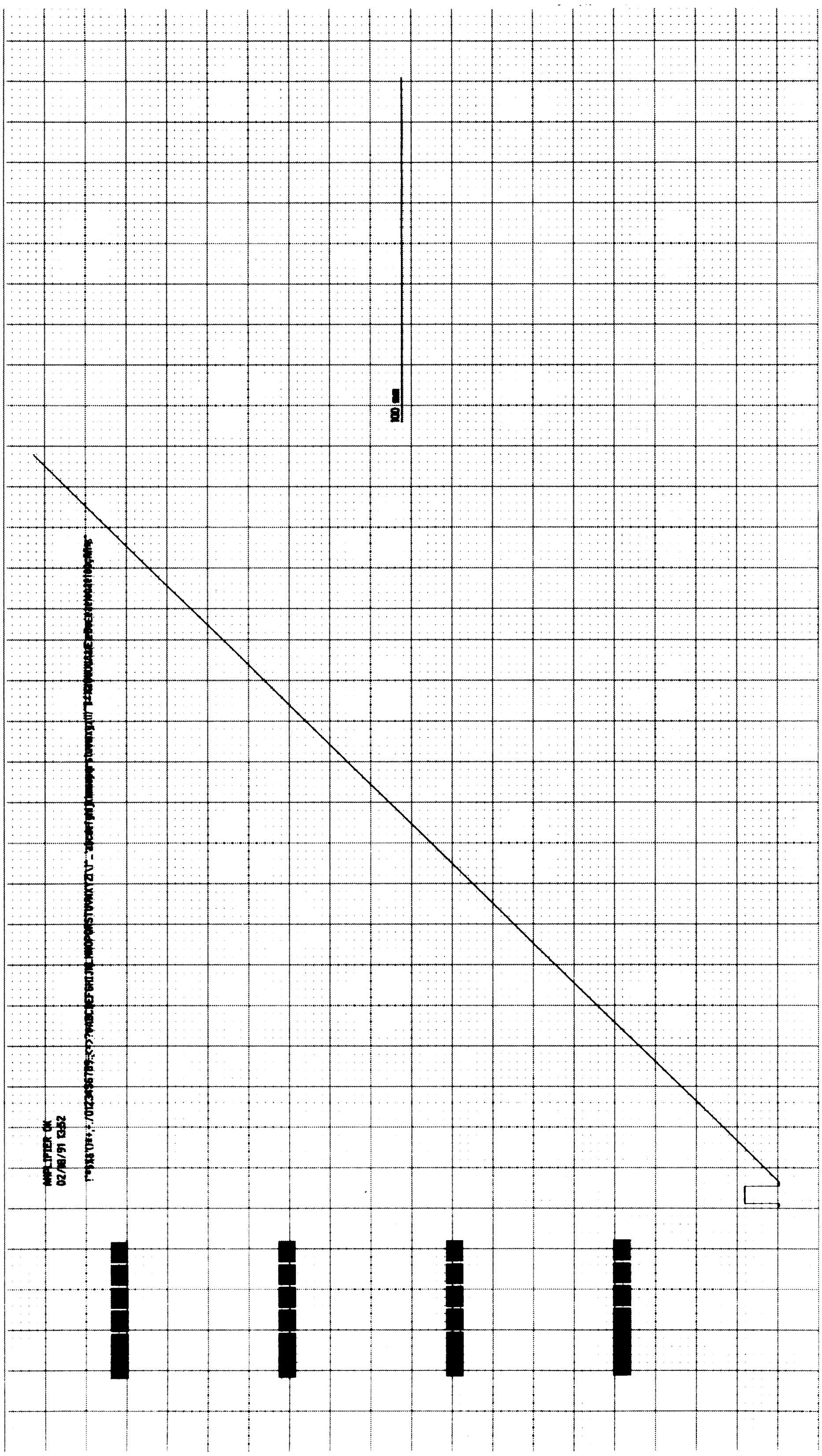


SAMPLE TRACE 4: DIRECTORY

Patient directory

Name	Patient ID	Date	Time	PLT	XMT	FTV	DEL
Qwertyuiopasdfghjklz	9020012751	02/18/91	14:02				
	9020012751	02/18/91	14:01				
	9020012751	02/18/91	14:00				
	9020012751	02/18/91	13:59				
	9020012751	02/18/91	13:57				
	9020012751	02/18/91	13:56				

SAMPLE TRACE 5: WRITER SELF TEST



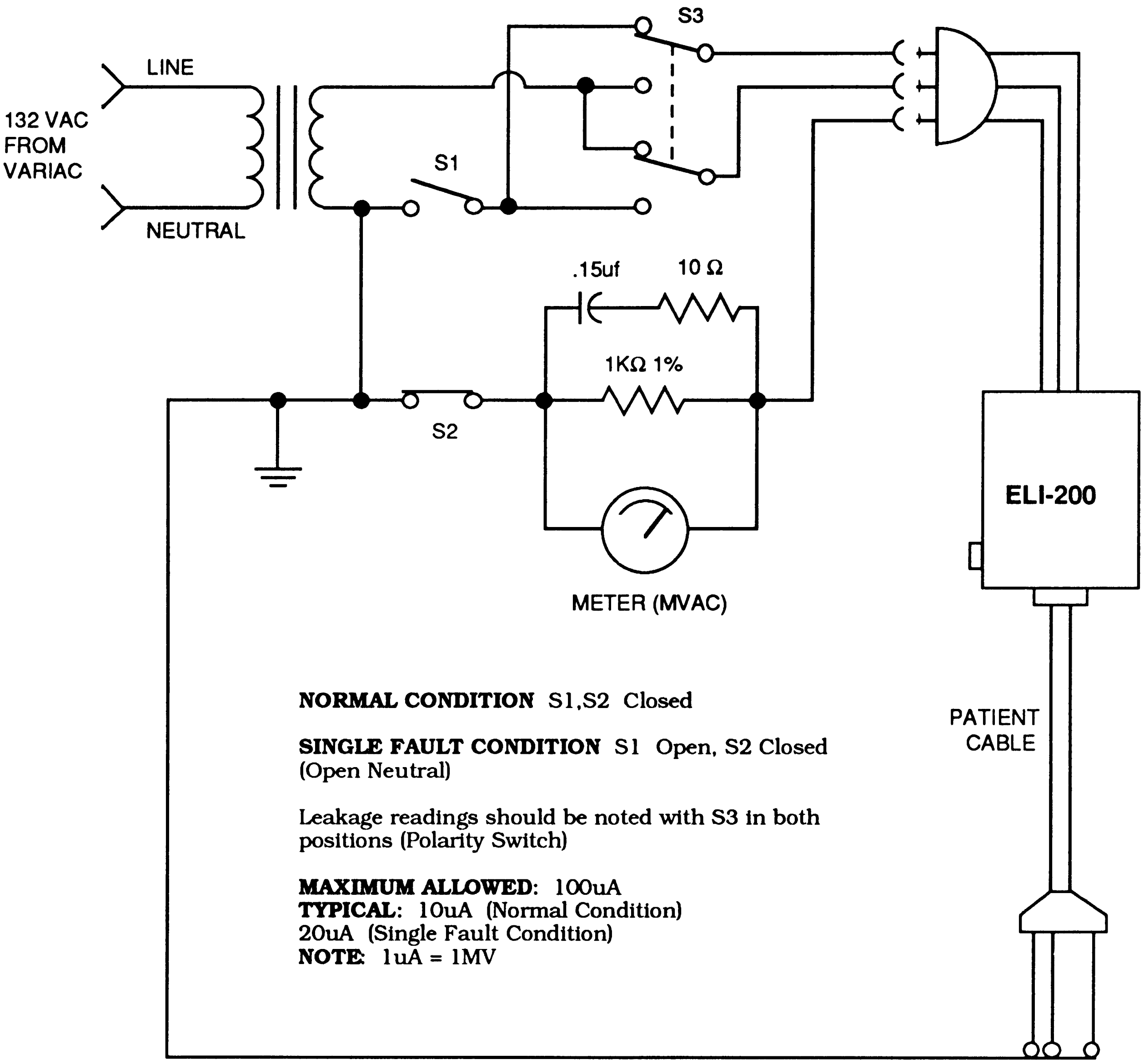
11.0 DESCRIPTION OF LEAKAGE TESTS

Note: Measure the safety ground at any exposed metal part of the ELI-200, except RS232 connector pins.

11.1 **Leakage Tests** must be performed whenever the PCB assembly, AC connector assembly, AC switch assembly, or the writer are removed and replaced. Tests should be performed using an AC variac adjusted to 10% over the normal line voltage.

11.2 **Earth Leakage Current Measurement** - This test measures the leakage from the AC input circuitry to the earth ground connection of the unit. Both normal and single fault conditions should be tested, as well as reversing the line polarity. Worst case readings can not exceed 100uA. Refer to figure 11.0.

EARTH LEAKAGE CURRENT MEASUREMENT



NORMAL CONDITION S1,S2 Closed

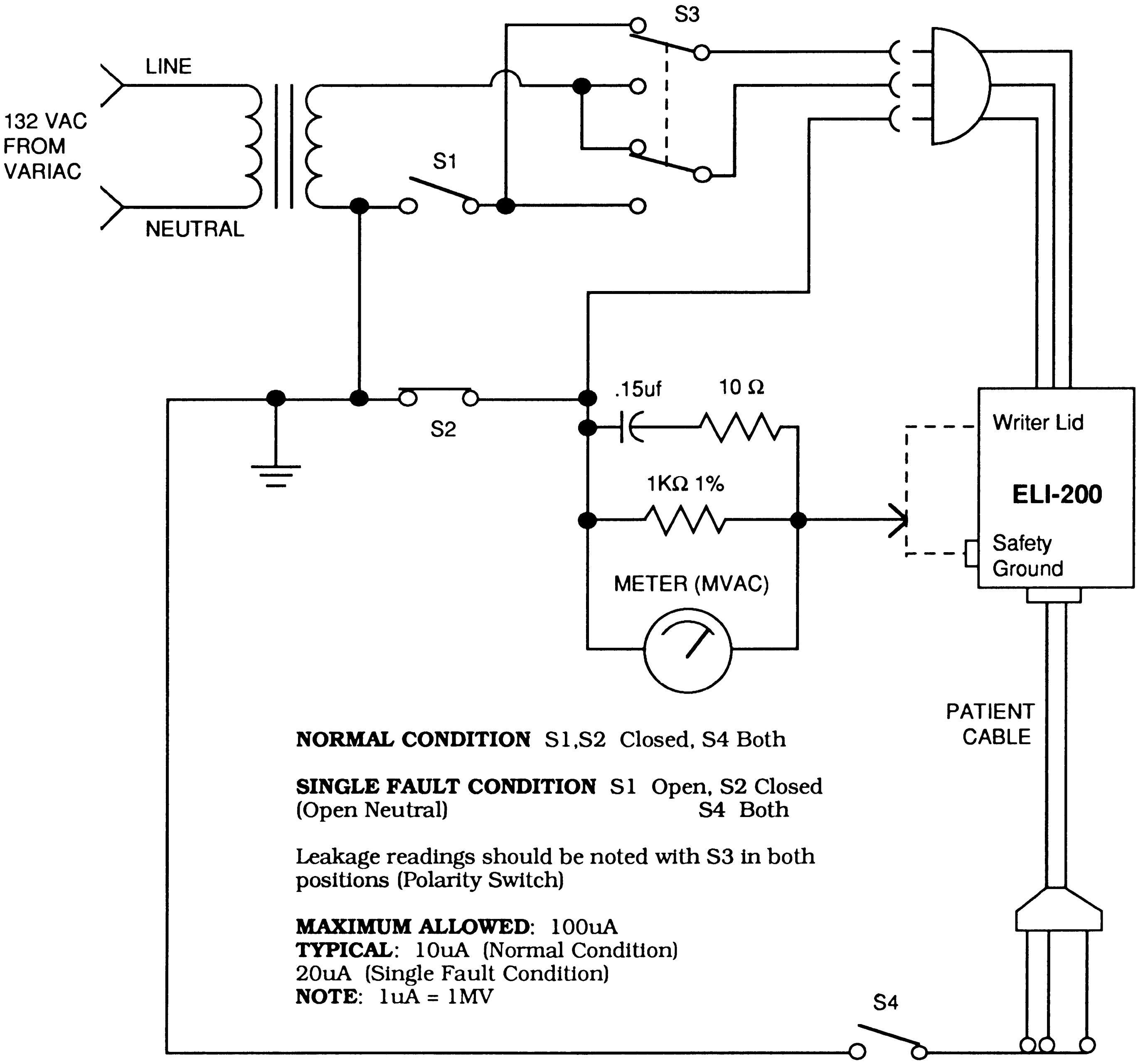
SINGLE FAULT CONDITION S1 Open, S2 Closed (Open Neutral)

Leakage readings should be noted with S3 in both positions (Polarity Switch)

MAXIMUM ALLOWED: 100uA
TYPICAL: 10uA (Normal Condition)
20uA (Single Fault Condition)
NOTE: 1uA = 1MV

11.3 Chassis Leakage Current Measurement - Same as 11.2, but the leakage current to various points on the chassis, such as the writer lid and the safety ground are measured instead. Refer to figure 11.1.

CHASSIS LEAKAGE CURRENT MEASUREMENT



NORMAL CONDITION S1,S2 Closed, S4 Both

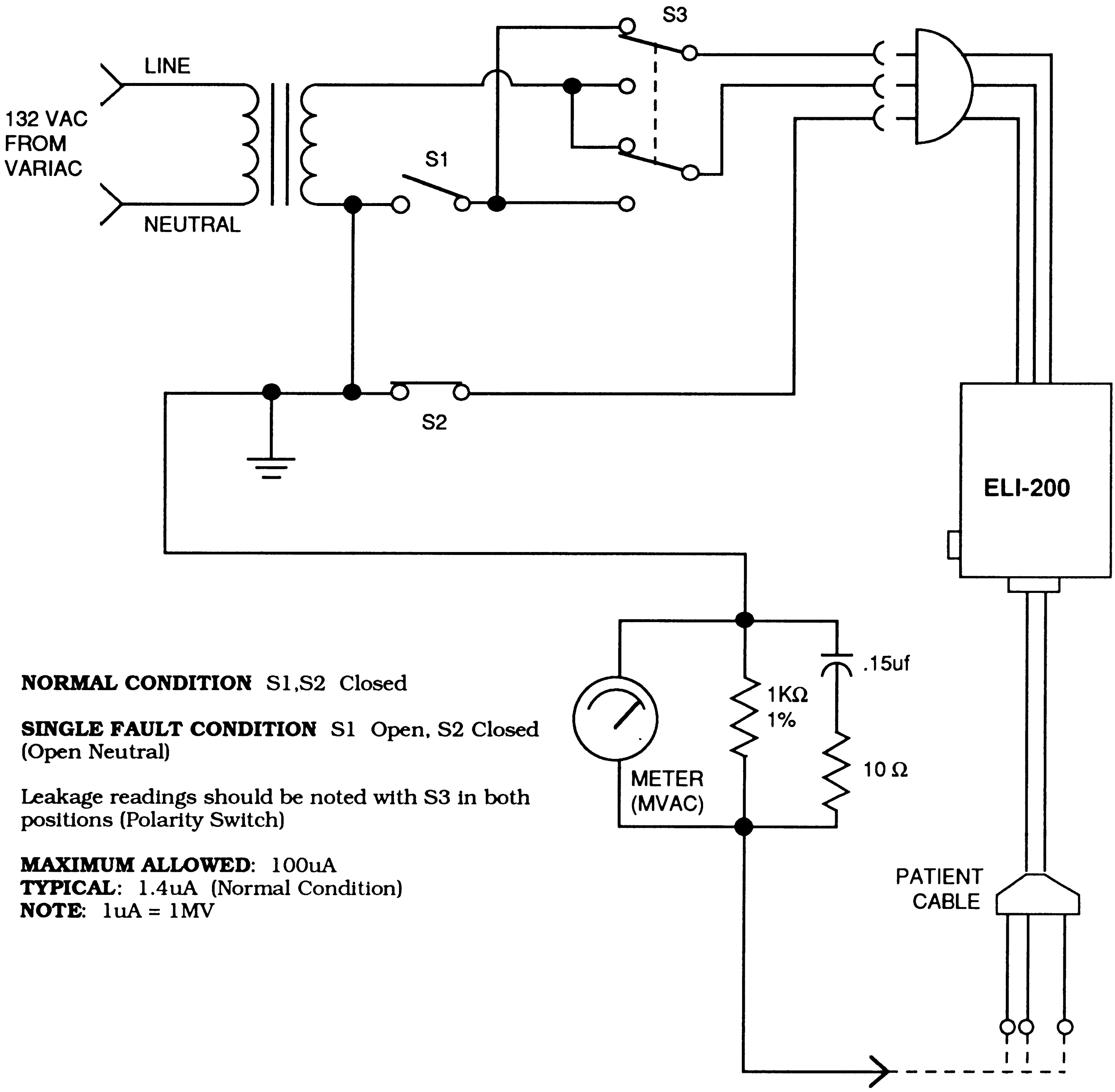
SINGLE FAULT CONDITION S1 Open, S2 Closed
(Open Neutral) S4 Both

Leakage readings should be noted with S3 in both positions (Polarity Switch)

MAXIMUM ALLOWED: 100uA
TYPICAL: 10uA (Normal Condition)
20uA (Single Fault Condition)
NOTE: 1uA = 1MV

11.4 Patient Leakage Current Measurement - This test measures the leakage current from the AC input circuitry to the isolated patient - connected circuitry. The normal condition with line polarity reversed should be tested. Worst case readings can not exceed 10uA. Refer to figure 11.2.

PATIENT LEAKAGE CURRENT MEASUREMENT



NORMAL CONDITION S1,S2 Closed

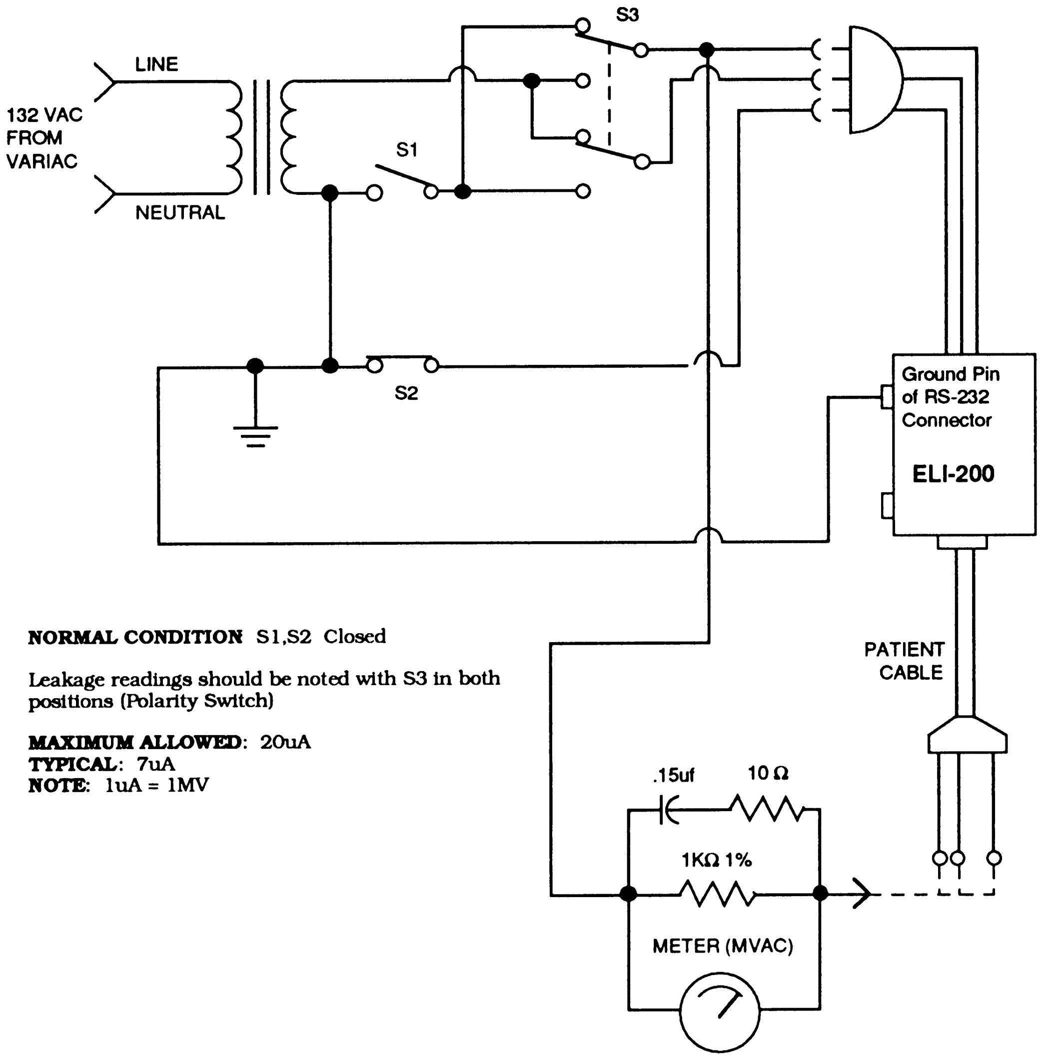
SINGLE FAULT CONDITION S1 Open, S2 Closed (Open Neutral)

Leakage readings should be noted with S3 in both positions (Polarity Switch)

MAXIMUM ALLOWED: 100uA
TYPICAL: 1.4uA (Normal Condition)
NOTE: 1uA = 1MV

11.5 Line Voltage Applied To Patient Connection Leakage Current Measurement - In this test, a potential at 10% over the line voltage is applied to the patient connection and the leakage current with respect to earth ground is measured. The normal condition with line polarity reversed should be tested. Worst case readings can not exceed 20uA. Refer to figure 11.3.

LINE VOLTAGE APPLIED TO PATIENT CONNECTION LEAKAGE CURRENT MEASUREMENT



NORMAL CONDITION S1,S2 Closed

Leakage readings should be noted with S3 in both positions (Polarity Switch)

MAXIMUM ALLOWED: 20uA
TYPICAL: 7uA
NOTE: 1uA = 1MV

11.6 Ground Integrity Test - Whenever the writer, PCB assembly, or AC connector assembly are removed and replaced, it is necessary to check continuity from the affected chassis ground points (writer lid, safety ground) to the unit's earth ground connection. The resistance can not exceed 0.1Ω.

ADDENDUM: FOREIGN ILLUSTRATIONS AND TABLES

GERMANY:

Illustration 1:

Netz- Filter: 60Hz	Speicher Format: 2.5s	EX

Illustration 2:

Datum und Zeit: 00/00/00 00:00
Neues Datum und Zeit: 00/00/00 00:00

Illustration 3:

Neues Datum und Zeit: 12/31/88 17:55

Illustration 4:

eli 200				HF: ???
SPF	25mm/s	10mm/mV	100Hz	ID

Illustration 5:

Neuer Patient? JA NOTF. ABR

Illustration 6:

Nachname:

Illustration 7:

Vorname:

ADDENDUM: FOREIGN ILLUSTRATIONS AND TABLES (continued)

Illustration 8:

```
Ident. - Nr.:
```

Illustration 9:

```
Name:                                    ID:
KOP   3K.   25mm/s  10mm/mV  100Hz  m.BEF  EX
```

Illustration 10:

```
Neuer Patient?          JA                NOTF.
```

Illustration 11:

```
II-VI-V5                                  HF: 68
ABL         25mm/s    10mm/mV    100Hz
```

Illustration 12:

```
        LST         ALLE
REG     REG          DOK     RUF  EMP  ABR  EX
```

Illustration 13:

```
Name: Quertyuiopasclfghjkl        ID: Unit's S/N
   LOESCHE    LST   WAEHLE                   EX
```

Illustration 14:

```
        LST         ALLE
REG     REG          DOK     RUF  EMP  ABR  EX
```

Illustration 15:

```
                Empfangsbereit
                                             EX
```

ADDENDUM: FOREIGN ILLUSTRATIONS AND TABLES (continued)

Illustration 16:

Uebertragung Laeuft
ID: Unit's S/N

Illustration 17:

ACHTUNG - SELBSTTEST LOESCHT EKG'S
WEITER EX

Illustration 18:

eli 200
SELBSTTEST MODUS 080000

Table 1:

Netz-Filter: 60Hz	Speicher Format: 2.5s	ENTER drücken
Dok Format: BEF	Befund Format: ERKL	ENTER drücken
Dok. Freq: 100Hz	Dok. Kanaele: 3	ENTER drücken
Einh.: Lb/in	Datum Format: USA	ENTER drücken
Baud Rate: 38400	Autom. Tilgen: AUS	ENTER drücken
Autom. Speich: EIN	Vorschub: AUS	ENTER drücken
Ort-Nr:, GerNr:, Kopien: 0, Serienanz. Laden: 0		ENTER 4 mal drücken
ID Format: LANG		ENTER drücken
Rhythm. - Abl. Auswahl K1/II, K2/V1, K3/V5		ENTER drücken
Klinkname:		ENTER drücken

ADDENDUM: FOREIGN ILLUSTRATIONS AND TABLES (continued)

FRANCE:

Illustration 1:

```
AC              Stock.
Filtre: 60Hz    Format:    2,5s        EX
```

Illustration 2:

```
Date et Heure du Jour: 00/00/00 00:00
Entrez Date et Heure: 00/00/00 00:00
```

Illustration 3:

```
Entrez Date et Heure:     12/31/88 17:55
```

Illustration 4:

```
eli 200                                 FC: ???
FSP     25mm/s    10mm/mV    100Hz      ID
```

Illustration 5:

```
Nouveau Patient?    OUI    STAT    REQ
```

Illustration 6:

```
Nom:
```

Illustration 7:

```
Prenom:
```

ADDENDUM: FOREIGN ILLUSTRATIONS AND TABLES (continued)

Illustration 8:

ID Patient:

Illustration 9:

Nom: ID:
CPY 3PI 25mm/s 10mm/mV 100Hz INTERP EX

Illustration 10:

Nouveau Patient? OUI STAT

Illustration 11:

II-VI-V5 FC: 68
GRP 25mm/s 10mm/mV 100Hz

Illustration 12:

	LIST	LOT				
FICHIER	FICHIER	ECG	RTV	RCV	REQ	EX

Illustration 13:

Nom: Quertyuiopasclfghjkl ID: Unit's S/N
SUPPRIMER LIST CHOISIR EX

Illustration 14:

	LIST	LOT				
FICHIER	FICHIER	ECG	RTV	RCV	REQ	EX

Illustration 15:

Pret pour reception

ADDENDUM: FOREIGN ILLUSTRATIONS AND TABLES (continued)

Illustration 16:

Transmission En Cours
ID: Unit's S/N

Illustration 17:

AUTO TEST RISQUE DETRUIRE LE FICHIER
CONTINU EX

llustration 18:

eli 200
MODE AUTO TEST 080000

Table 1:

AC Filter: 60Hz	Stock Format: 2, 5s	ENTER
Trace Format: INTERP	Interp Format: MOT	ENTER
Trace Freq: 100Hz	Trace Pistes: 3	ENTER
Units: LB/IN	Date Format: USA	ENTER
Baud Freq: 38400	Auto Effacer: OFF	ENTER
Auto Save: ON	Attente: OFF	ENTER
Site Num:, ECG Num:,: Copies: 0, Recheche ECG: 0		4x ENTER
ID Format: LONG		ENTER
Rythm Deriv Selection CH1/II, CH2/V1, CH3/V5		ENTER
Adresse:		ENTER