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Figure 1-1. Model 78670A Defibrillator/Monitor with Annotating Recorder and Model 78671A Defibrillator/Monitor with Recorder

SECTION I
GENERAL INFORMATION

1.1 INTRODUCTION

This manual contains service information for the Model 78670A and the Model 78671A Defibrillator/Monitors. This manual also contains complete theory of operation, mechanical disassembly, circuit board removal and replacement procedures, and component level troubleshooting for both instruments. Operating instructions and installation information are covered in the Model 78670A Operating Guide, 78670-91998 and in the Model 78671A Operating Guide, 78671-91998.

1.2 IDENTIFICATION

This manual applies to all Model 78670A and 78671A Defibrillator/Monitors having the same or lower serial number prefix as that shown on the title page. The serial number prefix digits are the first four of the ten-digit instrument serial number (XXXXA00000), and identifies the latest modification of the instrument. The letter separating the prefix and the serial number designates the country in which this instrument was manufactured (A = USA; C = Canada; G = Germany; J = Japan; U = United Kingdom).

The serial number of the 78670A Defibrillator/Monitor, 78671A Defibrillator/Monitor, and the 78669A Spare Battery Charger is indicated on the plate which is attached to the bottom cover, near the center of the instrument. The serial number for the 78668A Quick-Mount Power Base is located on the rear of the instrument next to the AC power receptacle.

Important information for correcting errors, and for adapting the contents of this manual to cover improvements that occur after the printing of the manual is provided in a blue Manual Changes Supplement inserted under the front cover of the manual. These supplements are keyed to the manual print date and part number, both of which appear on the title page, and are revised as often as necessary to keep the manual current and accurate. The Errata Section of a Manual Change sheet contains corrections for errors within the manual.

On the title page of this manual, preceding the manual part number, is a microfiche number. This part number can be used to order 6.5 x 15.2 cm (4x6 inch) microfiche transparencies of this manual. Each microfiche contains up to 60 photo duplicates of the manual pages. The microfiche package also includes the latest manual change as well as all pertinent Service Notes.

1.3 INQUIRES

Refer any questions or comments regarding this manual to the nearest Hewlett Packard Sales/Service Office. Always identify the instrument by both model number and complete 10-digit serial number in all correspondence. See the rear of this manual for a worldwide listing of the Hewlett Packard Sales/Service Offices.

1.4 DESCRIPTION

1.4.1 General

With the exception of the annotating printhead on the recorder, the paddle contact indicator and interchangeable paddle connector, the 78670A and the 78671A are the same. The printhead, paddle contact indicator, paddle connector,and associated functions and controls are deleted in the 78671A Defibrillator/Monitor.

DEFIBRILLATOR

Waveform: Critically damped sinusoidal.

Output Energy (Delivered): 5, 10, 20, 30, 50, 70, 100, 150, 200 300 and 360 joules.

Charge Control: Push-button on apex paddle.

Charge Time: Less than 10 seconds to 360 joules.

Delivered Energy Display: Liquid Crystal Display shows energy that will be delivered into 50 ohms load and self test energy.

Armed Indicators: Charge done tone, light and digital display.

Safety Interlock: Output limited to 50 joules with internal paddles connected.

Paddle Contact Indicator: 3-color LED bar graph array on sternum paddle indicates quality of defibrillator paddle contact before discharge.

Paddles: Standard paddles are Anterior/ Anterior, adult and pediatric. Adult electrodes twist off to expose pediatric electrodes. Full range of internal paddles available.

Synchronizer: SYNC indicator flashes off with each detected R-wave. Marker pulse on monitor indicates defibrillator discharge point. Discharge occurs within 30 ms. of marker pulse.

SIZE and WEIGHT

Dimensions: 22.9 cm H x 31.1 cm W x 47 cm L (9" x 12.25" x 18.50").

Weight: 12.7 kg (28 pounds).

MONITOR

Inputs: ECG from paddles or 3-lead patient cable. Lead I, II, III selectable in LEADS position. LEADS or PADDLES indicator lights to show selected source.

Lead Fault: INOP indicator flashes if patient lead becomes disconnected.

Common Mode Rejection: 112 dB with 5K ohm imbalance with respect to non-isolated ground.

Display Size & Type: 4.5 cm x 9 cm for 3.75 seconds of ECG data on screen; non-fade, fixed trace.

Patient Isolation: Twelve (12) megohms or greater at input connector.

Sweep Speed: 25 mm/sec nominal.

Frequency Response: 0.5 to 40 Hz

Heart Rate Display: Digital readout from 20 to 240 BPM.

ECG Output: 1V, Nominal.

Calibration: Momentary pushbutton switch simulates 1 mV signal to ECG amplifier.

RECORDER

Annotation: 10 characters/sec nominal.

Paper Size: 50 mm x 30 m (100 ft) with 40 mm offset grid.

Recorder Modes: Delayed by 4 seconds (Real Time available).

Frequency Response: 0.5 to 40 Hz

BATTERIES

Type: 2.0 A/hr rechargeable nickel-cadmium.

Charge Time: 16 hours for fully depleted battery.

Capacity: Fifty (50) full energy discharges or 2.5 hours of monitoring or 1.5 hours combined monitoring and recording.

Charge Indicator: Light is on when battery is charging; flashes when battery is low.

STANDARD ACCESSORIES

78668A Quick Mount Power Base

Redux® Paste, 1 oz., Part number 651-1029

ECG Cable, Part number 14489B

Electrode Lead Set, part number 14151A. Disposable Electrodes, part number 14445A.

Power Cable, Male NEMA-Female CEE22, 2.4 m (8 ft) part number 8120-3493.

Recorder Paper, spare roll, part number 9280-0980.

Adjustment Tool, part number 78660-27800.

Operating Manual: Part Number 78670-91998

Operating Instruction Card: Part Number 5952-6866

OPTIONAL ACCESSORIES

ECG Output Cable, Part number 8120-3164

Sync Cable, Part number 14482A.

78669A Spare Battery Charger

ORDERING INFORMATION

OPTIONS

A03	Delete interchangeable paddle connector.
C01	Add 78669A Spare Battery Charger.
C02	Delete 78668A Quick- Mount Power Base.
C03	Add Adult/Pedi Anterior/ Posterior Paddles 14412D.
C04	Add Adult Internal Paddles; includes handle set, part number 14990B and adult electrode (8.1 cm) set, part number 14993A.
C05	Add Pediatric Internal Paddles; includes handle set, part number 14990B and pediatric electrodes (5.1 cm) set, part number 14992A.
C06	Add Infant Internal Paddles (3.4 cm) part number 14416A

NOTE: Options C03, C04, C05 and C06 are not available with option A03.

L01	French Labels
L02	German Labels
L03	Dutch Labels
N01	CSA
N02	VDE/IEC Configuration
Z01	50 Hz Operation
Z02	100 volt Operation
Z05	230 volt Operation
900	UK Power Cord
901	Australian Power Cord
902	European Power Cord
906	Swiss Power Cord

Table 1-1. Model 78670A Defibrillator/Monitor/Annotating Recorder Specifications.

DEFIBRILLATOR

Waveform: Critically damped sinusoidal.

Output Energy (delivered): 5, 10, 20, 30, 50, 70, 100, 150, 200, 300 & 360 joules.

Charge Control: Push-button on apex paddle.

Charge Time: Less than 10 seconds to 360 joules.

Delivered Energy Display: Liquid Crystal Display shows energy that will be delivered into 50 ohms load and self test energy.

Armed Indicators: Charge done tone, light and digital display.

Paddles: Standard paddles are Anterior/Anterior, adult and pediatric. Adult electrodes twist off to expose pediatric electrodes.

Synchronizer: SYNC indicator flashes off with each detected R-wave. Marker pulse on monitor indicates defibrillator discharge point. Discharge occurs within 30 ms. of marker pulse.

Dimensions: 22.9 cm H x 31.1 cm W x 47 cm L (9" x 12.25" x 18.50").

Weight: 12.7 kg (28 pounds)

MONITOR

Inputs: ECG from paddles or 3-lead patient cable, Lead I, II, III selectable in LEADS position. LEADS or PADDLES indicator lights to show selected source.

Lead Fault: INOP indicator flashes if patient lead becomes disconnected.

Common Mode Rejection: 112 dB with 5K ohm imbalance with respect to non-isolated ground.

Display Size & Type: 4.5 cm x 9 cm for 3.75 seconds of ECG data on screen; non-fade, fixed trace.

Patient Isolation: Twelve (12) megohms or greater at input connector.

Sweep Speed: 25 mm/sec nominal.

Frequency Response: 0.5 to 40 Hz.

Heart Rate Display (Optional): Digital readout from 20 to 240 BMP.

ECG Output: 1V, nominal

Calibration: Momentary push-button switch simulates 1 mV signal to ECG amplifier.

RECORDER (Optional)

Paper Size: 50 mm x 30 m (100 ft) with 40 mm grid.

Recorder Modes: Delayed by 4 seconds (Real Time available).

Frequency Response: 0.5 to 40 Hz.

BATTERIES

Type: 2.0 A/hr rechargeable nickel-cadmium.

Charge Time: 16 hours for fully depleted battery.

Capacity: Fifty (50) full energy discharges or 2.5 hours of monitoring or 1.5 hours combined monitoring and recording.

Charge Indicator: Light is on when battery is charging; flashes when battery is low.

STANDARD ACCESSORIES

78668A Quick Mount Power Base

Redux® Paste, 1 oz., Part number 651-1029

ECG Cable, Part number 14489B.

Electrode Lead Set, Part number 14151A.

Disposable Electrodes, Part number 14445A.

Power Cable, Male NEMA-Female CEE22, 2.4 m (8 ft) part number 8120-1992.

Recorder Paper, spare roll, Part number 9280-0980.

Adjustment Tool, Part number 78660-27800.

Operating Manual: Part number 78671-91998

Operating Instruction Card: Part number 5952-6868

OPTIONAL ACCESSORIES

ECG Output Cable, Part number 8120-3493.

Sync Cable, Part number 14482A.

78669A Spare Battery Charger

ORDERING INFORMATION

OPTIONS

A01	Delete Recorder	L01	French Labels	Z02	100 volt Operation
A02	Delete Recorder & Heart Rate	L02	German Labels	Z05	230 volt Operation
C01	Add 78669A Spare Battery Charger	L03	Dutch Labels	900	UK Power Cord
C02	Delete 78668A Quick-Mount Power Base	N01	CSA	901	Australian Power Cord
		N02	VDE/IEC Configuration	902	European Power Cord
		Z01	50 Hz Operation	906	Swiss Power Cord

Table 1-2. Model 78671A Defibrillator/Monitor Specifications.

1.4.2 Model 78670A Defibrillator/Monitor with Annotating Recorder

The 78670A is a critically damped sinusiodal waveform defibrillator (see figure 1-2) combined with a non-fade ECG monitor and annotating strip chart recorder. Energy is selectable to 360 joules (delivered into a 50 ohm load) in eleven discrete steps, (400 joules replaces 360 joules with option A01).

The ECG Monitor displays HEART RATE, and ECG obtained through the paddles or through a three-lead patient cable. HEART RATE ALARMS are preset at 30 and 150

BPM. Size of the ECG waveform is automatically controlled or can be manually adjusted if desired.

The recorder automatically annotates DATE/TIME, HEART RATE, SELECTED ENERGY, DELIVERED ENERGY, PEAK CURRENT and PATIENT IMPEDANCE during a procedure.

The 78670A operates from a rechargeable 2.0 ampere-hour nickel-cadmium battery which provides fifty 360 joule discharges, or more than 2.5 hours of continuous monitoring or 1.5 hours of combined monitoring and recording. A Model 78668A (Quick-Mount Power Base) is provided as a standard accessory and allows AC line power operation of the Defibrillator/Monitor while simultaneously charging its battery. During battery operation, a BATTERY LOW indicator flashes when a low battery condition exists.

Mounting the 78668A Quick-Mount Power Base to the top of a cart or vertically on a wall provides a secure mounting for the instrument as well as a quick release for emergency portable use.

An accessory storage compartment provides convenient storage for patient leads, electrodes and Redux paste. The compact, lightweight package design, along with battery operation, permits its use in portable applications.

1.4.3 Model 78671A Defibrillator/Monitor/Recorder

The 78671A Defibrillator/Monitor combines a DC defibrillator, non-fade ECG monitor and recorder. The defibrillator recorder and monitor sections are essentially the same as the 78670A described in Section 1.4.2 with the following exceptions: no paddle contact indicator on the sternum paddle, no annotation on the recorder, and non-interchangeable paddles.

1.4.4 Monitor

Fixed or moving ECG waveforms are displayed on a 4.5 x 9 cm display area. The monitor is internally programmed to display either a fixed or moving trace with internal programming switch S2, mounted on the memory board (78660-60170). Fixed trace display is comparable to a conventional oscilloscope where new information appears to be written from left to right across the screen by repetitive sweep. The oldest information is erased by a moving erase bar before new information is written in its place. The moving trace mode provides a display similar to that of a strip chart recorder. New information is written in at the right edge of the screen and moves across from right to left. The oldest information disappears from view at the left edge of the screen. Sweep speed is 25 mm/sec.; display time is approx 3.75 seconds.

1.4.5 Recorder

Real time or 4 second delayed ECG waveforms are printed on the recorder paper. The recorder is internally programmed to print either a real time or 4 second delayed trace with internal programming switch S1, mounted on the memory board (78660-60170).

1.4.6 Defibrillator Output Information

The defibrillator stores sufficient energy to discharge 360 joules into a fifty ohm impedance. However, the actual energy delivered into a patient is a function of the total impedance to the defibrillator charge. As a practical matter, the operator controls the largest portion of this impedance by the quality of the skin preparation. If sufficient electrolyte is applied,and paddle pressure of 20-25 pounds is used, then an impedance of approximately 50 ohms would be expected and a near normal discharge would occur.

The output waveforms shown in Figure 1-2 indicate that with decreased impedance, higher peak current is obtained. Recent clinical evidence indicates that the peak current value must reach a certain threshold for defibrillation and should therefore be optimized for any particular energy setting. The primary method available to the operator for accomplishing this is through proper paddle preparation techniques. As an aid to the operator, the 78670A provides a paddle contact indicator (on sternum paddle) that helps achieve best paddle contact, before discharge, optimizing current delivered to the patient.

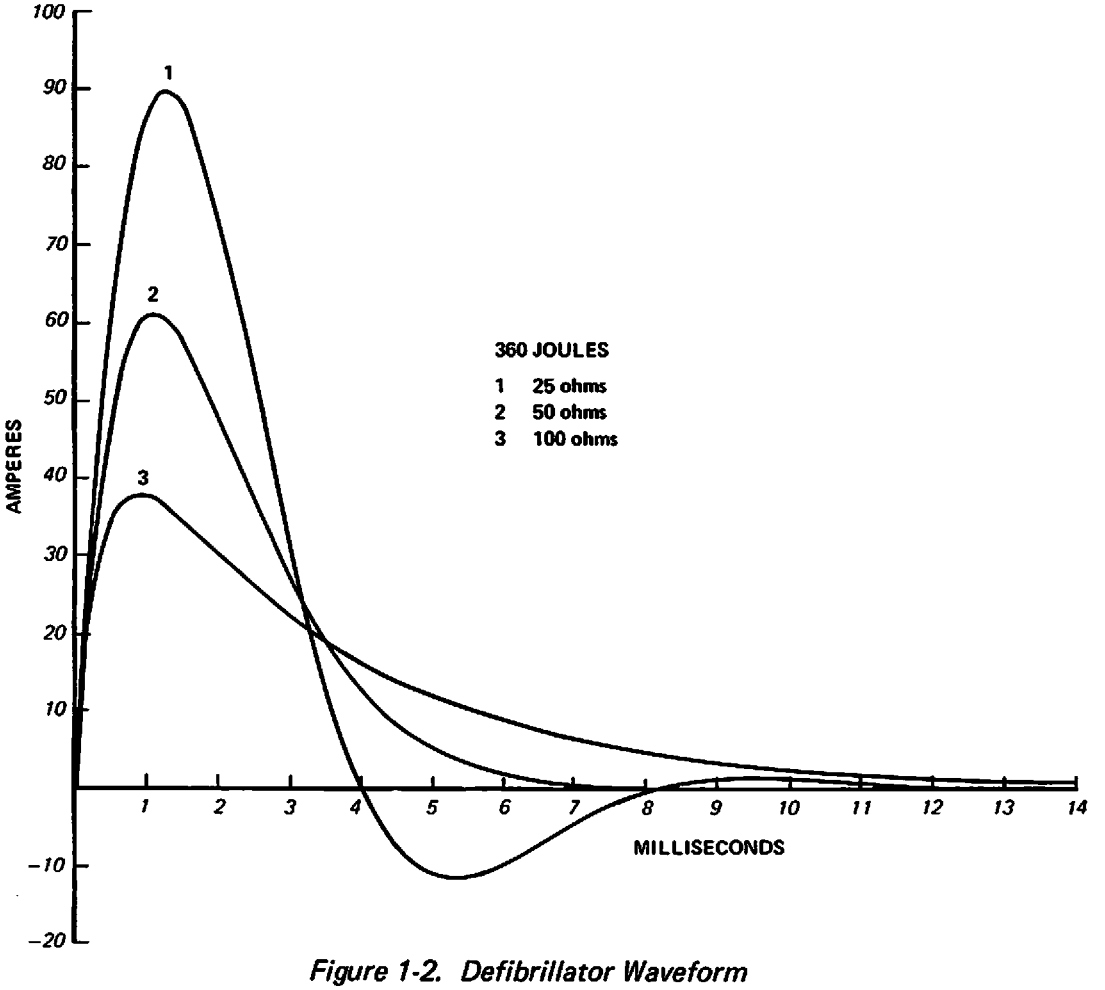


Figure 1-2. Defibrillator Waveform

1.4.7 Self Diagnostics

The 78670A and 78671A Defibrillator/Monitors use microprocessor technology to control and monitor system operation. This advanced design enables the unit to perform a self-diagnostic routine.

Each time the Defibrillator/Monitor is turned ON, a self check is performed on the control section. If all is O.K., the DELIVERED ENERGY display will alternately flash "HP" and "888". If a problem exists, the DELIVERED ENERGY display will flash an ERROR CODE such as: "P1", "P2", "P3", or "P5". If an ERROR CODE flashes on the DELIVERED ENERGY display refer to Section V for troubleshooting information.

1.4.8 Defibrillator Charge Time

Charge time to 360 joules (delivered): less than 10 seconds with fully charged battery or rated mains voltage with 78668A Power Base; less than 11 seconds with fully charged battery (after 15 maximum energy discharges) or 90% of the rated mains voltage with 78668A Power Base.

1.4.9 Paddles

The 78670A and 78671A paddle set is equipped with pediatric electrodes under the twist-off adult electrodes. If pediatric paddles are required, remove the adult electrodes as follows:

Press down on the adapter locking lever and rotate the adult electrodes in a counterclockwise direction.

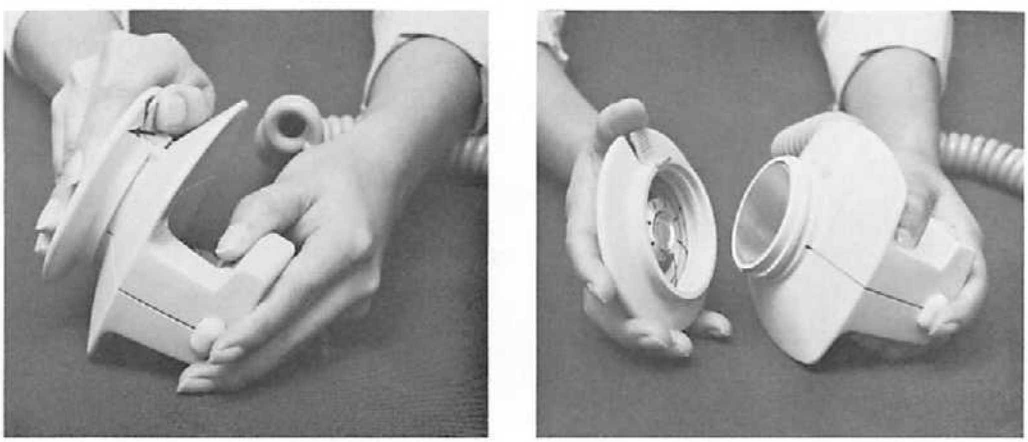


Figure 1-3A. Paddles

To replace the adult electrodes, simply reverse the above procedure.

The 78670A incorporates a paddle contact indicator on the sternum paddle. A 3-color (red, yellow, green) LED bar graph array helps operator achieve best paddle contact, optimizing current delivered to patient.

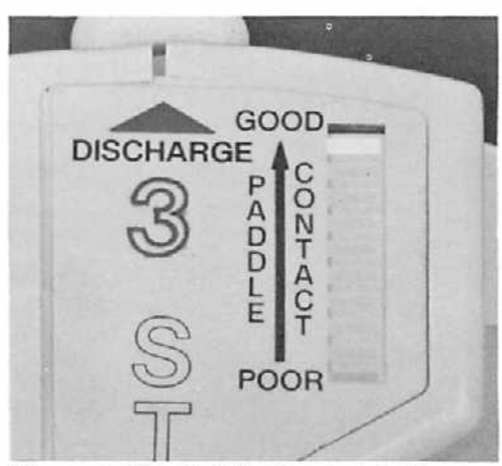


Figure 1-3B. Paddle Contact Indicator.

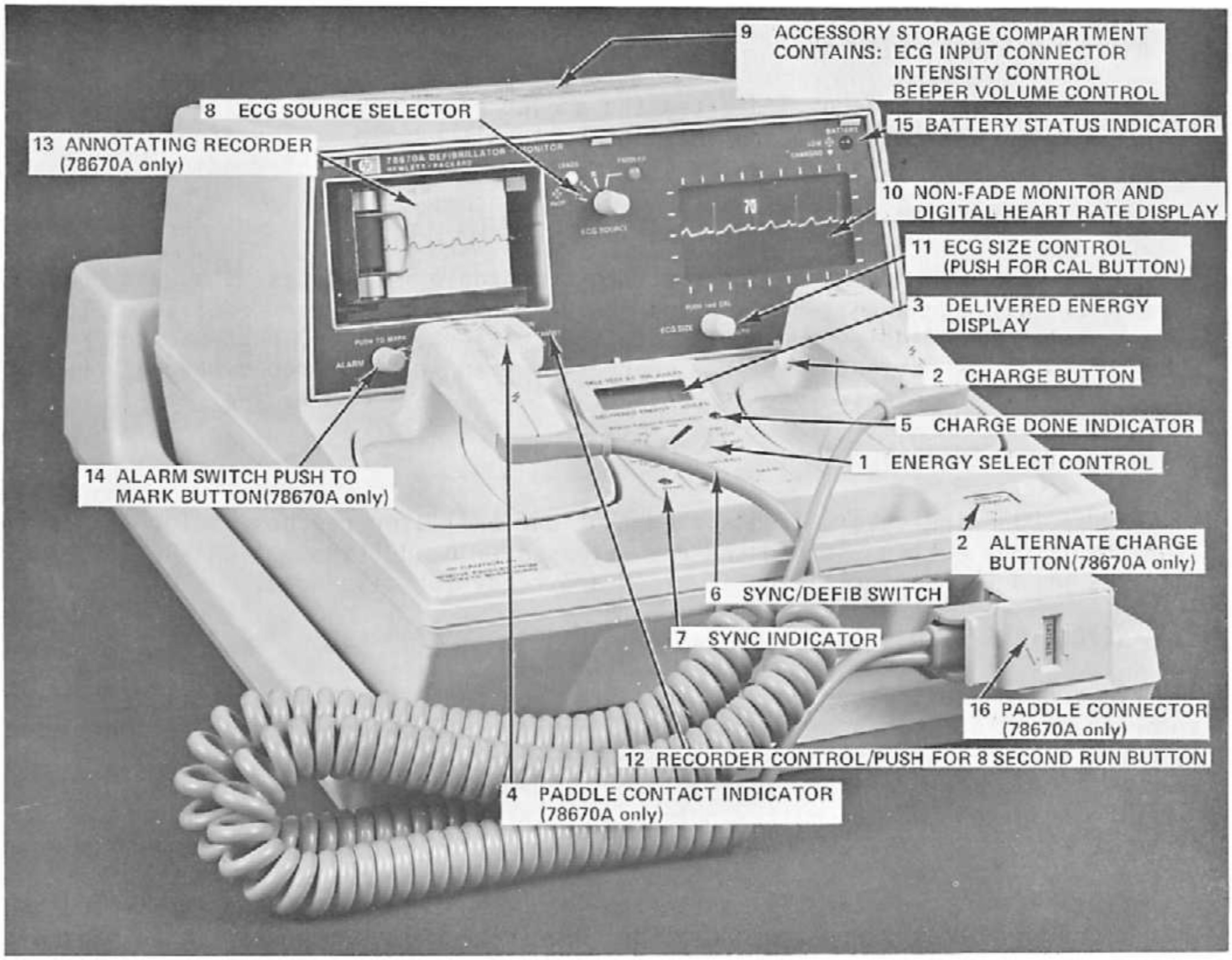


Figure 1-4. Model 78670A and 78671A Controls.

1.5 MODEL 78670A/78671A OPERATING CONTROLS

1. ENERGY SELECT

The ENERGY SELECT control turns the Defibrillator/Monitor ON and OFF as well as selecting delivered energy in eleven discrete steps. Switch positions are OFF, ON, 5, 10, 20, 30, 50, 70, 100, 150, 200, 300 and 360 joules (watt-seconds).

2. CHARGE BUTTON

Press and release the CHARGE button to charge the defibrillator. When the button is pressed, the defibrillator charges in approximately 10 seconds to the energy selected by the ENERGY SELECT control. The ENERGY SELECT must be set to the desired level before pressing CHARGE button. If you wish to change the energy level AFTER the defibrillator is charged, simply reset ENERGY SELECT control. Defibrillator will charge to the new level.

3. DELIVERED ENERGY DISPLAY

The DELIVERED ENERGY readout indicates the amount of energy which will be delivered into a 50 ohm load when the defibrillator is discharged. The liquid crystal, digital display permits easy viewing in almost any ambient light condition.

4. PADDLE CONTACT INDICATOR

The PADDLE CONTACT indicator on the sternum paddle indicates the best paddle contact, before discharge. This helps the user optimize current delivered to the patient. When the paddles are applied to the patient, the LED changes from RED to YELLOW to GREEN as patient impedance decreases - indicating proper paddle pressure and that sufficient electrolyte is applied.

5. CHARGE DONE INDICATOR

The CHARGE DONE indicator lights when the defibrillator reaches selected energy after the charge button is pressed and released. In addition, a CHARGE DONE TONE indicates when the defibrillator is armed and ready for discharge.

6. SYNC/DEFIB SWITCH

The SYNC/DEFIB switch selects either the instant defibrillation (DEFIB) or synchronous (SYNC) mode of operation. In the DEFIB mode, the defibrillator discharges as soon as both of the discharge buttons on the paddles are pressed. In the SYNC mode, the defibrillator will discharge at the first point on the ECG waveform indicated by the marker pulse -- after both discharge buttons have been pressed.

The defibrillator automatically sets itself to the DEFIB mode when the instrument is turned on. For synchronized operation, move the switch momentarily to the left (SYNC position). The defibrillator can be reset for instant discharge at any time by moving the switch momentarily back to the DEFIB position or turning this instrument off and on.

Note: For synchronized operation, the ECG SOURCE selector must be in the LEADS position. If the ECG SOURCE selector is in the PADDLES position, the unit will NOT go into the sync mode.

7. SYNC INDICATOR

The SYNC indicator flashes off with each detected R-wave during the synchronized mode of operation.

8. ECG SOURCE SELECTOR

The ECG SOURCE selector selects the source of the incoming ECG signal: 3-lead ECG cable (LEADS) or ECG pick up from paddles (PADDLES). LEADS I, II and III may be selected in the LEADS position. In addition, in the LEADS position, the indicator will flash should an electrode become disconnected, indicating an INOPerative condition.

9. ACCESSORIES STORAGE COMPARTMENT

The accessories storage compartment provides a convenient place to store patient leads, electrodes and Redux paste. In addition, the ECG (LEADS) input conector, MONITOR INTENSITY and R-WAVE BEEPER VOLUME controls are located in this compartment.

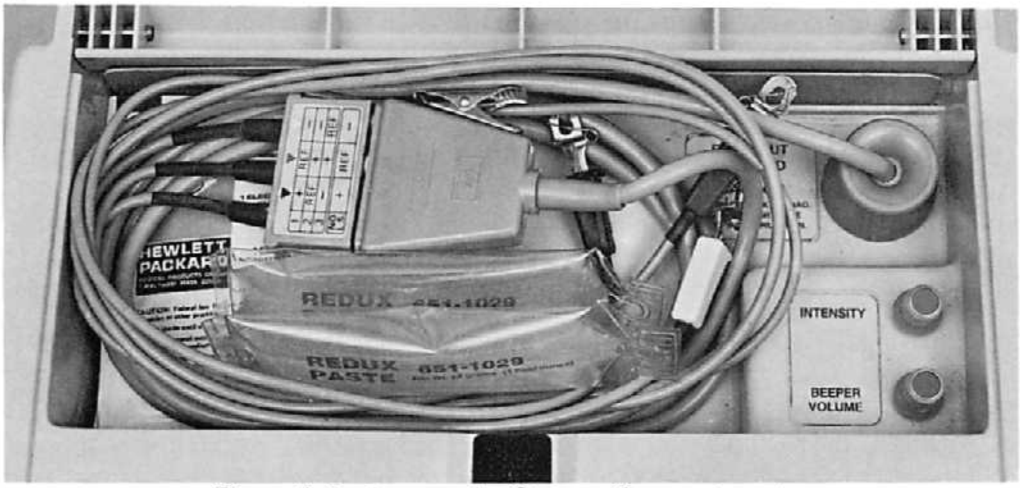


Figure 1-5. Accessories Storage Compartment.

The R-wave beeper aids in audible detection of some arrhythmias; volume is adjusted using the VOLUME control. When heart rate alarms are enabled and the limits are exceeded, the beeper provides an audible warning. Turn the ALARM switch to OFF to silence the alarm.

10. NON-FADE MONITOR AND DIGITAL HEART RATE DISPLAY

The non-fade oscilloscope is internally programmed to display either a fixed or moving ECG waveform and digital heart rate. Fixed-trace display is comparable to a conventional oscilloscope where new information is written across the screen by a repetitive sweep from left to right. The oldest information appears to be erased by a moving "erase" bar before new information is written in its place.

The moving trace mode provides a display similar to that of a strip chart recorder. New information appears at the right edge of the display and moves across the screen. The oldest information disappears off the left edge of the screen.

Sweep speed is 25 mm/second and display time is 3.75 seconds.

DIGITAL HEART RATE is displayed on the monitor screen in beats per minute as shown below.

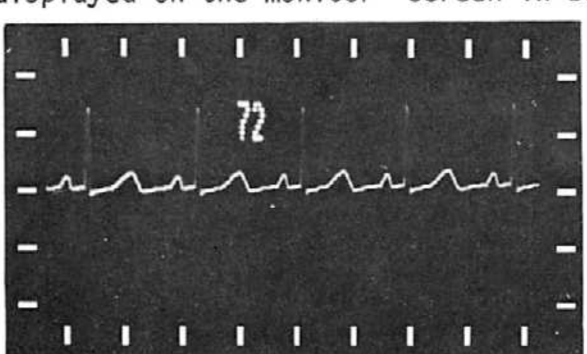


Figure 1-6. Non-Fade Display.

11. ECG SIZE CONTROL

The ECG SIZE control (combined with 1 mV Cal button) adjusts and maintains the size of the ECG waveform displayed on the monitor. Turn clockwise to the AUTO position and the height of the waveform is automatically maintained between 0.8 and 1.6 cm when in the DEFIB or instant mode. When the defibrillator is operated in the synchronized or SYNC mode, the AUTO setting is locked out.

When the ECG SIZE control is pressed, the monitor generates a simulated 1 mV signal for calibrating the display. The calibration signal will also appear on the recorder, if it is running (delayed by four seconds in the delayed mode).

12. RECORDER CONTROL/PUSH FOR 8 SECOND RUN BUTTON

The RECORDER control has three positions -- STANDBY, RUN and PUSH FOR 8-SEC RUN.

With the RECORDER control in the STANDBY position, the recorder turns on automatically when the ALARM switch is in the ON position and heart rate alarm limits (30 and 150 BPM) are exceeded, and/or when the defibrillator CHARGE button is pressed. When initiated by alarm violation, the recorder run lasts for 16 seconds. When initiated by pressing the CHARGE button, the recorder runs lasts for 12 seconds after discharge.

With the RECORDER control in the RUN position, the recorder runs continuously until the operator returns the RECORDER control to the STANDBY position or the low paper switch activates.

CAUTION: To prevent possible printhead damage, the recorder should not be operated without paper installed. A new paper roll provides approximately 20 minutes of recording time and a red warning strip appears approximately 30 feet from the end of the paper roll.

PUSH FOR 8-SEC RUN turns the recorder on for a timed 8 second run. Multiple taps of the control result in consecutive 8-second runs up to a maximum of 60 seconds.

Any recorder run can be terminated by moving the RECORDER control switch to the RUN position and back to STANDBY.

13. ANNOTATING RECORDER (78670A only)

The annotating recorder uses 50 mm, thermal paper (HP Part Number 9270-0980) with a 40 mm offset grid to allow printing along the top edge. Stylus heat and baseline position are screwdriver adjustments from the front of the recorder enclosure (they are preset and should not need adjustment).

Each time the recorder runs, DATE/TIME and patient HEART RATE are alternately annotated at 5 second intervals as shown in Figure 1-7.

When the recorder run is initiated by pressing the CHARGE button, SELECTED ENERGY is annotated. When the DISCHARGE buttons are pressed, actual DELIVERED ENERGY, PEAK CURRENT and PATIENT IMPEDANCE are annotated (if the patient impedance is measured to be less than 200 ohms). A sample strip is shown in Figure 1-8.

Note: At a 5 Joule setting, no delivered energy information will be printed.

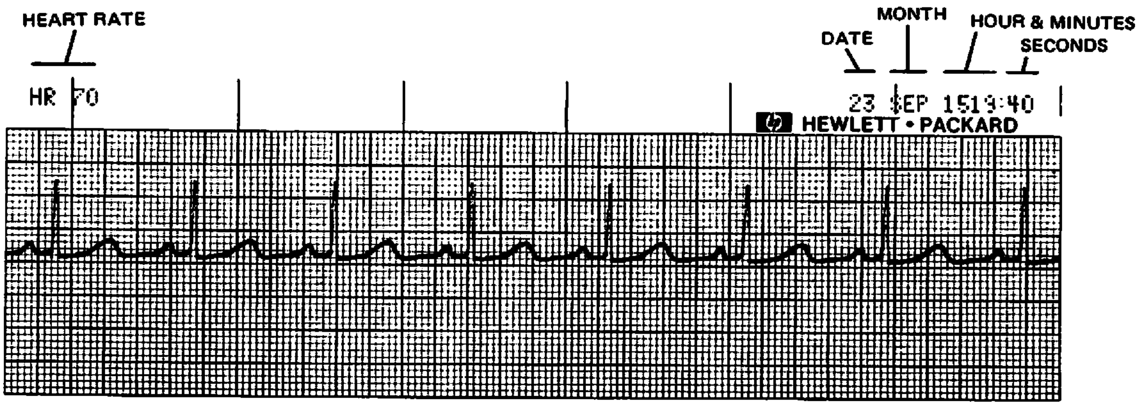


Figure 1-7

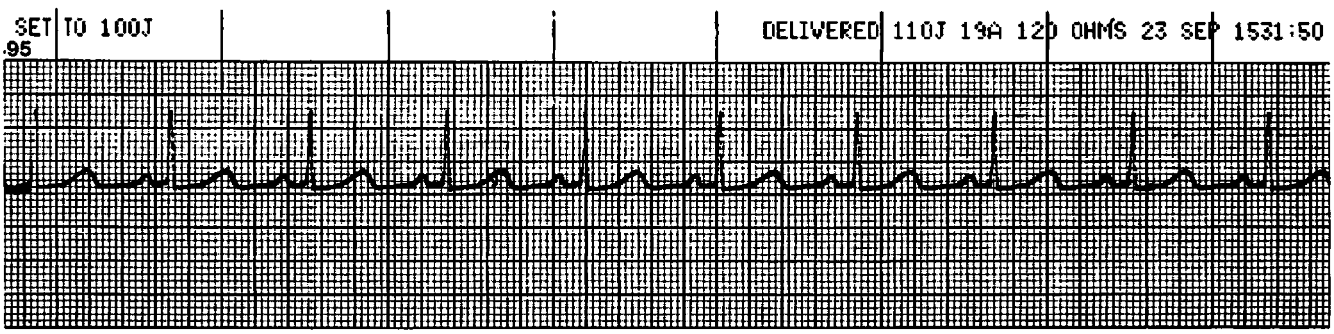


Figure 1-8

14. ALARM SWITCH/PUSH TO MARK BUTTON

The ALARM switch has three positions -- ON, OFF and PUSH TO MARK (78670A only).

With the ALARM switch in the ON position, an audible warning and automatic 16-second recorder run are initiated when patient heart rate remains lower than 30 BPM or higher than 150 BPM for more than 4 seconds.

The alarm limits are not adjustable. Alarm reset occurs automatically if the heart rate returns to the 30 to 150 BPM range.

With the ALARM switch in the OFF position, the alarm circuitry is disabled.

PUSH TO MARK (on 78670A only) gives a down ARROW (↓) and the TIME on the recorder paper. This function is useful in recording the occurrence of significant events

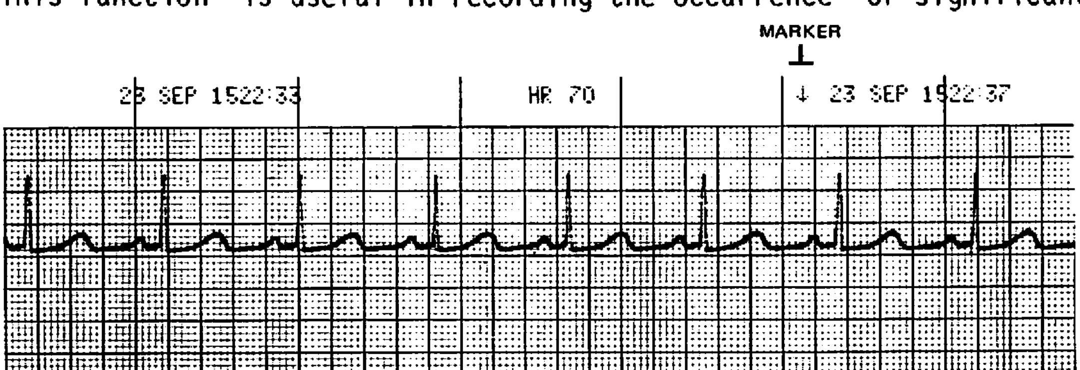


Figure 1-9

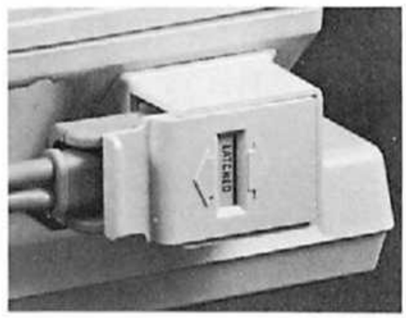
during the episode. An arrow is annotated each time the switch is pressed enabling the clinician to develop codes for common events such as drug infusion, administration of oxygen, etc.

15. BATTERY STATUS INDICATOR

The battery status indicator flashes when a low battery condition exists and lights steady when the defibrillator is in the Quick-Mount Power Base with the power base connected to AC power and the battery is installed. When the light is on steady, it indicates the battery is charging. If the indicator begins flashing, either replace the battery with a fully charged one from the spare battery charger or place the 78670A in the power base. The Defibrillator/Monitor is available for use whenever it is in the power base (and the power base is plugged in) regardless of battery charge status. Battery charge time is 16 hours.

16. PADDLE CONNECTOR

Provides two-wire differential ECG signal input to Defibrillator/Monitor and provides power output to the paddles.



REAR PANEL

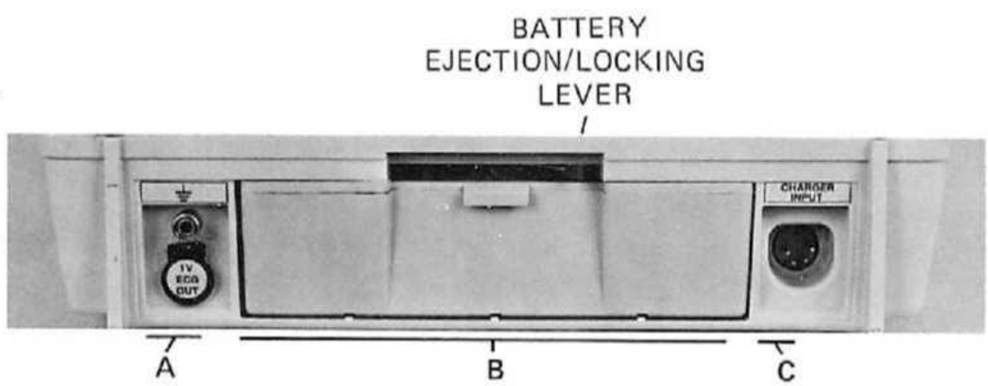


Figure 1-10. Rear Panel, Model 78670A & 78671A Defibrillator.

A. 1V ECG OUT

The rear panel mounted 1V ECG OUT mini-phone plug connector provides a high level (1V) ECG signal from the monitor.

B. BATTERY PACK

The battery pack ejection/locking lever ejects the battery pack when moved to the left and locks the battery pack in place when moved to the right. (Refer to Section Four for Battery Pack Replacement).

C. CHARGER INPUT

The CHARGER INPUT connects to the output plug of the 78668A Quick-Mount Power Base to provide operation from AC power while the internal battery pack is recharging.

1.6 OPTIONS

Options available for use with both the 78670A and 78671A Defibrillator/ Monitors are listed in Tables 1-1 and 1-2.

1.7 GENERAL INSTALLATION INFORMATION

1.7.1 Initial Inspection

1.7.1.1 Mechanical Inspection

As soon as the shipping container is opened, check the instrument for visible damage, such as broken controls or connectors, and dents or scratches on the panel surface. If damage is found, refer to Paragraph 1.8.2 for the recommended claim procedure and repacking information. If the shipping carton is not damaged, check the cushioning material and note any signs of severe stress as an indication of rough handling in transit. This may be necessary to support claims for hidden damage which may become apparent only during subsequent testing. Retain the packaging material for possible future use.

1.7.1.2 Electrical Inspection

Check the electrical performance of the instrument as soon as possible after receipt, using the recommended performance checks in Section 6 of the Operating Manual.

1.7.2 Claims and Repackaging

1.7.2.1 Claims for Damage

If physical damage is evident or if the defibrillator does not meet specified operational requirements when received, notify the carrier and the nearest Hewlett-Packard Sales/Service Office at once.

1.7.2.2 Original Packaging

Containers and materials used to ship your 78670A and 78671A are specifically designed for the instrument and not readily available through local Hewlett-Packard offices, therefore, RETAIN THE ORIGINAL MATERIALS FOR FUTURE USE. If the instrument is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number and full serial number. Also, mark the container FRAGILE to ensure careful handling. In any correspondence, refer to the instrument by model number and full serial number.

1.7.2.3 Other Packaging

Follow these general instructions when repackaging with commercially available materials:

Wrap the instrument in heavy paper or plastic. If shipping to a Hewlett- Packard office or service center, attach a tag indicating the type of service required, return address, model number and full serial number.

Use a strong shipping container. A double-wall carton made of 350 pound test material is adequate.

Use enough shock absorbing material (3 or 4 inch layer) around all sides of the instrument to provide firm cushioning and to prevent movement inside the container. Protect the control panel with cardboard.

Seal the shipping container securely.

Mark the shipping container FRAGILE to ensure careful handling.

1.8 Preparing for Operation

Refer to Section 6 of the Operating Manual for checkout and installation procedures.

1.9 ENVIRONMENT

1.9.1 Operating Environment

The location of your Defibrillator/Monitor should be reasonably free from vibration, dust, corrosive or explosive vapors or gases, extreme temperature and excessive humidity. The operating environment for the 78670A and 78671A including all options is:

Temperature: -20 degrees C through 55 degrees C (-4 degrees F through 131 degrees F)

Relative Humidity: 5% through 95%

Altitude: 4,500 m (15,000 ft) max

Note: Instrument meets all specifications from zero degrees C to 55 degrees C (32 degrees through 131 degrees F). For maximum battery life the instrument should not be used on the 78668A Power Base below zero degrees C (32 degrees F).

WARNING: DO NOT USE THE DEFIBRILLATOR IN A FLAMMABLE ATMOSPHERE (i.e. OXYGEN TENTS OR WHERE CONCENTRATIONS OF FLAMMABLE ANESTHETICS MAY OCCUR). AVOID USING PORTABLE OR EMERGENCY VEHICLE-MOUNTED DEFIBRILLATORS AROUND AUTO WRECKS. SPILLED GASOLINE AND PUDDLES OF WATER PRESENT EXTREMELY DANGEROUS EXPLOSION AND SHOCK HAZARDS.

1.9.2 Storage and Shipment Environment

The storage and shipping environment for the 78670A and 78671A are:

Temperature: -40 degrees C through 65 deqrees C (-40 degrees through 149 degrees F)

Altitude: 9,000 m (30,000 ft) max

Relative humidity: 5% through 95%

1.10 POWER REQUIREMENTS (MODEL 78668A POWER BASE)

The Model 78668A Quick-Mount Power Base allows AC operation of both models. The instruments will operate from a line voltage of from 100 to 130 Vac (115 Vac nominal) at 50-60 Hz with the 78668A rear panel line selector in the 115 position. In addition, operation from a line voltage of 200 to 250 Vac (230 Vac nominal) at 50-60 Hz is possible with the line selector in the 230 position.

1.11 INSTRUMENT GROUNDING AND POWER CORD SETS (78668A POWER BASE)

To protect hospital personnel and the patient, the Power Base must be properly grounded. Accordingly, the Power Base is equipped with a detachable 3-wire power cable which grounds the instrument to the power line ground when plugged into an appropriate 3-wire receptacle. Available power sets, USA and non-USA are identified and described in Table 1-3, Power Cable Sets.

WARNING: FOR PROPER GROUNDING, THE POWER RECEPTACLE MUST BE A 3-WIRE GROUNDED OUTLET. A HOSPITAL GRADE OUTLET IS RECOMMENDED. NEVER ADAPT THE 3-PRONG PLUG FROM THE MONITOR TO FIT A 2-SLOT OUTLET. IF THE OUTLET HAS ONLY TWO SLOTS, SEE THAT IT IS REPLACED WITH A 3-SLOT GROUNDED OUTLET.

The 78670A and 78671A store high voltage energy and are capable of delivering up to 360 Joules. Simply removing the defibrillator from the Quick-Mount Power Base or unplugging the power base will not remove power from a battery-powered instrument. The ENERGY SELECT switch must be placed in the OFF position or the discharge buttons pressed to discharge a charged instrument. As a safety feature, the defibrillator is designed to automatically discharge internally if it has been charged for more than 32 seconds.

The 78670A and 78671A are designed with all plastic covers and controls to minimize shock hazard. Because a battery-powered instrument has no reference to earth ground, small static charges can be generated during defibrillator discharges. The static charges present a minor shock potential to the operator, BUT ONLY through the exposed metal surfaces (ground connector connector, 1V ECG OUT, and recorder housing). Avoid touching these surfaces during battery operation.

1.12 MOUNTING (78668A POWER BASE)

Mounting instructions for the 78668A Quick-Mount Power Base are located in Section 6 of the Operating Manual.

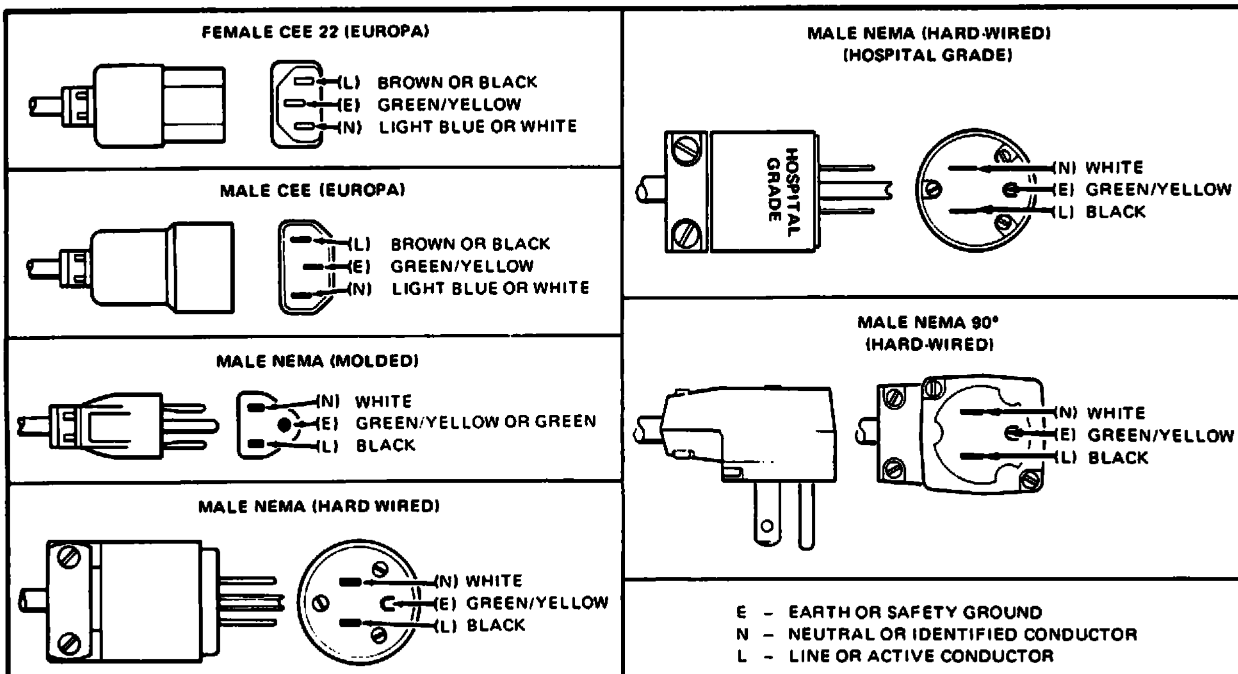
WARNING

REPLACEMENT POWER CABLES MUST PROVIDE CORRECT POLARITY AND GROUNDING AS ILLUSTRATED. INCORRECT CONNECTIONS CAN RESULT IN AN ELECTRICAL HAZARD.

Table 1-3. Power Cable Sets.

Table 1-3 contains descriptions, Hewlett-Packard stock numbers and wire color codes for AC power cable sets that connect to instruments manufactured by the HP Medical Products Group.

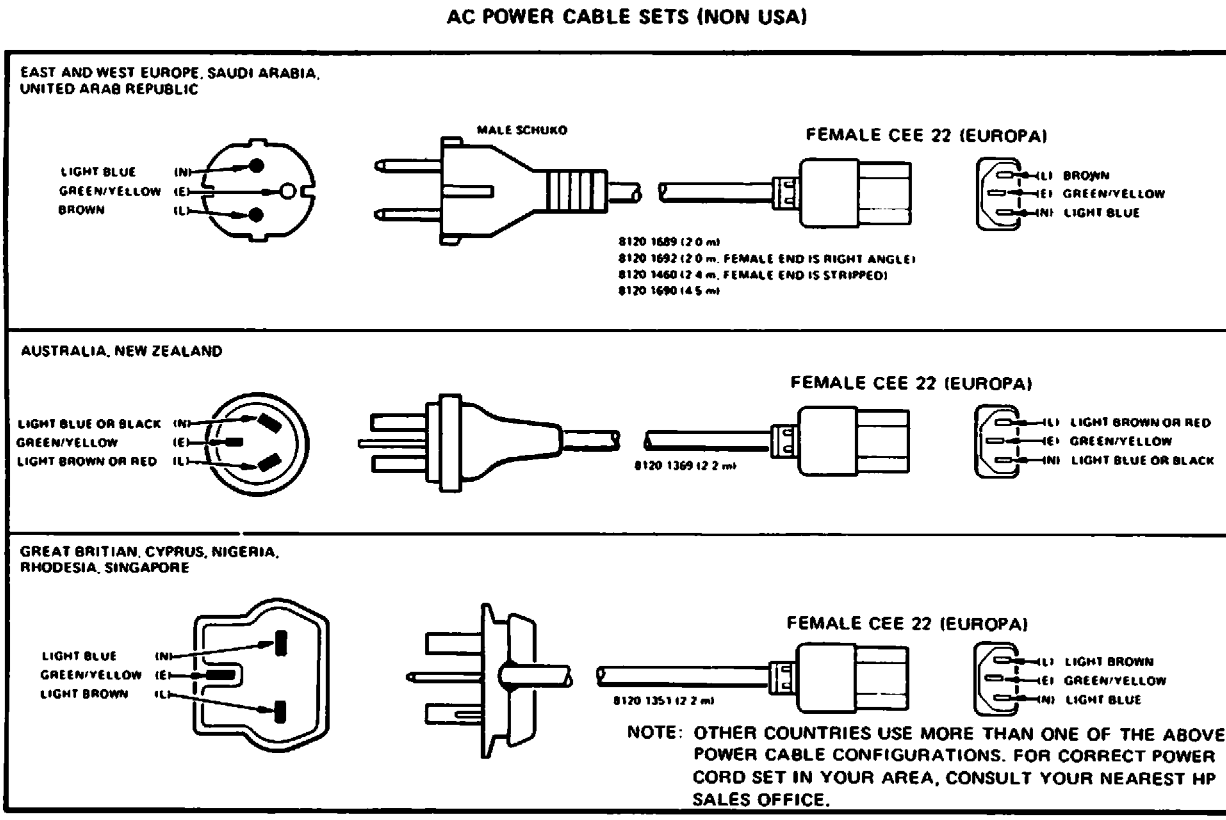
AC POWER CABLE SETS (U.S.A.)



CONNECTORS		POWER CABLE		AWG/NO. OF	HP PART
MALE END	FEMALE END	LENGTH		CONDUCTORS	NUMBER
NEMA (HARD-WIRED)	CEE 22	2.4M	(8.0 FT)	16/3	8120-1931
NEMA (HARD-WIRED)	CEE 22	3.6M	(12.0 FT)	16/3	8120-1932
NEMA (HARD-WIRED)	5 CM (2 IN.) STRIPPED ENDS	4.5M	(15.0 FT)	14/3	8120-1706
NEMA (HARD-WIRED)	2.6 CM (3 IN.) STRIPPED ENDS	3.6M	(12.0 FT)	16/3	8120-1935
NEMA (HARD-WIRED) HOSPITAL GRADE	CEE 22	2.4M	(8.0 FT)	16/3	8120-3493
NEMA (HARD-WIRED) HOSPITAL GRADE	CEE 22	3.6M	(12.0 FT)	16/3	8120-1993
NEMA (HARD-WIRED) HOSPITAL GRADE	CEE 22	4.5M	(15.0 FT)	16/3	8120-1995
NEMA (HARD-WIRED) HOSPITAL GRADE	CEE 22	76 CM	(2.5 FT)	16/3	8120-1996
NEMA (HARD-WIRED) HOSPITAL GRADE	2.6 CM (3 IN.) STRIPPED ENDS	3.6 CM	(12.0 FT)	16/3	8120-1994
NEMA (HARD-WIRED) 90°	CEE 22	2.4M	(8.0 FT)	16/3	8120-0609
NEMA (HARD-WIRED) 90°	CEE 22	76 CM	(2.5 FT)	16/3	8120-0610
CEE 22	CEE 22	76 CM	(2.5 FT)	16/3	8120-1900
CEE 22	CEE 22	2.4 M	(8 FT)	16/3	8120-2133
CEE 22	2.6 CM (3 IN.) STRIPPED ENDS	76 CM	(2.5 FT)	16/3	8120-1933
CEE 22	2.6 CM (3 IN.) STRIPPED ENDS	1.2M	(4.0 FT)	16/3	8120-1934

NOTE: OTHER COUNTRIES SUCH AS CANADA, JAPAN (100 or 200 VOLTS), MEXICO, PHILLIPPINES, AND TAIWAN MAY USE SOME OF THE ABOVE SETS. CONSULT YOUR NEAREST HP SALES OFFICE.

Table 1-3. Power Cable Sets (Continued).



1.13 OPTIONAL ACCESSORY CABLES

Synchronizing from a Bedside Monitor

The 78670A and 78671A can be externally synchronized by applying a high level ECG signal through a 1000:1 divider, to the ECG LEADS input. A molded cable assembly is available for this application (P/N 14482A).

High Level ECG Output Cable

When it is necessary to connect the 1 volt ECG output to another instrument, an accessory cable is available (P/N 8120-3164). This (8) foot cable has a right angle mini-phone plug on one end and a standard phone plug on the other end.

STERILIZATION OF HEWLETT-PACKARD'S INTERNAL PADDLES

AUTOCLAVING

Only the internal paddles supplied with the defibrillator are autoclavable (autoclave temperature 275° F (135° C) maximum. To maintain sterility after autoclaving, good packaging is essential.

NOTE

The high temperature and humidity to which the paddles are exposed during autoclaving shorten their useful life. Typically, HP's internal paddles can withstand up to 200 autoclave cycles before sustaining damage to the cables or discharge switch.

GAS STERILIZATION

The paddles and other defibrillator accessories (cables, etc.) will not be damaged when subjected to the following gas sterilization procedure:

1. Clean the exterior of the item to be sterilized to remove surface contamination.

2. Dry the item completely to avoid formation of toxic ethylene glycol during ethylene oxide sterilization.

3. Use ethylene oxide/freon mixture as the sterilant (12% ethylene oxide with 88% Freon-12).

4. Follow the operating instructions provided by the manufacturer of the gas sterilizer with these reminders:

   a. When sterilizing the external paddles, sterilizer temperature must not exceed 54.4° C (130° F). Temperatures that exceed this limit could affect the reliability of the item or damage its components.

   b. Maximum gas pressure not to exceed 6 psi (310 mmHg) for up to six hours.

   c. At the end of the sterilization cycle, use vacuum (-26 inches of mercury) for 5 to 15 minutes to expel some of the residual gas.

SECTION II
THEORY OF OPERATION

2.1 INTRODUCTION

This section describes the theory of operation of the 78670A and 78671A Defibrillator/Monitors. The first section is a brief overview with a simplified block diagram. The second section covers circuit theory in detail.

2.2 SYSTEM OVERVIEW

Refer to the block diagram, Figure 2.1. The ECG section consists of three circuit boards: an ECG switch board, an analog input board and a digital gain control board.

The ECG analog board is divided into two sections, an isolated or "floating" section which isolates the patient from potentially unsafe voltages, and a grounded section.

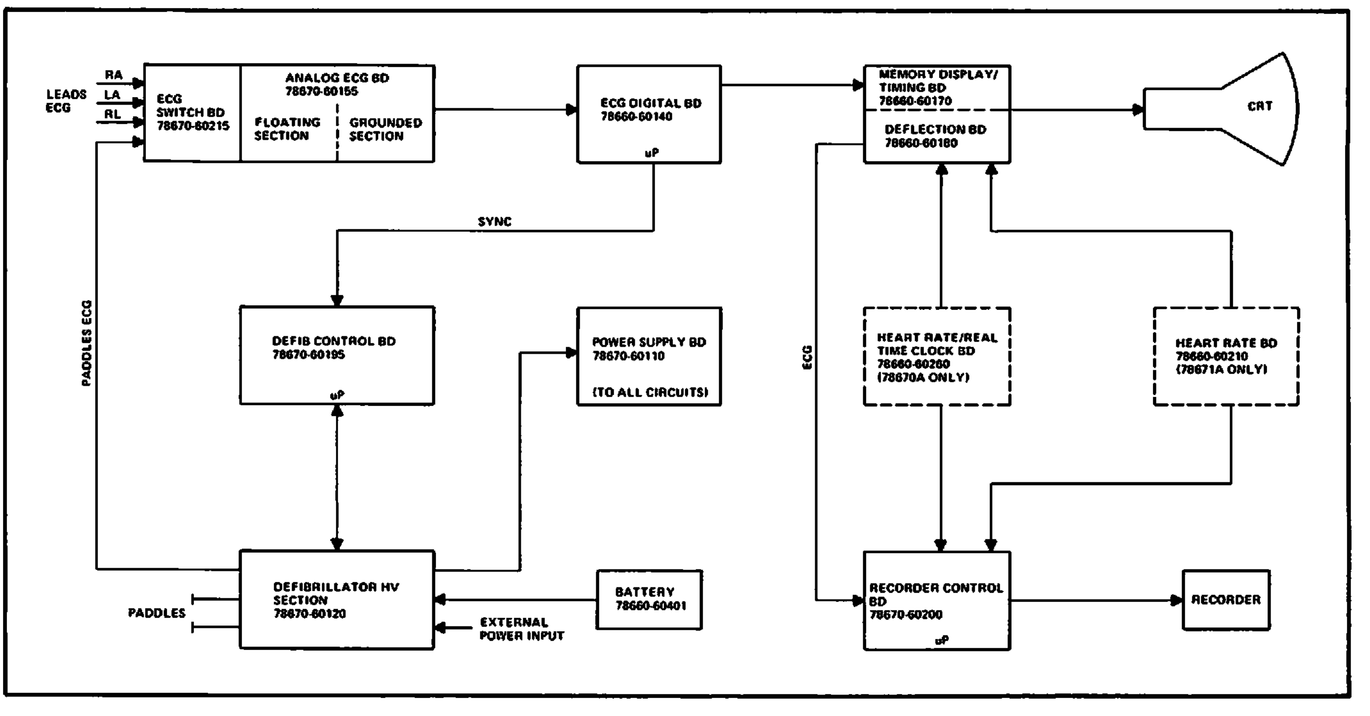


Figure 2-1. Model 78670A Block Diagram.

2.2.1 ECG Switch Board and Analog Board

The ECG leads and paddles inputs enter through the floating analog section. Each input has protective networks to prevent transient voltages from damaging the ECG amplifiers. The inputs are selected by a LEADS/PADDLES switch. Front panel mounted LED's indicate the source selected.

Following the source selector is a fixed gain differential amplifier. If one of the leads becomes disconnected, it unbalances the amplifier. The unbalanced condition is sensed by a detector circuit which flashes the LEADS indicator lamp.

The output from the differential amplifier is chopper modulated and transformer coupled to a demodulator, which is in the grounded side of the ECG circuit. The demodulated signal is amplified about 11.5 times and is passed over to the ECG digital board.

The patient's impedance (measured at 31.25 kHz) at the paddles is reflected across a transformer to the grounded side. This PDZ (Pre-Discharge Impedance) is then converted to a DC signal which will later be used to indicate the patient conductivity between the paddles.

2.2.2 Digital ECG Circuits

The ECG from the analog ECG board first goes through a notch filter (switch selectable for 50 or 60 Hz operation) to remove any extraneous, power line related signal. Then the signal enters a variable gain amplifier. The gain may be manually controlled, or if in the auto gain mode, the gain is controlled by a microprocessor. The microprocessor also supplies signals to drive a small loudspeaker (beeper), control an analog to digital converter and furnish sync signals to the defibrillator control for synchronized cardioversion.

2.2.3 CRT Timing Circuit and Memory

3.6 seconds of ECG information is displayed on the monitor CRT. As new information is added, old information is erased. The information is stored in a semiconductor memory which refreshes the CRT display every 16 milliseconds. This circuitry also includes the clock oscillator for the memory, and the erase bar generator. The erase bar generator turns the CRT beam off at the point where new information is being written on the screen. After processing, the digital ECG signal is changed back to analog by a D to A converter.

2.2.4 CRT Driver Circuit

This circuit provides the beam positioning drive signals for the CRT deflection yoke, CRT intensity blanking and brightness biasing. It consists of horizontal and vertical amplifier channels plus an intensity control amplifier.

2.2.5 Heart Rate Circuit

This circuit controls the heart rate displayed on the CRT. It controls the alarm audio output and provides inputs for the ALARM and SERVICE switches. Resistors are added to an I/O device to inform the recorder microprocessor of the language and real time clock options.

2.2.6 Real Time Clock

This section contains a clock integrated circuit which keeps track of month, date, and time in hours and minutes. This information is printed out on the strip chart during recorder operation. The clock entry may be changed to reflect any changes required (time zone change, etc.).

2.2.7 Recorder Circuit

This circuit controls the strip chart recorder operation and annotation. It also calculates the heart rate and sends the digital information to the heart rate circuit for the CRT display. The recorder control microprocessor has inputs from the recorder control switches and the defibrillator CHARGE and DISCHARGE switches. The microprocessor controls the recorder drive motor, stylus pen heat and annotating print head. Amplified signals from the display timing circuit drive the recorder galvanometer.

The recorder prints out real time and date, indicates patient impedance and notes stored and delivered energy. The recorder starts automatically whenever the defibrillator CHARGE switch is pressed and released.

2.2.8 Defibrillator Control

The primary task of the defibrillator control circuit is to control the charging and discharging of the defibrillator HV capacitor and calculate the post-discharge delivered energy, peak current, and patient resistance. Other functions include control of the paddle contact signal and flashing the low battery indicator LED.

2.2.9 Defibrillator H.V. Circuits

The high voltage circuitry consists of a high voltage DC to DC converter, high voltage defibrillator energy storage, discharge circuits and monitoring and control to interface with the defib control microprocessor.

The high voltage supply consists of a flyback circuit driven by a pulse width modulator, which provides fixed frequency, variable duty cycle control. If the battery is low, charging stops until the battery voltage recovers giving maximum available energy without disrupting the other circuits.

The battery voltage is stepped up by the flyback transformer, rectified and stored in the H.V. defibrillator capacitor. Metering resistors provide H.V. samples to the control microprocessor so that charging stops when the selected energy level is reached. This level is maintained until the energy is discharged.

After H.V. charging, the energy is discharged either through the patient relay to the defibrillator paddles, or through the safety relay to a load resistor. The discharge path depends on the signal received from the microprocessor.

If the patient relay is activated, a current transformer circuit provides a peak current signal to the microprocessor, as a measure of discharge performance. When the patient relay is in the nonactivated position, the paddles are connected to the ECG amplifier to permit monitoring from the paddles.

If the battery voltage falls below 9.5 volts, while charging the defibrillator, the H.V. circuit is locked out. This allows additional monitoring time but the defibrillator cannot be charged until the battery is replaced or the unit connected to an external power source.

2.2.10 Low Voltage and CRT Power Supply

This circuit consists of a pulse width modulator controlled flyback supply. The flyback transformer has multiple secondaries which furnish the various voltages required.

Input voltage from the battery can vary from 9.0 to 13.5 volts. If this battery voltage falls below 9.0 volts, the power supply is locked out of operation to prevent damage to the battery.

In addition to the low voltages, this circuit furnishes +200 volts and +5000 volts to the monitor CRT. The +5000 volts is derived through the use of a voltage multiplier.

In order to stabilize output voltage, with varying battery voltage, a sample of the secondary voltage is fed back to the pulse width modulator which controls duty cycle, thereby controlling output voltage. Fixed voltage regulators are employed for circuits that have more stringent voltage regulation requirements.

2.2.11 Battery and Battery Relay

The defibrillator is powered by a 12 volt nickel-cadmium battery pack. A fully charged battery, that is in good condition, can provide 2.5 hours of monitoring time or 50 full power defibrillator charge cycles.

The battery relay connects the defibrillator circuits to the battery through normally closed contacts. When the defibrillator is operated from an external power source, the relay disconnects the battery from the defibrillator and onto a battery charging supply. The defibrillator is then connected to the external supply.

If the external power is interrupted by power line failure, the relay switches the system back to battery power.

2.2.12 Quick-Mount Power Base 78668A

This accessory allows the defibrillator/monitor to operate from 115-230 volts, 50 to 60 Hz power lines. It furnishes three outputs to the defibrillator: 1. A current limited battery charging output maintains the battery at full charge. Charging takes place at all times whether or not the defibrillator is turned on; 2. A regulated 12 volt supply furnishes power to all other circuits except the defibrillator H.V. supply; 3. The defibrillator section operates from a high current unregulated supply. See Section VII for all additional information of the power base.

2.2.13 Spare Battery Charger 78669A

The battery charger is a separate, self-contained unit that will charge two battery packs at a time. It has LED's which indicate that energy is being supplied to charge the battery, and when the battery has been on charge for eight hours (half charge) and for sixteen or more hours (full charge). Like the AC power pack, the battery charger operates from 115-230 volts, 50-60 Hz. See Section VII for all additional information on the battery charger.

Figure 2-2. Detailed Block Diagram, Model 78670A (fold-out).

2.3 DETAILED THEORY OF OPERATION

(Refer to the detailed block diagram Figure 2-2)

2.3.1 ECG Switch Board 78670-60215

2.3.1.1 ECG Source Switch (Fig. 2-3).

The 5 pole switch on this board selects the source of ECG. Either the paddles or one of the 3 leads configurations is connected with the AC differential amplifier and the leg drive op amp. It also indicates which source has been selected by lighting either the "LEADS" or "PADDLES" LED on the front panel.

2.3.1.2 Protective Circuitry

DS1, DS2 and DS3 along with the 1 K ohm resistance built into the ECG leads limits the input to the AC diff amp to 270 V or less.

2.3.2 ECG Analog Board 78670-60155

The ECG analog board consists of a floating section, which isolates the patient from potentially unsafe voltages, and a grounded section. The selected source of ECG is amplified, filtered and transferred to the grounded section for further processing. Circuitry for measuring PDZ is included on this board.

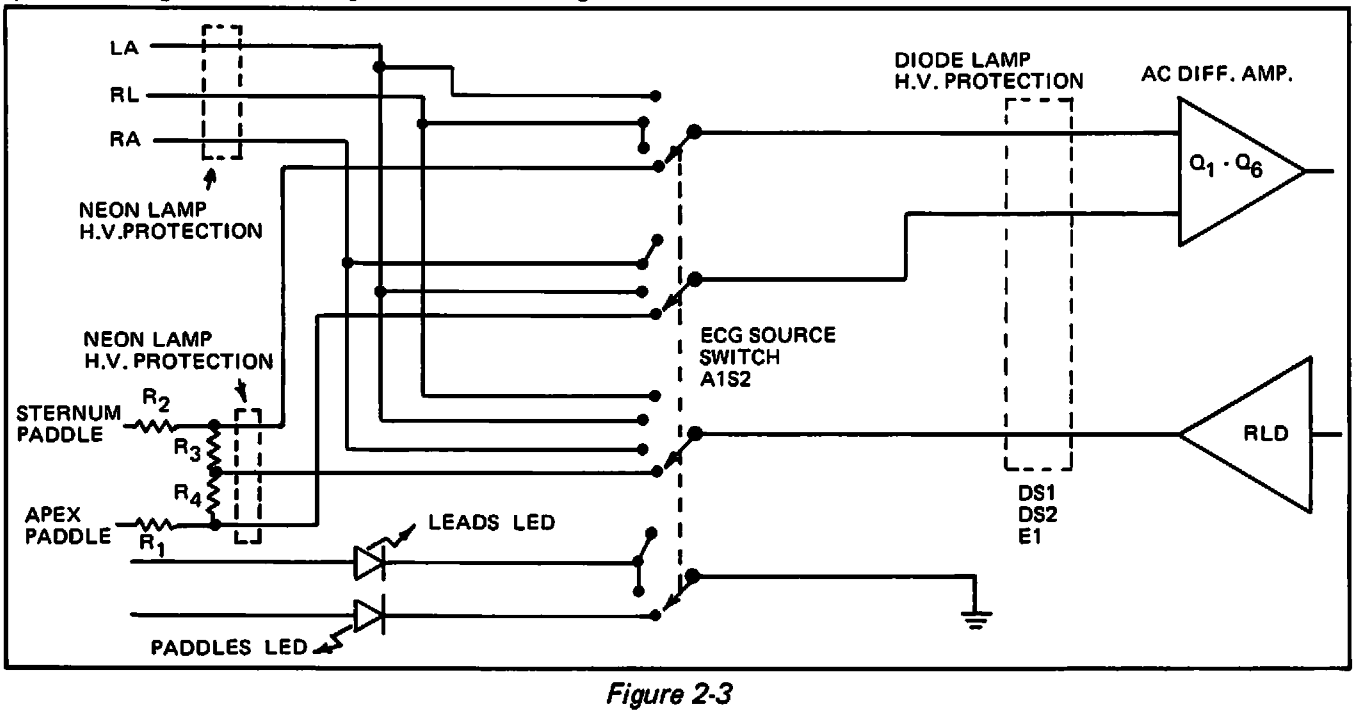


Figure 2-3

2.3.2.1 Protection Circuitry (Fig. 2-4)

The paddles ECG amplifier input protection circuits consist of resistors R1, R2, neon lamps, DS1, DS2 and spark gap E1. The spark gap protects the LEADS/PADDLES switch from high voltage breakdown in the unlikely event that defibrillator high voltage is applied between the ECG source leads and paddles. This can only occur if the 78670/78671 is used with another defibrillator. CR8 through CR13 clamp the inputs to within 0.7 volts above +Vcc and 0.7 volts below -Vee. R43, R44 and R45 limit the input current to less than 5 mA.

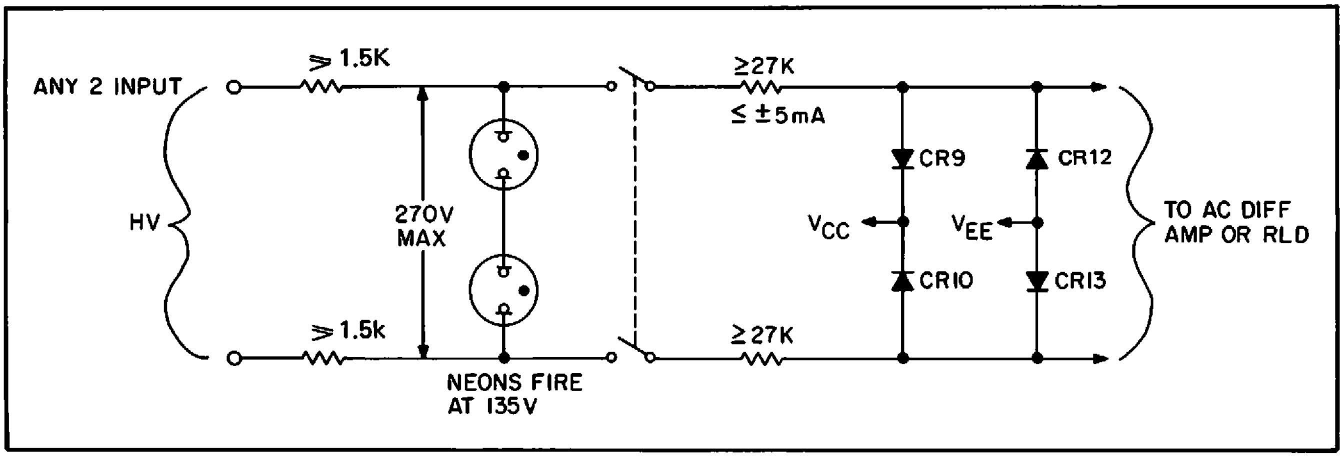


Figure 2-4

2.3.2.2 Differential Amplifier (Fig. 2-5)

Q1 through Q6 form a high gain AC amplifier with differential input and output. R12, R14, R31, R33, C5 and C17 set the gain at 23 above 0.32 Hz. Gain is unity below 0.01 Hz. R8 and R27 set the input bias current near 60 nA.

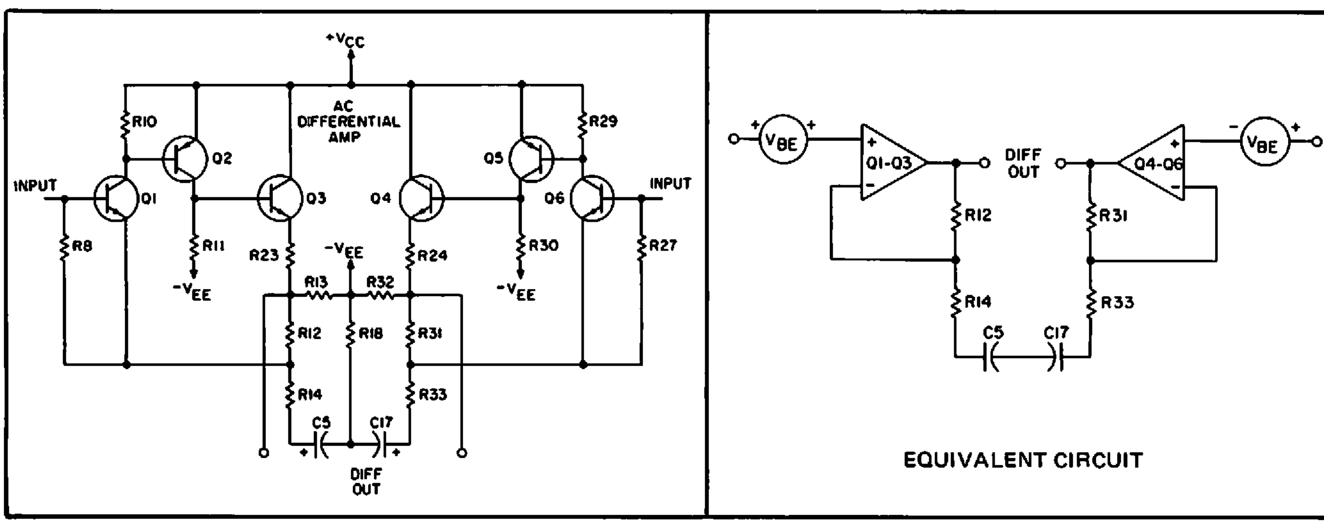


Figure 2-5

2.3.2.3 Right Leg Drive (RLD) (Fig. 2-6)

Common mode voltage, from the differential AC amplifier output is amplified 100 times by U2, inverted and driven back into the right leg of the patient. If the paddles are selected, the signal is fed back through R1 and R2 between the inputs. RLD forces the average voltage at the outputs of the differential amplifier (the junction of R12, R13 and R23 and the junction of R24, R31 and R32) to be zero. Without any offset voltage from the patient, the voltage at the base of Q1 and Q6 should be about

$$Vbe(Q2)\ (R12/R10) + Vbe(Q10) = 0.8 \text{ volts}$$

The output of RLD U2, which supplies bias current to Q1 and Q6, should be about 10 to 15 mV higher.

C13 rolls off the feedback of the RLD at about 35 Hz for stability.

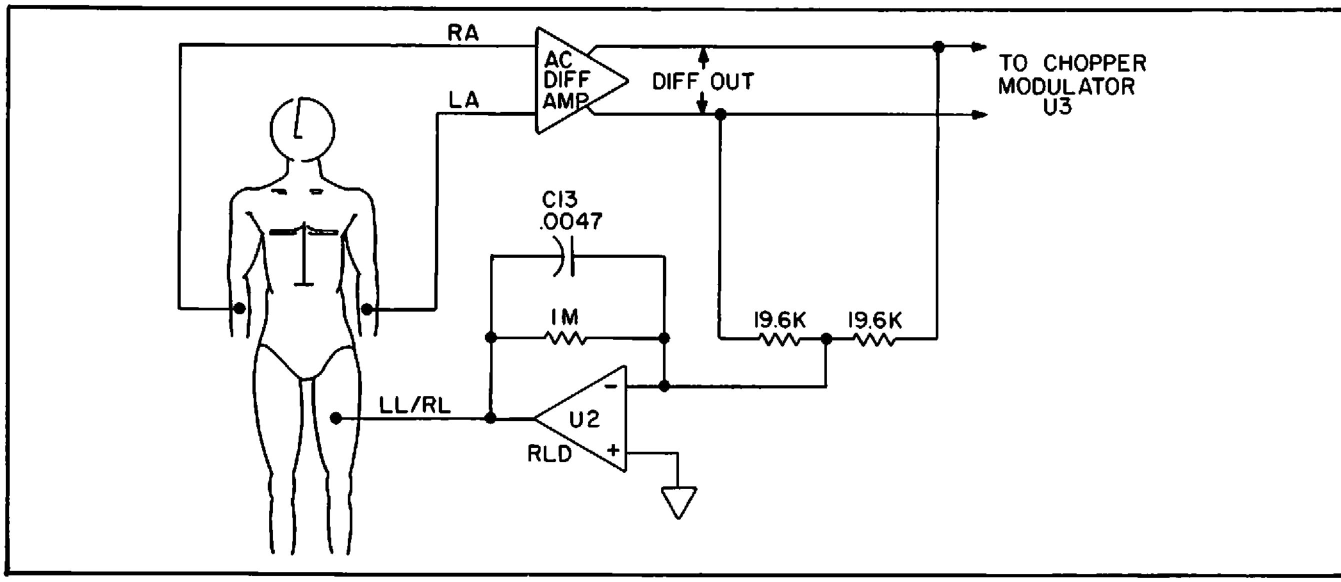


Figure 2-6

2.3.2.4 ECG Leads Off Indicator (Fig. 2-7)

The operation of this circuit is only visible in the LEADS mode. RLD supplies input bias current to the AC differential amplifier. If any one or more of the 3 leads should become disconnected from the patient, one or both halves of the amplifier turn off and RLD goes high. Beyond a threshold of about 2.9 volts, set by R6 and R7, comparator U1A goes low and allows U1B to oscillate at about 2 Hz. This causes the LEADS LED to flash. When U1A goes low, the chopper modulator U3 is disabled through CR1 and CR3. This results in a flat line on the monitor.

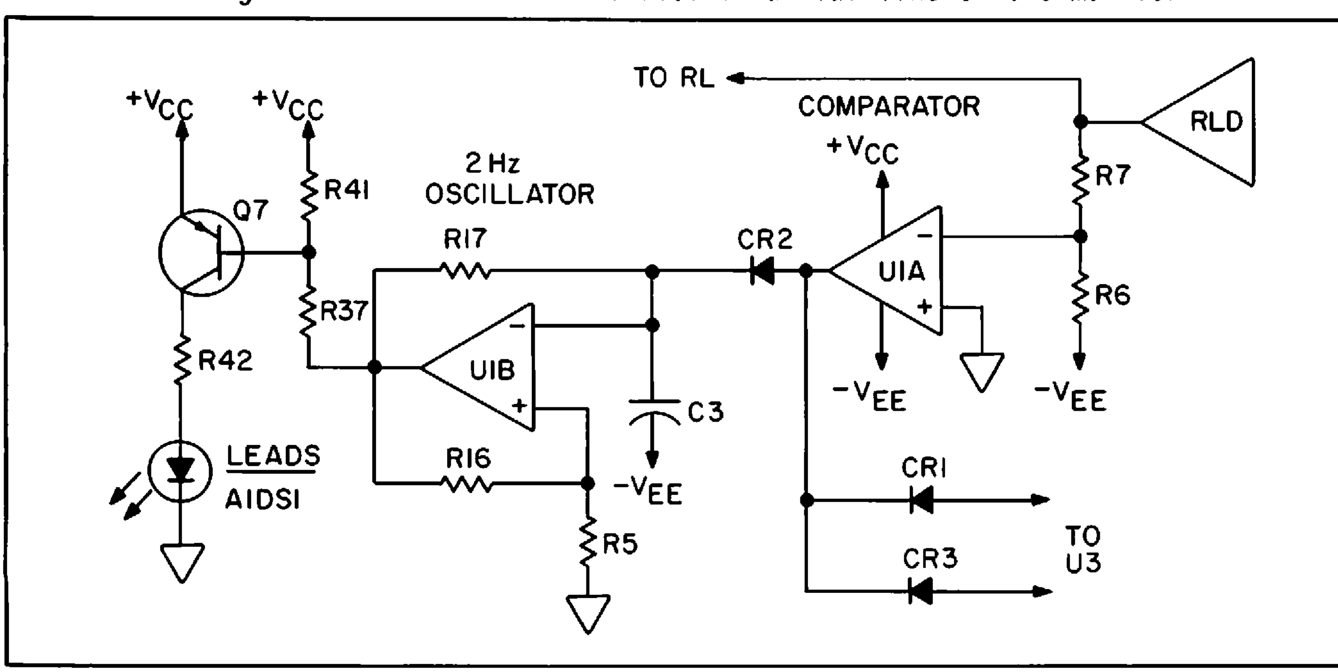


Figure 2-7

2.3.2.5 Chopper Modem and Power Supply (Fig. 2-8)

The ECG signal from the differential amplifier is modulated by chopper U3. BY modulating the signal with a high frequency chopper, the ECG signal can be passed on to the grounded section via signal isolation transformer T2. At the grounded side, the chopped ECG is demodulated by U55 to reproduce the actual signal again.

The chopper drive signal is rectified by the full wave bridge CR4 through CR7 to provide plus and minus 4.2 volts (+Vcc and -Vee) on the floating section. Series connected R46 and R50, 22 megohm each, tie the floating section to the grounded section. Function of these 2 resistors is to prevent static charges from building up between the two sections.

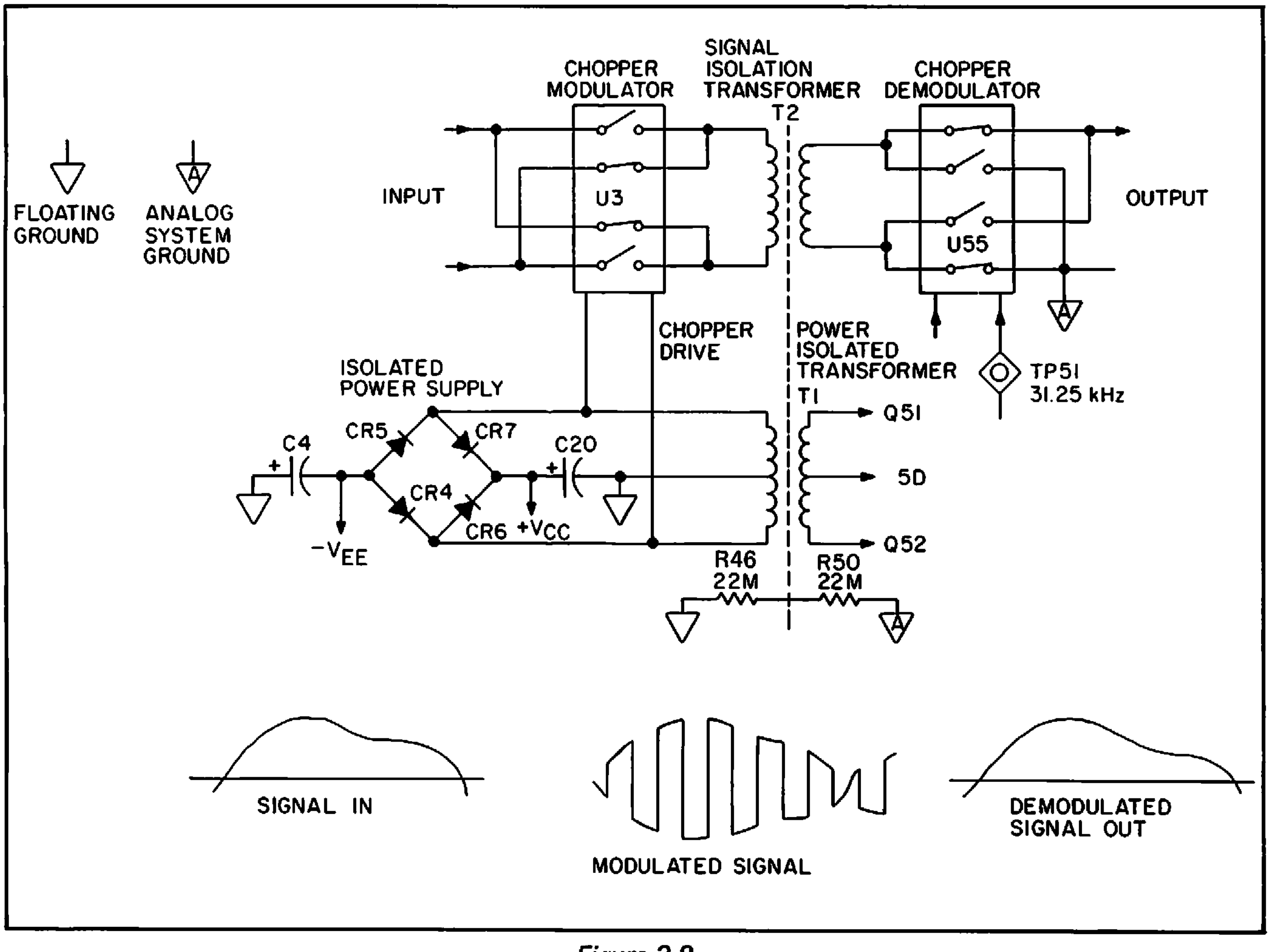


Figure 2-8

2.3.2.6 EMI Rejection

The following components serve to reduce the susceptibility of the ECG amplifier to electro-magnetic interference:

R1, R2, C1, R15, C10, R34, C12, R44, C23, R45, C24, C11, L1-4,
C8, C9, C14, C15, R20, C6, R25, R26, C16, C21, C22.

In addition to EMI suppression, R1, R2, R44, and R45 are part of the high voltage protection circuitry described earlier.

Grounded Section

2.3.2.7 Chopper Driver (Fig. 2-9)

U51B is connected as a level translator, translating a 62.5 kHz clock of 0-5 volt level to +/-3.75 volts. U52B divides this signal by 2 to provide complimentary phase chopper signal of 31.25 kHz. These two signals alternately turn on Q51 and Q52 to drive the power-isolation transformer T1. C52 and C53 AC couple the chopper signals to Q51 and Q52. If for any reason the chopper signal is lost, the AC coupling prevents Q51 and Q52 from shorting out the +5D power supply. U52A delays the chopper drive to the demodulator by a small amount, to help compensate for phase delay in T1 and T2.

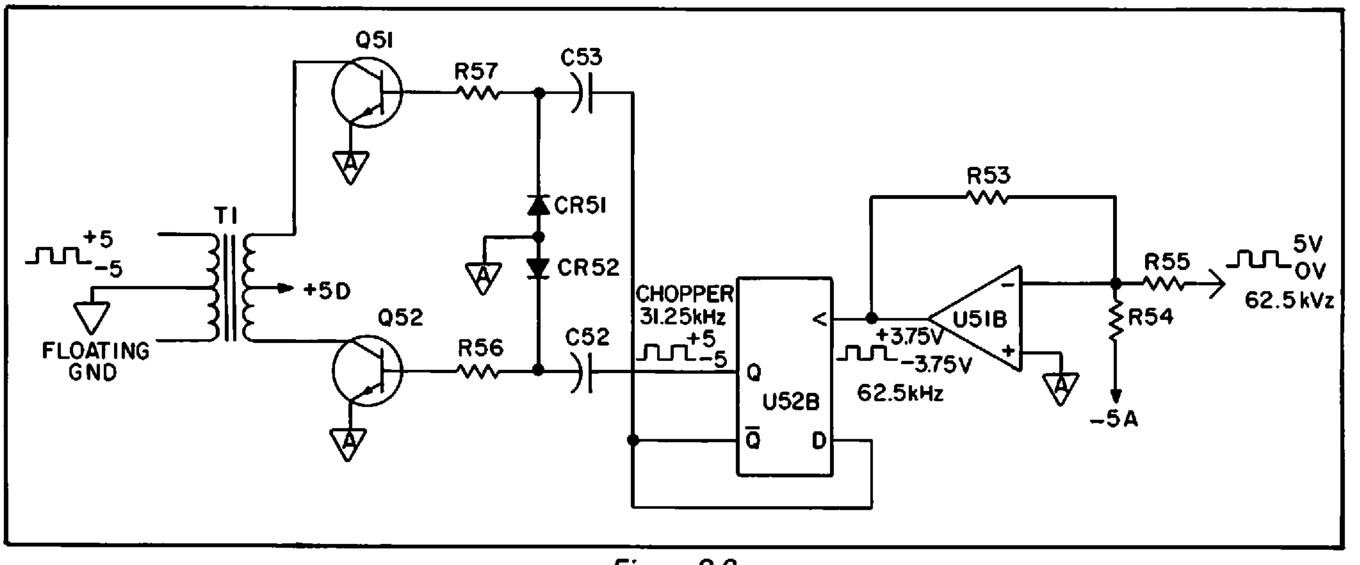


Figure 2-9

2.3.2.8 Baseline Restore (Fig. 2-10)

The ECG signal from the demodulator U55 is filtered by R66 and C62, to remove chopper artifacts. It is then AC coupled by the high pass pole formed by C60 and R70. If the baselne begins to drift, it is sensed by the microprocessor which turns on Q53 for about 1.5 seconds. When Q53 is on the pole that was at 0.2 Hz is shifted to 4.2 Hz, which is determined by C60 and the parallel combination of R70 and R71. Put in another way, when Q53 is conducting, the excessively high DC potential on C60, which accompanies a high baseline, is discharged through R71.

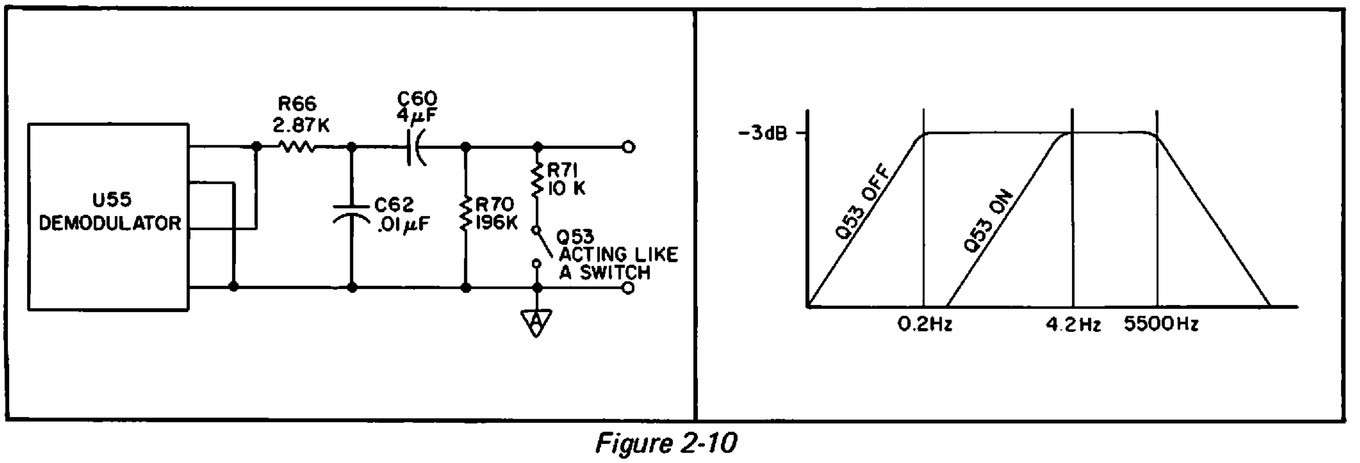


Figure 2-10

2.3.2.9 Fixed Gain Stage (Fig. 2-11A)

R58, R61 and U51A form a gain stage with a fixed gain of 11.7. C55 rolls off the gain at approximately 600 Hz.

2.3.2.10 Zero Offset Potentiometer

The zero offset adjust potentiometer, R73, removes any offset voltages that may be present in the op amp U51A and succeeding op amps on the ECG DIGITAL board. R67 and R69 bias the non-inverting input of U51A, at 8.2 mV above ground, so that the zero offset potentiometer, connected between an accurate +12V and ground, can remove both positive or negative offset.

2.3.2.11 Calibration Potentiometer

When the CAL switch A1-S5 is pressed, a calibration signal is applied through potentiometer R72, R64, R62 and R65. R72 is adjusted so the magnitude of the calibration signal is equivalent to 1 millivolt applied to the ECG inputs. Q2 on the ECG DIGITAL board informs the microprocessor that the CAL switch is activated.

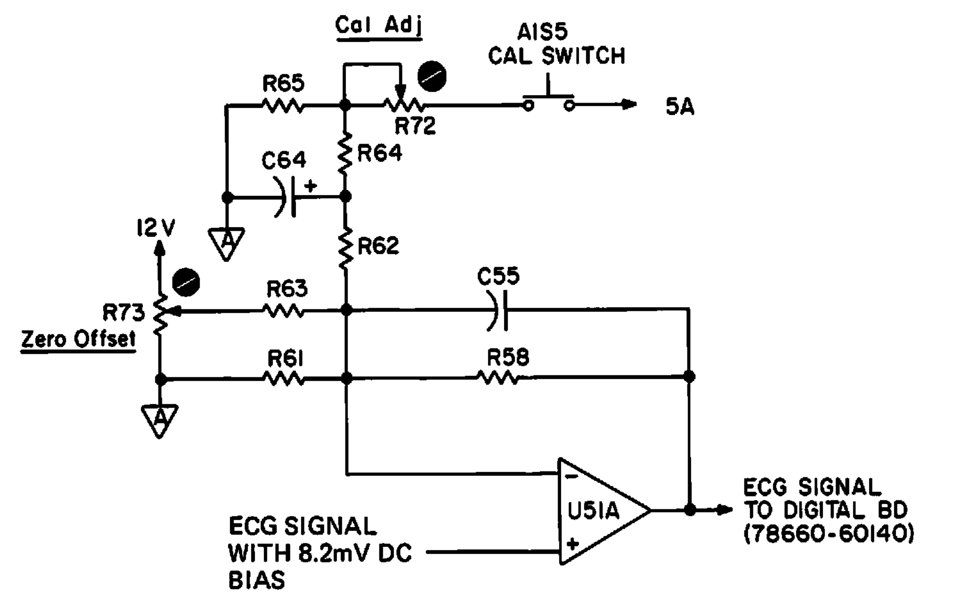


Figure 2-11A

2.3.2.12 Analoq Power Supply

U53 and U54 supply plus and minus 5 volts for use only by the analog circuits on the ECG boards. The ground on the ECG ANALOG board and on the analog portion of the ECG DIGITAL board is connected to the instrument ground at only one point. This basically isolates the ECG's sensitive circuits from the rest of the instrument. R51 and R52 reduce the heat that must be dissipated by U53 and U54. CR53 and CR54 prevent U53 and U54 from latching up in the event that +12V or -12V are lost for a very short period of time (milliseconds).

2.3.2.13 Electromagnetic Interference Rejection

R59, R60, C56 and C57 make the circuits less susceptible to EMI.

2.3.2.14 Paddle Contact (PC)

The 31.25 kHz signal at TP51 is attenuated by R78, R85 and U58A to produce a square wave of 25 mVp-p for sensing PC. U56 acts as a switch for disabling the circuit when external paddles are not being used or if the external paddles are placed in their storage pockets.

U58B and U58C form a gain stage where, at 31.25 kHz, the gain is essentially

$$\frac{-R83}{R84 + Rpatient}$$

(See Fig. 2-11B) U58B and U58C are cascaded to increase the loop gain and may be considered as one op amp. C70 is a compensating cap and does not contribute to the gain equation above.

U58D and associated resistors and capacitors make up the band pass filter which selects only the 31.25 kHz harmonic for measuring PC, the output of which is a clean sine wave. R91 is for adjusting gain and Q.

U57, R74, CR55, C65 and R75 together make a peak detector which holds the peak value of the sine wave in C65. This DC output is a function of the resistance (impedance) placed between the paddles. R76 and R79 perform a level shift on the incoming sine wave to give the desirable PC vs. patient resistance curve.

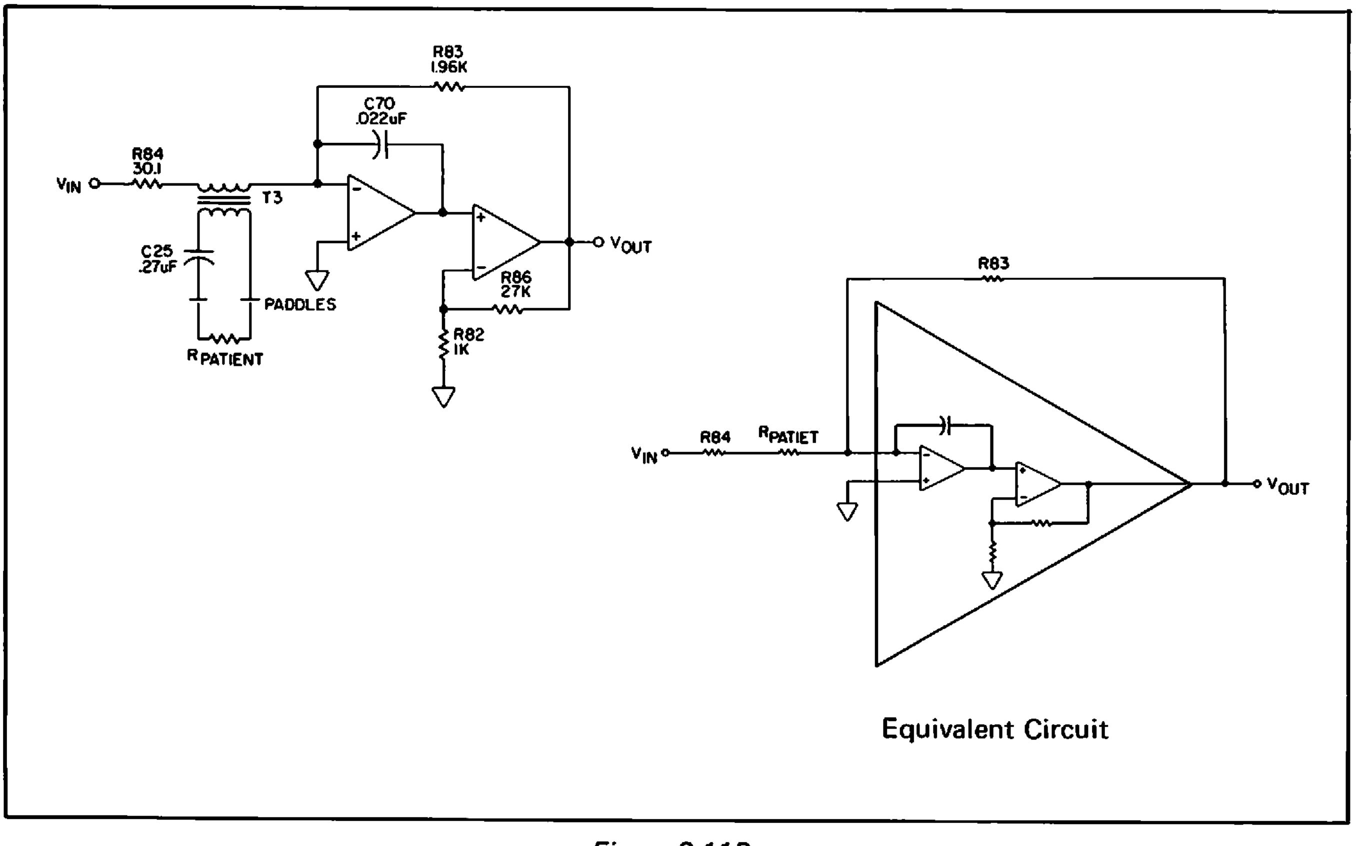


Figure 2-11B

2.3.3 ECG Digital Circuit Board (78660-60140)

(Refer to detailed block diagram, Figure 2-2,and detailed schematic, Figure 6-4.)

The ECG DIGITAL board contains a microprocessor, a 50/60 Hz notch filter, an auto gain attenuator, a voltage to frequency converter (V/F) and an auto baseline circuit. The power for the analog circuits on this board, is supplied by U53 and U54 on the ECG ANALOG board. Analog ground also comes from the ECG ANALOG board. Digital ground on this board is the same ground as used by the rest of the instrument.

2.3.3.1 50/60 Hz Notch Filter (Fig. 2-12)

U4 together with C5, C6 and R9 through R18 form a bi-quad filter. The circuit board mounted switches, S1 and S4 through S8 select the notch for either 50 or 60 Hz reject, or no notch. The output from the notch filter goes to the auto gain attentuator.

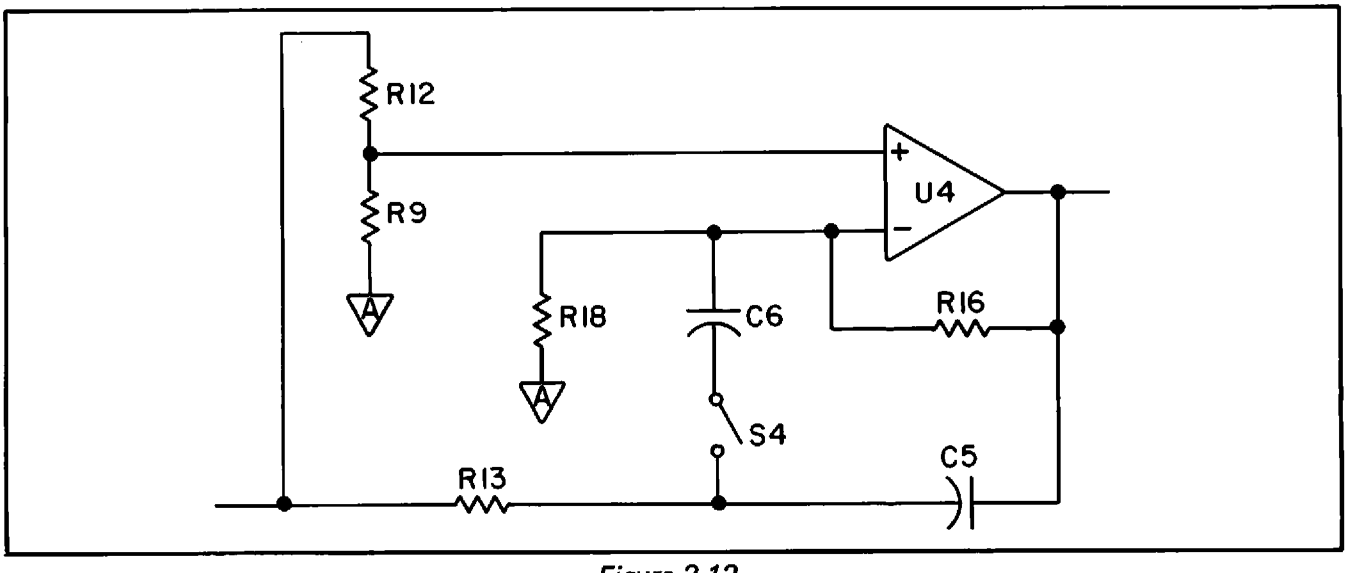


Figure 2-12

2.3.3.2 Auto Gain Attenuator (Fig. 2-13)

U2, U5A, R2 through R6 and R19 through R23 form a microprocessor controlled attenuator network. This allows the automatic selection of five different ECG gains, depending on the input ECG signal level. The relative gain of any two adjacent stages is 1.4.

2.3.3.3 Manual Variable Gain

When the MANUAL/AUTO switch A1-S6 is in the MANUAL position (open), the microprocessor, U6, selects channel 5 in U2. This connects the variable gain potentiometer A1-R6 to U5A. The potentiometer provides a 20:1 gain variation.

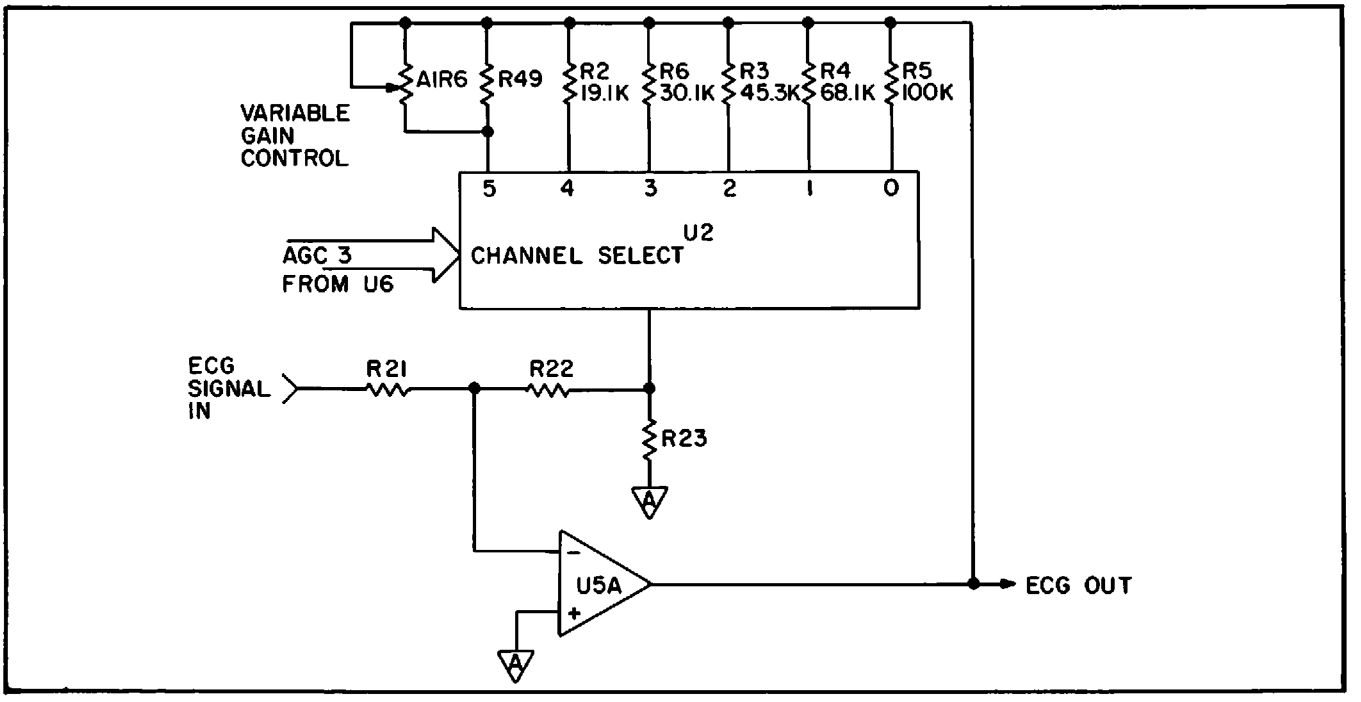


Figure 2-13

2.3.3.4 Voltage to Frequency Converter (V/F) (Fig. 2-14)

A V/F converter is made up of integrator U5B, comparator U5C, flip-flops U1A and U1B, FET Q4, charge capacitor C15, R24, R25 and R41. This is a charge dumping circuit where the input charge to the integrator is balanced by periodic discharges through Q4. Each discharge lasts exactly 8uS. A/D conversion is accomplished by counting the number of discharges in a fixed period.

The nominal operating rate is 128 discharge pulses in 4.096 milliseconds, baseline condition (without an ECG signal). The maximum rate is 255 pulses, in the same period.

At the beginning of every A/D conversion, U1A is set, U1B reset and charge capacitor C15 discharged by Q5. This eliminates any uncertainty in conversion which could be introduced if the state of U1A or U1B or the charge on C15 was unknown at the beginning of the conversion.

2.3.3.5 Auto Bias (Fig. 2-15)

U5D, R36-R40, C12, C14, C14, C17, C25 and U3A form an auto baseline circuit which drives the V/F converter to an average count of 128/4.096 mS. U3A buffers the auto zero signal from the micro- processor before it goes to integrator, U5D.
Fig. 2-15

2.3.3.6 Microprocessor

The microprocessor, U6, counts the V/F, outputs the ECG signal in digital form, detects R-wave, selects the proper channel in the auto gain attenuator, and performs various other tasks.

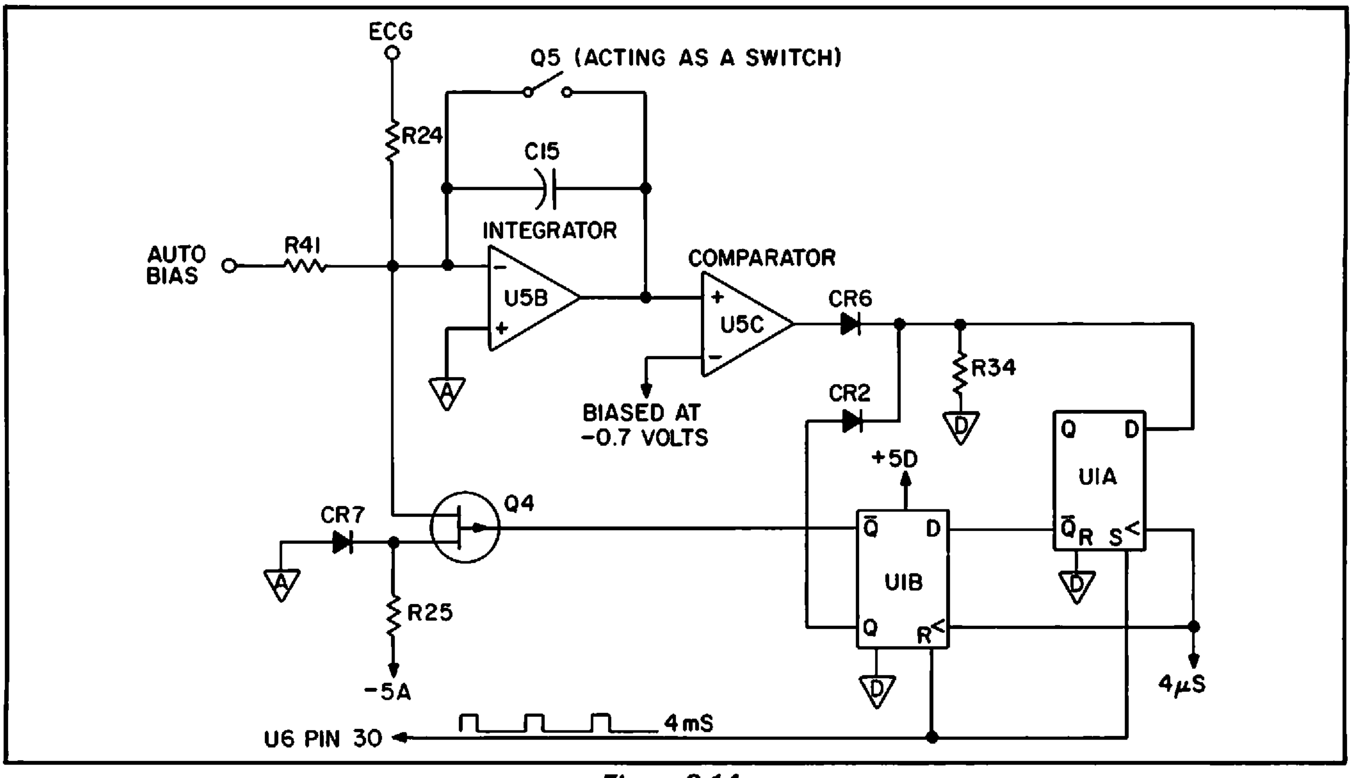


Figure 2-14

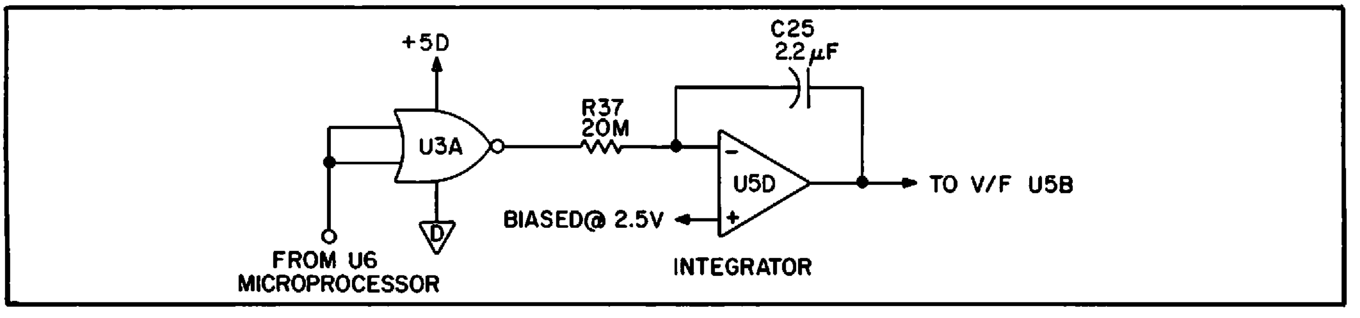


Figure 2-15

2.3.4 Microprocessor Reset "Tickle" Circuit (Fig. 2-16)

Should the microprocessor ever hang up due to a defibrillation or other noise, the free-running oscillator formed by Q3, U3C, U3D, R1, R8, R28, R32, C1, C3 and CR4 resets the microprocessor.

When the microprocessor is operating properly, C3 couples a signal that resets Q3 every 4.267 milliseconds. If the signal from the microprocessor is lost, U3D will oscillate until the microprocessor is reset and the AC signal appears at Q3.

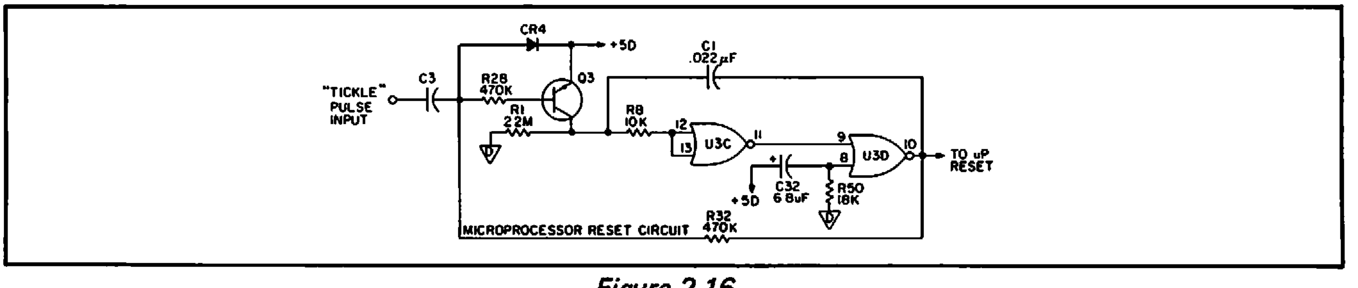


Figure 2-16

2.3.4.1 Beeper

U8, on the memory circuit board, generates a continuous train of pulses with a frequency of approximately 488 Hz. This signal and the R-wave signal connect to the inputs of U3B.
At the detection of each R wave, U3B is enabled for about 160 mS. When enabled, a 488 Hz signal goes to Q1 to drive the speaker. Volume is controlled by potentiometer A1-R5.

2.3.4.2 Electromagnetic Interference Rejection

The following components serve to reduce EMI susceptability and/or protect I/O lines on the processor:

C4, R17, C7, R20, C9, R30, C28, C29, C30, C31, R31, C19, R33,
C18, R35, C24, R46, R47.

2.3.5 Memory/Display Board 78660-60170

2.3.5.1 Functional Overview

The semiconductor memory stores 3.6 seconds of ECG waveform for display on the CRT. The timing signals to control memory, the horizontal ramp generator and a CRT signal multiplexer are also located on the memory board. Signals generated for the CRT are shown in figure 2-17.(See Figure 6-5 for detailed schematic)

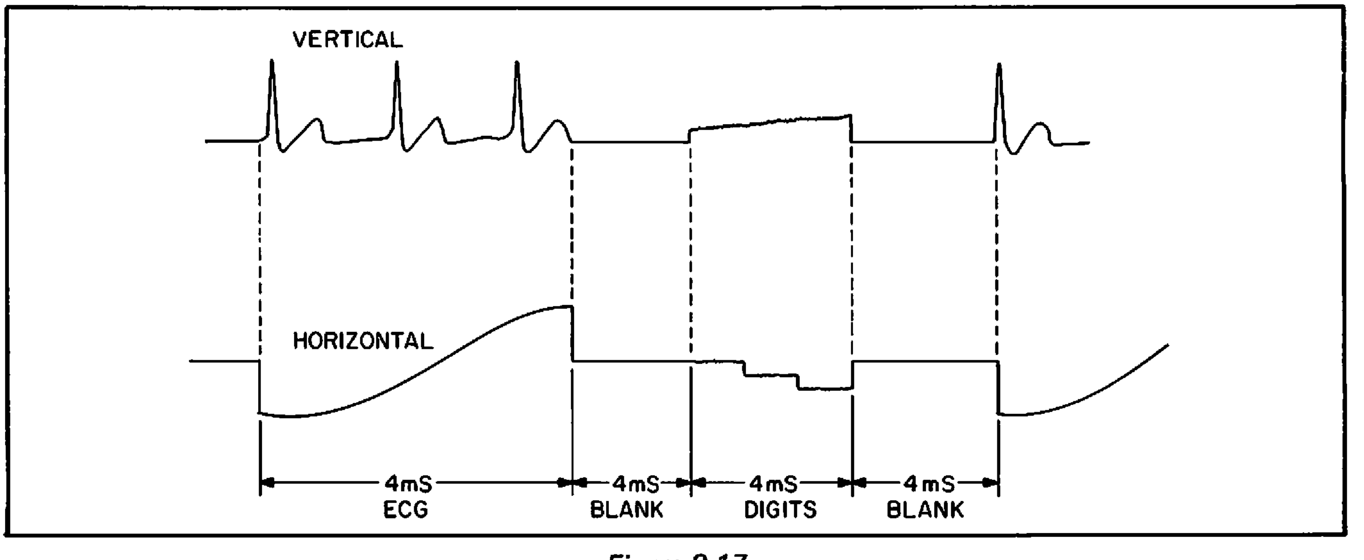


Figure 2-17

The memory element U9 is a 1K x8 random access static MOS memory (RAM) integrated circuit. It has 1024 memory cells; each cell containing 8 bits of data. Every 4 milliseconds the ECG digital microprocessor, located on the digital ECG board, converts the ECG signal to an 8 bit digital signal, which is stored in the memory. The memory cells are sequentially addressed from location 0 to 1023 by signals from an address counter U5B U6B and U7B. The 8 bit contents of each cell is later converted back to an analog signal by the digital to analog (D/A) converter, U13. Analog signals are created for both the CRT and the recorder.

A ramp generator, U17C, controls the horizontal position of the CRT beam. When memory location 0 is addressed, the CRT beam is at the extreme left. It moves linearly to the right as addresses are sequenced. Each location corresponds to a specific horizontal location on the CRT screen, with 1023 located on the extreme right.

The 8 bits of data in each cell are converted into one of 256 possible vertical locations. Zero is at the bottom of the screen; 128 is beam center and 256 is the top.

The time required to read the entire memory is 4 milliseconds. Four seconds are required to store in all 1024 cells, therefore, the CRT signal is 1024 times the input frequency. Thus a signal of 10Hz into the ECG amplifier is presented to the CRT as a 10kHz signal.

As new ECG information is received, the oldest information is lost from memory. For a graphic description of the read-write sequence, see Figure 2-18. Line 1 represents the RAM memory from 0 through 1023. Line 2 is the write pulse which advances one memory cell with each output pulse. In the real time mode, the 1025 pulse is both the write and read command. In the delay mode the 1025 pulse writes in the new information and the 1026 pulse reads the next memory cell which is the oldest information in memory.

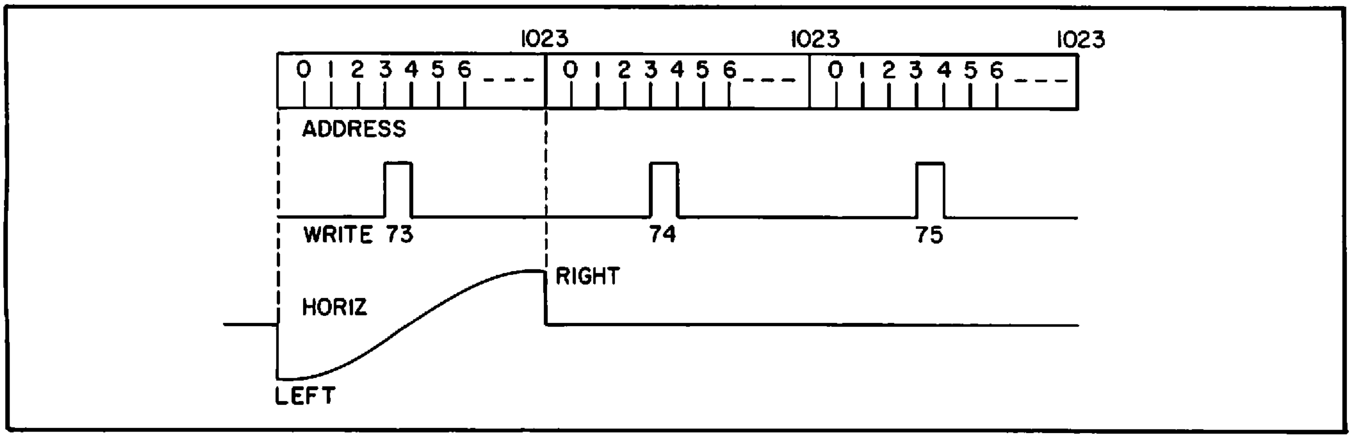


Figure 2-18A

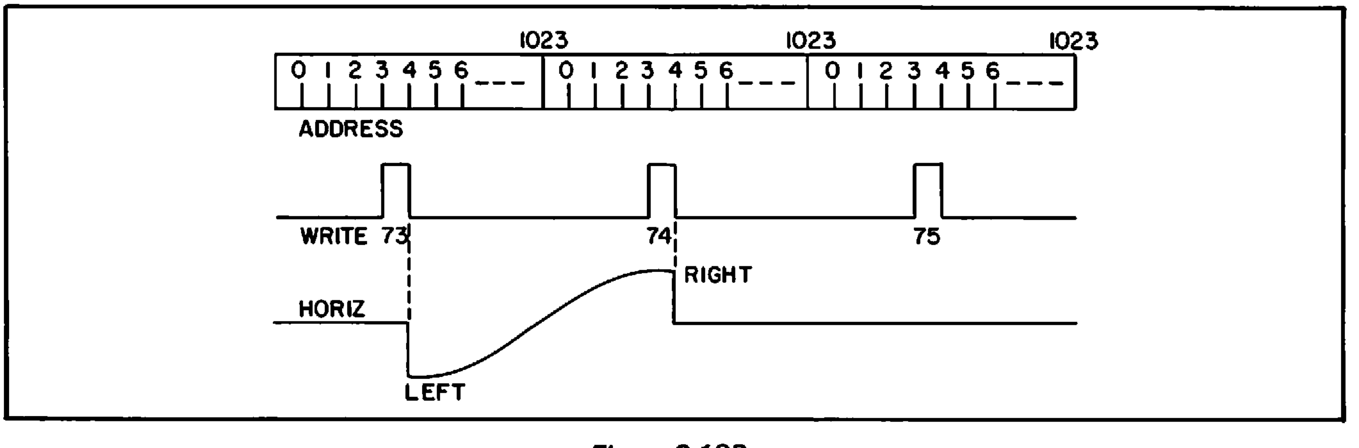


Figure 2-18B

Erase Bar

In the FIXED TRACE mode the erase bar is a signal which turns off the CRT for a short interval just after new information is written into memory.The operator is then able to differentiate between old and new information on the CRT. In the MOVING TRACE mode the erase bar is not used. The new information, in this mode, is always at the right side of the CRT. Refer to Figure 2-19 for a simplified erase bar generator circuit.

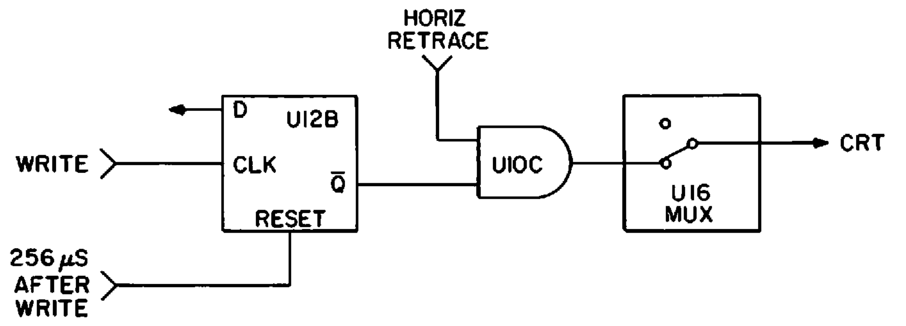


Figure 2-19

2.3.5.2 Oscillator and Johnson Counter (Fig. 2-20)

A one MHz signal is provided by a CMOS, crystal controlled oscillator U18C. This signal drives a Johnson counter, U1, which produces the four phase timing signals. Phase 1 is the clock for the address counters. Phase 2 resets the 1025 counter and provides a 4 microsecond signal to the ECG digital board. Phase 3 enables the CRT and recorder sample/hold FETS. Phase 4 resets the Johnson counter.

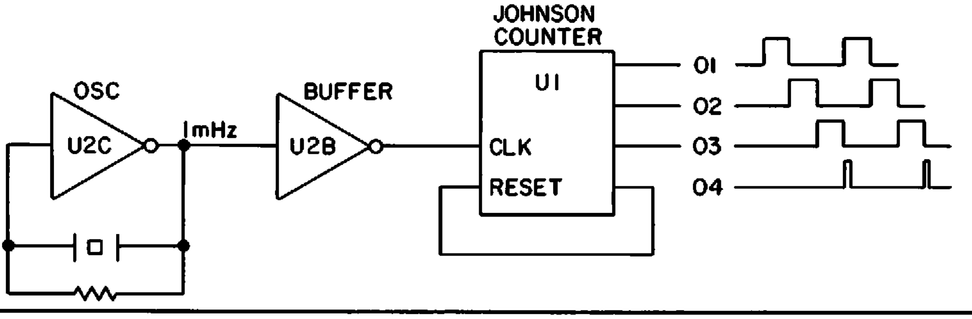


Figure 2-20

2.3.5.3 1025 Counter (Fig. 2-21)

Recall that the memory has 1024 cells and a write occurs to a sucessive cell each time. This is accomplished with a counter which resets itself after 1025 counts. The 1025 pulse or write signal output of U11A enables the strobes, U15 and U14A, placing new ECG data onto memory bus. It also provides the write signal to the RAM, U9. At this point, new ECG data is written into memory.

2.3.5.4 Delay ECG Gate (1026 count)

The oldest data in memory will be updated next and is located in the next cell after the one which is being written into. The write signal (1025) is input to the D flip-flop U11B and is tranferred at the next occurance of phase 3, to create the write +1 signal (1026). It is used to sample the oldest signal out of memory for the recorder and EXTERNAL ECG.

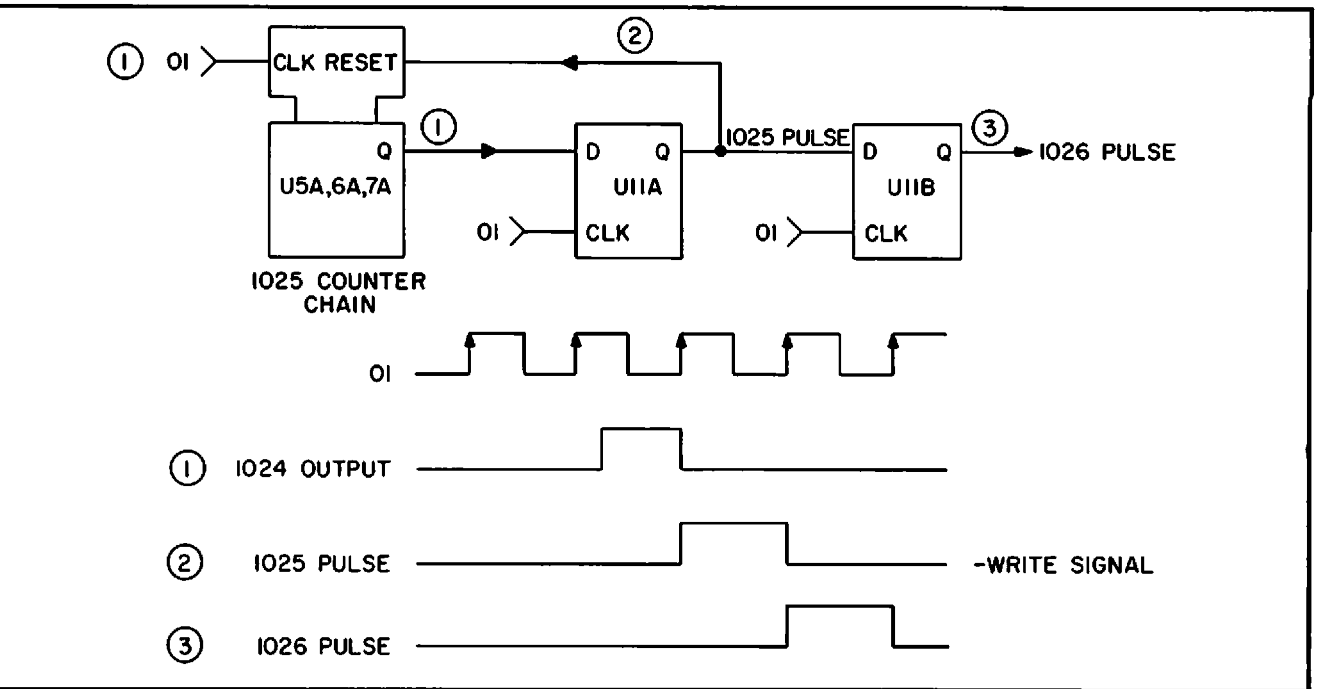


Figure 2-21

.3.5.5 Address Counter

10 stage binary counter is formed by U5A, U6A and U7A. The counter outputs go to he address inputs of the RAM. The counter sequentially steps through the ddresses from 0 through 1023, then repeats. The binary counter is incremented by hase 1. Each address is held for 4 micro- seconds.

.3.5.6 RAM Read-Write

o read data out of memory, the R/W input is a logic high and the chip enable (CE) s a logic low. Data will be stored in the memory cell being addressed if the R/W nd CE inputs are both low. When the CE line is a logic high, the data lines ecome tristate (high impedance).

.3.5.7 Bidirectional Data Bus

CG information, from the ECG amplifier board is placed on the data bus by the data trobes U14A and U15A. The RAM, U9, receives and gives back stored information to he data bus. This information is applied to the digital to analog converter U13.

.3.5.8 Digital to Analog Converter (D/A)

he D/A is a circuit element which converts digital data from the data bus, to an nalog signal to the vertical deflection amplifiers, the recorder and the ECG utput jack. The D/A translates 256 possible combinations (8 bit data), to a urrent of zero to 0.8 milliamperes. The operational amplifier, U17D, converts his current to a voltage of zero to 3.4 volts.

.3.5.9 Sample and Hold (Figure 2-22)

hese circuits are composed of a MOS transmission gate and a capacitor. U14B and 7 is the recorder sample/hold while U14C and C9 are in the CRT circuit. During hase 3 timing signal, the voltage output of the D/A circuit is passed through the ransmission gates and stored on the capacitors.

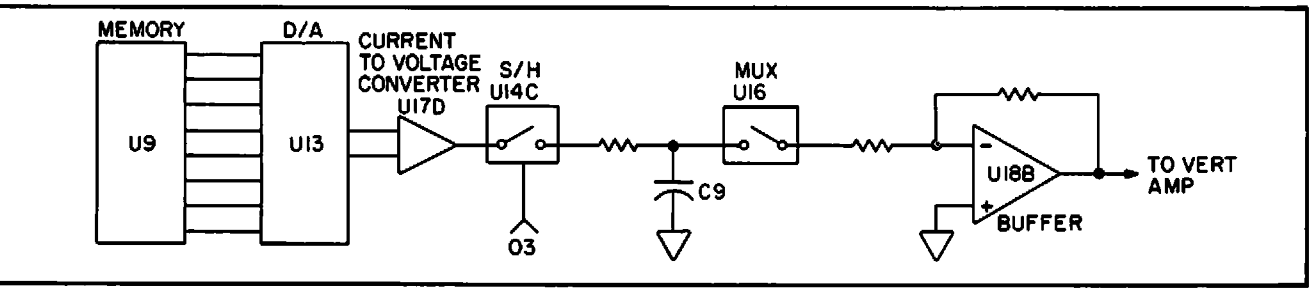


Figure 2-22 A

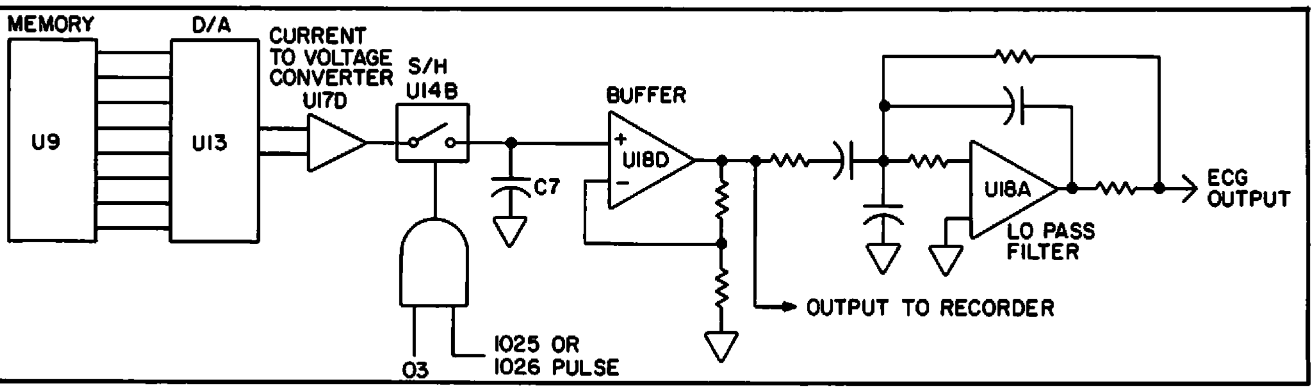


Figure 2-22B

.3.5.10 Ramp Generator (Figure 2-23)

he ramp generator produces a modified sawtooth waveform for horizontal deflection. 17C is the ramp generator switched by comparator U17B. When the comparator output s high, C11 and C12 charge through R20 to produce a rising ramp voltage. At the nd of 4 milliseconds, the comparator output switches negative which rapidly ischarges the capacitors through CR5, moving the beam back toward the left. iming for the ramp generator originates with the 1025 counter or the address ounter, depending on the position of the FIXED-MOVING trace switch.

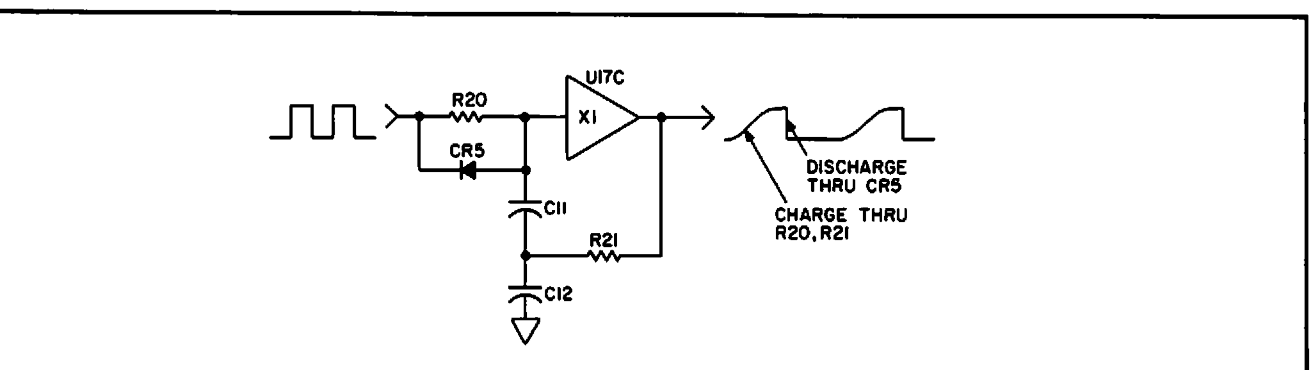


Figure 2-23

.3.5.11 Analog Multiplexer (MUX) (Figure 2-24)

he analog multiplexer, U16, alternately switches between ECG and HEART RATE digits s a source for the vertical, horizontal and intensity information. The ECG source is on for 4ms and the HR digits are connected for the next 12ms. (The recorder microprocessor only uses about 4 ms to place digits on the CRT and the remaining time the CRT intensity and deflection are off.)

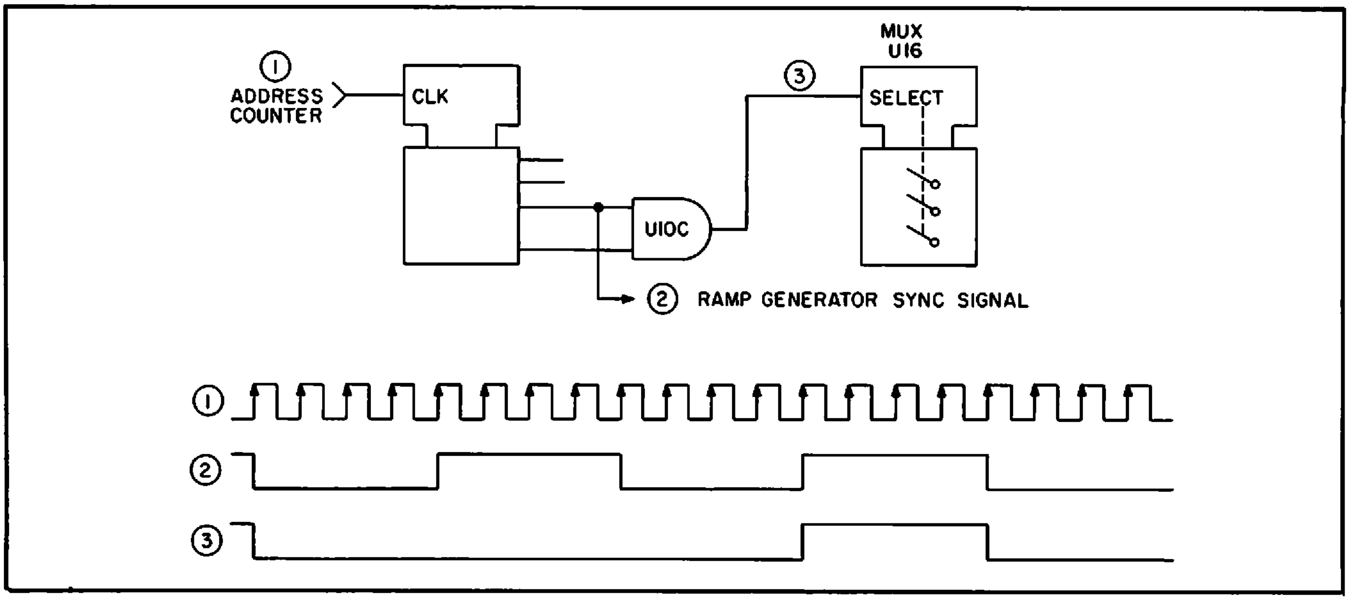


Figure 2-24

2.3.6 Deflection Board 78660-60180 (Refer to Figure 6-6 for detailed schematic)

This board provides the drive signal for the CRT and deflection yoke. It contains a vertical amplifier, a horizontal amplifier and an intensity driver.

2.3.6.1 Vertical Amplifier.

The vertical signal is applied to a bifet opamp through the gain adjustment potentiometer and a phase lead network. The purpose of the phase lead network is to emphasize the higher frequency signals. The opamp drives complementary preamplifier transistors Q2 and Q3, which in turn drive complementary output transistors Q4 and Q5. The output transistors apply +16 or -16v to the deflection yoke. Current through the yoke flows through R13 to ground, producing a voltage which is fed back to the inverting input of the opamp. When an input signal, say 1v is applied to the opamp, the output of the opamp goes to the plus rail, +12v, turning on the positive amplifiers, applying 16 volts to the yoke. The current in the yoke will increase slowly since it is primarily inductive. When the current causes the voltage across R13 to reach 1v, the opamp output will be reduced to a level sufficient to maintain that current in the yoke. It is this negative feedback which causes the CRT beam (which is deflected proportionately to current in the yoke) to closely follow the input voltage. (Refer to Figure 2-25)

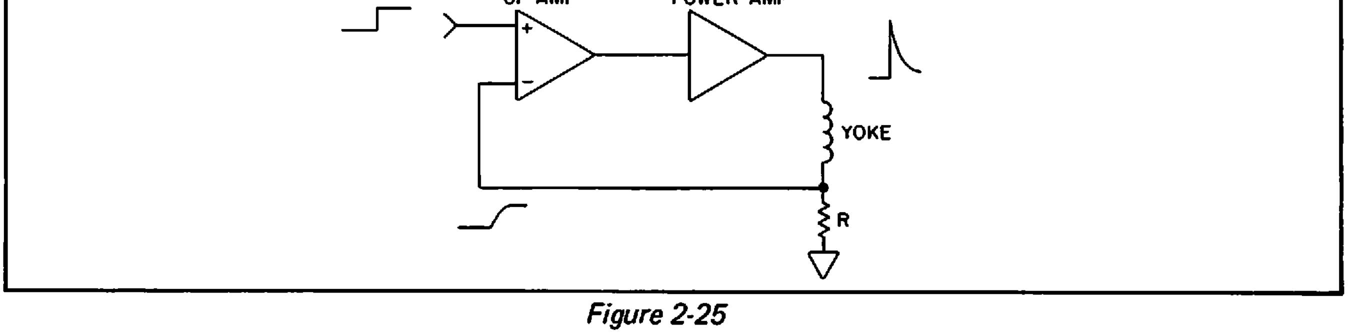


Figure 2-25

The purpose of Q1 is to modify the point at which the positive and negative amplifiers turn off and thus serves to eliminate crossover distortion.

2.3.6.2 Horizontal Amplifier

The horizontal amplifier operates exactly the same as the vertical except it has no phase lead network or preamplifers. Capacitors C2,3,and 4 aid in ellimination of crossover distortion.

2.3.6.3 Intensity Driver (Figure 2-26)

The purpose of the intensity driver is to bias the CRT to the intensity level desired by the operator per the INTENSITY potentiometer.

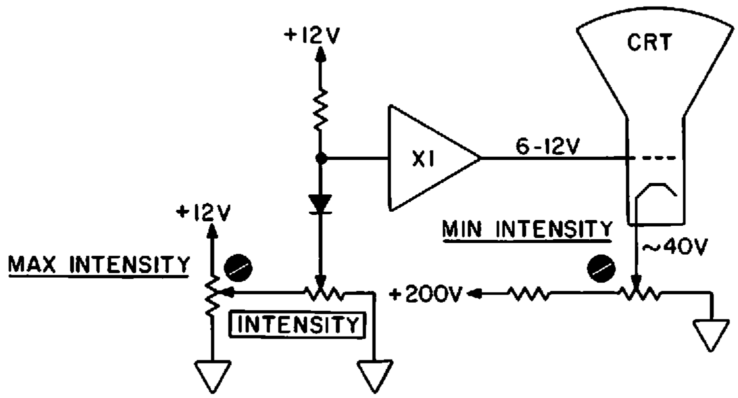


Figure 2-26

It also turns off the beam when necessary such as between digits, during the erase bar, during retrace of the horizontal beam, and during periods in between displaying the ECG signal and the digits signal. (Refer to Figure 2-27).

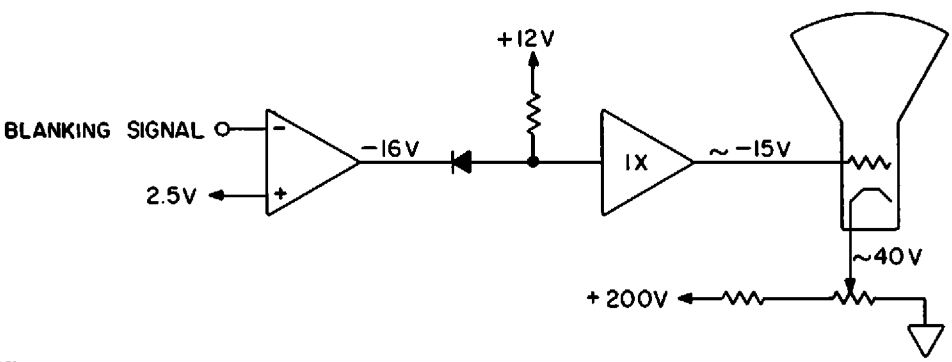


Figure 2-27

The intensity information from the MEMORY PCA enters the board at logic levels 0 to +5 volts and is changed by opamp U1b to levels of -16 to +12 volts. The input of opamp U1C receives intensity signals (within 1 diode drop) of -16 volts to between 0 and +12 volts depending on the setting of the intensity controls.

2.3.7 Clock/Heart Rate Board 78660-60260

(Refer to Figure 6-7 for detailed schematic)

This board generates the heart rate digits displayed on the monitor CRT and contains the clock circuit that keeps time for the recorder print out. Additional circuits include heart rate alarm switch and service switch sense, and alarm speaker driver.

2.3.7.1 Heart Rate Circuit (Refer to Figure 2-28)

The R-wave pulses, from the ECG digital board, are counted by the recorder control microprocessor to calculate the heart rate and generate the horizontal and vertical digital codes, which are passed to the I/O expander U1, on the clock/heart rate board.

2.3.7.2 Heart Rate Digital Display

D/A converters, U2 and U3, produce the horizontal and vertical components that make up the heart rate numerals displayed on the CRT, with U4A and U4B acting as unity gain buffer amplifiers. Intensity information comes directly from the I/O expander, U1.

2.3.7.3 Language Option Selector

The dip switch array, A7S1, is used to select documentation and language, printed by the recorder, and real time clock.

2.3.7.4 Heart Rate Alarm Switch

When the alarm switch is on, U1 will enable the gates U5a, b, and c if the heart rate is outside the limits. The beeper signal is then passed on to the speaker driver transistor Q1.

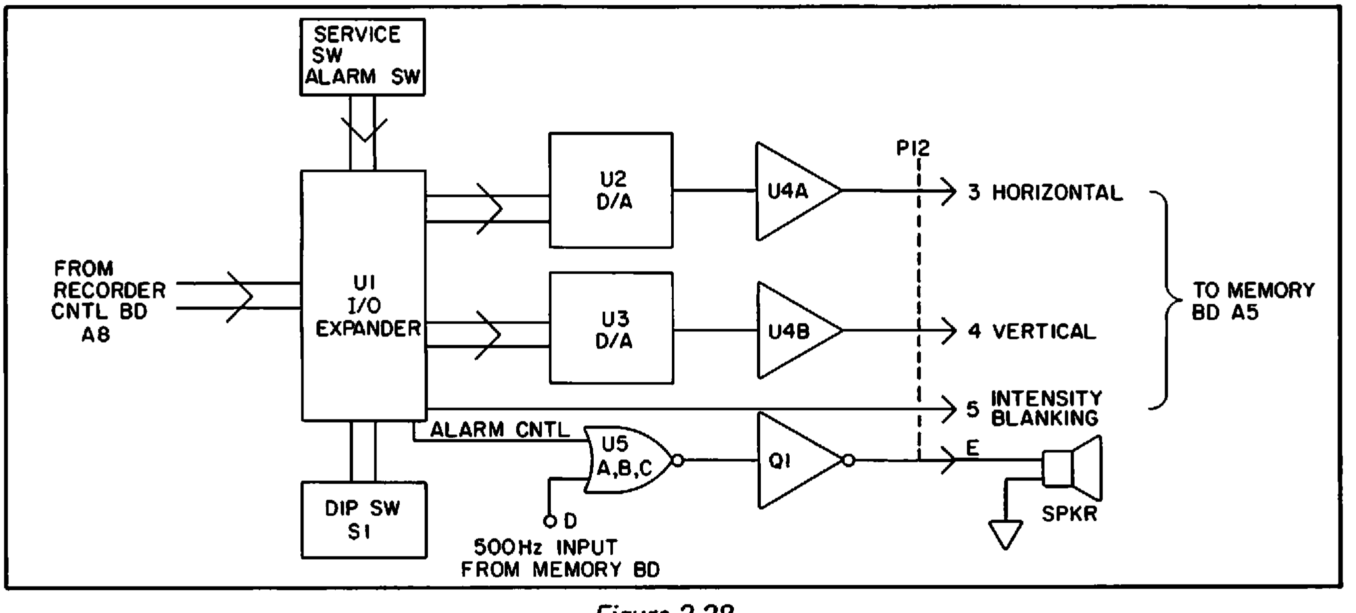


Figure 2-28

2.3.7.5 Clock Circuit (Refer to Figure 2-29)

U7 is a CMOS calendar/clock integrated circuit. This circuit keeps track of months, days, hours, minutes and seconds, and supplies this information to the recorder control microprocessor. This data is passed on to the recorder board on power up and once each hour on the hour when the instrument power is on. Between updates the recorder control microprocessor keeps track of time and date in software.

The chip select signal calls up U1 or U6. To read the clock, U6 is selected.

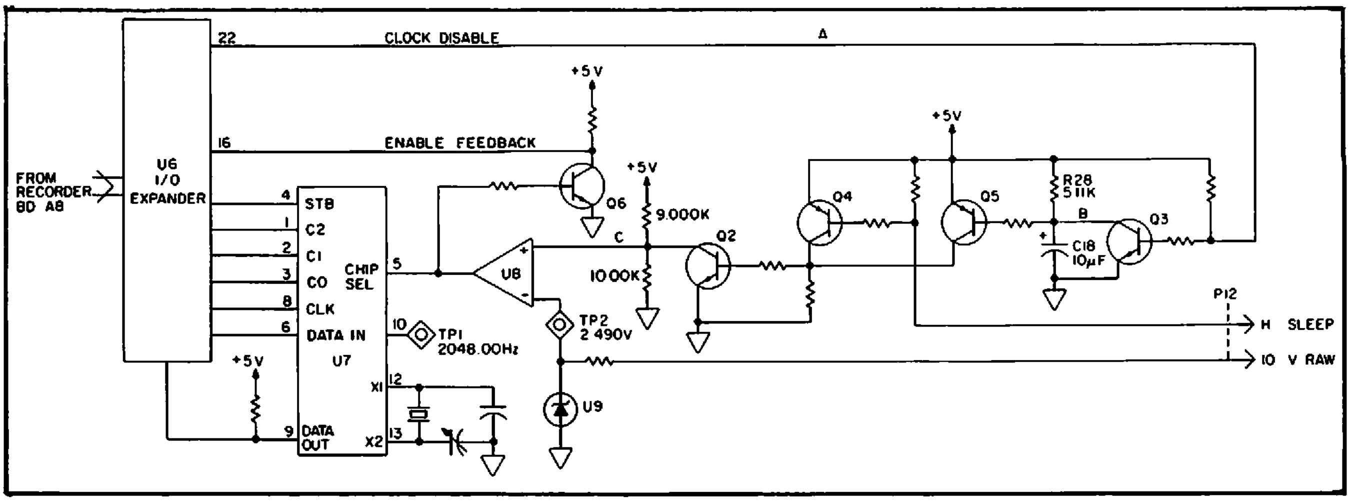


Figure 2-29

U6 then outputs a low on pin 22, the clock disable line. The collector of Q2 goes high approximately 100 msec later, having been delayed 2 times the time constant of R28 and C18. The + input of U8 (a CMOS comparator) then is at about 2.6 volts, and its output goes high enabling the clock chip. This signal is fed back through Q6 and U6 to the recorder control microprocessor telling it that the clock is ready for data input or output (time set or read). During a clock read the output of U8 will be high approximately 20 msec (Figure 2-30).

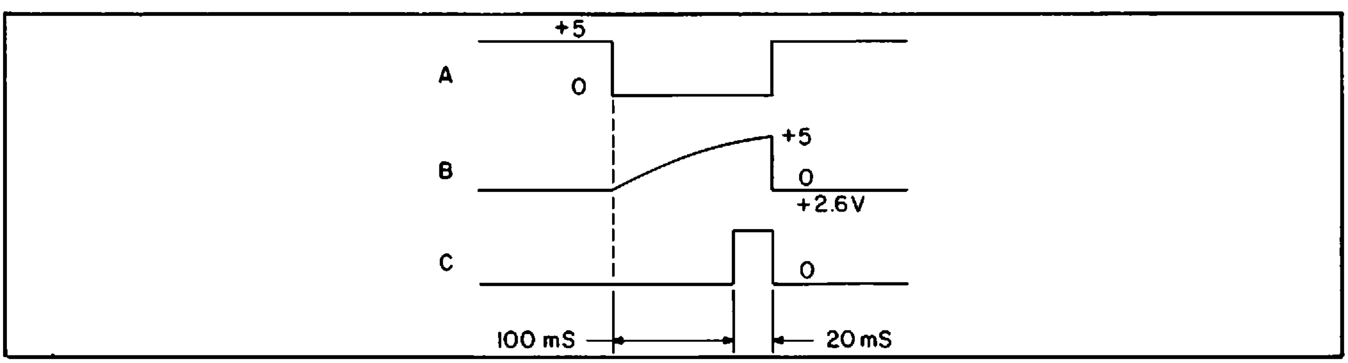


Figure 2-30

The clock accepts parallel commands over three lines, C2,C1, and C0. These are pins 1,2, and 3. The commands are strobed in by pulses on pin 4. The data are shifted in on pin 6 (time set) and out on pin 9 (time read). The shift clock is on pin 8.

The clock's oscillator frequency can be checked at test point TP1, which should be 2048.00 Hz.

On a read cycle (time read) there are four commands executed:
(See figure 2-31)

C2	C1	C0		
1	1	0	TP=2048 Hz	test point frequency set
0	1	1	time read	time is parallel loaded into internal shift register
0	0	1	register shift	allows shifting out of data
0	0	0	register hold	holds shift register,shift clock ignored

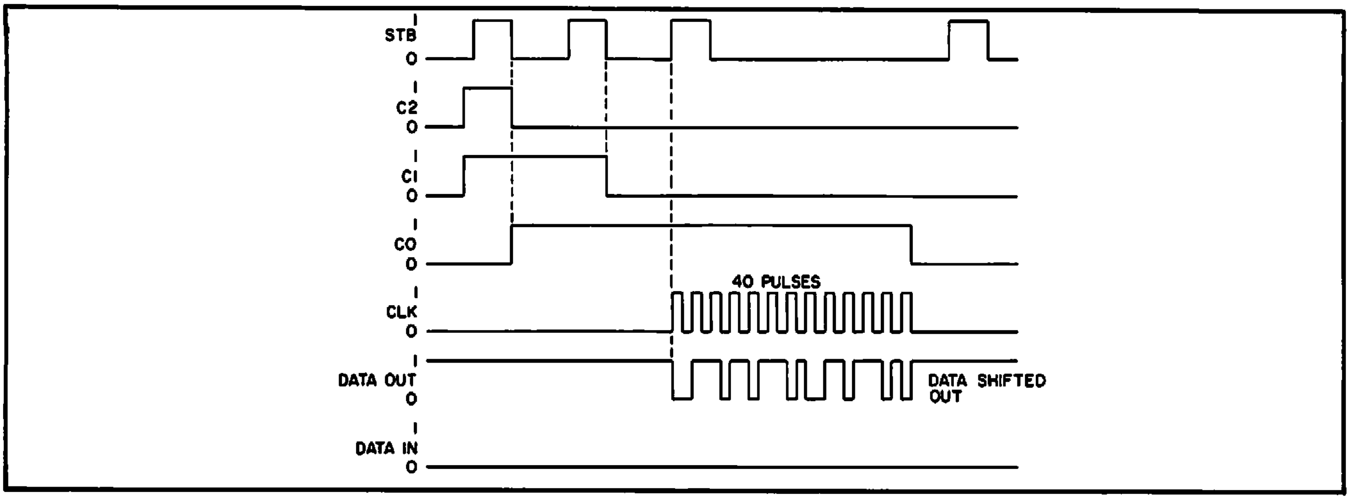


Figure 2-31

On a write (time set) cycle there are three commands executed: See figure 2-32

C2	C1	C0		
0	0	1	register shift	allows shifting in of new data
0	1	0	time set	new time/date information is parallel loaded into internal counters
0	0	0	register hold	holds shift register, shift clock ignored

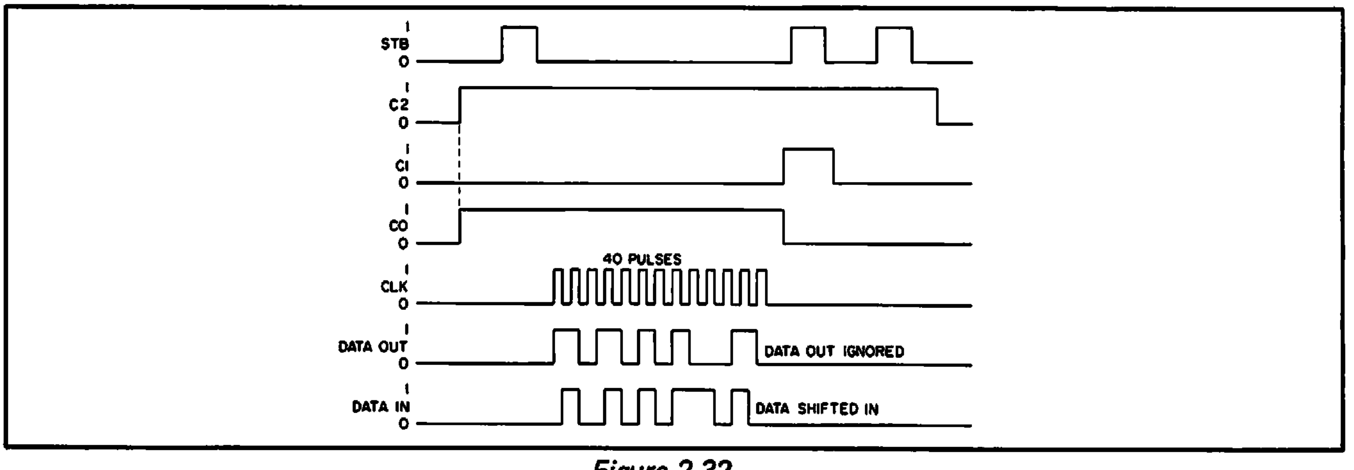


Figure 2-32

After a write cycle is finished a read cycle is executed. By pushing the PUSH TO MARK button the new time and date can be checked.

2.3.7.6 Voltage Reference

U9 is a precision temperature compensated voltage regulator which furnishes a 2.490 volt reference voltage to the comparator U8. This reference is compared with a fraction of the +5 volt supply to detect power failure and disable the the clock. This reference operates at all times from unswitched raw system battery power. The current drain is about 1 milliampere, which is less than the self discharge rate of the nickel-cadmium battery.

2.3.7.7 Clock Battery

The clock chip, U7, is powered by a small battery which is located on the Clock/Heart Rate Board. Since the clock is independent of external power sources, it keeps time when those sources are removed. The clock chip current is only a few microamperes, so the battery life should equal the rated shelf life of the battery.

2.3.7.8 Clock Protection

A low on the sleep line causes the collector of Q2 to go low which disables the clock during the defibrilator discharge (Figure 2-29).

2.3.7.9 Clock Crystal

A quartz crystal, operating at 32.768 KHz, maintains the accuracy of the clock. Typical accuracy of the clock is 5 minutes per month, plus adjustment tolerance over the temperature range of 0 to 50 degree C. At a reasonably constant room temperature, accuracy is about 5 minutes per year.

2.3.8 Recorder Control Board 78670-60200

(Refer to Figure 6-8 for detailed schematic)

This board controls the operation of the recorder, annotation, and calculation and display of heart rate. The recorder functions include chart drive motor and sylus heat control, ECG signal amplitude limiting and switching, and print head drive.

2.3.8.1 ECG Monitor to Recorder Signal

The ECG signal to the recorder is buffered by a unity gain inverting amplifier composed of U5a, R10, and R11. To prevent the recorder stylus from moving when the recorder is turned off, the signal is switched by Q5. When Q5 is on the gain of the amplifier is reduced to a very small value ($\ll 1$) and essentially no signal is passed (see Figure 2-33).

2.3.8.2 ECG Memory to Recorder Signal

The ECG signal from the memory board to the recorder board has a DC offset of about 2.56 volts. This is cancelled to approximately zero by the circuit consisting of CR12, R43, and R44 (figure 2-33).

2.3.8.3 Recorder Movement and Stylus Heat Control

The recorder chart movement and stylus heat are controlled by a signal at edge pin 1. A high here (>2.5 volts) turns the chart drive and stylus heat off, and a low (0 volts) turns them on. These signals are controlled by microprocessor U1, through Q3 and Q4.

2.3.8.4 Recorder/Signal Control

A high (+BAT) at the collector of Q4 turns the recorder off, and Q5 on, to prevent signal transmission. A low (-5 volts) at the collector of Q4, turns the recorder on and Q5 off, allowing signal to pass through to the recorder stylus deflection circuitry.

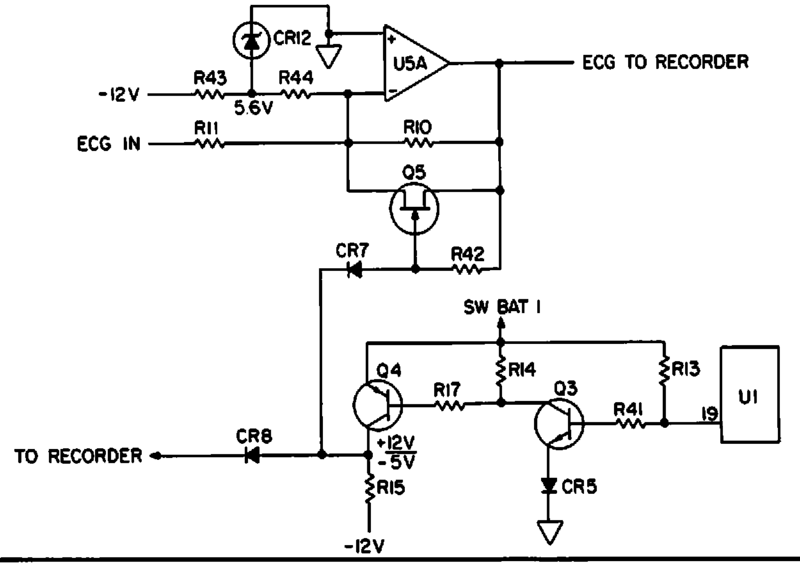


Figure 2-33

2.3.8.5 ECG Signal Ampltude Limiting and Switching

To prevent excess power consumption in the recorder stylus deflection circuits, an active limiting circuit is employed to prevent overdrive of the recorder input. This circuit is composed of Q1,Q2,CR2,CR3, and R4 through R9. In normal operation, Q1 and Q2 are biased off. However, when the output signal excursion is greater than approximately + or - 2.1 volts, Q1 or Q2 turns on, drastically increasing the negative feedback and reducing the gain of the amplifier (Figure 2-34). The effect of this is to limit the output signal excursion to + or - 2.1 volts. CR2 and CR3 prevent reverse bias breakdown of the base-emitter junctions of Q1 and Q2.

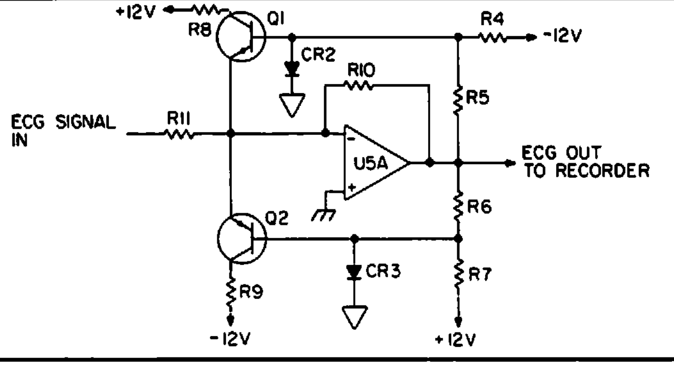


Figure 2-34

2.3.8.6 Microprocessor Reset (Tickle) Circuit

A defibrillator is a very high noise environment. The noise impulses produced by the defibrillating pulse and the associated high voltage relays can cause the recorder control microprocessor operation to be disrupted. To prevent this, a circuit known as a "tickle" or "heartbeat" circuit is used. It is a retriggerable oscillator which is retriggered at periodic intervals by a software routine in the microprocessor. If noise causes program disruption and the failure of the microprocessor to retrigger the circuit, after 20 to 25 milliseconds the tickle circuit will force a reset of the recorder control microprocessor.

This circuit consist of U5b, Q6, Q7 and associated passive components (figure 2-35). The circuit operation is similar to that of the three gate oscillator (figure 2-36). The two series gates are simulated by the op-amp U5b using its non-inverting input, and the third gate by Q6 operating as an inverting amplifier.

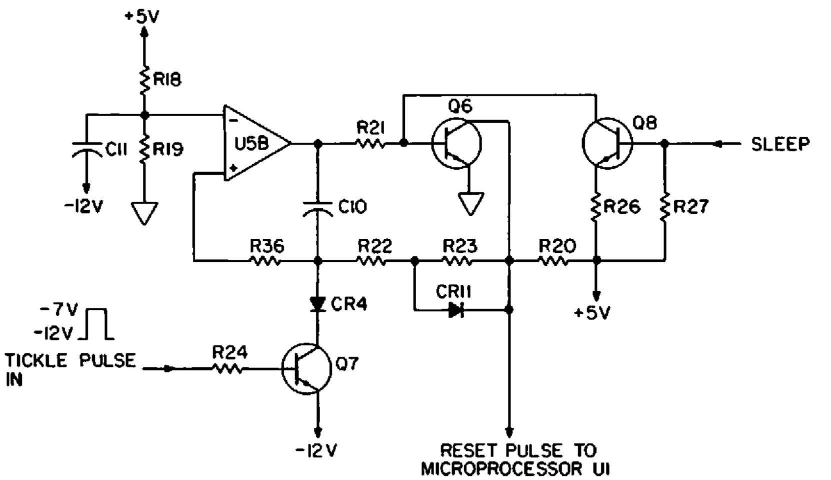


Figure 2-35

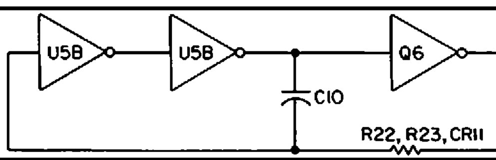
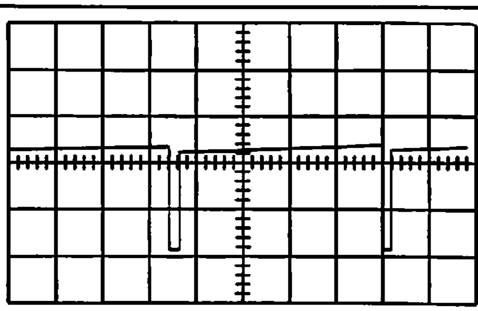


Figure 2-36

When allowed to free run (no retrigger signal from microprocessor) the "tickle" circuit produces a series of negative going pulses approximately 1 millisecond wide (figure 2-37) with a period of 20 to 25 milliseconds.



VERT. *1.0 V/Div.*
HORIZ. *5 ms/Div.*

Figure 2-37

To "tickle" or retrigger the circuit, a pulse about 1 millisecond wide is generated by the microprocessor U1, which turns on Q7, charges C10, and forces the output (collector of Q6) to a high or non-reset state. These pulses are generated every 16 milliseconds during normal operation of the instrument.

C11 forces a reset, on powering up the instrument, by pulling down on the inverting terminal of U5b, forcing its output high and turning on Q6.

Q8 allows an external signal from the defib control microprocessor to reset the recorder control microprocessor and put it to "sleep" during defibrillator discharge for additional noise protection.

2.3.8.7 Print Head Driver

The printhead consists of 7 resistors with one common terminal, and a nominal resistance of 87.5 ohms. The printhead is bonded to a flex cable one end of which inserts into a connector (J30) on the the recorder control board.

The common terminal is connected to the positive volt power supply through protective circuitry. The Darlington transistor array U2 sinks current through each resistor to heat it and produce a dot on thermally sensitive paper (figure 2-38). U2 is driven in turn by CMOS gates U3 and U4. One input of each of seven gates are tied together to the output of the eighth gate through a network consisting of C1,R1,R2, R3, and CR1. The seven gates act as signal switches for the printhead drive signals coming from U1. The RCD network prevents the printhead from being enabled longer than 3-5 milliseconds. This is to protect the printhead in the event of a microprocessor failure. The inputs are biased up to +4 volts by R2 and R3. A negative going edge at pin 11 of U4 causes the seven gates to be enabled for a length of time controlled by the time constant of C1 and the parallel combination of R2 and R3. The diode allows quick charging of C1 on positive going edges. R1 is to limit capacitive current.

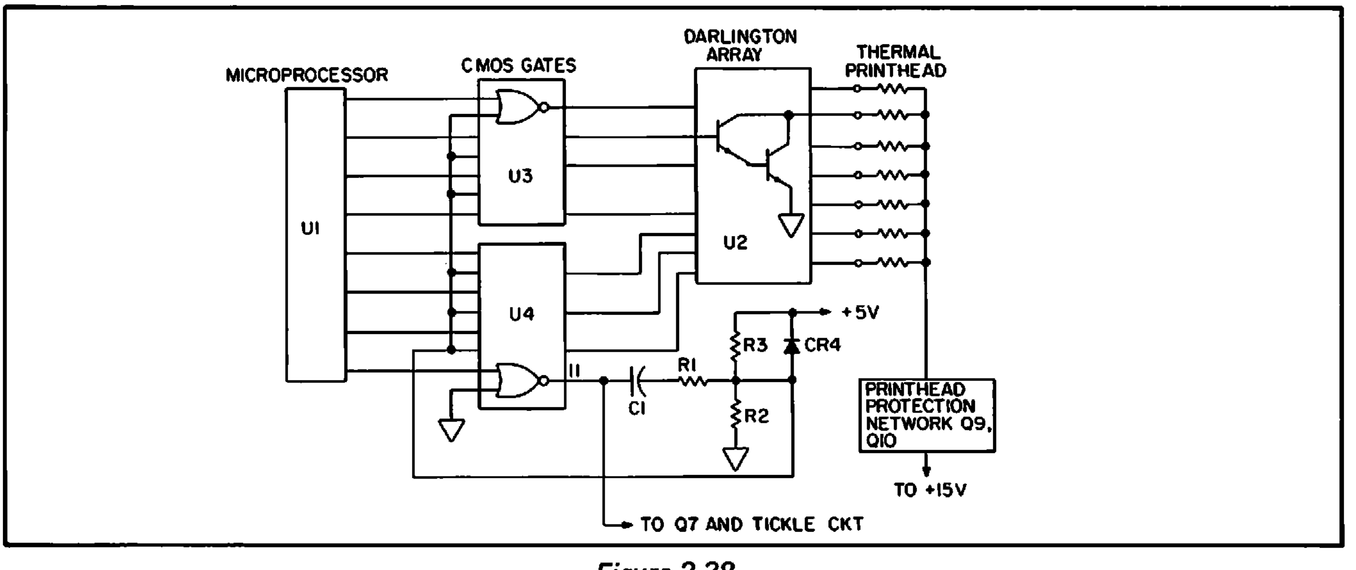


Figure 2-38

The output pin 11 of U4 also drives Q7 to retrigger the "tickle" circuit (see above)

The drive signal to U2 is shown in Figure 2-39.

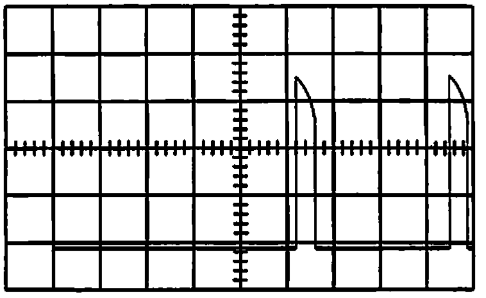


Figure 2-39

2.3.8.8 Print Head Protective Circuit

Q9, Q10 and associated components protect the print head from power up and power down transients. On power up, C21 clamps the Q9 base to -12 volts, holding it off. C21 slowly charges through R47 until Q9 turns on which turns on Q10, applying power to the print head. On power down, the +5 volts decays rapidly, forward biasing CR15, which forms a capacitive voltage divider of C20 and C21. This decaying voltage turns off Q9 and Q10, removing voltage from the print head (Figure 2-40).

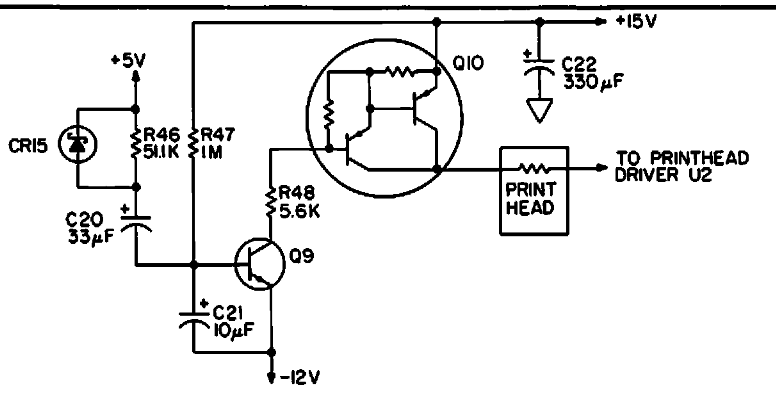


Figure 2-40

2.3.8.9 Input/Output Lines

See the detail schematic (Figure 6-8) for the following circuits.

U1 lines P10 thru P13 (pins 27 thru 30) go to the defibrillator control board. Information to be printed is passed to U1 over these lines. The data available signal from the defib control board generates an interrupt which signals U1 that a message is available.

PROG, P20 through P23 (U1, lines 21 through 25) communicate with the two I/O expanders, U1 and U6, on the clock board. The chip select line controls which of the I/O expanders is selected.

The 16 millisecond line comes from the memory board and is used to synchronize the printing and the CRT display.

The R-wave line comes from the ECG digital board. U1 counts R-wave pulses and calculates heart rate which is printed and displayed on the CRT.

The TAP line (U1, pin 33) goes to the PUSH 8 SEC RUN switch on the front panel. For every time the switch is actuated the recorder will run 8 seconds up to a maximum of 60 seconds.

The MARK line (U1, pin 32) goes to the PUSH TO MARK switch. Closure of this switch tells U1 to run the recorder and print a down arrow and the time/date information.

The RUN line (U1, pin 31) goes to the RECORDER switch. It tells U1 to turn on the recorder.

The SERVICE line (U1,pin 37) goes to the SERVICE switch. It is used in conjunction with the PUSH TO MARK switch to enter the time/date set mode. This mode is entered if while the PUSH TO MARK switch is held down and the power is off, the power is turned on and approximately 1 second later the SERVICE switch is pushed or pulled.

2.3.9 Defibrillator Control Circuit Board 78670-60195

The defibrillator control board contains an 8051 microprocessor, a digital I/O expander, LCD drivers, a "tickle" reset circuit, the chopper for the paddle contact signal, transistor drivers for the low battery LED and charge done tone, an analog multiplexer and an A/D converter.

2.3.9.1 Microprocessor

The 8051 uP is the heart of this board. It is directly or indirectly tied to everything on the board. The main loop of software is executed every 4 mS, the 4 mS being generated by an internal timer.

2.3.9.2 "Tickel" Reset Circuit

U6, Q3, and associated components make up the "tickle" reset circuit. See Fig. 2-41.

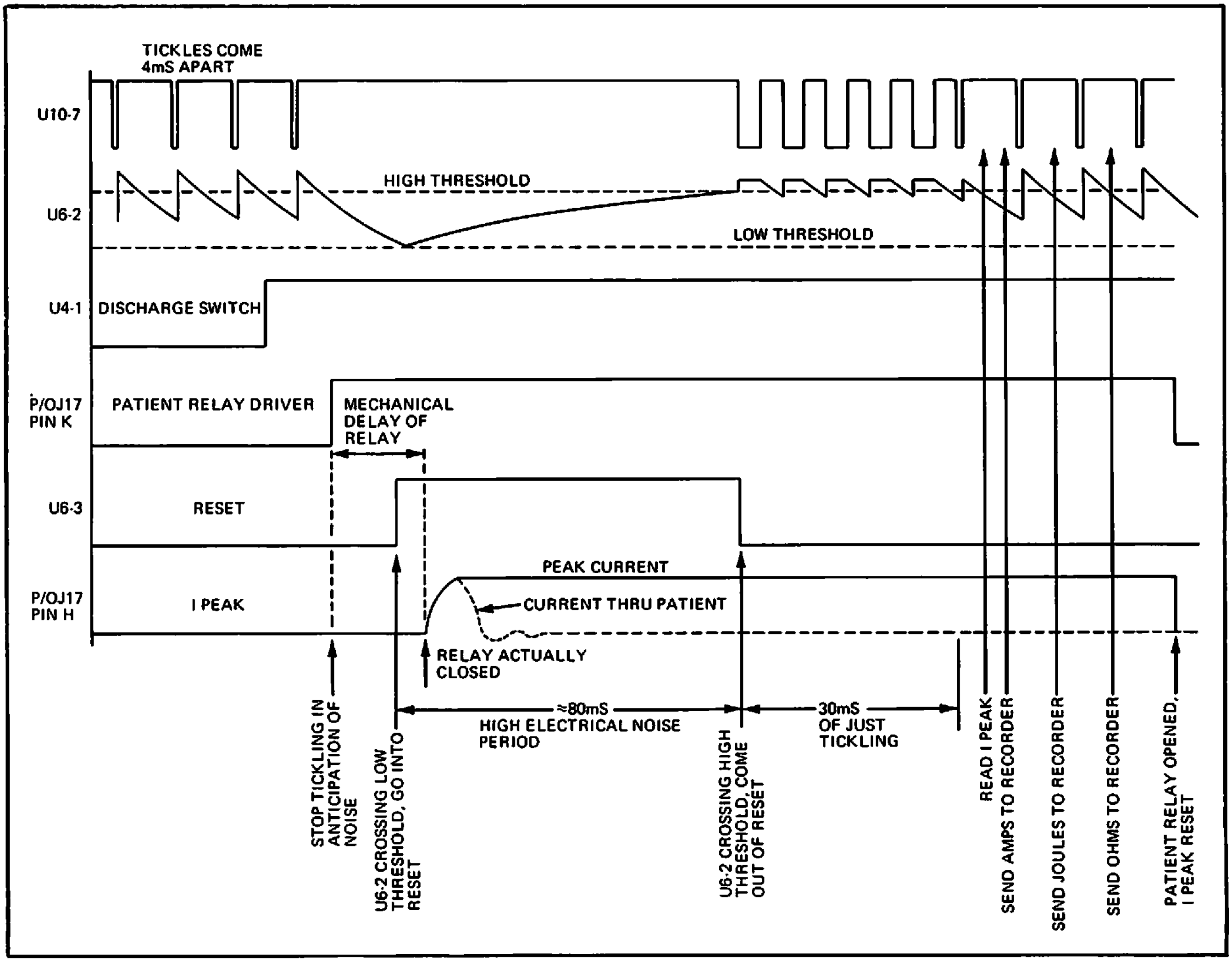


Figure 2-41

U6 is configured as a free running oscillator which would reset the uP once every 80-100 mS, if not inhibited. When the uP is running properly, a "tickle" pulse is delivered from P1.6 (U10, Pin 7) every 4 mS to prevent U6 from oscillating. If noise spikes upset the uP so as to reset the uP and start it running again at propram address location 0.

When the uP closes the high voltage relays, it has also been programmed to stop tickling, and U6 will then hold the uP in reset for the duration of high electrical interference, thus increasing the immunity of internal registers. When the uP is reset, the I/O expander (U4) is also de-selected and U5F will send a sleep* signal to reset the recorder uP on the recorder board.

2.3.9.3 LCD drivers and recorder data

U7, U8 and U9 are CMOS BCD to 7 segments latch/decoder/drivers. BCD data are put out by the uP port 0 bits 0-3 (U10, pins 36-39). Port 1 bits 0-2 (U10,pins 1-3) strobe the data into the LCD drivers. If information is to be sent to the recorder board, the DATA AVAILABLE* signal is used to inform the recorder uP that data is ready. Since inverter buffers are used (U5A, B, C, and D), the BCD data are inverted for the recorder uP whenever DATA AVAILABLE* is low. See Fig. 2-42 for timing.

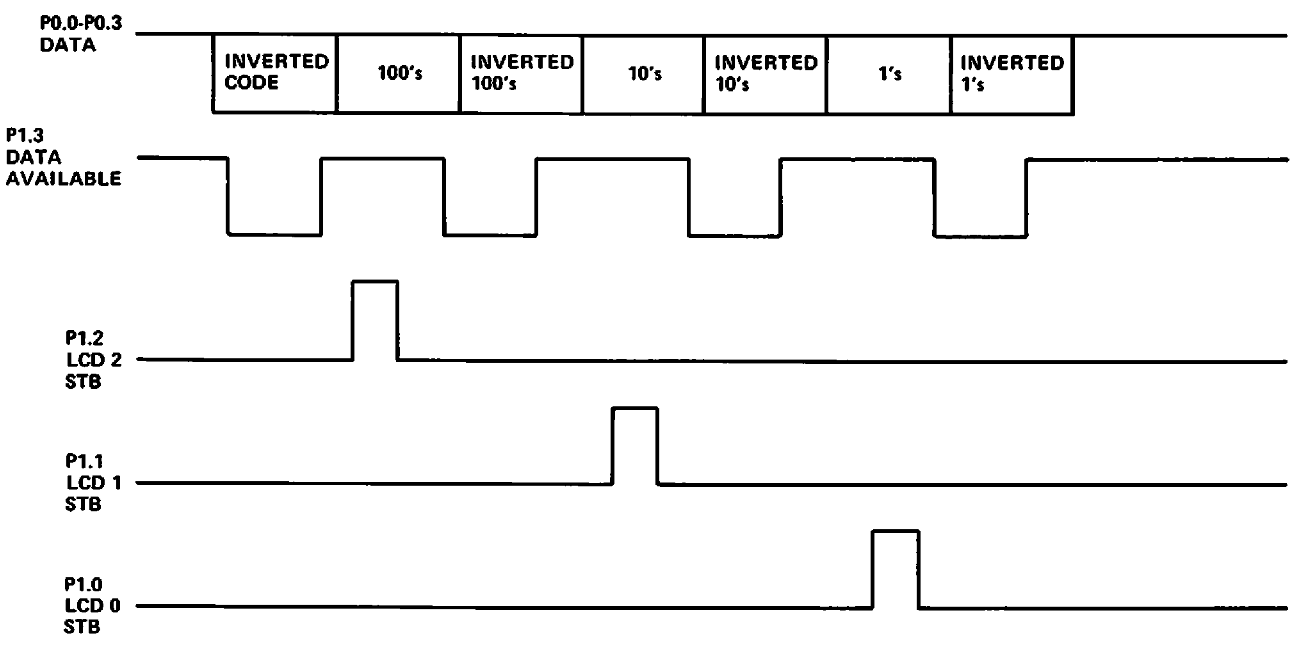


Figure 2-42

2.3.9.4 Analog Multiplexer and A/D Converter

U12 is an 8 to 1 analog multiplexer. P2.0 - P2.2 of the uP (U10, pins 21-23) select the analog signal to be sampled. U11 is an 8 bit successive approximation A/D converter. R37 and C18 set the clock speed for the converter at about 300 kHz. After an analog signal is selected, A/D conversion is initiated by a WR* signal from U10 pin 16. When the conversion is completed, an interrupt is issued by U11. The uP services this interrupt by sending a RD* signal (U10, pin 17), which clears the interrupt request and brings the 8 bits of data to the bus of the converter. The bus is normally in tri-state except when RD* is low. U13B, placed between the multiplexer and A/D converter, serves as a unity gain buffer when Q5 is on, or, if the analog signal is low and Q5 is off, as a 4x gain stage. The gain is controlled by P2.3 of the uP (U10, pin 24). U1A is an open drain CMOS buffer which acts as a level shifter so that in the high state, the gate of Q5 can be pulled up to +12V by R30. R53, R64, CR12, and CR13 protect U13B and U11 from over-current.

2.3.9.5 I/O Expander

The I/O expander, U4, expands the number of I/O lines which the uP controls. The expanded ports are labelled P4 through P7 and each port is 4 bits wide. There are 4 instructions that it recognizes; write to port, OR with port, AND with port, and read from port. An instruction and port selection from uP are latched into U4 on the falling edge of a strobe, P1.7 of the uP (U10, pin 8); data is transferred to/from U4 on the rising edge.

P4-P6 are input ports; P7 is output. P4 senses the front panel SYNC/DEFIB switch and R-wave from the ECG DIGITAL board (RSYNC*) for conversion. P5 takes the input from the charge switch, discharge switches, internal/ external* paddle selection (ie, 50 J interlock), and the reed switch which senses when the paddles are in the pockets. P6 reads the binary position of the energy select switch. P7 controls the CHARGE DONE LED, patient relay driver and safety relay driver.

2.3.9.6 Relay drivers

The safety and patient relay drivers on this board, composed of U1D, U1E, Q1 and associated R's and C's, are only the intermediate stages between the controlling I/O port and their respective transistor driver on the HV CHARGER board. At discharge, it is desirable to have the safety relay lag behind the patient relay so that most of the energy is dissipated into the patient and virtually none into the 10K ohm safety resistor. The commands from the uP to close both relays are given simultaneously. After the commands are given, the uP is reset and it must be the hardware (R23, C16, and CMOS input of U1E) which delays the safety relay.

2.3.9.7 Charge Done Tone

Q2, R24, C11 and CR3 form the speaker driver. The signal going to the base of Q2 is shown in Fig. 2-43. The fundamental frequency is 250 Hz. Therefore, to the ear, the tone sounds different from the R-wave tone or the heart rate alarm tone, both of which emphasize the harmonics of roughly 500 Hz.

2.3.9.8 Battery LED driver

Q4 sinks the BATTERY LED current. When the battery is being charged, Q4 is turned on continuously with base current being supplied through R28. When the battery is low (SwBatt 2 is sensed by uP) and is not being charged, the uP flashes Q4 via CR5 with a 1 second signal of 33% duty cycle.

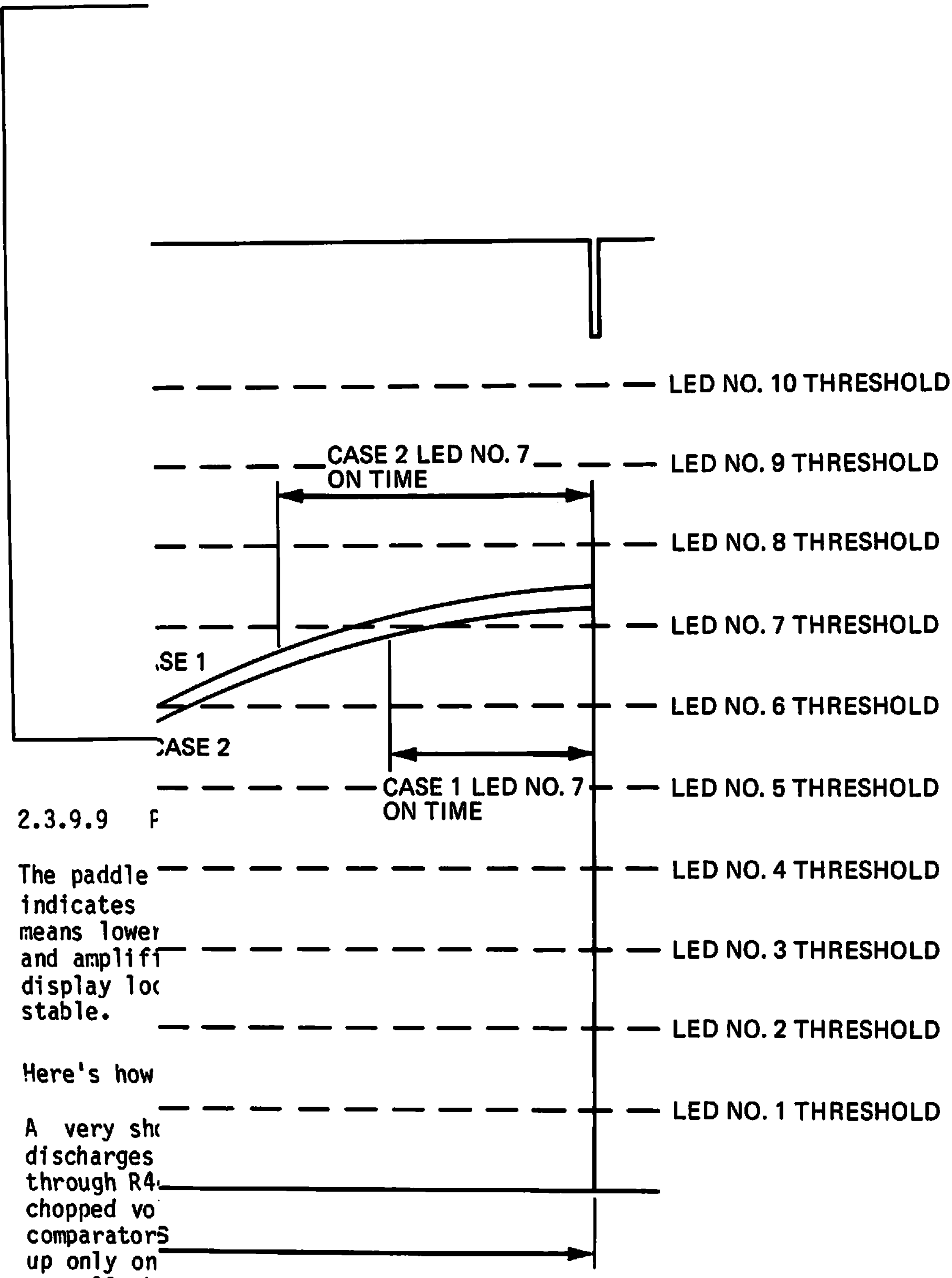


Figure 2-44

2.3.9.9 F

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2.3.9.10 Monitoring the HV capacitor

Figure 2-45 shows a simplified schematic of the HV capacitor monitoring circuit. As the capacitor is being charged, the current flowing through the 24.9M resistors on the HV charger board, will keep the capacitor balanced around 2.7 volts. At the same time, U1D increases in voltage (referenced to ground) and U1C decreases by the same amount (but with reference to 5.4 volts). On the control board, U13A inverts the signal from U1C so that, at the input to the multiplexer, both signals will be of the same polarity and increasing with respect to ground. Thus the numerical sum of these two signals will indicate the voltage on the capacitor, even if the capacitor is imbalanced by some stray resistance to ground on one side.

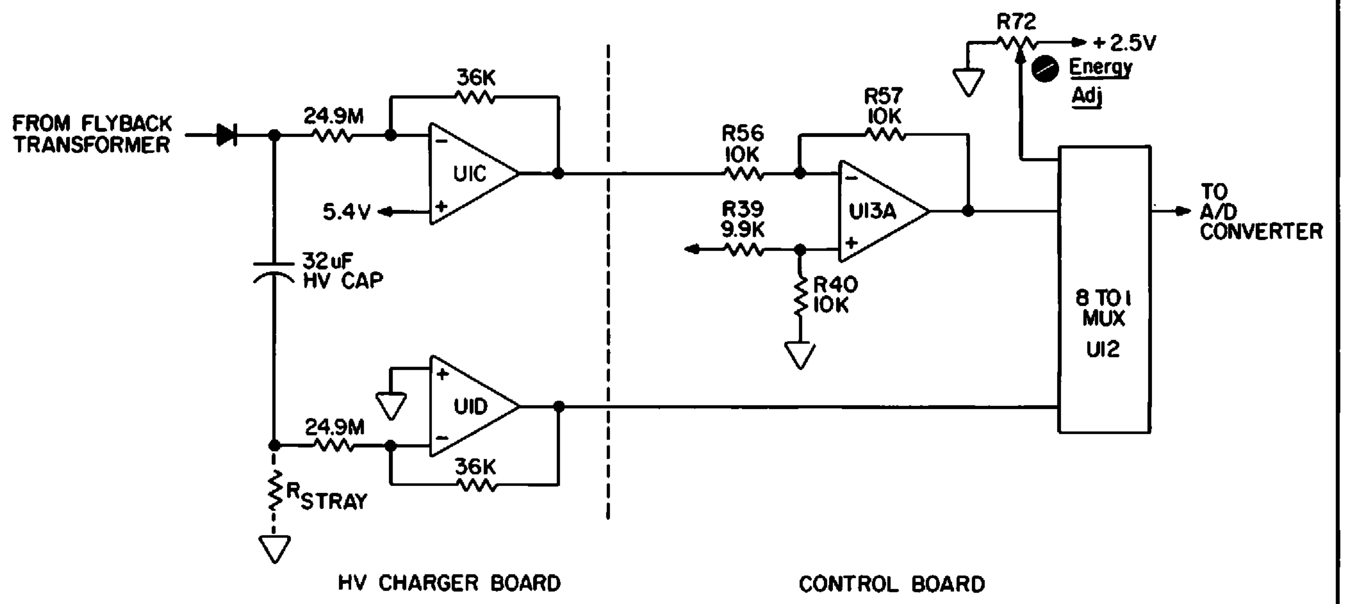


Figure 2-45

Energy Adjust Pot (R72) is an adjustment made to correct for the HV capacitor tolerance.

2.3.9.11 Charge and Discharge Cycle

A defibrillation episode is initiated by pressing and releasing the charge switch (a high and then low at U4 pin 22). The uP then reads the (U10 pin 6) low to start the charger circuit. When the capacitor voltage reaches its selected value, SHUTDOWN will go high and will periodically go low to keep the capacitor voltage as close to the set value as possible. If the energy select switch is changed before the capacitor is discharged, the uP will charge to the new setting, dumping the capacitor into the safety resistor if necessary.

When the proper capacitor voltage is reached, the charge done tone will be activated. The charge done LED is turned on (U4 pin 13 goes low), and the uP now looks for a high on U4 pin 1. A high means both discharge switches have been pressed simultaneously. When the high is detected, the uP will turn on the patient relay driver and turn off the safety relay driver (i.e., close both relays) and wait for reset as described in Section 2.3.9.2. The only exception is cardioversion or synchronized defibrillation.

2.3.9.12 Cardioversion

For cardioversion, everything in the charge and discharge sequence is the same except the relay drivers now are closed only on a high to low transition of RSYNC*. The sync mode is selected or de-selected by a switch on the front panel which momentarily grounds SYNC ON* or DEFIB ON* respectively. This switch information is sensed by the uP through U4 pins 2 and 3. Sync mode may not be selected unless the monitor is picking up the ECG from leads instead of the paddles. This LEADS/PADDLES* signal from the ECG ANALOG board comes to the uP at U10 pin 27. The uP tells the ECG DIGITAL board of sync mode through SYNC EN* (U10 pin 25). The ECG uP responds by pulling RSYNC* high. When RSYNC* is high, the sync LED on the front panel is turned on by U1F. On each detected R-wave, RSYNC* goes low for about 200 mS and the LED is turned off for that time period.

2.3.9.13 Software Safety Features

The software in the uP monitors for certain failures in the HV cirucits and will disable the charge and discharge cycle if an unsafe condition is detected. Some of the problems it looks for are: overcharge, HV capacitor grounded, leaky capacitor, safety relay failed to open or close, arc in patient relay, and certain reference voltages out of specifications.

2.3.10 Defibrillator High Voltage Section

(Refer to Figure 6-11 for detailed schematic)

2.3.10.1 General

This section describes the following:

1. Defibrillator paddle set, with CHARGE and DISCHARGE switch.
2. HV defibrillator inverter power supply PCB 78670-60120.
3. HV defibrillator energy storage capacitor.
4. HV patient relay and drive circuit.
5. Discharge current transformer and sample/hold circuit.
6. HV safety relay and drive circuit.
7. Voltage reference/low battery shutdown circuit.

2.3.10.2 Power Circuits

The HV defibrillator inverter PCB contains power circuit wiring, between the battery, Power Base and the mother PCB. The battery connects to J43 and J44; the Power Base at J45 through J48. V-REG from the Power Base closes relay K1, supplying V-REG to the mother PCB and V-RAW to the HV flyback transformer/drive circuit. CR114 guarantees K1 coil dropout for Power Base AC loss, reconnecting the battery to all power circuits. C17 and C19 suppress noise. Battery charge current (J48) flow through CR9 and R129 to the battery. The Q22 circuit gives steady lighting of the front panel BATTERY LED if both charging voltage and battery are present.

Switched voltage Vc, returns to this PCB via J19, pin 17, for all low level circuits.

NOTE: Power connects to T1 via A11F1 at all times, unless both battery and Power Base are removed or A11F1 open.

2.3.11 Pulse Width Modulator (Figure 2-46)

U3 is an I.C. Pulse Width Modulator (PWM), including a +5 volt regulator circuit for power to I.C. circuits, with pin 16 for external use. C11 and R31 set the oscillator frequency at about 8 kHz. This supplies a sawtooth drive to the internal comparator and gating to the internal flip-flop, which enables the gates, ensuring the output transistors are never both on at the same time.

The other comparator input, pin 9, controls the duty cycle, (nominal 1.0 volt off and 3.5 volt maximum). The output can be reduced or shut down by (1) pulling down on pin 9; (2) applying a positive voltage to pin 10; (3) if pin 1, error amplifier, pulls above the pin 2 reference of 2.5 volts, or (4) if pin 4, current limit circuit, rises above the nominal 200 millivolt cutoff. CR4 limits pin 9 maximum voltage, to give a nominal 90% maximum duty cycle.

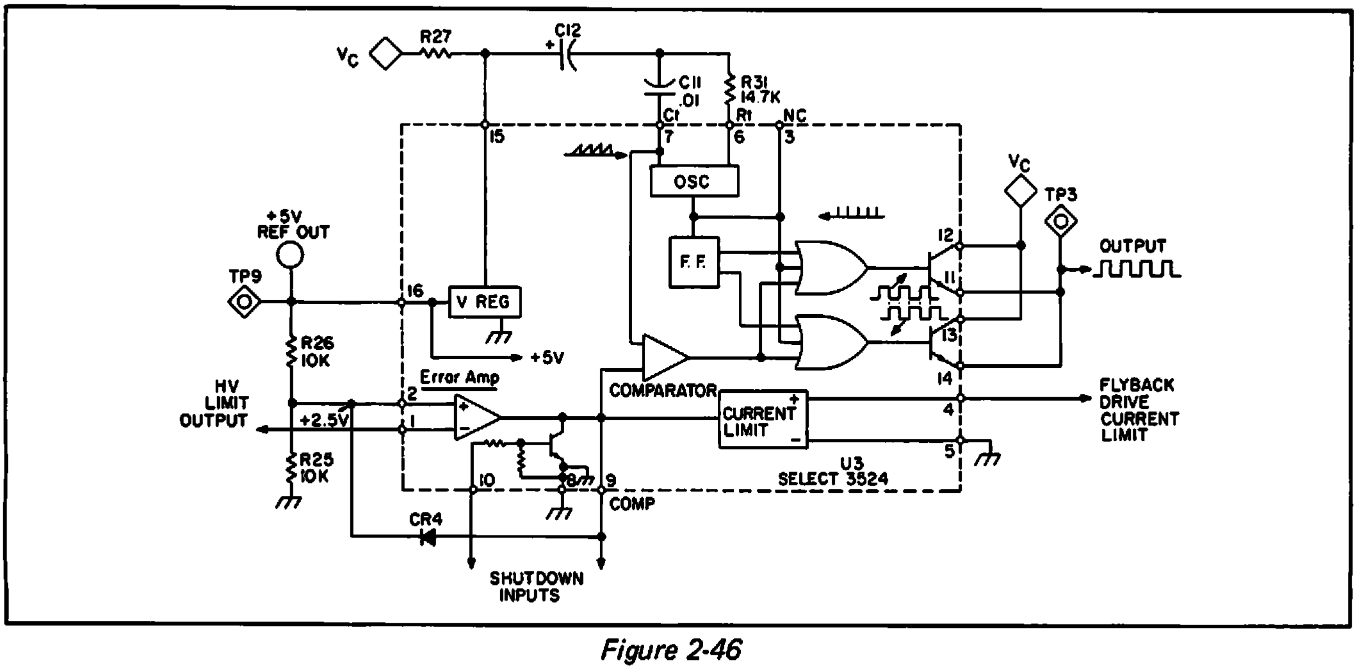


Figure 2-46

2.3.11.1 PWM Shutdown (Figure 2-47)

This circuit acts as a soft-start ON/OFF switch for the PWM, U3, discussed above. Pin 8, J19 connects to U10, pin 6 in the Defibrillator Control PCB. This is open circuit when not charging the defibrillator capacitor, so the base of Q9 is pulled up with current flowing from Vc through R48, CR13 and CR11. Q9 clamps pin 9, U3 to ground through the Schottky diode CR111, keeping U3 shut down. The PWM is selected for guaranteed minimum cutoff voltage of 0.7V.

2.3.11.2 Soft Start

The defibrillator HV capacitor charge cycle is started by pressing the APEX paddle CHARGE switch S10, which connects +5V to the defibrillator control PCB. The control microprocessor clamps the voltage at pin 8, J19 to about 0.5 volt. CR13 and CR11 provide sufficient drop to assure Q9 turnoff. COMP current then flows from U3, pin 9 through CR111 and R121 to charge C105, giving a startup time constant of about 1/3 second - important for accurate low energy selections. C8 inhibits PWM restart during the OFF part of the duty cycle, while under current limit control.

CR112 normally gives enough drop so the shutdown circuit, U3, pin 10 is not activated, but will operate if the Q9 circuit open circuits, but without Soft Start. The Low Battery Shutdown circuit inhibits charge by pulling up on the base of Q9.

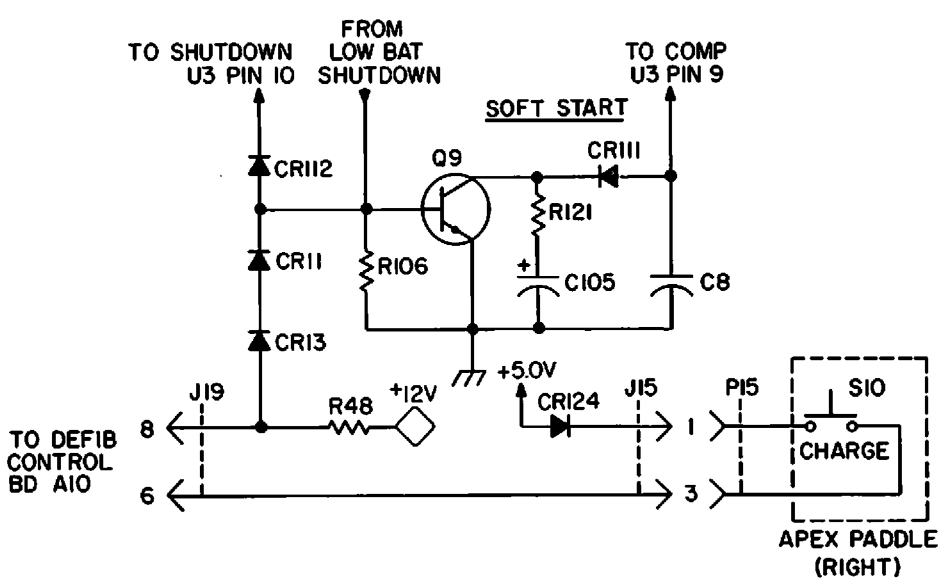


Figure 2-47

2.3.12 HV Defibrillator Inverter Circuit (Figure 2-48)

This circuit, driven by the Pulse Width Modulator (U3) output, provides the high voltage to charge the defibrillator HV capacitor, A1-C1.

The PWM "on" drive switches Q2 on, in turn switching on Q5, through C13 and R32. The primary of T1 thus starts a linear current ramp, with slope determined by V/raw (or V/bat) and the T1 primary inductance. When U3 turns off, Q1 abruptly turns off Q5, producing the "flyback" high voltage discharge from the secondary of T1. The T1 primary tap provides sufficient turn-off bias (across R32 and C13) for Q5. CR5 and CR100 define safe voltage limits for Q2 and Q5.

The HV rectifier contains HV metering resistors, a rectifier diode and noise filter capacitor. Note that two metering resistors define the ground point for the HV defibrillator capacitor approximately midpoint between the 2 terminals voltages, e.g., +2.6 kV and -2.6 kV nominal for the 360 joule charge condition.

The defibrillator HV energy storage capacitor (32 uF, 5.5 kV) is a compact, long-life polyester (e.g., "Mylar ") type component. As is typical, it can self-charge after operation, and must be short circuited during handling, for safety. The usual failure mode is a dead short. HOWEVER, AN OPEN CIRCUIT INTERNAL CONNECTION CAN OCCUR, WITH POSSIBLE RECONNECTION, DURING HANDLING, AT LETHAL ENERGY VALUES: KEEP A SHORTING WIRE ON THE TEMRINALS WHEN NOT IN THE CIRCUIT.

The actual duty cycle, during charging, is determined by the current limit circuit in the PWM. It is adjusted by R34 , set for a charge time to 360 joules of 9 seconds with a fully charged battery, or 7 seconds with the Power Base, with the AC line at 110 to 120 volts.

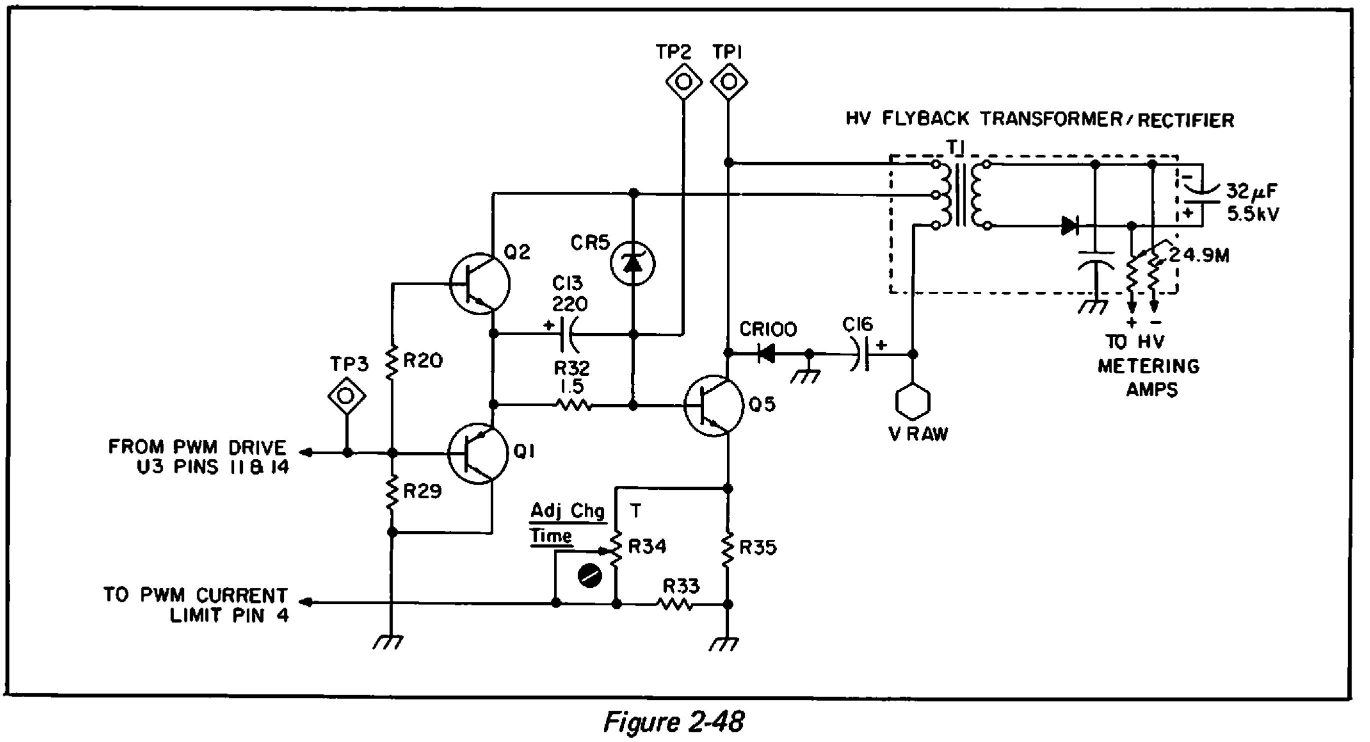


Figure 2-48

2.3.12.1 HV Monitor Circuit (Figure 2-49)

As the Inverter charges the defibrillator capacitor, the 24.9 M ohm metering resistors provide positive drive to amplifier U1C and negative drive to amplifier U1D. After inversion by these amplifiers, the "V-Cap 1" output will rise above ground, while the "V-Cap 2" output will drop below the noise filtered (R140,c4)

55.4 V Ref. as the defibrillator capacitor is charged. R141 and R142 connect to the error amplifier (U3, pin 1). Both the "V-Cap 1" and "V-Cap 2" provide defibrillator cap voltage samples to the Defibrillator Control Board A/D converter, where these determine the defibrillator "Charge" shutdown point, such that the preset energy will be delivered to a defibrillator energy meter, after adjustment.

The divided output of U1D will turn off the PWM when the Error AmplifierInput, U3 pin 1, rises to 2.5 volts, limiting the high voltage to a nominal 6.3 kV.

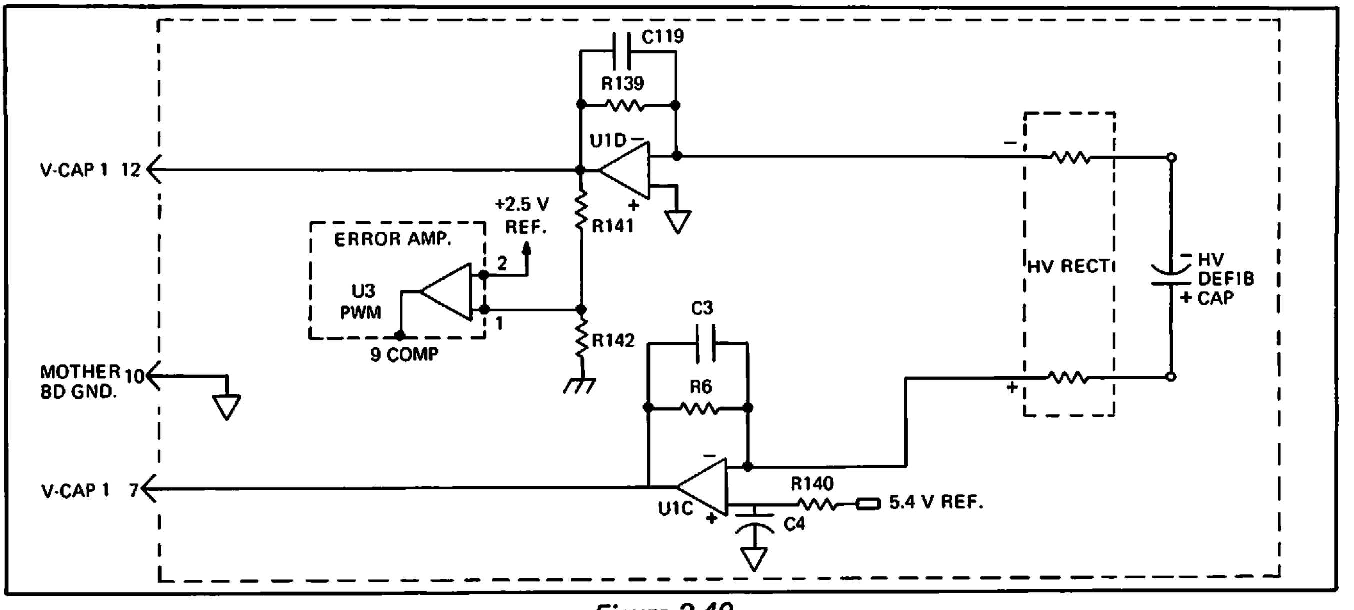


Figure 2-49

2.3.12.2 Patient Relay Circuit (Figure 2-50)

The Patient Relay is a high current, high voltage pressurized D.P.D.T. relay. One know end-of-life failure mode is "flashing", which may result in abrupt failure of the pressurized glass envelope. ALWAYS WEAR APPROVED GLASSES OR OTHER EYE PROTECTION WHEN HANDLING OR WORKING AROUND THIS RELAY.

Discharge of the energy from the HV Defibrillator Capacitor to the patient or test load requires simultaneous closing of both paddle DISCHARGE switches. Vc, J16 1, thus connects through the STERNUM paddle switch to 2, then to J15 2 through the APEX paddle switch to 1. This provides required power to the Patient Relay and turns on Q8, sending the DISCHARGE REQUEST signal to the Control PCB via J19, pin 15.

The Defibrillator Control PCB originates the discharge command, which lasts about 120 msec., through J19, pin 13. This high signal (1) opens circuit Q6 (Figure 2-51), preparing the I/pk sample/hold capacitor C2, and (2) drives Q3, activating the Patient Relay.

If Q3 is driven on or shorted. U4B prevents high voltage charge via the low battery shutdown circuit, U1B.

Except when discharging, the patient relay connects the paddle electrodes to the Analog ECG PCB, via P26. Coaxial cables minimize noise pickup on this high impedance circuit.

The discharge circuit includes the HV defibrillator capacitor, a current transformer, and an inductor to give the proper discharge waveform. This could produces an intense pulsed field, giving a "bang" during discharge if the defibrillator is placed on any metal table top. A 50 ohm test load is automatically connected when the paddles are locked in the upper case paddle storage compartments.

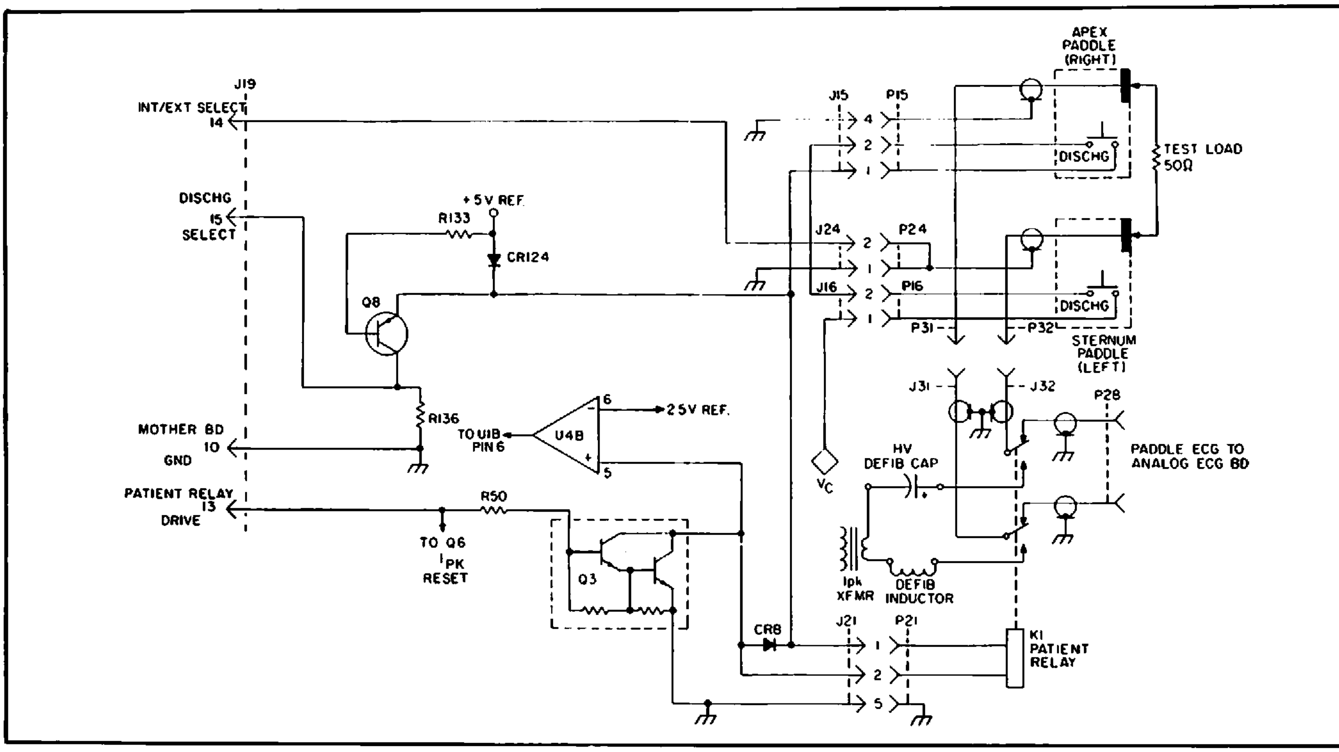


Figure 2-50

2.3.12.3 Peak Current Detector Circuit (Figure 2-51)

A HV discharge lead loops through the current transformer, A1T2, which has a 0.004 current output ratio. This output drives the A13-R2, R3 and R10 load/voltage divider. CR103 clips noise at the filtered (R138, C118) 5 V ref. level while CR2 clips negative spikes, R7, C103, R36 and C108 filter noise. U4A is an open collector output, MOSFET input comparator. When the voltage input signal at U4A, pin 3, is higher than the voltage on hold cap C2, the comparator output is high (open collector off) and C2 is charged through R41 and CR1. When C2 is charged to equal the input voltage, the comparator output goes low (open collector on), reversing biasing CR1, and C2 holds the peak. C106 is AC positive feedback which causes the comparator to switch quickly and prevents oscillation. In normal operation, when the signal is rising (heading for peak), the output of U4A (pin 1) will be high frequency pulses (100's of kHz), whose amplitude tracks the input signal.

As mentioned in Section 2.3.12.2, C2 is reset except during the '120 msec discharge ON pulse. Since it takes about 15 msec for the patient relay to close, Q6 is open and C2 unclamped when the current transformer output rise begins. The C2 hold time allows adequate time for relay noise to end and defibrillator control microprocessor reset prior to sampling.

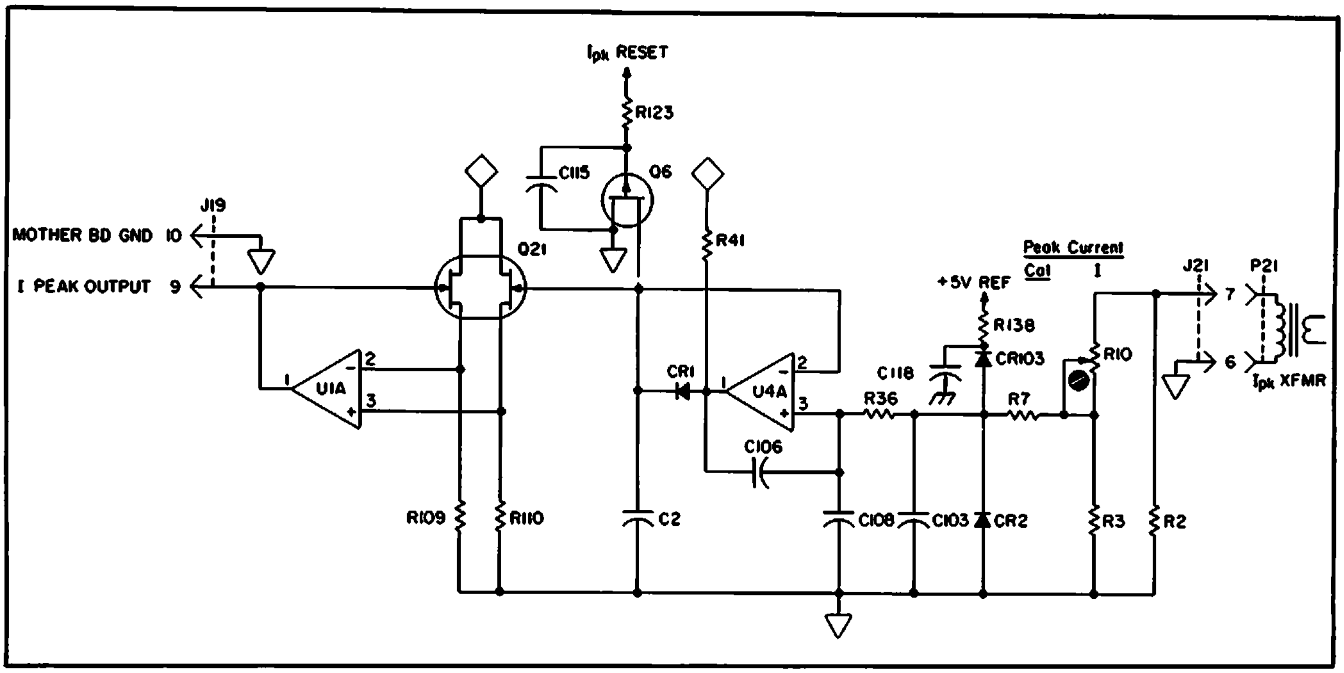


Figure 2-51

2.3.12.4 Safety Relay Circuit (Figure 2-52)

This circuit connects a 10 K resistor, A1-R1 across the HV defibrillator capacitor, except during the charging and hold period. This safety resistor is under the defibrilaltor inductor HV safety cover.

The S.P.S.T. normally closed HV vacuum safety relay is shunted by an R-C potted snubber circuit, for improved contact life and noise suppression.

The Defibrillator Control PCB activates the relay drive at the start of a defibrillator charge cycle by clamping pin 16, of J 19 to ground. Q4 then turns on, opening the safety relay. The safety relay is reclosed by the Defibrillator Control PCB at:

a. about 16 msec after Patient Relay is activated; or

b. time out at about 30 seconds is not discharged; or

c. when the ENERGY SELECT switch is turned to MONITOR or OFF; or

d. when the ENERGY SELECT switch setting is reduced with a charged HV defibrillator capacitor: then the safety relay reopens at slightly below the new setting, with recharge up to the new energy setting.

2.3.12.5 5.4 V Reference/Low Battery Shutdown (Figure 2-53)

U6 is an adjustable reference, with R132 used to obtain 5.40 +/- 0.20V. This 5.4 V reference is used for: (1) comparator U1B, which switches Q9 to turn off U3 if V-bat (or V-reg) drops to 9.5 V and "restart enable" if it goes back up to about 10V. (Note: these trip points may vary +/- 0.4 due to normal component tolerances); (2) similar circuitry to shut down the low voltage power supply board; (3) pull-up reference on HV Monitor Amplifier U1C (Figure 2-52), and related HV monitor circuitry on the Defibrillator Control board.

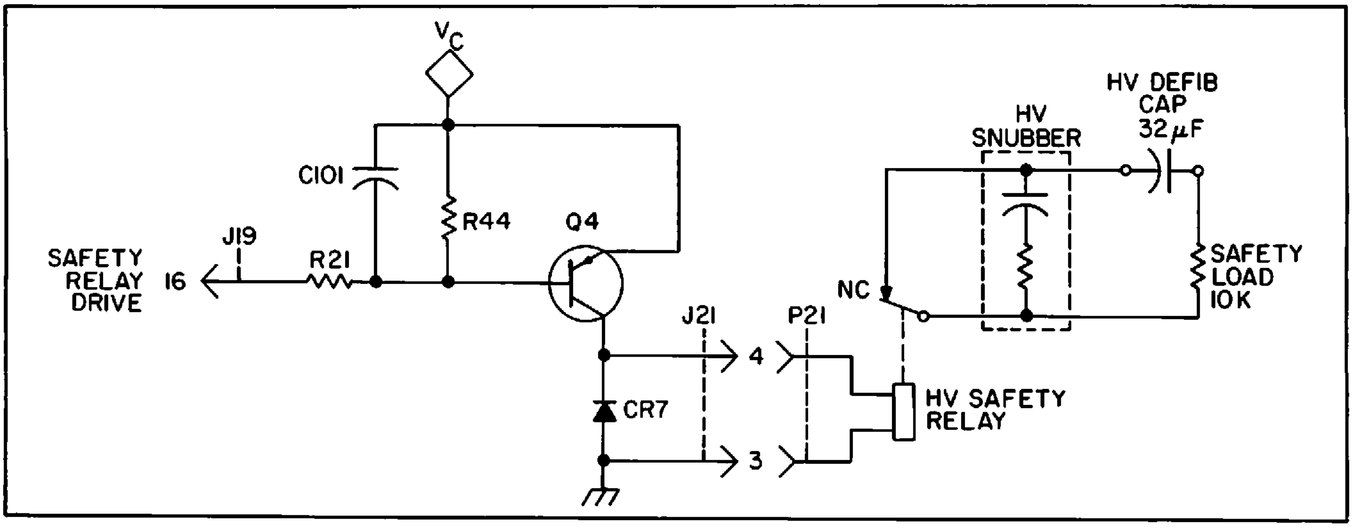


Figure 2-52

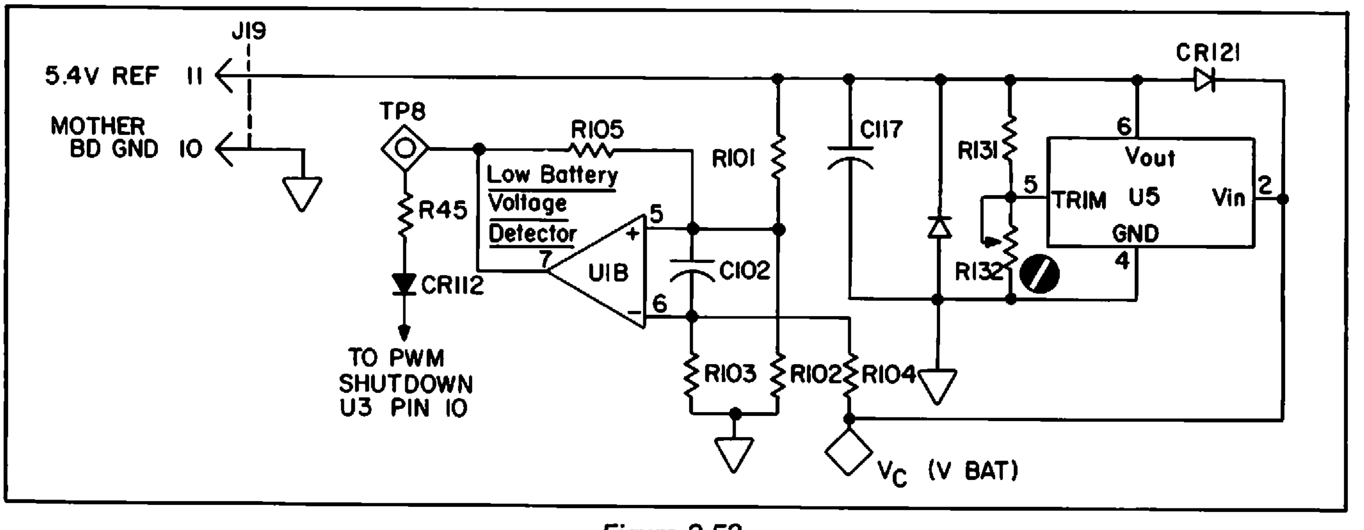


Figure 2-53

2.3.13 LOW VOLTAGE POWER SUPPLY BOARD 78670-60110

(Refer to Figure 6-12 for detailed schematic)

This circuit board furnishes power to all circuits except the defibrillator H.V. supply. It incorporates a fly-back power supply which is controlled by a pulse width modulator (PWM). Refer to Figure 2-54. The fly-back transformer has multiple secondary windings to meet the various voltage requirements. Input voltage is 9.0 V to 13.2 V on battery and 12.8 V from the 78668 power base.

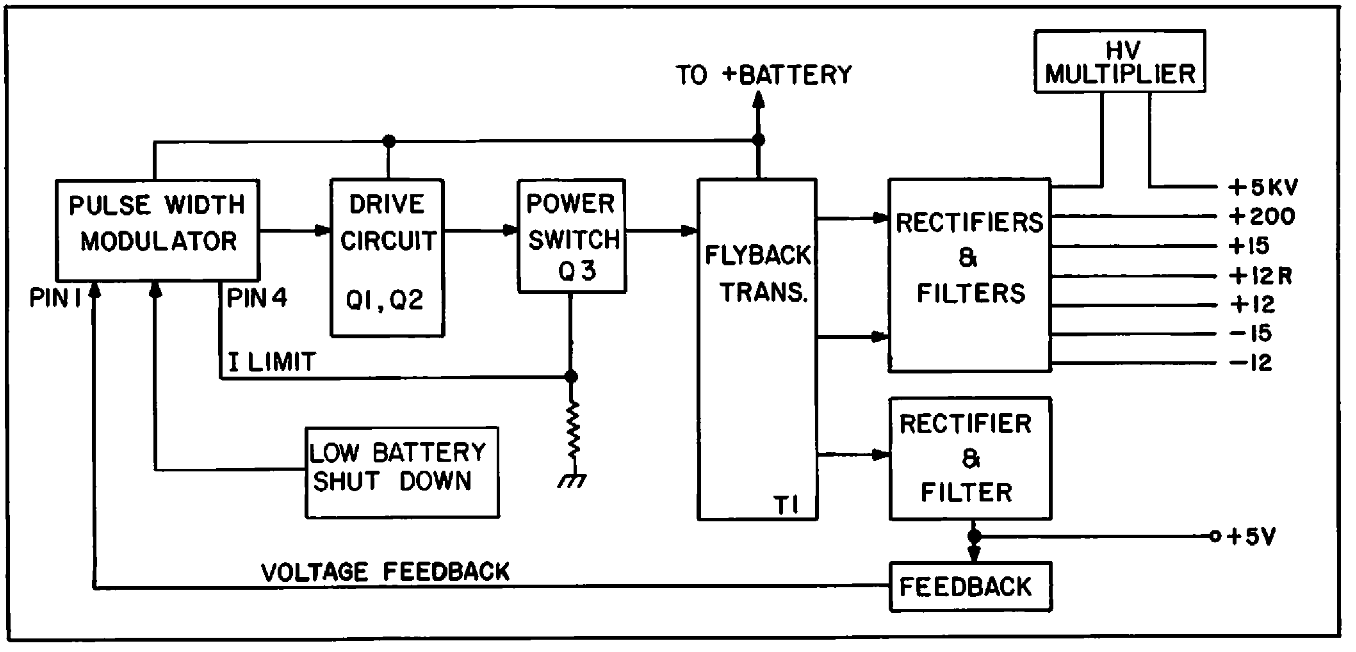


Figure 2-54

2.3.13.1 Pulse Width Modulator (PWM) Internal Circuits

Refer to Figure 2-55.
The pulse width modulator integrated circuit, U1, is the control element for the power supply. It operates at a fixed frequency of approximately 18 kHz. Duty cycle control is used to regulate the energy supplied to the transformer, by varying the "on"time of the transformer switching transistor. The PWM incorporates an internal +5 volt reference supply, an oscillator, error amplifier, comparator, current limit, and duty cycle controlled outputs. The following circuit description will discuss the PWM operation.

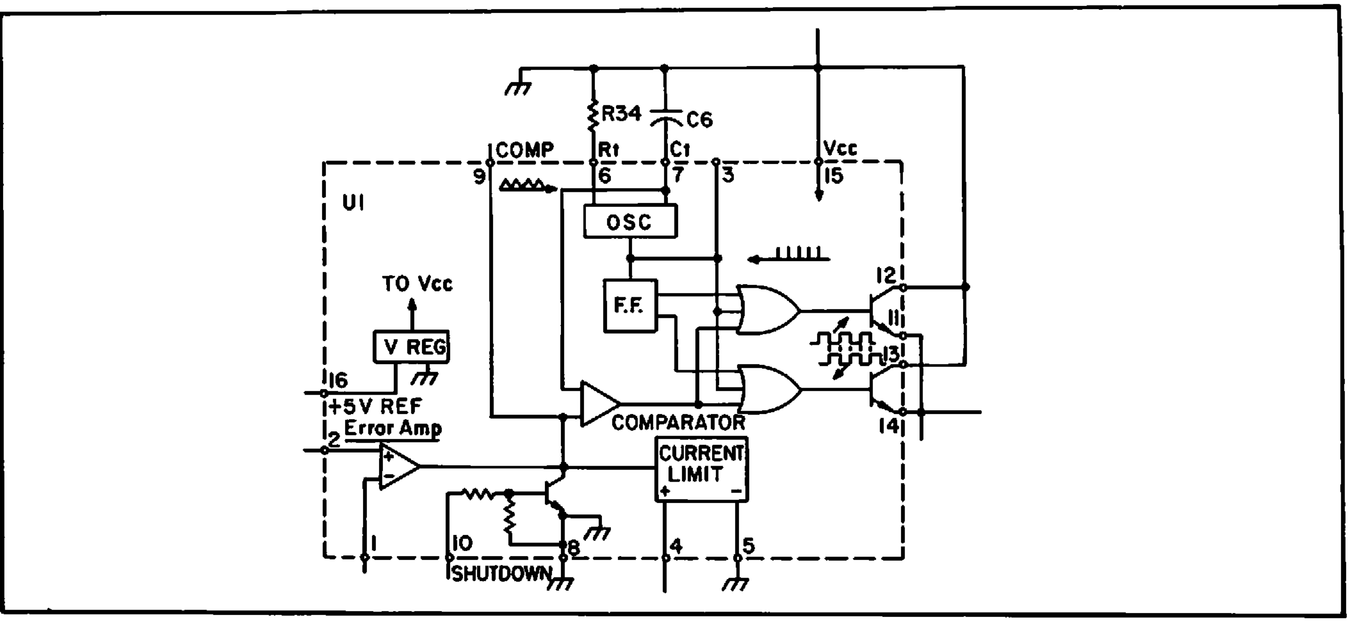


Figure 2-55

+5 Volt Internal Reference (Pin 16)

All circuits, within the PWM integrated circuit, operate from this built in 5 volt regulator. It is used as a reference for the error amplifier. The +5 volts is brought out at pin 16 for use in external circuits.

Oscillator (Pins 6 and 7)

The PWM contains an R-C oscillator. The frequency is controlled by R34 and C6. The oscillator supplies two signals. One is a linear sawtooth which goes to the internal comparator. The other is a narrow clock pulse which switches the internal flip-flop.

Flip-Flop

The PWM has two outputs. The flip-flop directs the PWM signal to alternate between these outputs. The second function of the flip-flop is to ensure that the two outputs are never on at the same time.

Error Amplifier (Pins 1 and 2)

The error amplifier supplies a variable reference voltage to the internal comparator. The error amplifier derives its reference voltage from the internal 5v regulator through the resistive divider R5 and R7. The error amplifier has a relatively high output impedance.This output is brought out on pin 9. This makes external duty cycle control possible, by setting the maximum input reference voltage to the internal comparator.

Internal Comparator

The comparator changes its output by sensing voltage differences at the inputs. The comparator "on time" (duty cycle) decreases whenever the error amplifier output voltage is less than the sawtooth voltage applied to the other comparator input.

Current limit (Pins 4 and 5)

The current limiter amplifier reduces the duty cycle by pulling the error amplifier output toward ground. The error amplifier input threshold is about 200 millivolts with linear response above this point.

Output stage (Pins 11 and 14)

The output stage consists of a pair of open collector NPN transistors. The transistors supply drive signal to switch transistors Q1,Q2. The PWM outputs are parallel connected for flyback power supply applications.

Shutdown (Pins 10)

A small positive voltage (0.7v) applied to pin 10 will accomplish a complete shutdown of the PWM. The shutdown transistor pulls the error amplifier output toward ground thus preventing any output from the internal comparator.

2.3.13.2 External PWM Circuits

Soft Start

Refer to Figure 2-56

This function prevents large primary current surges during power supply start up. CR2, C2 and R4 make up the soft start circuit. When power is applied, pin 9 of U1 is held at ground by C2. As C2 charges through R4, the error amplifier output voltage increases. This allows the duty cycle to increase from zero to a point where the feedback loop takes control,allowing the output to ramp up slowly.

Pulse Width Limit

The pulse width limit protects the power supply in case of excessive loading. The resistive divider R2 and R3 form a +1.9 volt reference. CR1 clamps the error amplifier output to this reference which prevents the error amplifier output from going above 2.5 volts. This level corresponds to approximately a 60% pulse width limit.

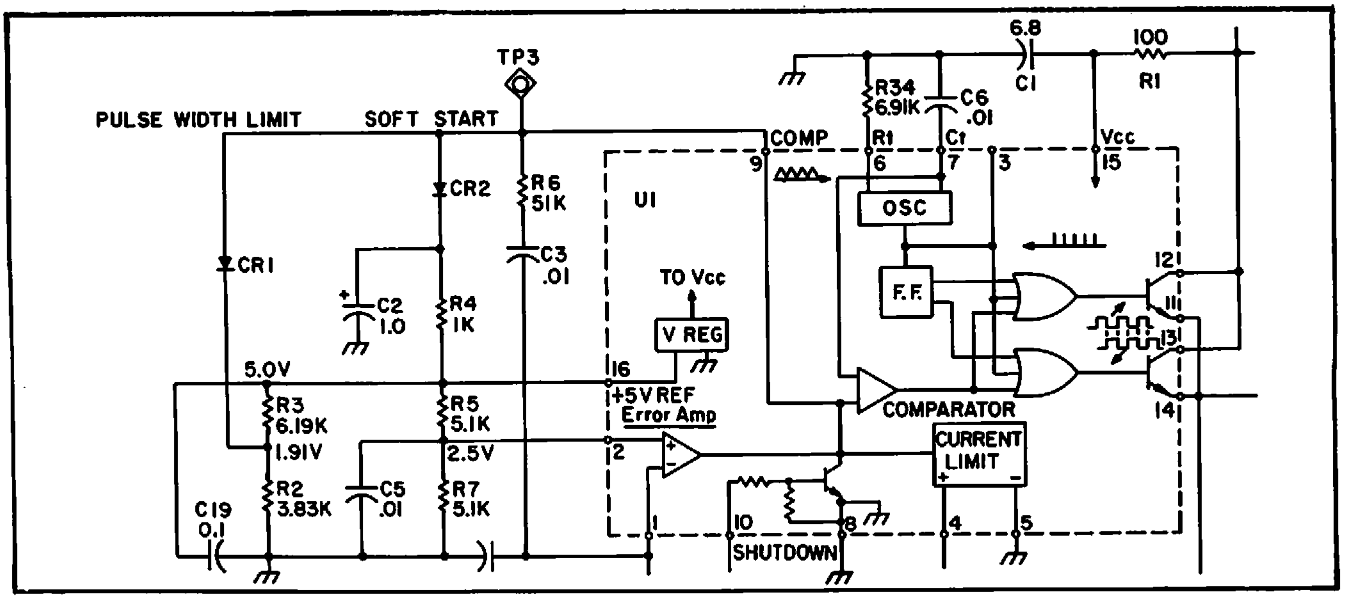


Figure 2-56

Drive Amplifier (Refer to Figure 2-57)

The output of the PWM is not sufficient to drive the power switching transistor Q3. As the PWM produces a positive output pulse, Q1 conducts applying turn on bias to Q3. As Q3 conducts, current flows through the primary of the power transformer, T1, causing energy to be stored in the magnetic field.

When the PWM output goes low, Q1 turns off and Q2 turns on, rapidly removing base drive from Q3. The magnetic field collapses transferring energy to the secondary windings. Q2 is normally off when the PWM output is high but turns on when the output goes low. This ensures a rapid turn off of Q3.

VR1, CR14 and the extra primary winding provide transient protection for Q3, by preventing inductive kickback spikes that could damage the transistor.

Current Limit Feedback

When Q3 is conducting, a small voltage appears across the emitter resistor, R11. This voltage is fed back to the PWM current limit input and limits the average current to approximately 2.5 amperes.

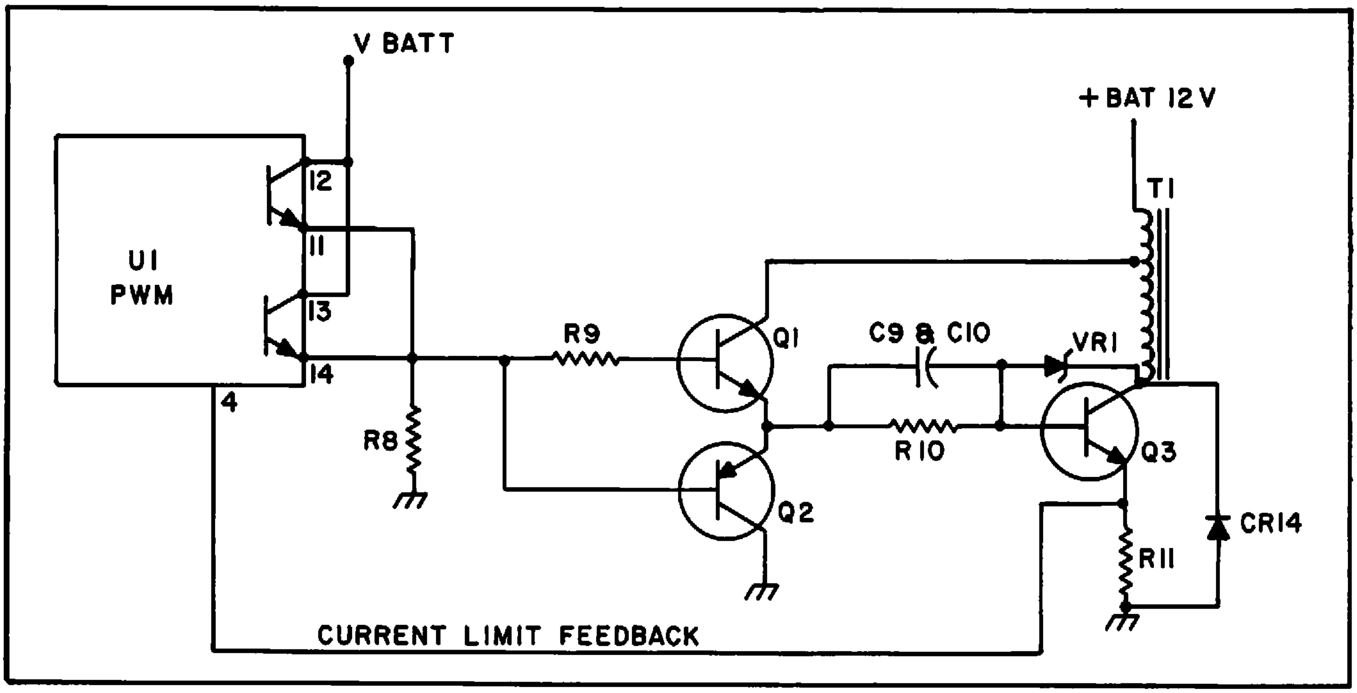


Figure 2-57

Low Battery Shutdown (Refer to Figure 2-58)

U7 is configured as a comparator. Its reference comes from the 5.4 volt reference regulator on the defibrillator H.V. power supply board. When the battery output falls below 9.0 volts, the normally high comparator output goes low and Q4 turns off. This causes a high to appear at the PWM pin 10 which results in PWM shutdown.The shutdown circuit provides about 1.4 volts of hysteresis. If the battery recovers or another power source is substituted, U7 output goes high and normal operation resumes.

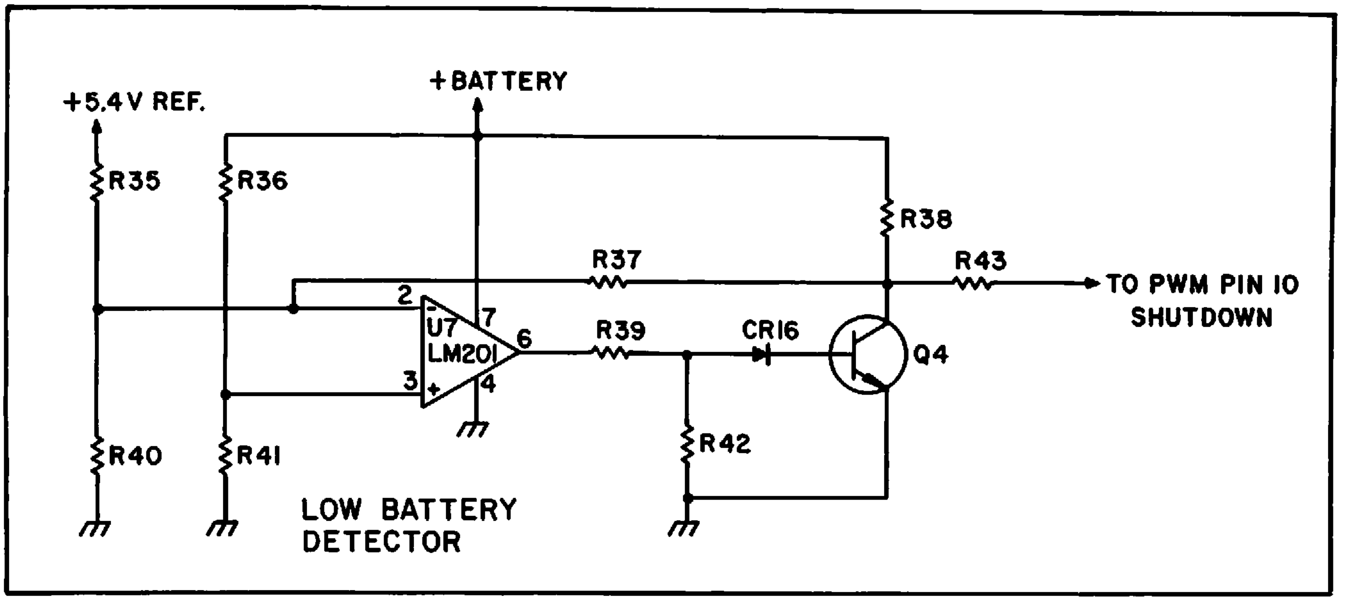


Figure 2-58

2.3.13.3 5V. Supply Voltage Regulation (Refer to Figure 2-59 and 2-54)

The +5 volt supply is directly regulated by controlling the duty cycle of the pulse width modulator. R14 and R16 form a voltage divider. 2.5 volts is fed back to the negative error amplifier input (U1 pin 1). Since all transformer windings are tightly coupled reasonably good regulation is accomplished on all other supplies.

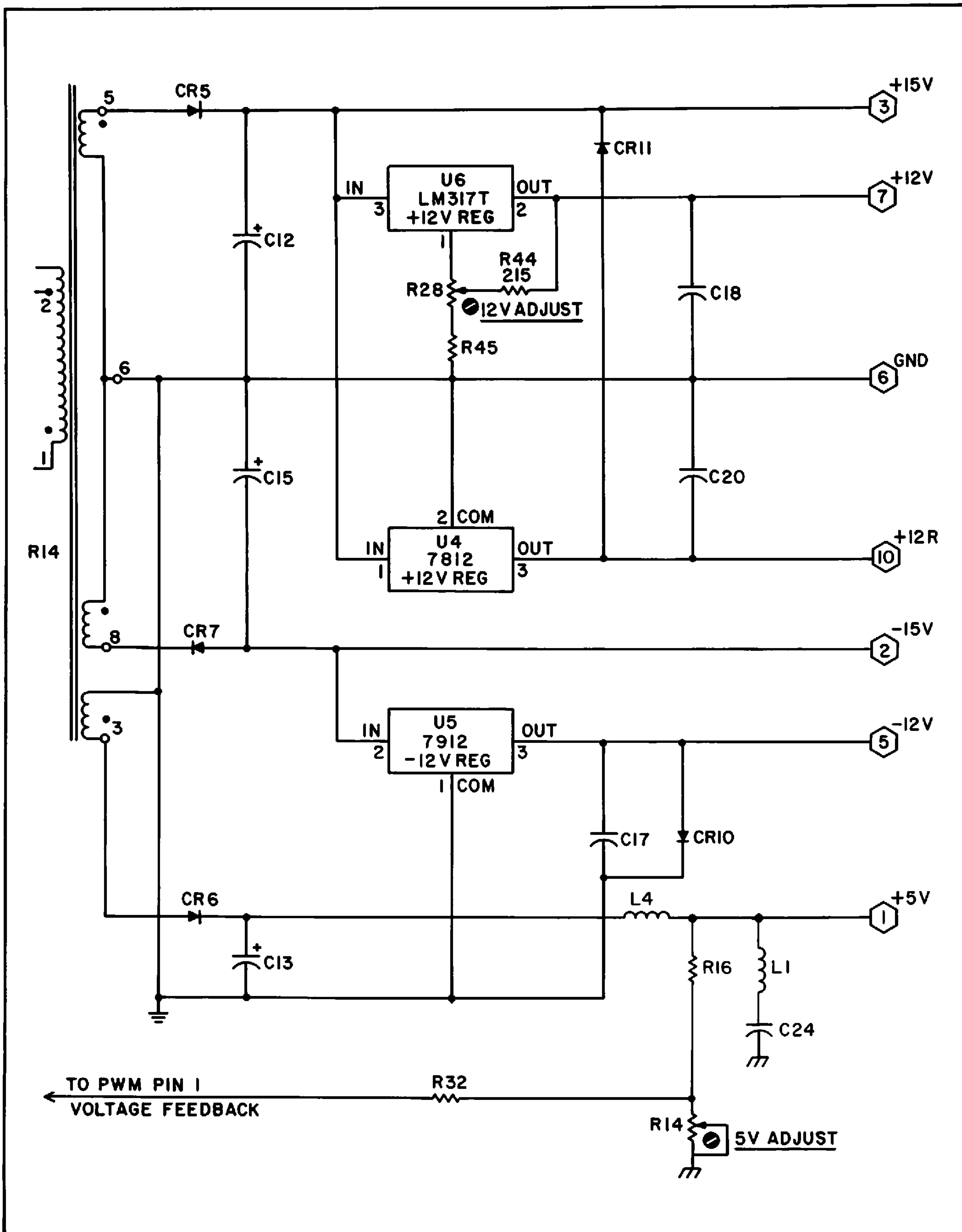

CR5
+15V
3
5
CR11
U6
LM317T
+12V REG
IN
3
OUT
2
+12V
7
C12
1
R44
215
R28
12V ADJUST
C18
2
R45
6
GND
6
1
C15
C20
2 COM
U4
7812
+12V REG
IN
1
OUT
3
+12R
10
R14
8
CR7
-15V
2
3
U5
7912
-12V REG
IN
2
OUT
3
-12V
5
1 COM
C17
CR10
CR6
L4
+5V
1
C13
R16
L1
C24
TO PWM PIN 1
VOLTAGE FEEDBACK
R32
R14
5V ADJUST

Figure 2-59

2.3.13.4 CRT Supplies (+5000 and +200 volts)

The CRT grids require approximately +200 volts, while +5000 volts is needed for the anode. The source for both supplies is a single 975 volt secondary.

Voltage regulation of the CRT Supplies

Figure 2-60 shows the output waveform of the high voltage secondary winding and where the clipping action of the Zeners occurs. The ringing of the waveform is always present but the degree will vary depending on the load presented to the power supply.

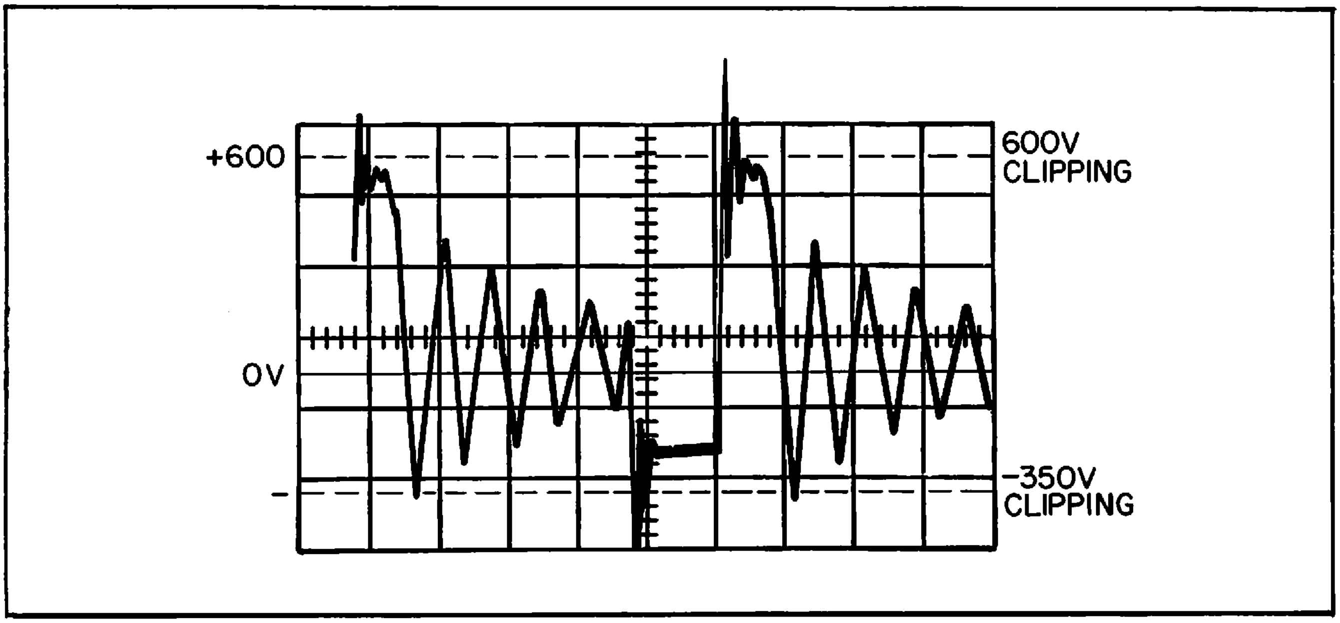


Figure 2-60

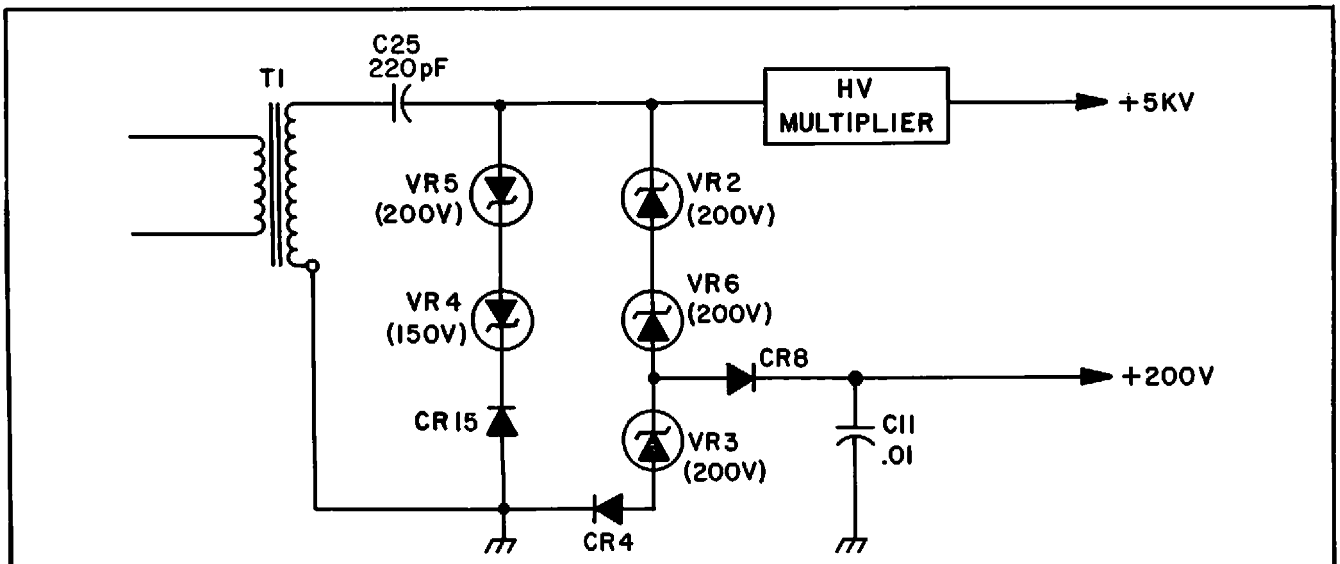


Figure 2-61

Theory of Operation-CRT Supply

1. During positive peaks VR2, VR6, VR3 and CR4 conduct when the voltage exceeds +600 volts. The zeners form a voltage divider with VR3 providing +200 volts reference to ground.

2. Refer to paragraph 2.4.9.19 and 2.4.9.20 for details on the energy discharge function.

3. The high voltage multiplier receives a waveform which is clipped at +600 and -350 volts = 950V P-P.

4. The negative peak varies with battery voltage while the positive peak varies with battery voltage, loading and duty cycle.

5. The series capacitor, C25, limits current, and to a degree, controls the clipping action of the zener diodes.

2.3.13.5 + and -15 Volt Supplies (Refer to Figure 2-59)

The + and -15 volt supplies are used for the CRT deflection amplifier and print head dots. These supplies incorporate only the moderate regulation afforded by the close magnetic coupling to the 5V. winding.

2.3.13.6 + and -12 Volt Supplies

Two +12 volt and one minus 12 volt supplies are required by the instrument. U4 and U5 are linear, fixed voltage 3 terminal regulators. U6 is a 3 terminal adjustable regulator, which provides power to reference circuits that require a more accurate voltage than the tolerance of the fixed voltage regulator allows.

2.3.13.7 Noise Filtering

By its very nature, a switching type power supply is a noisy device. The + and -15 volt and the +5 volt power supplies incorporate series inductors, L2, L3 and L4 in their outputs, to reduce noise on the supply lines. L1 and C14 filter the 5 volt supply feedback to the PWM.

2.3.14 Service Switch

The service switch, located on the QRS beeper volume control, is used to place the unit in various self test modes and when setting the real time clock. The beeper volume control is pulled to place the unit in the service mode.

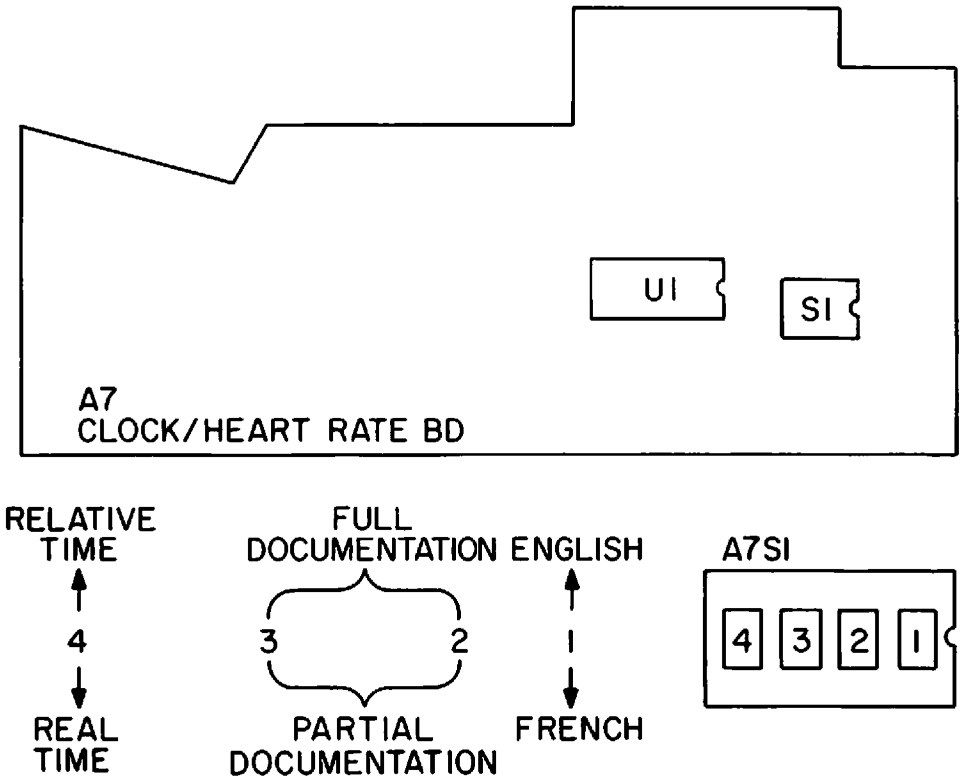
Refer to paragraph 2.4.9.19 and 2.4.9.20 for details on the energy discharge function.

Paragraph 3.4.2.3 describes the service mode for checking the recorder. The test pattern is also displayed on the monitor CRT which provides a method of checking the response of the ECG section.

2.3.12 Annotation Printout

Dip switch assembly A7-S1 selects printout by the annotating recorder. The printout information and switch positions are shown in Figure below.

Full documentation prints delivered energy, current and patient impedance. Partial documentation omits delivered energy and current and prints only patient impedance.



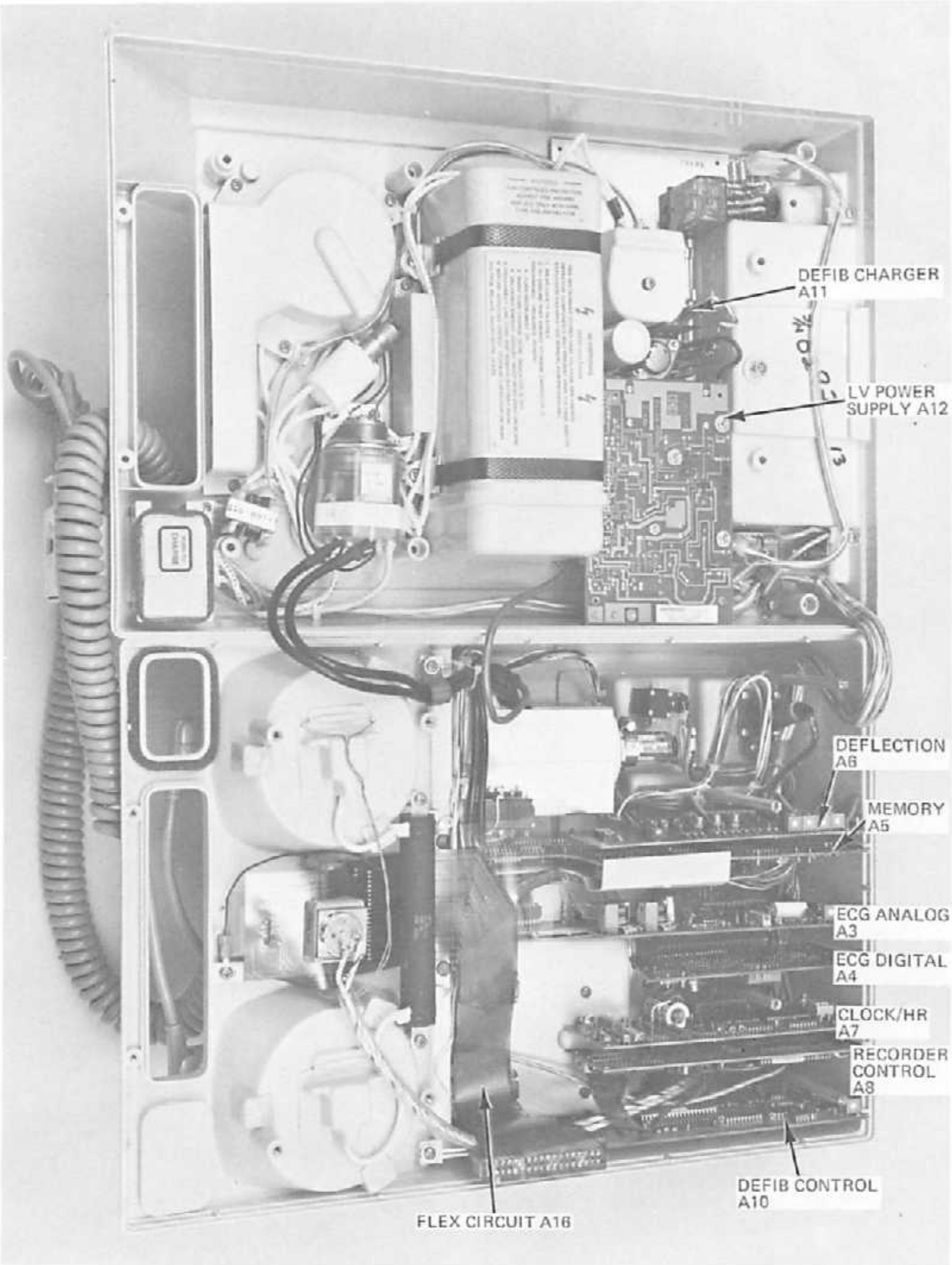


Figure 3-0. Circuit Board Locator.

SECTION III
CHECKS AND ADJUSTMENTS

3.1 INTRODUCTION

This section contains three major parts as follows:

A. Level II Performance, Safety and Maintenance Checks

These checks include a battery capacity test procedure, and should normally be performed every six months.

B. Internal Adjustment Procedures

Internal adjustments are made at the factory and normally do not require attention. If assemblies are repaired or replaced, however, check and adjust as necessary. Adjustment location and purpose of adjustments are listed in Table 3-3.

C. Specification Checks

This part consists of test procedures to ensure the instrument is operating to specification.

3.2 LEVEL II PERFORMANCE, SAFETY AND MAINTENANCE CHECKS

Perform these checks every six months. For best results, use the equipment recommended. Record the defibrillator serial number and the date the checks were performed.

3.2.1 Test Equipment

Test equipment required for performing the level II performance, safety and maintenance checks is listed in Table 3-1. Table 3-2 lists the equipment necessary if the Dempsey model 431F safety analyzer is not used.

Test equipment characteristics and a recommended commercial model are included. If the recommended model is not available, select another with similar characteristics and capablities.

> WARNING
>
> LETHAL VOLTAGES ARE PRESENT INSIDE THE DEFIBRILLATOR AND ARE EXPOSED WHEN THE DEFIBRILLATOR COVERS ARE REMOVED. DO NOT WORK INSIDE THE INSTRUMENT WHEN POWER IS APPLIED OR IF DEFIBRILLATOR IS CHARGED.

Table 3-1

REQUIRED TEST EQUIPMENT FOR LEVEL II PERFORMANCE, SAFETY, and MAINTENANCE TESTS

DIGITAL VOLTMETER Recommend: HP 3466A	Capable of 5 to 15 V DC +/- 1% measurements
OHMMETER HP 3466A	Capable of 0.1 to 10 ohm +/- 2% measurements
ENERGY METER Recommend: Dempsey Model 429	Capable of 5 to 400 Joule, critically damped sinusoidal waveform measurements with +/- 2% of full scale accuracy. Load resistance 50 ohm +/- 0.5%.
STOPWATCH OR TIMER	Capable of measuring 2 to 12 second events with hand start/stop actuation to 1/4 sec. accuracy
ECG SIMULATOR Recommend: Parke-Davis 3175	Output Level: 1 mV Range: 60 and 120 BPM calibrated outputs
TEST LOAD HP 78620-60860	2Ω, 200 WATT 5%
Paddle Contact Indicator Test Resistors	61.1 ohms, 64.9 ohms, 250.0 ohms, all 1%
TEST CABLES AND COMPONENTS	
(1) HP 14489A	Patient Cable
(1) HP 14151A	Electrode Lead Set
(1) HP 14445A	ECG Electrodes
(1) HP 78660-67800	Test Load Adapter
SAFETY ANALYZER Recommend: Dempsey Model 431F	See Table 3-2 for substitute equipment

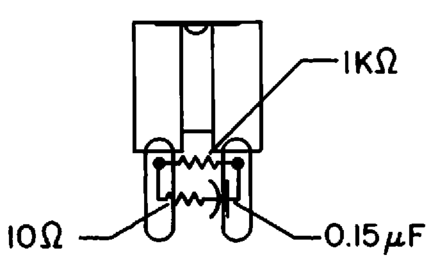
Table 3-2

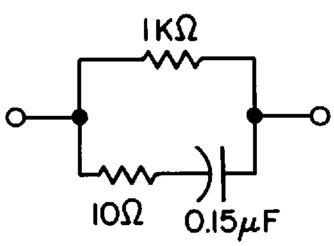
EQUIPMENT NECESSARY IF THE DEMPSEY MODEL 431F SAFETY ANALYZER IS NOT USED

REQUIREMENT	NECESSARY QUALIFICATIONS
DIGITAL VOLTMETER Recommend: HP 3466A	Capable of 10 mV DC +/- 0.5% measurements
2 TO 3 WIRE AC PLUG ADAPTOR HP 1251-1852	Must have ground wire pig-tail
TEST PLUG FOR 120 VAC SOURCE HP 04655-60100	1 MΩ resistor in hot lead

CURRENT METERING NETWORK	HP 1251-1284 HP 0757-0159 HP 0757-0984 HP 0160-3238	Dual Banana Plug 1 KΩ 1% Resistor 10KΩ 1% Resistor 0.15 uF Capacitor

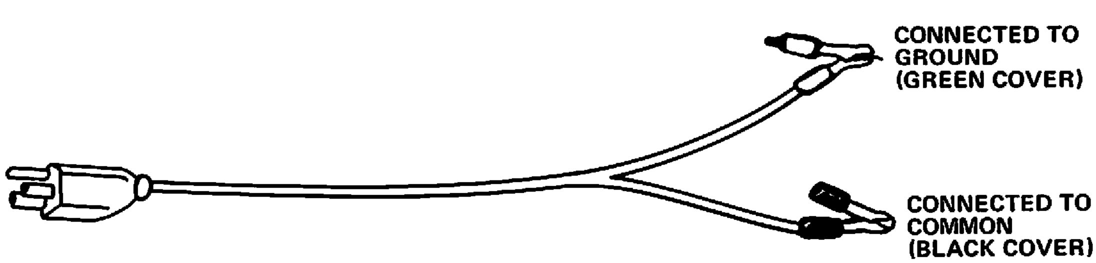
CONNECTED AS FOLLOWS:





Ground Test Cable	HP 1251-3133 HP 8120-0022 (2) H. H. Smith, 331	NEMA Male Plug Cable, 6 feet required Alligator Clip, 1 green, 1 black

CONNECTED AS FOLLOWS:



3.2.2 Functional Performance Testing

These tests are performed to assure that the Defibrillator is functioning reliably.

3.2.2.1 Energy Accuracy.

Connect the equipment as shown in Figure 3-1.

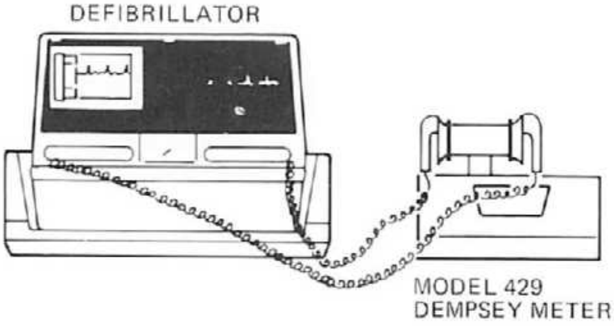


Figure 3-1. Energy Accuracy Test Setup.

Set the ENERGY SELECT control to each of the positions indicated in the table below; press the CHARGE button and allow the unit to charge. The CHARGE DONE lamp will light at the end of each charge cycle. Firmly press the paddles to the energy meter and press both DISCHARGE buttons simultaneously. Record the energy levels measured. If the unit is equipped with an annotating recorder (78670A), refer to the printed information for confirmation of the delivered energy waveform information.

THE OUTPUT SHOULD CONFORM TO THE FOLLOWING:

Energy Select Setting	Delivered Energy (Joules)
5	5 +/- 4
10	10 +/- 4
20	20 +/- 4
30	30 +/- 4.5
50	50 +/- 7.5
70	70 +/- 10.5
100	100 +/- 15
150	150 +/- 22.5
200	200 +/- 30
300	300 +/- 45
360	360 +/- 54

3.2.2.2 Self Testing Accuracy

1. Make sure the paddles and the paddle contacts in the storage pockets are clean and free of contaminants. This is to assure good electrical contact to prevent paddle surface damage during discharge.

2. Place the paddles firmly in their storage positions.

3. Put the unit in the service mode.

   To enter the service mode, proceed as follows:

   a. Turn the unit off.

   b. Pull up on the BEEPER VOLUME knob.

   c. Turn the unit on and immediately push down on the BEEPER VOLUME knob. At this point you should see the test waveform displayed on the CRT. If this display does not appear, repeat the procedure.

4. Put the ENERGY SELECT switch in the 100 Joule position. Charge and discharge the unit.

5. The LCD display should flash the test discharge energy of 90-110 Joules and if the unit is equipped with an annotating recorder (78670A) it should print out the test energy.

6. Place the ENERGY SELECT switch in the 360 Joule energy position. Charge and discharge the unit. The LCD should display 324-396 Joules.

7. Turn the unit off to get out of the service mode.

3.2.2.3 Defibrillator Capacitor Charge Time

1. Install a fully charged battery of known good condition or connect the defibrillator to a Model 78668A Power Base. The A-C line voltage to the Power Base must be 110 to 120 VAC.

2. Use a stop watch or similar device to measure the time from pressing the CHARGE button until the unit's CHARGE DONE light comes on.

3. The following indicates the allowable charging times:

Energy Setting	Charge Time (Seconds) Battery	Charge Time (Seconds) Power Base
360	8-10	6-8

3.2.2.4 Synchronizer

1. Put the ECG SOURCE SELECT switch in the LEADS I position.

2. Adjust the ECG SIZE control for 1.0 cm deflection on the CRT display when the CAL button is pressed.

3. Press the SYNC/DEFIB switch to the SYNC position and release. A negative going sync pulse should appear at the leading edge of every CAL pulse each time the CAL switch is pressed.

4. Place the paddles in their storage pockets.

5. Set the ENERGY SELECT CONTROL to 20 Joules and press CHARGE.

6. After the CHARGE DONE indicator lights, press and hold the DISCHARGE buttons. The defibrillator should not fire until the CAL button is pressed generating a sync signal.

7. Place the ECG SOURCE SELECT switch in the paddles position and repeat step 3. No sync pulses should appear since the sync feature is locked out in the paddles position.

3.2.2.5 ECG Amplifier Noise

Turn the ECG SOURCE switch to the LEADS II position. Turn the ECG SIZE control clockwise (but not past the detent into AUTO) to full gain. Observe the trace for excessive line width. Compare the line width with that at minimum gain. Repeat tests with the paddles in their storage pockets and the ECG SOURCE switch in the PADDLES position.

3.2.2.6 ECG Amplifier Gain

1. Turn ENERGY SELECT control to MONITOR ON.

2. Turn the ECG SIZE control fully counter-clockwise. Press the CAL button and observe the CRT trace. The deflection should be equal to, or less than 0.250 cm.

3. Turn the ECG SIZE control fully clockwise to maximum gain, but not past detent into AUTO. Again press the CAL button. The trace should deflect upwards to the top of the screen. Rapidly press and release the CAL button repeatedly. The trace baseline should gradually move downward until the full deflection of the CAL signal is viewable. The deflection should be at least 2.0 cm.

4. Place the instrument in the service mode (turn the instrument OFF, pull the BEEPER VOLUME knob UP. Turn the instrument ON and quickly push the BEEPER VOLUME knob DOWN). Turn the ECG SIZE control clockwise past detent to AUTO. Observe the ramp/step waveform. Immediately following the largest step, there is a two second period of flat baseline preceding the triangular ramp. During this baseline period, quickly press the CAL button five times and observe five steps of increasing amplitude on the CRT screen. (Refer to Figure 3-2). This represents the five gain stages of AUTO and can also be observed on the Recorder if so equipped. Turn unit off to get out of the service mode.

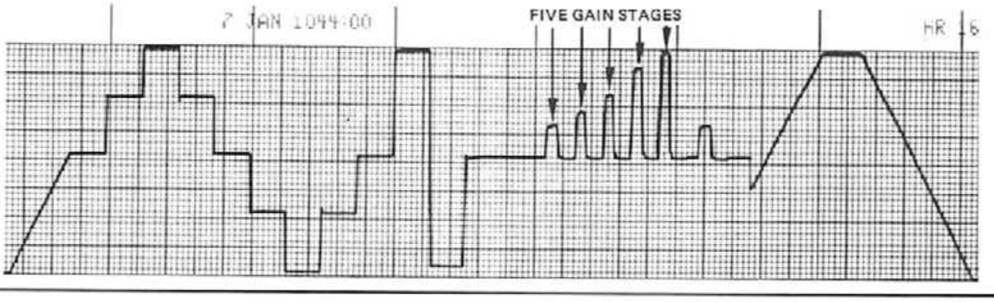


Figure 3-2. Five Gain Stages of AUTO.

WARNING

BEFORE PERFORMING STEP 5, VERIFY THAT UNIT IS ON MONITOR AS INSTRUCTED IN STEP 1.

5. Switch the ECG SOURCE to PADDLES with the ECG SIZE to AUTO. Turn the paddles over in their holders to expose the contact electrodes. Rest the heel of your hands on the electrodes and relax. Watch for the ECG waveform indicating the paddle ECG is functional.

3.2.2.7 Heart Rate Accuracy and Alarm

1. Connect the test equipment as shown in Figure 3-3.

2. Turn the defibrillator ON; turn ECG SOURCE to LEADS I position.

3. Turn the ECG Simulator ON and adjust the defibrillator ECG SIZE control display for 1 cm R-wave deflection on the monitor.

4. Check the heart rate digital display in the calibrated 60 BPM and 120 BPM switch positions of the ECG Simulator. The heart rate accuracy specification is +/- 5% or 2 BPM (whichever is greater).

5. Place the ALARM switch in the ON position with the ECG Simulator at 120 BPM. The alarm should not sound.

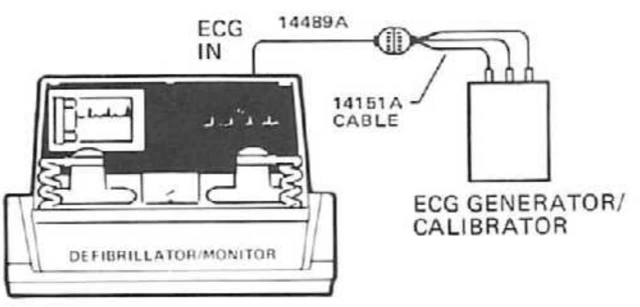


Figure 3-3. Heart Rate Accuracy and Alarm (78670A & 78671A—deleted on 78671A with Option A02).

6. Press the CAL button rapidly enough to raise the heart rate to over 150 BPM. Maintain the higher rate until, after about 4 seconds, the alarm sounds. The recorder will run for 16 seconds; time and heart rate are annotated (78670A only).

7. Turn the ALARM OFF and set the ECG Simulator to 60 BPM. After the count has stabilized, turn the alarm back on.

8. Turn the ECG Simulator OFF, and again the ALARM should sound in about four seconds.

3.2.2.8 Paddle Contact Indicator (PCI) Test

1. Turn the instrument ON to MONITOR and remove the paddles from the storage pockets. The first light bar (closest to the handle) on the PADDLE CONTACT indicator should light and blink on and off.

2. Connect a 61.1 ohm resistor between paddle electrodes. All the light bars should light.

3. Connect a 250.0 ohm resistor between paddle electrodes. Only two light bars should light.

3.2.3 Safety and Maintenance Checks

3.2.3.1 Preliminary Safety Checks

Make these initial checks before performing the safety tests.

1. Check that paddle electrodes are in good condition, clean and not pitted. Check paddles for obvious cracks (small chips, gouges and scratches are acceptable and will not affect instrument performance). Check cable strain reliefs for cracks or other signs of deterioration at the paddles.

2. Check resistance of paddle cables (from paddle to paddle), WITH CABLE STRESSED by stretching the cables out to their entire length while resistance is being measured. Resistance should be approximately 303 KΩ, paddle to paddle, which includes a high voltage suppressor network in the paddle ECG input. If the defibrillator case is open, a direct resistance measurement of each cable can be made from the paddle electrode face to the H.V. connector which mates the paddle cable to the unit. This reading should be less than 1.0 ohm.

3. Check that the CHARGE button will initiate charge when the cable is stretched to its full length.

4. Check that both DISCHARGE buttons must be pressed to discharge the defibrillator. This is done by attempting to discharge the defibrillator by only pressing ONE of the buttons then the other, after releasing the first. Do this test with the cables stretched to their full length.

3.2.3.2 Power Cord to Chassis Ground Resistance Check.

This applies when the Defibrillator is used with a 78668A Power Base.

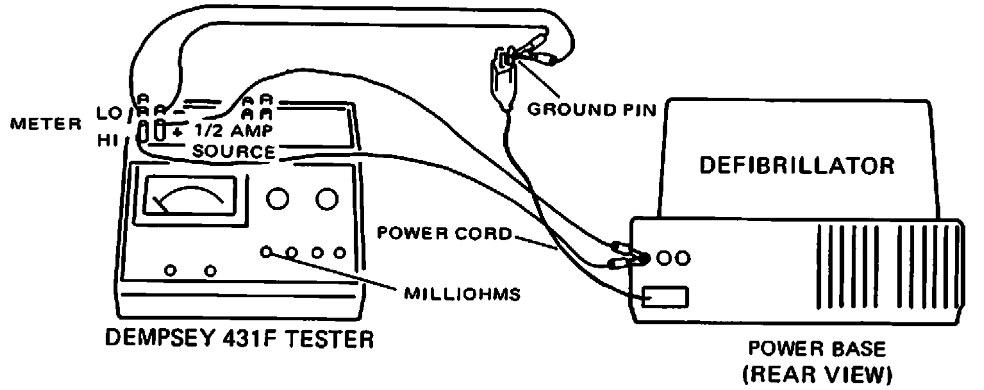


Figure 3-4. Power Cord to Chassis Ground Resistance Check.

1. Set the instrument up for the test as shown in Figure 3-4. Connect a short heavy wire to the external ground jack on the rear panel of the defibrillator to allow access of this point during the test. If the Dempsey 431F is not available, use a conventional ohmmeter capable of accuracy at 0.2 ohms.

2. Connect the dual banana plug of a Kelvin Kable between the LO meter terminal of the Dempsey and the - (negative) terminal of the 1/2-AMP source on the Dempsey.

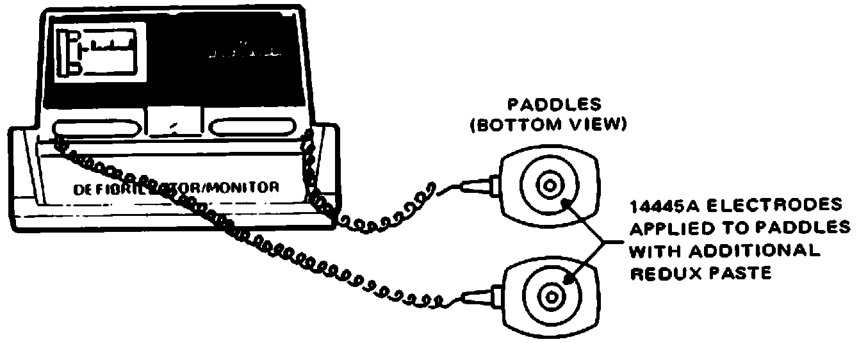
3. Connect the clip on the other end of the Kable to the ground pin of the male power connector.

4. Connect the dual banana plug of the second Kelvin Kable between the HI terminal of the meter section and the + terminal of the 1/2-AMP source.

5. Connect the clip on the other end to a banana/banana cable inserted in the external ground jack on the rear panel of the Power Base.

6. Press MILLIOHMS and read the resistance on the current ranges. The test limit is less-than-or-equal-to 0.20 ohms.

7. Reconnect the clip on the Power Base external ground to the short wire attached to the defibrillator external ground jack. Take a resistance reading. The test limit maximum is 0.20 ohms. If the limit is slightly exceeded, make a resistance measurement of the short access wire and subtract the reading from the total resistance to obtain actual ohmic resistance of the units.



ALLIGATOR-ALLIGATOR CLIP LEADS, LENGTH LESS THAN 6 INCHES, SHOULD BE USED TO CONNECT ELECTRODES TO TEST EQUIPMENT AS SHOWN IN THE STEP DIAGRAMS.

Figure 3-5. Test Connections to Paddles.

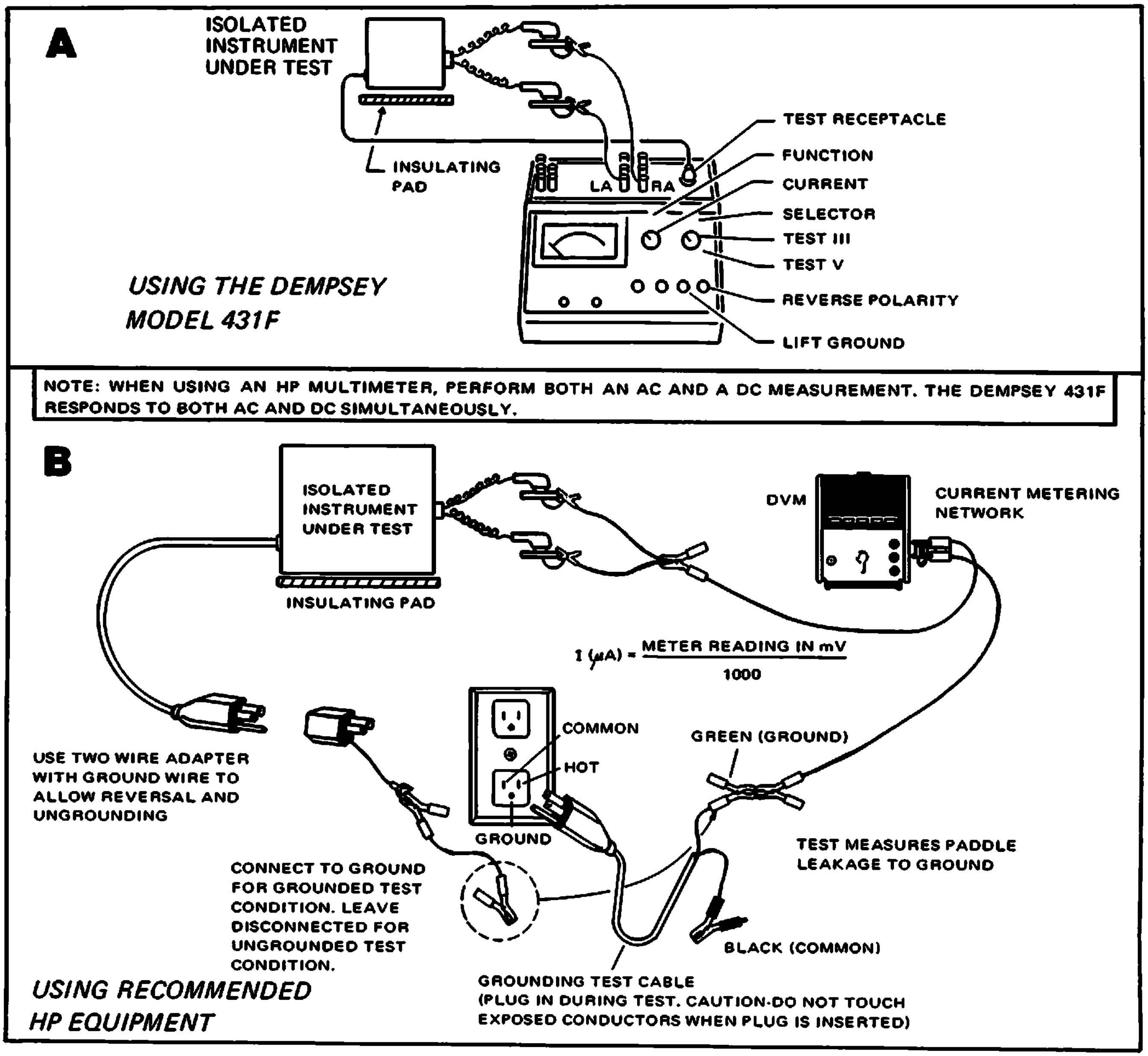


Figure 3-6. Paddle Leakage Current to Ground.

3.2.3.3 Paddle Leakage Current (Source Leakage) to Ground.

Perform the check as follows:

1. Connect the test equipment as shown in Figure 3-6. If the Dempsey 431F is used, follow instructions included in the figure. Use clip leads (see Figure 3-5) to connect the Apex paddle to the RA output of the Dempsey and the Sternum paddle to the LA output.

2. Set Dempsey FUNCTION switch to CURRENT. (Set the SELECTOR switch to either RA or LA to test either paddle. For paddle-to-paddle checks, ground either paddle and test the other.)

3. Using the SELECTOR switch to connect the appropriate paddle, measure paddle source leakage to ground for each paddle individually. Current should be no more than 20 uA paddle-to-ground.

4. Perform the same test under each of the following conditions with the power ON and with the power OFF.

> WARNING
>
> MAKE ALL PADDLE TEST CONNECTIONS BEFORE PERFORMING CHECK NUMBER FIVE. KEEP PADDLES SEPARATED AND ON INSULATED PAD DURING TEST.

(a) Chassis grounded, standard power polarity.

(b) Chassis grounded, reverse power polarity.

(c) Chassis ungrounded, standard power polarity.

(d) Chassis ungrounded, reverse power polarity.

(e) Defibrillator charged to highest energy setting.

(f) Defibrillator discharged (discharged by turning power OFF with energy select control. DO NOT PRESS DISCHARGE BUTTONS).

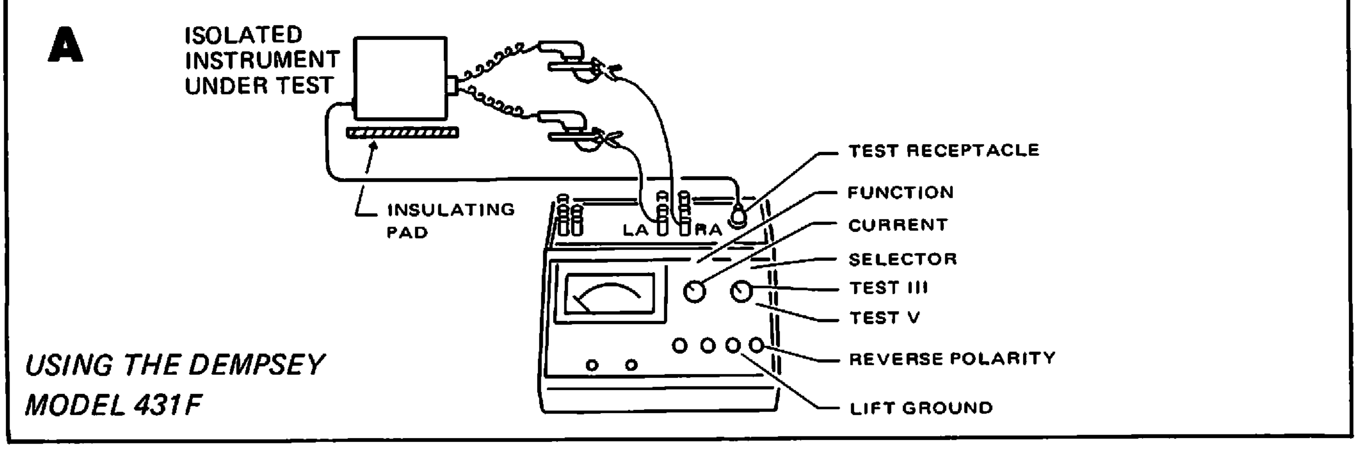


Figure 3-7A. Paddle Leakage Test with 115V Applied.

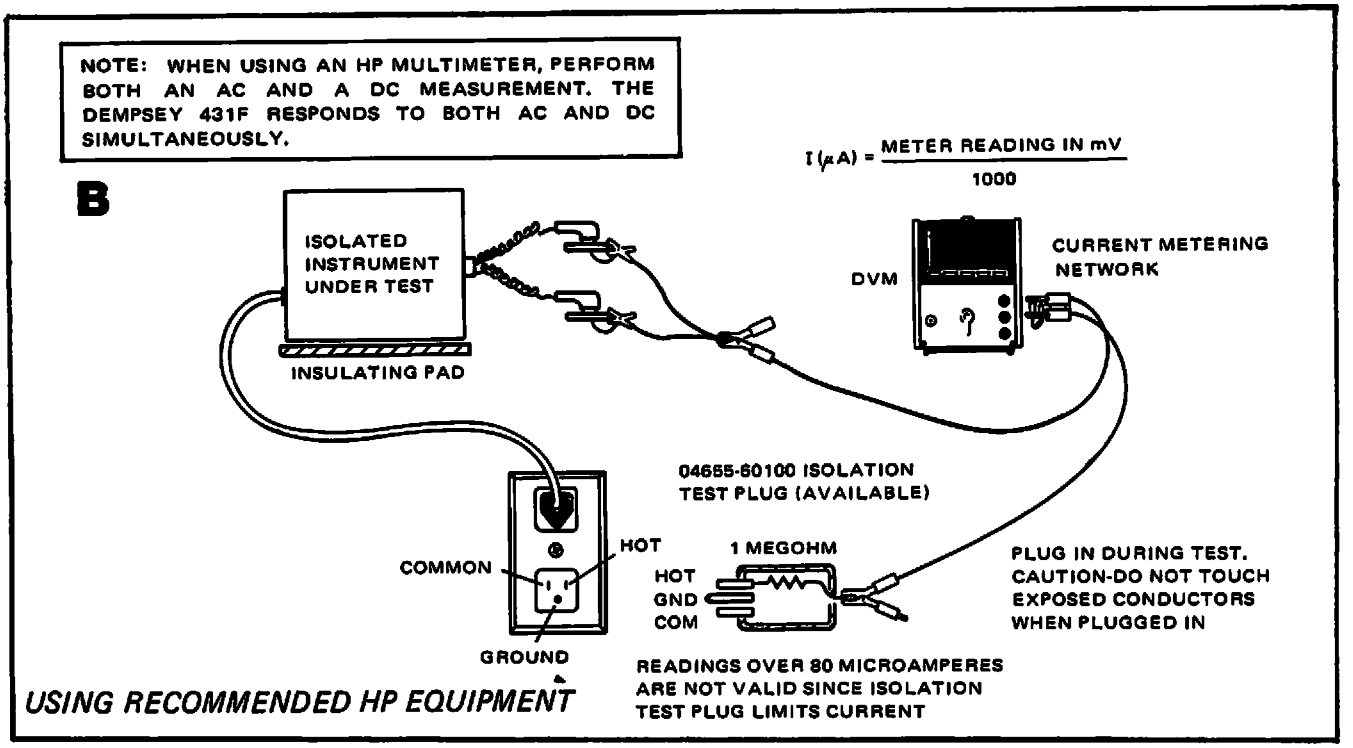


Figure 3-7B. Paddle Leakage Test with 115V Applied.

3.2.3.4 Paddle Leakage Current (Sink Current) with 115 Volts Applied.

Perform the check as follows:

1. Connect the test equipment as shown in Figure 3-7. If the Dempsey 431F is used, also follow the instructions included in the figure. Use clip leads as in Figure 3-5, to connect the Apext paddle to the RA output of the Dempsey and the Sternum paddle to the LA output.

2. Set Dempsey FUNCTION switch to CURRENT.

3. Turn the SELECTOR to Test V.

4. Press red 115V test button under each of the following conditions with the power ON and the power OFF. Current should be no more than 100 uA.

CONDITIONS:

(a) Chassis grounded, standard power polarity.

(b) Chassis grounded, reverse power supply.

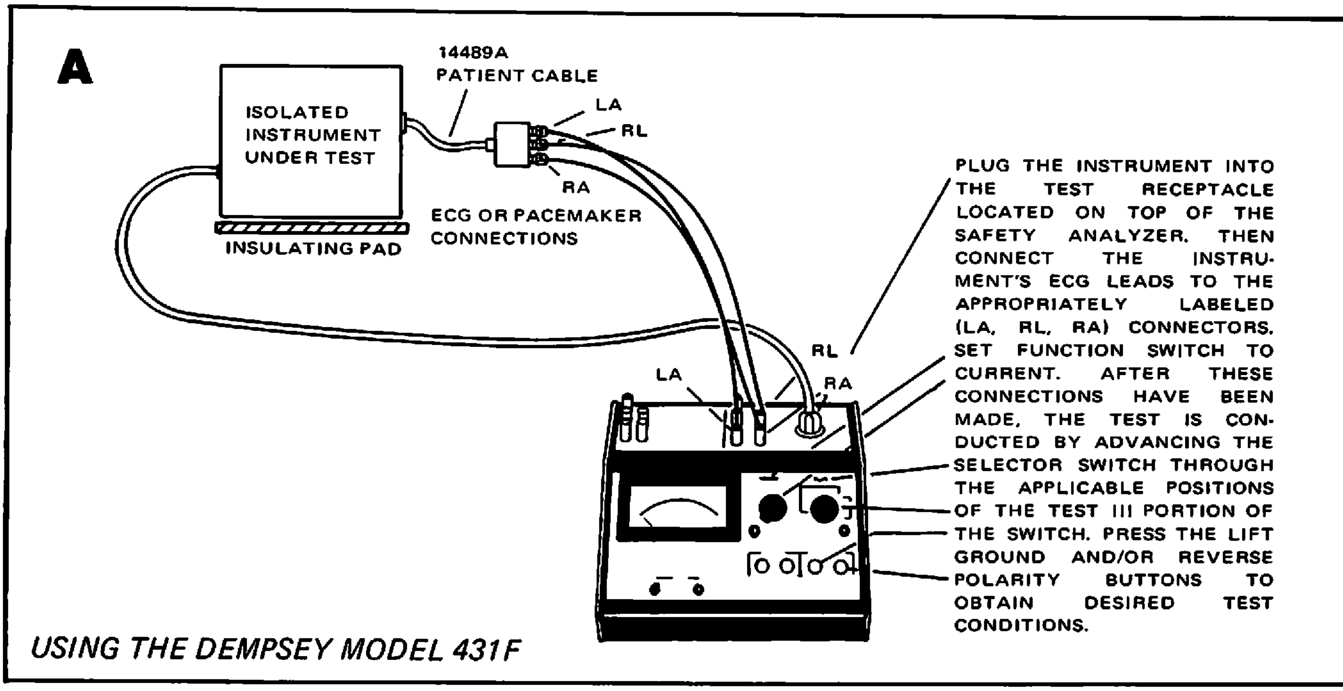


Figure 3-8A. Patient Lead Leakage Current to Ground Test.

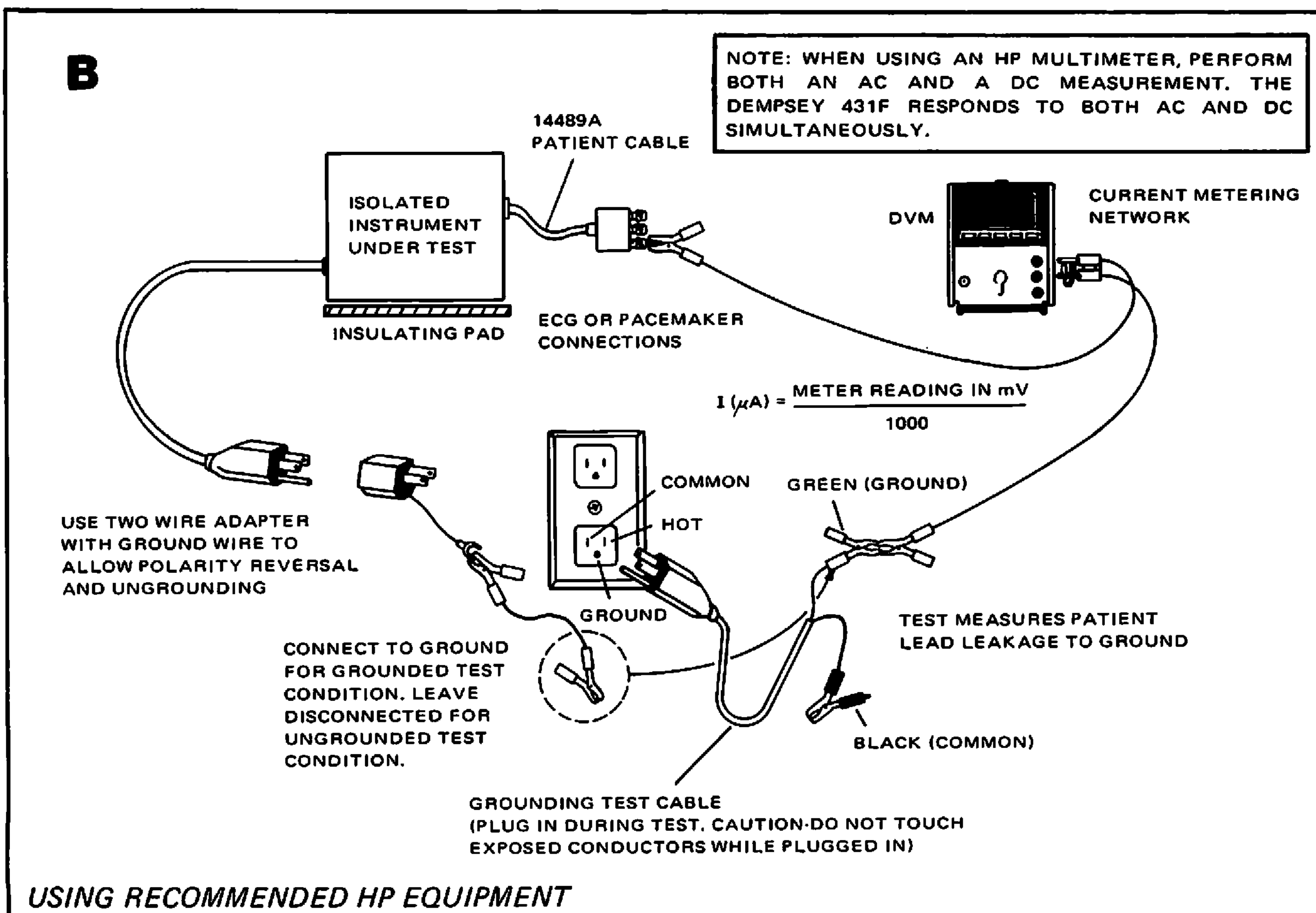


Figure 3-8B. Patient Lead Leakage current to Ground Test.

3.2.3.5 Patient Lead Leakage Current (Source Leakage) to Ground.

Perform the check as follows:

1. Connect the test equipment as shown in Figure 3-8. If the Dempsey 431F is used, follow instructions included in the figure.

2. Perform the tests of Step 3 under each of the following power polarity and grounding conditions with the power ON and with the power OFF.

(a) Chassis grounded, standard power polarity.

(b) Chassis grounded, reverse power polarity.

(c) Chassis ungrounded, standard power polarity.

(d) Chassis ungrounded, reverse power polarity.

3. Using the patient cable in the test setup, measure each patient lead leakage current to ground. When a voltmeter is used to derive leakage current, divide the meter reading in millivolts by 1000. Result is current in microamperes.

TEST LIMIT: NOT TO EXCEED 10 MICROAMPERES.

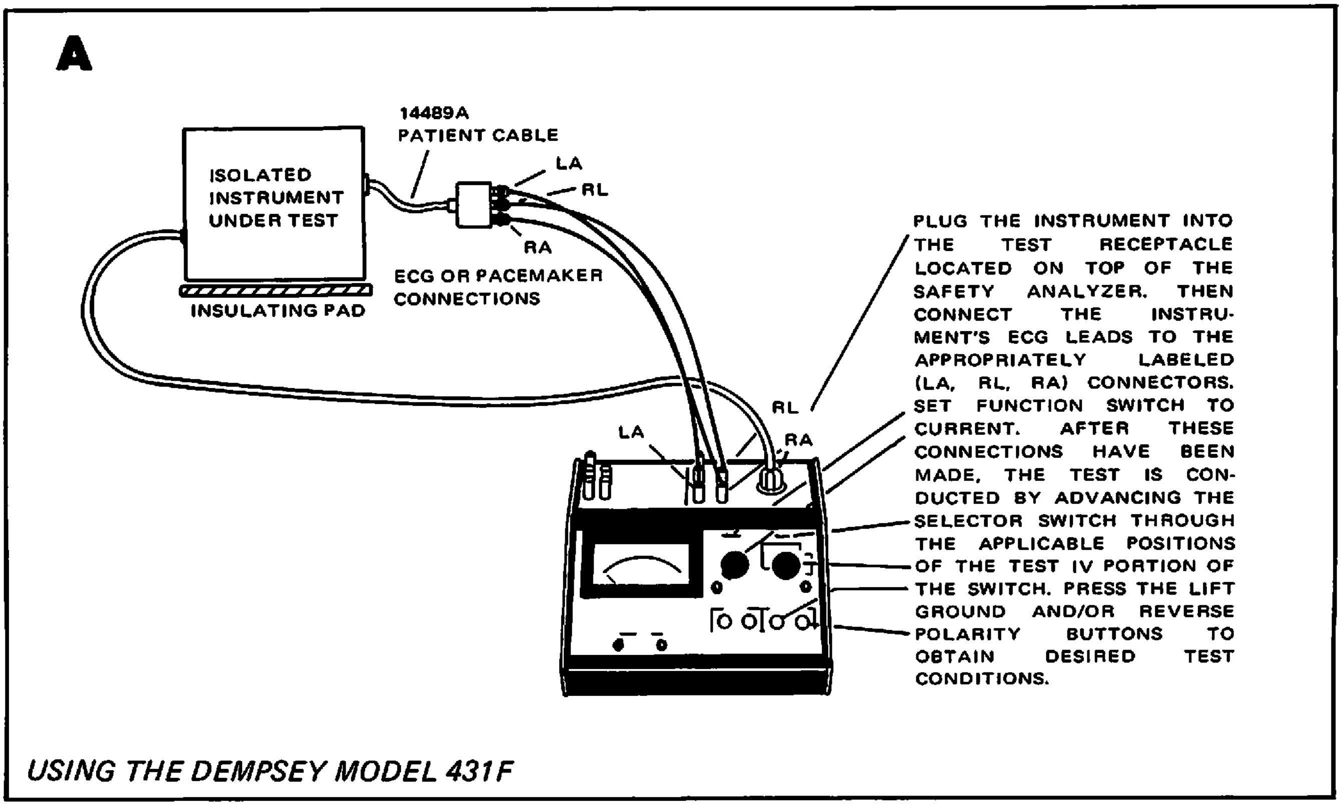


Figure 3-9A. Leakage Current Between Patient Leads Test.

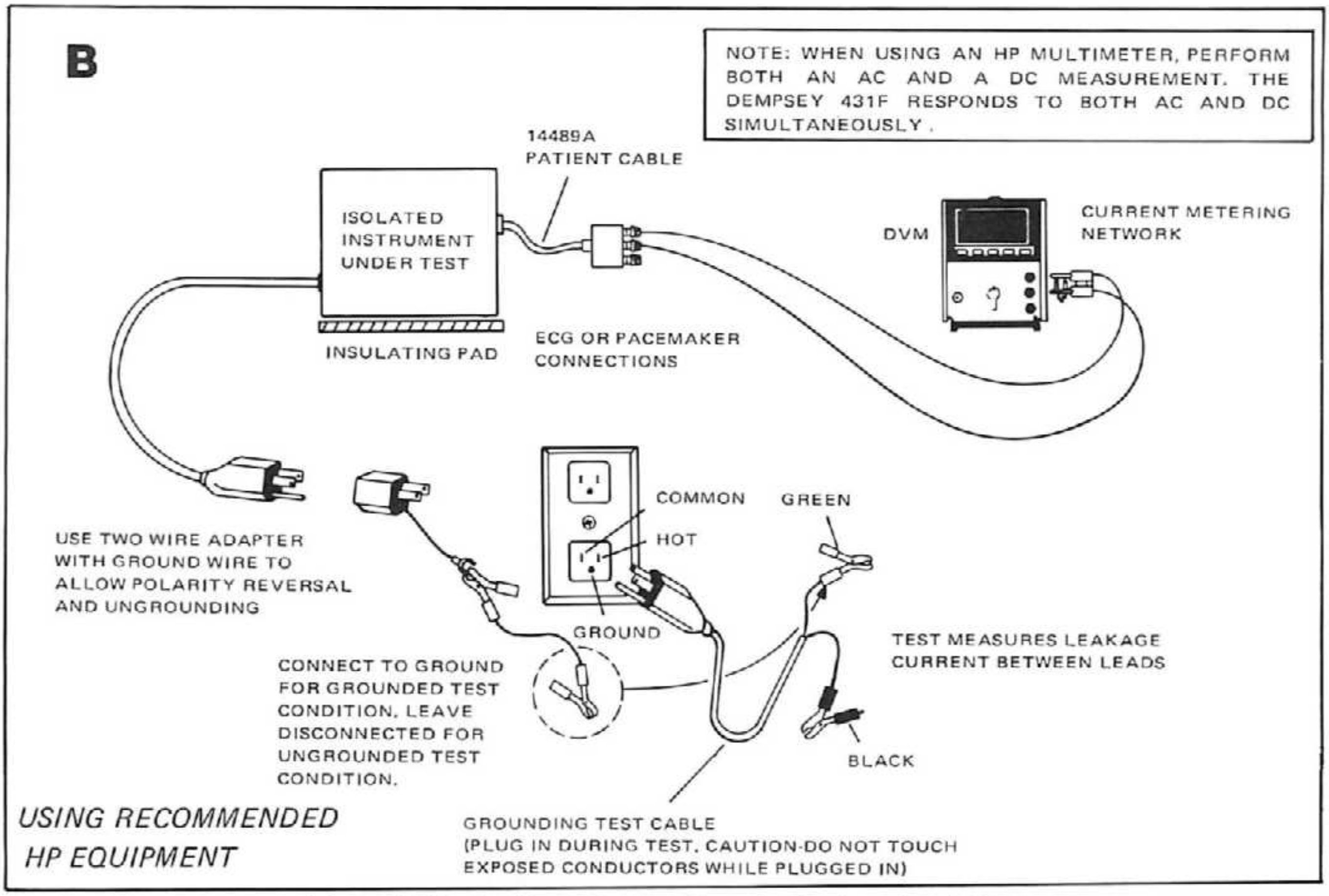


Figure 3-9B. Leakage Current Between Patient Leads Test.

3.2.3.6 Leakage Current Between Patient Leads Check

Perform the check as follows:

1. Connect the test equipment as shown in Figure 3-9. If the Dempsey 431F is used, also follow the instructions included in the figure.

2. Perform the tests of Step 3 under each of the following power polarity and grounding conditions with the power ON and with the power OFF.

   (a) Chassis grounded, standard power polarity.

   (b) Chassis grounded, reverse power polarity.

   (c) Chassis ungrounded, standard power polarity.

   (d) Chassis ungrounded, reverse power polarity.

3. Using a patient cable, measure the leakage current between individual patient input leads. When a voltmeter is used to derive leakage current, divide the meter reading in millivolts by 1000. Result is current in microamperes. Test limit: less than or equal to 10 microamperes.

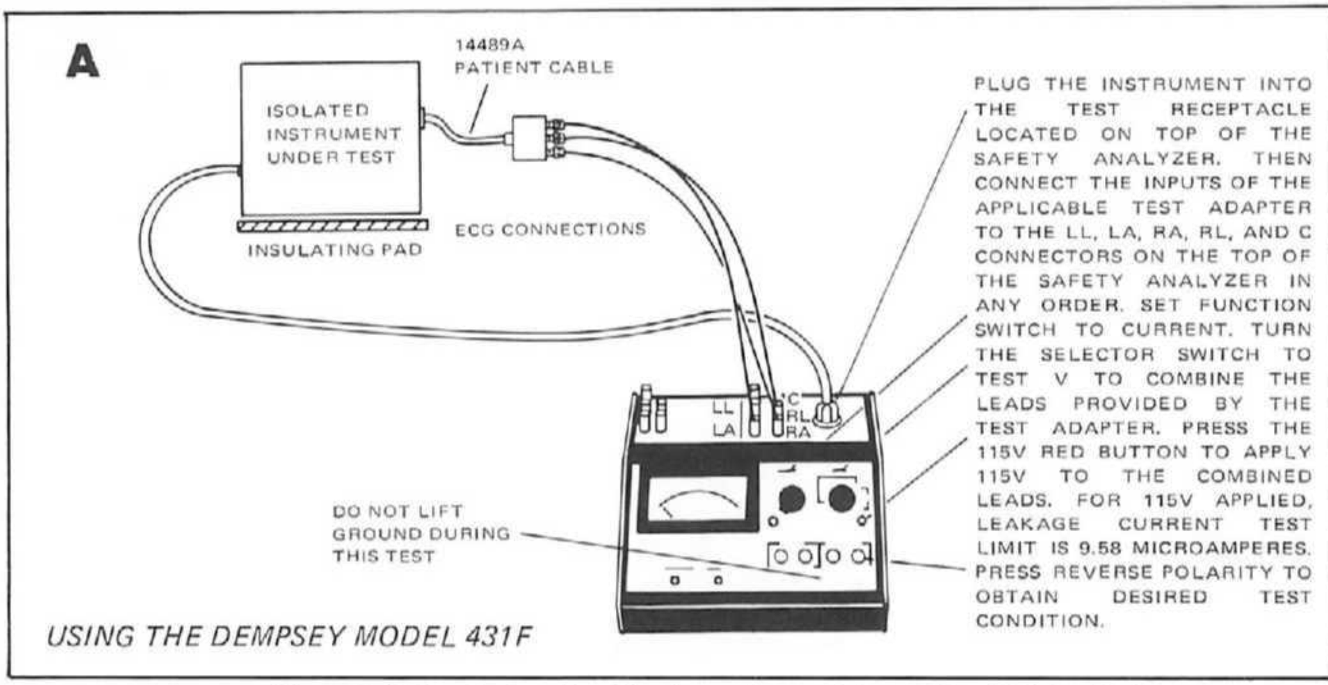


Figure 3-10A. Patient Lead Leakage Current Test with 115V Applied.

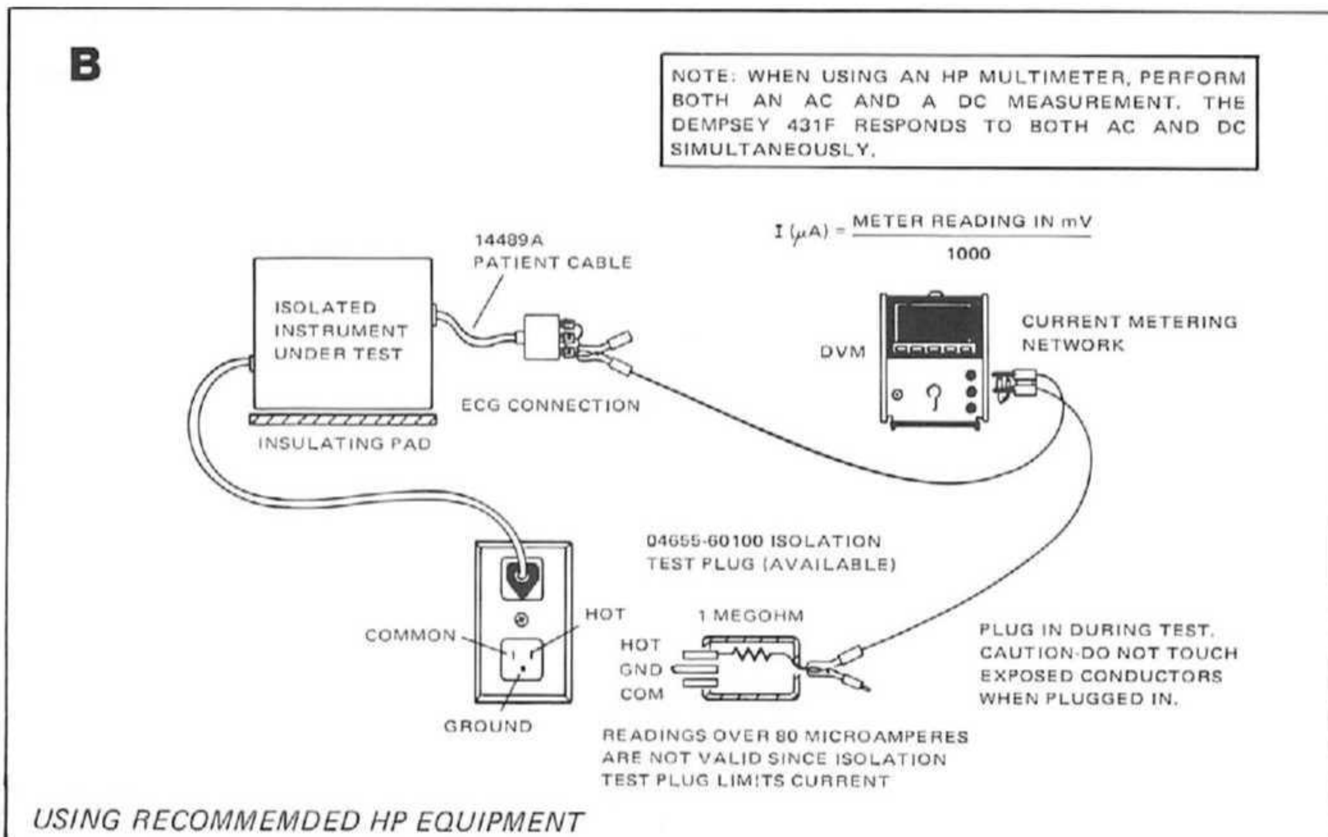


Figure 3-10B. Patient Lead Leakage Current Test with 115V Applied.

3.2.3.7 Patient Lead Leakage Current (Sink Current) with 115 Volts Applied.

Perform the check as follows:

1. Connect the test equipment as shown in Figure 3-10. If the Dempsey 431F is used, also follow the instructions included in the figure.

2. Perform the tests of Step 3 under each of the following power polarity conditions with the chassis GROUNDED and with the power ON and with the power OFF.

(a) Chassis grounded, standard polarity.

(b) Chassis grounded, reverse power polarity.

3. Using the exact test setup shown, measure the patient lead leakage current for all leads tied together while driving the leads with line voltage. When a voltmeter is used to derive the leakage current, divide the meter reading in millivolts by 1000. Result is current in microamperes. Test limit: < 10 microamperes. In addition, perform both an AC and a DC measurement when using a voltmeter for the measurements. The Dempsey 431F responds to both AC and DC simultaneously.

3.2.3.8 Battery Capacity Check.

This check tests the capacity of the defibrillator battery. To perform the test, use an HP 78620-60860 Battery Test Load, and 78660-67800 Cable Adaptor.

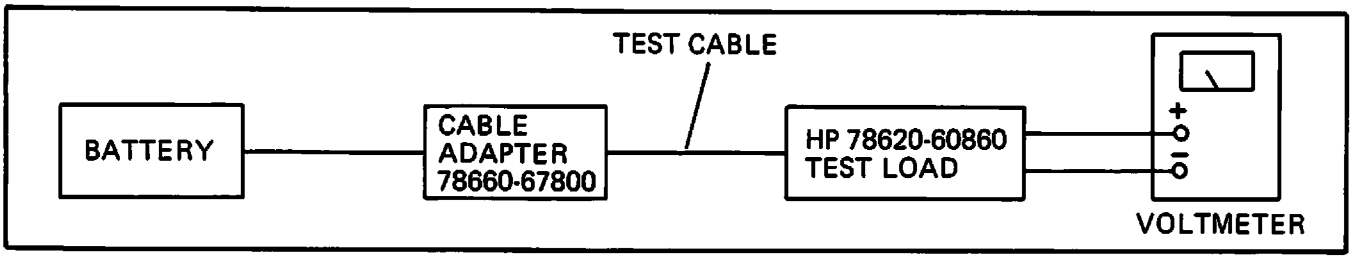


Figure 3-11. Test Setup for Battery Capacity Check.

1. The battery should be fully charged at the start of this test. Charge for at least 16 hours if the battery has been discharged.

2. Connect the DVM to the test load voltmeter terminals. Use the adapter cable to connect the battery to test load.

3. Connect the battery to the test load and time the discharge. The voltage should not fall below 10 volts in 15 minutes.

4. If the battery fails the test, recharge for 16 hours and repeat the test.

5. If the battery fails the second time, recharge and repeat.

6. If it fails the third time, replace the battery (P/N 78660-60401).

NOTE: Do not allow the battery voltage to fall below 9 volts. Doing so can cause cell reversal which will damage the battery.

WARNING

THE BATTERY TEST LOAD BECOMES HOT WHEN USED TO TEST BATTERY CAPACITY. DO NOT TOUCH OR PLACE NEAR ANY PLASTIC OR COMBUSTIBLE MATERIALS. SURFACE TEMPERATURES OF THE TEST LOAD ENCLOSURE WILL APPROACH 75 DEGREES C (167 DEGREES F) DURING TESTING.

3.3 ADJUSTMENTS

3.3.1 Equipment Required

All test equipment necessary to make the adjustments is listed in each Adjustment Procedure. In addition to the test instruments, an Extender board (H-P 78304-60260) will be needed to make adjustments to the Real Time Clock/Heart Rate Board (78660-60260).

Adjustments for both Models 78670A and 78671A are listed in Table 3-3.

3.3.2 Related Adjustments

Although most internal adjustments can be made individually, some controls interact and some adjustments affect parameters on other circuit boards. Interactions will be noted in the procedures.

3.3.3 Adjustment Location

To gain access to the adjustment controls, the instrument case must be opened and, for certain adjustments, the metal circuit board shield removed. See Section IV of this Service Manual for instructions. The individual adjustment location is shown in the Adjustment Procedures.

TABLE 3-3

Adjustment	Procedure Number	Reference Designator	Location
Paddle Contact Indicator Adj.	3.3.4	A3-R91	ECG Analog Board (78670-60155)
+5 V Adj.	3.3.5	A12-R14	Low Voltage Power Supply (78660-60110)
+12 V Adj.	3.3.5	A12-R28	Low Voltage Power Supply (78660-60110)
ECG Cal Adj.	3.3.6	A3-R72	ECG Analog Board (78670-60155)
ECG Baseline Offset Adj.	3.3.7	A3-R73	ECG Analog Board (78670-60155)
Minimum Brightness Adj.	3.3.8	A6-R26	Deflection Board (78660-60180)

Maximum Brightness Adj.	3.3.8	A6-R25	Deflection Board (78660-60180)
Vertical Gain (Y-Axis) Adj.	3.3.8	A6-R1	Deflection Board (78660-60180)
Horizontal Gain (X-Axis) Adj.	3.3.8	A6-R2	Deflection Board (78660-60180)
Beam Centering	3.3.8	---	CRT Deflection Board (78660-60190)
Clock/Heat Rate Adj. V Ref Adj	3.3.9	A7-R40	Real Time Clock/Heart Rate Board (78660-60260)
Real Time Clock Rate Freq. Adj.	3.3.10	A7-C9	Real Time Clock/Heart Rate Board (78660-60260)
CMR Notch Filter Setting	3.3.11	A4-S1-S8	ECG Digital Board (78660-60140)
V Ref, Defibrillator Charger Board Adj.	3.3.12	A11-R132	Defibrillator Charger (78670-60120)
Output Energy Calibration	3.3.13	A10-R72	Defibrillator Control Board (78660-60195)
H.V. Charge Time Adj.	3.3.14	A11-R34	Defibrillator Charger (78660-60120)
Self Test Accuracy Adj. (also determines print out accuracy)	3.3.15	A11-R10	Defibrillator Charger (78660-60120)
Recorder Pen Heat Adj.	3.3.16	---	Recorder
Recorder Stylus Pressure	3.3.17	---	Recorder
Recorder Pen Positioning	3.3.18	---	Recorder
Print Head Adjustment	3.3.19	---	Recorder Controls
Setting Real Time Clock	3.3.20	---	External Controls

3.3.4 Paddle Contact Indicator Adjustment (A3-R91)

R91 is located on the ECG Analog Board (78670-60155-A3)

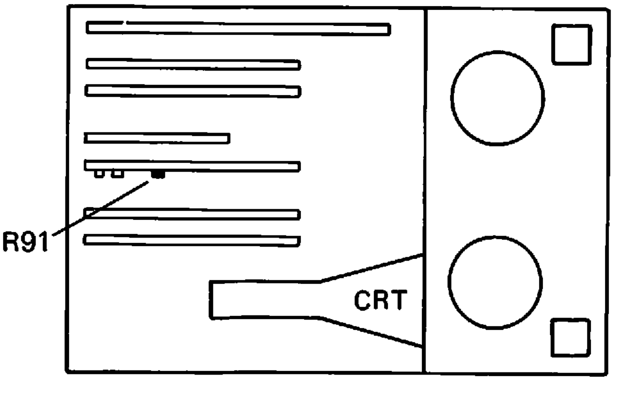
3.3.4.1 Equipment Required:

Reference Resistor 64.9 ohms, 1%

3.3.4.2 Procedure:

1. Connect the resistor between the paddle electrodes. A good electrical connection is essential.

2. Adjust R91 until all the light bars on the Sternum Paddle Contact Indicator are just lit. Try to find the threshold at which the last two bars have equal brightness.



TOP SECTION

3.3.5 Low Voltage Power Supply Adjustments (A12-R14, A12-R28)

Adjust the 5V Supply Voltage to 5.1 ± 0.05V (R14).

Adjust the 12V Supply Voltage to 12.0 ± 0.1V (R28).

3.3.5.1 Equipment Required:

Digital Voltmeter (DVM): Accuracy 0.1%. (Recommend HP 3466A).

NOTE: Other supply voltages are tightly coupled therefore indirectly regulated by the 5V Supply. If after adjusting the 5V, the other voltages are incorrect, consult the troubleshooting section.

3.3.5.2 Procedure:

1. Remove the five nuts that secure the power supply board to the lower case. Lift and turn the board over to access the component side. Assure it will not contact other conductive parts.

2. Put the negative DVM probe on TP4.

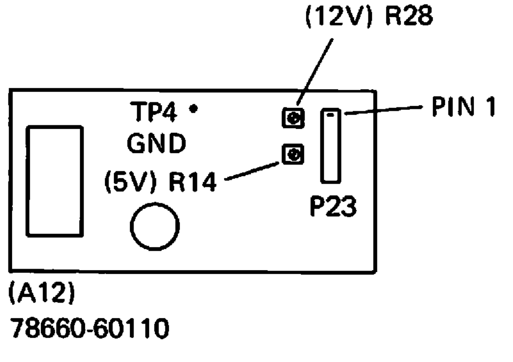
3. With the positive probe on P23 - pin 1, adjust R14 for 5.1 ± 0.05V.

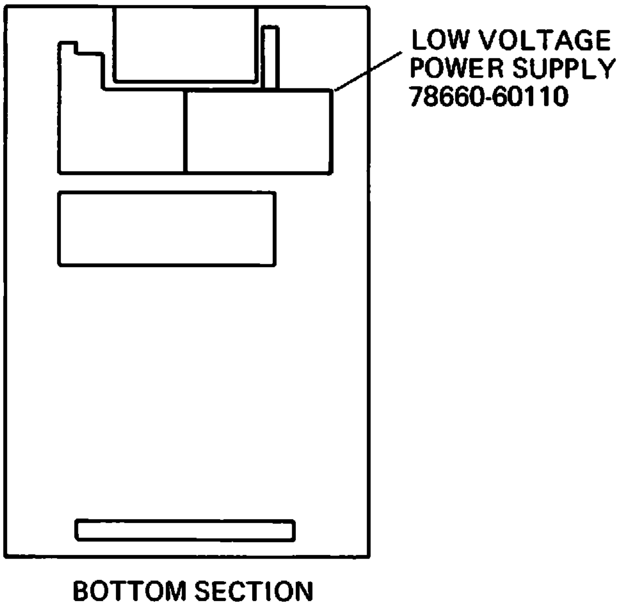
4. With the positive DVM probe on P23 - pin 7, adjust R28 for 12.0 ± 0.1V. If it is necessary to adjust the 12V supply, the ECG baseline offset voltage should be checked, (Section 3.3.7) since this will be affected.

5. Allowable voltage deviation of the supplies is shown below:

SUPPLY	P23 PIN NO.	VOLTAGE RANGE MIN.	MAX.
+5 adjustable	1	5.05	5.15
+12 adjustable	7	11.96	12.04
+12 fixed	10	11.5	12.5
-12 fixed	5	-11.5	-12.5
+15 fixed	3	14.5	15.5
-15 fixed	2	-14.5	-15.5
+200 fixed	9	+180	+210
+5 kV	*	4000	4400

*Measure at CRT anode. Use 1000 MΩ probe.





BOTTOM SECTION

3.3.6 ECG Cal Adjustment (A3-R72).

Adjusts the CAL reference for 1 mV. Adjustment located on the ECG Analog Board 78670-60155 (A3)

3.3.6.1 Equipment Required:

Oscilloscope

Display:	Storage/Variable Persistance Desirable
Time Base:	1 sec./Div. Range included
Vert. Deflection:	Includes 0.5V/Div. range. Accuracy, 0.5%
Function Generator Recommend HP 3310A/B	5-10 Hz, 0.5V pp Capability

NOTE: There is some interaction between the ECG CAL adjustment and the ECG baseline offset adjustment. Adjust in conjunction.

1. Determine the exact gain of the highest auto gain stage. This is done by inputting a very small ECG signal and measuring the output. (With small or no signal present the auto gain is automatically set at maximum).

2. Connect the equipment as shown in Figure 3-11.

3. Carefully set the function generator at 0.5 V p-p, 5 Hz, as measured on a calibrated oscilloscope. This applies 0.5 mV p-p to the ECG input. Call this V1.

4. Measure the voltage at the 1V ECG output jack. Call this V2 which will be approximately 1.25 V p-p.

5. The gain of the maximum auto gain stage is G=V2/V1.

6. Now set the oscilloscope controls:

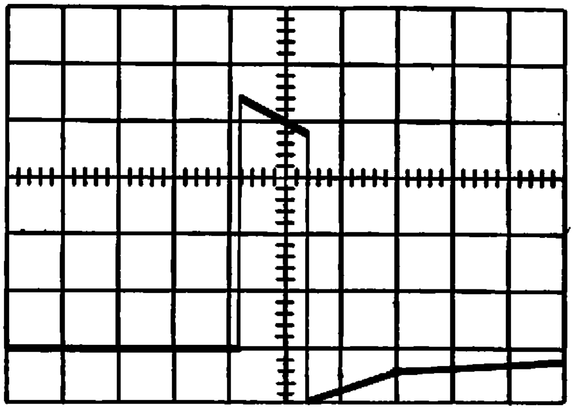
(1)	Vertical sensitivity	0.5 V/div
(2)	Time Base	1 sec/div
(3)	Positioning	On graticle line at bottom of screen
(4)	Triggering	free run
(5)	Mode	storage

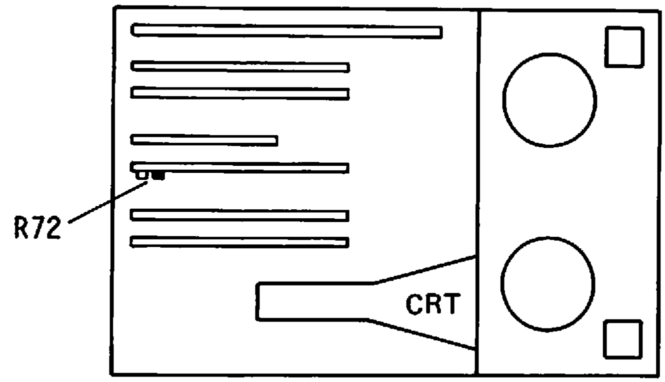
7. As the trace moves across the CRT screen, press the CAL button. Measure the leading edge of the deflection on the oscilloscope. This voltage is V3. Calculate the calibration amplitude thus:

Cal Amplitude = V3/G

8. The CAL step amplitude should be 0.95 to 1.05 mV. Adjust the CAL ADJ. R72 if necessary.

Calibration Signal





TOP SECTION

Alternate method for Adjusting R72 (Cal)

Note: Since the recorder is required, this method will not work for the 78671A (delete recorder option).

Use the test equipment listed previously. Connect as shown in Figure 3-12B on page 3-40.

1. Connect the oscilloscope to the function generator output. Set the function generator for 10 Hz sine wave, one volt p-p output as measured on the oscilloscope. Do not change this setting. This will apply a 1 millivolt p-p signal to the ECG input.

2. Place the ECG Size control in the AUTO position (fully clockwise). Set the recorder switch to RUN.

3. Allow the unit to run until the display stabilizes, then briefly press the CAL switch. If the internal switches are in the delay position, it will be about 4 seconds until the CAL signal appears on the recorder chart.

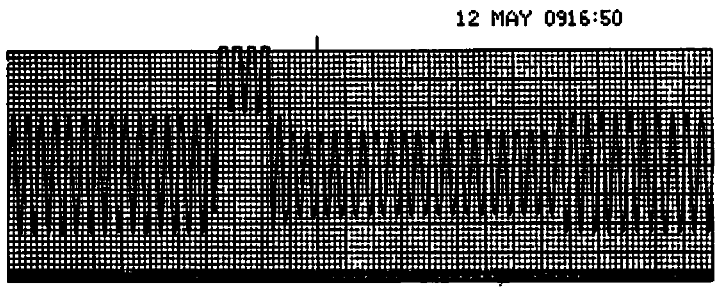
4. After the CAL signal appears, it will be several seconds until the display stabilizes.

5. Lay a straight edge along the top of the 10 Hz waveform on the chart. If the CAL is correctly adjusted, the bottom of the area where the CAL switch was pressed should just meet the top of the 10 Hz sine wave.

6. If the CAL signal does not agree with the description in step 5, adjust R72 and repeat steps 3, 4 and 5 until the correct results are obtained.

Explanation:

When the CAL switch is pressed, a 1 millivolt DC signal is applied causing the baseline to shift in the positive direction. The 10 Hz signal is superimposed on the shifted baseline. If the CAL switch is held for more than a few cycles, the AUTO baseline circuit will shift the entire display downward to center it on the CRT and recorder.



3.3.7 ECG Amplifier Baseline Offset Adjustment (A3-R73)

Adjust the Baseline Offset for no trace movement between MIN and MAX settings of the ECG SIZE control. The baseline adjust is located on the Analog ECG Board 78670-60155 (A3).

3.3.7.1 Equipment Required:

Oscilloscope helpful but not required.

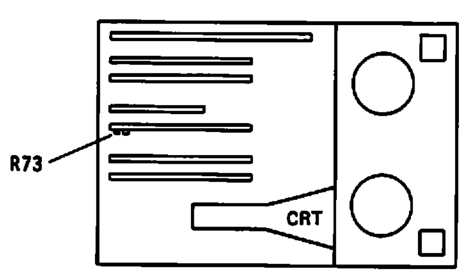
NOTE 1: The +12V supply voltage affects the baseline offset. Check and adjust the 12V supply, if required, before adjusting the baseline offset (Section 3.3.5).

NOTE 2: There is some interaction between ECG baseline offset and ECG CAL adjustment. Adjust in conjunction.

1. If an oscilloscope is used, connect to the 1V ECG output jack.

2. Turn the ECG SIZE control through its full range from minimum to maximum gain, noting any vertical movement of the trace. (If using an oscilloscope, free run the sweep and adjust the vertical sensitivity for good definition of any offset voltage.)

3. Adjust the zero offset, R73, until less than 40mV voltage change on the oscilloscope or no discernible movement on the defibrillator monitor is observed, while turning the ECG SIZE control from MIN to MAX gain.



TOP SECTION

3.3.8 CRT Display Adjustments

Includes the CRT beam positioning and brightness adjustments on the Deflection Circuit Board 78660-60180 (A6).

3.3.8.1 Equipment Required:

Digital Voltmeter: Capable of 3% accuracy (on complex waveform) at 0.5 VAC
Recommend HP 3466A

3.3.8.2 Procedure:

1. Brightness Adjustments (A6-R26, A6-R25)

A. Connect the voltmeter to TP1 and TP2 on the deflection board A6. See Figure 6-6.

B. Turn the INTENSITY control fully counter-clockwise. This control is located under the accessory door on top of the instrument. Adjust the MINIMUM BRIGHTNESS trimmer A6-R26 until the CRT trace is visible.

C. Turn the INTENSITY CONTROL fully clockwise. Adjust the MAXIMUM BRIGHTNESS trimmer A6-R25 for a meter indication of 0.33 volts.

D. Disconnect the meter. Rotate the INTENSITY CONTROL from MINIMUM to MAXIMUM BRIGHTNESS, noting that the trace does not completely extinguish and does not get so bright that the trace shrinks from the sides of the CRT.

2. Vertical Gain Adjustment (A6-R1)

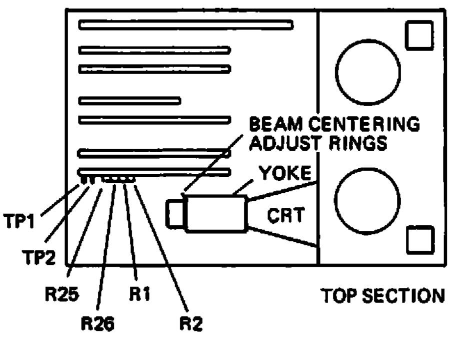
Place the instrument in the service mode. (Pull the BEEPER switch up. Turn the instrument off. Turn the instrument on and quickly push the BEEPER switch down). A ramp-step waveform should appear on the CRT. Adjust the vertical potentiometer, R1, until the steps are each 1 cm in height. Note the graticule marks on either side of the CRT are 1 cm apart.

3. Horizontal Gain Adjustment (A6-R2)

Turn the instrument on, switch to LEADS input without the leadset plugged in. Allow the instrument to warm up for a minute or so. Adjust the horizontal gain potentiometer, R2, until the beam on the CRT just extends to the edges of the screen. Some adjustment of the beam centering may also be necessary.

4. Beam Centering

Two ring magnets are placed around the rear of the deflection yoke to center the beam vertically and horizontally. Tabs are provided on the ring magnets to facilitate rotation. Before moving them, make the horizontal gain adjustment. Note that a great amount of interaction takes place but attempt to center the vertical while making the horizontal edges of the beam just hit the sides of the CRT. Readjustment of the horizontal gain and vertical gain may be necessary.



3.3.9 Real Time Clock/Heart Rate V Ref Adjustment (A7-R40)

Adjusts the reference voltage. This voltage effects the circuits immunity to +5V supply fluctuations. Adjustment location is on 78660-60260 (A7).

NOTE: This adjustment is set at the factory and normally should not require attention. However, if components associated with this circuit are replaced, connect the test equipment as described and adjust if necessary.

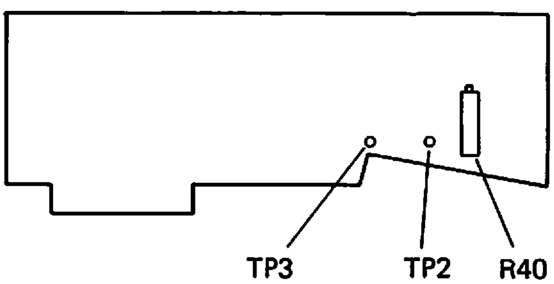
3.3.9.1 Equipment Required:

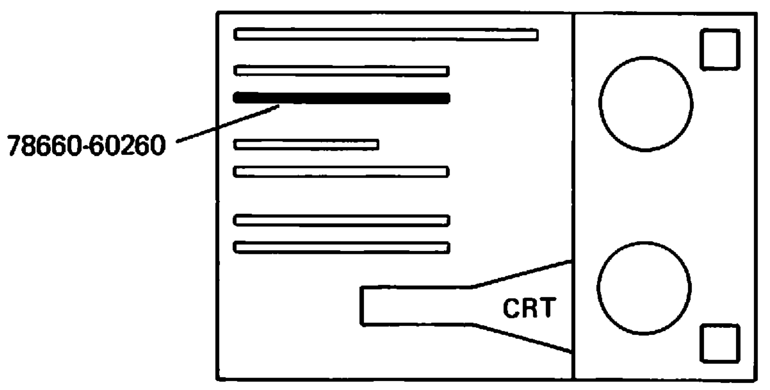
Digital Voltmeter Recommend Hp 3466A	Accuracy 0.05% at 2.49V
Extender Board (2) x 12 pin	HP 78304-60260 or other suitable board.

3.3.9.2 Procedure:

1. Connect the Voltmeter between TP3 (low side) and TP2.

2. Adjust R40 to attain 2.490 VDC.





TOP SECTION

3.3.10 Real Time Clock/Heart Rate Frequency Adjustments (A7-C9)

Check/adjust the basic clock frequency which controls the Real Time Clock.Adjustment location is on the Clock/Heart Rate Board 78660-60260 (A7).

NOTE: This adjustment is set at the factory and normally should not require attention. However, if components associated with this circuit are replaced, connect the test equipment as described and adjust if necessary.

3.3.10.1 Equipment Required:

<u>Counter</u> (Recommend HP 5314A with Option 001)	Accuracy: +0.005 Hz at 2048.00 Hz
<u>Extender Board</u> (2) x 12 pin	HP 78304-60260 or other suitable board

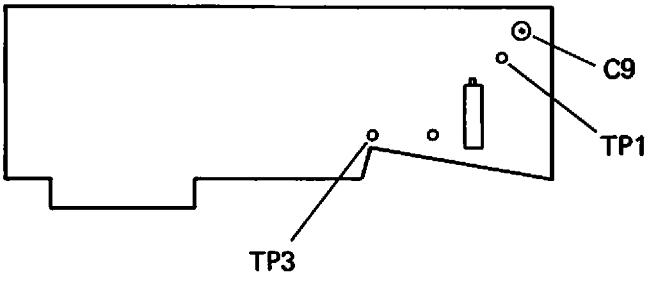
3.3.10.2 Procedure:

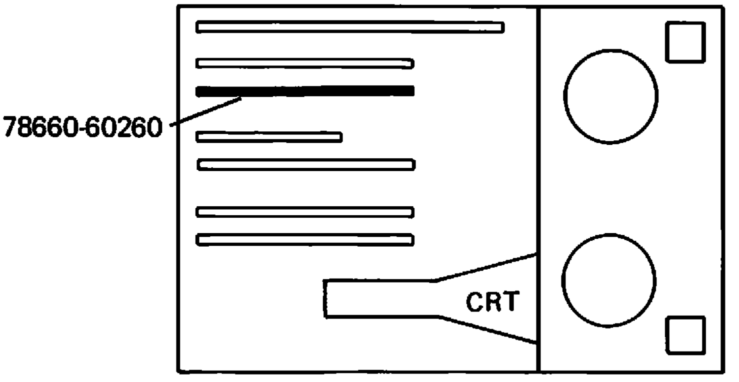
1. Connect the counter between TP3 (low side) and TP1.

2. Leave the monitor ON, press the recorder PUSH TO MARK button once.

3. Set the controls on the counter to read the divided down test frequency.

4. Adjust C9 if necessary until the counter reads 2048.00 Hz.





TOP SECTION

3.3.11 Common Mode Rejection Notch Filter Switches (A4, S1-8)

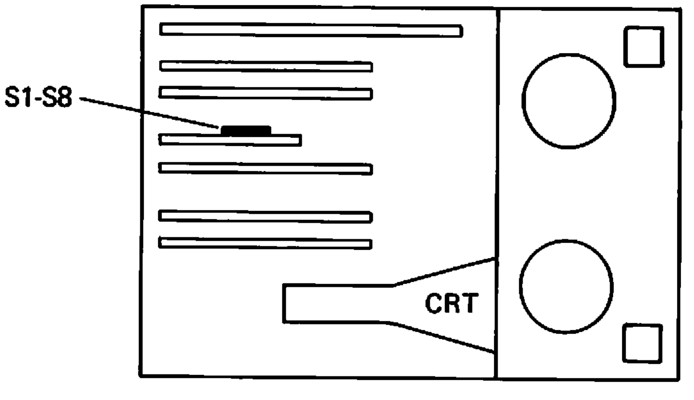
Selects the power line frequency to be rejected or switches the Notch Filter out completely. Located on the Digital ECG Board 78660-60140 (A4).

3.3.11.1 Procedure:

1. Set the miniature switch cluster S1 through S8 as shown below:

DESIRED CONDITION	S1	S2	S3	S4	S5	S6	S7	S8
50	0	X	X	C	0	0	0	0
60	C	X	X	C	C	C	C	C
No Notch	C	X	X	0	C	C	C	C
No Notch	0	X	X	0	0	0	0	0

Code: 0 = Open
C = Closed
X = No Effect - Either Position



TOP SECTION

NOTE: This adjustment is set at the factory and normally should not require attention. However, if components associated with this circuit are replaced, connect the test equipment as described and adjust if necessary.

3.3.12 Voltage Reference, Defibrillator Charger Circuit Board (A11-R132)

Adjusts the voltage reference used for low battery shutdown of the high voltage charging circuits. Adjustment is located on 78670-60120 (A11) defibrillator charger board.

NOTE: This adjustment is set at the factory and normally should not require attention. However, if components associated with this circuit are replaced, connect the test equipment as described and adjust if necessary.

3.3.12.1 Equipment Required:

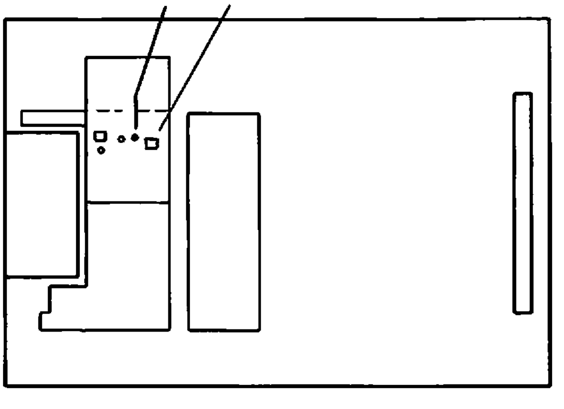
Digital Voltmeter Recommend HP 3466A	Capable of 0.1% accuracy at 140 mV and 5.4 V

3.3.12.2 Procedure:

1. Disconnect power from the defibrillator.

2. Remove the five nuts holding the Low Voltage Power Supply Circuit Board in place; lift it up and in a position to avoid electrical contact with other parts.

3. Connect voltmeter between TP5 and ground. The voltage should be between 5.29 to 5.51V (5.4 + 2%); adjust R132 as necessary.



BOTTOM SECTION

3.3.13 Defibrillator Output Energy Calibration (A10-R72)

Adjust the output energy delivered upon discharge. Adjustment location is on the Defibrillator Control Board 78670-60195 (A10).

3.3.13.1 Equipment Required:

Energy Meter Recommend Dempsey 429/428A,B	Capable of 5 to 400 Joule measurements with critically damped sinusoidal waveform. ± 2% of Full Scale Accuracy Load Resistance 50Ω ± 0.5%

3.3.13.2 Procedure:

1. Set the ENERGY SELECT Control to 100 Joules.

2. Place the paddles in contact with the energy meter contacts, press the CHARGE button and after CHARGE DONE indicator lights press both DISCHARGE switches.

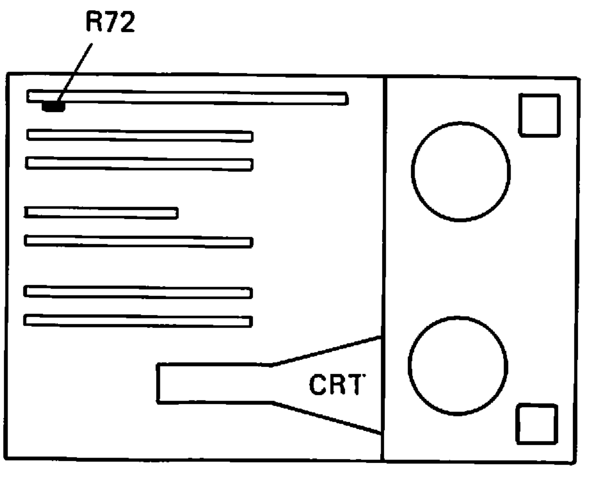
3. Adjust the V adjust, R72, if necessary to obtain proper delivered energy.

4. Set the ENERGY SELECT control to 360 Joules.

5. Charge and discharge the defibrillator into the energy meter and again make adjustments with the V adjust, R72 until the energy delivered matches the energy select switch setting.

6. Check the lower settings to confirm they are meeting specifications of +15% or 4 Joules (whichever is greater).

7. If an adjustment is required, the H.V. charge time adjust and self-test accuracy tests should be performed.



TOP SECTION

3.3.14 High Voltage Charge Time Adjust (A11-R34)

Sets the charging rate of the high voltage defibrillator capacitor. Adjustment located on the Defibrillator Charger Board 78670-60120 (A11).

3.3.14.1 Equipment Required:

Fully charged battery (of known good condition)	HP 78660-60401
OR	
Power Base	Model 78668A (A-C input must be 110 to 120V)
Stopwatch or other timer	

NOTE: Energy Accuracy must be within specification before making this test. Refer to Section 3.3.13, Defibrillator Output Energy Calibration.

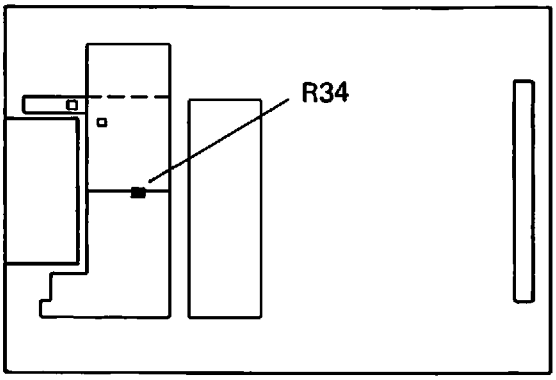
3.3.14.2 Procedure:

1. Set the ENERGY SELECT Control to 360 J.

2. Time the interval between pressing the CHARGE button and when the CHARGE DONE indicator lights.

3. This interval should be as shown below:

ENERGY SETTING	ALLOWABLE CHARGE TIME	
	BATTERY	POWER BASE
360	8-10 sec	6-8 sec



BOTTOM SECTION

4. Adjust R34 to change the charge time. When adjusting, set to a median of the allowable range.

3.3.15 Self Test Accuracy Adjust (A11-R10)

Set the I PEAK adjustment for self test mode accuracy. This also determines the accuracy of the delivered energy printout information on the recorder. The adjustment is located on the Defibrillator Charger C.B. 78670-60120 (A11).

NOTE 1: The Energy Accuracy Calibration Check must be made before this check and adjusted if necessary.

NOTE 2: To avoid overheating of the internal 50 ohm test resistors with consequent inaccuracies of the derived information, do not exceed the equivalent of three 360 Joule discharges/min.

NOTE 3: If the defibrillator has a strip chart recorder, the discharge energy will be printed on the strip chart.

3.3.15.1 Procedure:

1. Place the instrument in the Service Mode (pull the BEEPER VOLUME switch up, turn the instrument off. Turn the instrument on and quickly push the BEEPER VOLUME switch down). The CRT will display a step/ramp deflection.

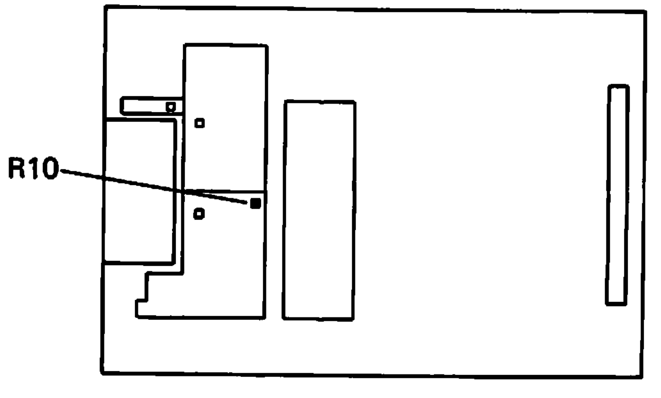
2. Place the paddles in their storage pockets.

3. Set the ENERGY SELECT to 100 Joules. Charge and discharge the defibrillator.

4. Adjust the I PEAK potentiometer R10 to obtain a reading of 100 Joules on the LCD display with successive discharges.

5. Set the ENERGY SELECT to 360 Joules and with further charge/discharge cycles, readjust R10 for a 360 Joule reading on the LCD display.

6. Return ENERGY SELECT to 100 Joule position and recheck the discharge reading. It should read between 90 and 110 Joules.



BOTTOM SECTION

3.3.16 Recorder Pen Heat Adjust

Adjusts the darkness of the chart recording line.

3.3.16.1 Equipment Required:

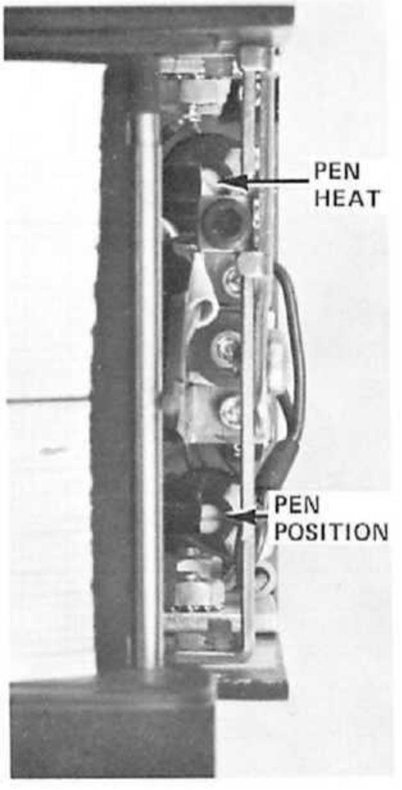
Adjustment tool	HP 78660-27800
OR	
screwdriver	Common type, 0.1 in. blade, blade length 5 in. min.

3.3.16.2 Procedure:

1. Access to the adjustment is along the right (stylus side) of the enclosure near the top. (See below)

2. Adjust for desired writing qualities.

3. The pen heat time is specified for less than 1.5 seconds. After adjusting give 1 minute for the pen to cool, then check for pen heat time. (Best done with some signal applied such as Service Mode.)



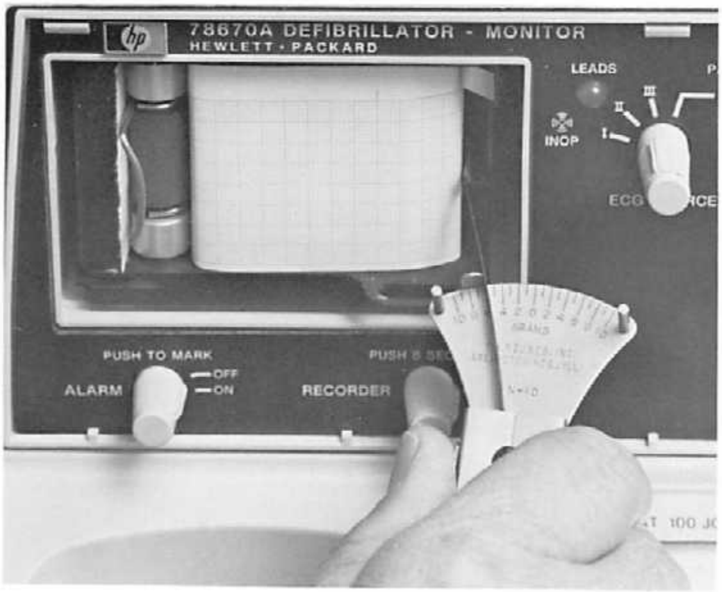
3.3.17 Recorder Stylus Contact Pressure Adjustment

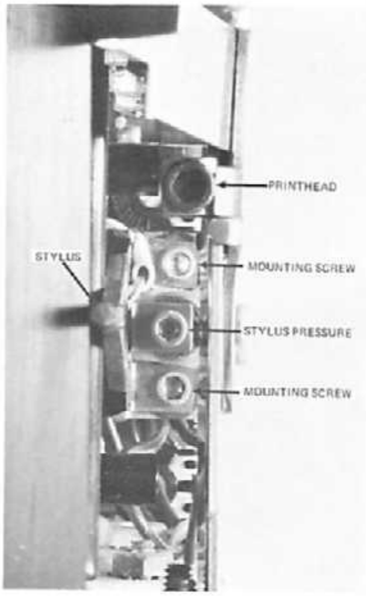
Adjusts the stylus/paper contact pressure.

3.3.17.1 Equipment Required:

Pressure Gauge	HP 8750-0345
5/64" Hex Driver	HP 8710-1196

Slide the pressure gauge under the stylus tip. Move the pressure gauge slowly to the right; when there is a slight gap between the stylus and recorder paper, read the pressure gauge indication.





Correct stylus pressure is 6.0 $\pm$ 2 grams. If necessary, adjust the pressure screw on the stylus plate so that the gauge reading is approximately 6.0 $\pm$ 2 grams.

3.3.18 Recorder Pen Positioning

Adjusts centering of trace with no signal applied.

3.3.18.1 Equipment Needed:

Adjustment tool	HP 78660-27800
OR	
Screwdriver	Common Type, 0.1 in. blade width 5 in. min blade length

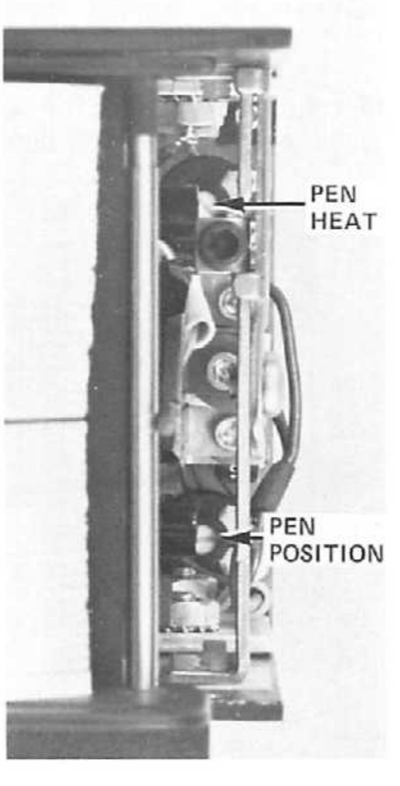
3.3.18.2 Procedure:

1. Access to the adjustment is along the right (stylus side) of the enclosure near the bottom. See Figure below.

2. Switch the ECG SOURCE to LEADS position. Turn ECG SIZE control fully counter clockwise.

3. Observe the stylus position while the Recorder is running.

4. Adjust the pen positioning to the chart center while the recorder is running and the paddles are shorted.



3.3.19 Recorder Print Head Adjustment

The thermal printhead operates by heating resistive elements contained within the ceramic head assembly. It produces square dots.

The thermal dots are positioned approximately .05 inches (1.25 mm) after the forward end of the ceramic substrate. Make an initial adjustment visually by adjusting printhead to place the dots over the paper contact point. This adjustment is usually close enough to produce printing when the recorder is first turned on and reduces the time required for full adjustment.

3.3.19.1 Equipment Required:

Hex driver 3/32"	HP 8710-0523
8-10 x magnifier	useful for examining dot clarity

3.3.19.2 Procedure:

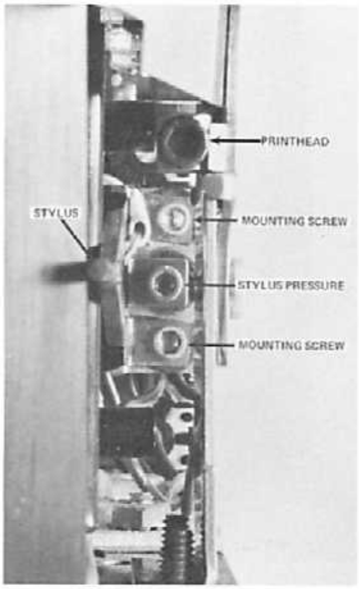
1. Turn the instrument on and press the mark switch. This will cause the recorder to print the time and date.

2. Examine the printout with an 8 to 10x magnifier, for uniformity of dots.

3. If the dots get lighter on the trailing edge, the printhead is too far back and must be moved forward. If the dots are light on the leading edge and get darker at the trailing edge, the printhead is too far forward and must be moved back.

4. Turn the printhead adjustment screw (shown in figure below) clockwise to move the printhead back or counter-clockwise to move it forward. DO NOT turn more than one half to one turn for coarse adjustments or one quarter turn for fine adjustments at a time.

5. Move the printhead in the required direction and obtain another printout. Continue the process until the dots are of uniform density.



3.3.20 Setting Real Time Clock

3.3.20.1 Procedure:

1. Turn BEEPER VOLUME up beyond minimum level. (Knob in inside accessories compartment on top of instrument).

2. Pull BEEPER VOLUME switch up to "Service" position.

3. Turn ENERGY SELECT switch to "OFF" position (power off).

4. Press and hold PUSH TO MARK switch with left hand.

5. Using right hand, turn ENERGY SELECT switch to "monitor" (ON) position and quickly push BEEPER VOLUME switch to the down position when the beeper tone is heard.

6. Don't release the PUSH TO MARK switch until after 5 seconds.

7. After the CRT is warmed up (within 15 seconds) a three digit number should appear on the display.

NOTE: If the unit is not displaying the three digits, turn off the power and repeat steps 2 through 6.

8. The "1" indicates that the unit is in a time set routine and is ready to accept a change of date. The date of the month currently set is displayed as the two digits behind the "1".

NOTE: If the information displayed in this or the following steps (date, month or etc.) is already correct and no change is desired, proceed to the following step by pressing the PUSH TO MARK switch.

9. To change the date; press and hold the RECORDER switch until the date displayed is correct. When it is correct, release the RECORDER switch and press the PUSH TO MARK switch.

NOTE: The first digit will now increment to a "2" indicating that the unit is now ready to accept changes to the month.

10. To change the month, press and hold the RECORDER switch until the numerical equivalent of the correct month is displayed (e.g. "9" will cause the month of September to be set as the correct month, and printed out on the annotating recorder during run cycles).

11. When the correct month is displayed, release the RECORDER switch and press the PUSH TO MARK switch.

NOTE: The first digit will now increment to a "3" indicating that the unit is now ready to accept changes to the hour of the day.

12. To change the hour of the day; press and hold the RECORDER switch until the correct hour is displayed in "24 hour clock format" (e.g. 09 is the equivalent of 9 AM, and 21 is the equivalent of 9 PM).

13. When the correct hour is displayed, release the RECORDER switch and press the PUSH TO MARK switch.

NOTE: The first digit will now increment to a "4" indicating that the unit is now ready to accept changes to the minutes.

14. To change the minutes, press and hold the RECORDER switch until the correct minutes are displayed.

15. When the correct minutes are displayed, release the RECORDER switch and press the PUSH TO MARK switch.

If all changes have been made correctly, the new date/time values are now loaded into the memory of the unit, and can be verified by pressing the PUSH TO MARK switch which will run the recorder and print out the day, date, and time of day as well as a marker ↓ .

NOTE: If the entire process is not followed, i.e., all steps accomplished through the minutes segment, the unit will assume that the date/time setting sequence is aborted and revert to the day, date, time stored in memory prior to entering the date/time setting routine.

16. Turn unit OFF to get out of the time set mode.

3.4 SPECIFICATION CHECKS

3.4.1 ECG Amplifier/Heart Rate Section

3.4.1.1 Test Equipment.

Required test equipment for performing ECG Amplifier/Heart Rate specification checks are listed in Table 3-4.

TABLE 3-4

TEST EQUIPMENT REQUIREMENTS FOR ECG AMPLIFIER/HEART RATE SPECIFICATION CHECKS

REQUIREMENT	NECESSARY QUALIFICATIONS
FUNCTION GENERATOR Recommend: HP 3310A/B	Output level: 30 V pp Open Circuit Frequency Range: 0.25 to 60 Hz. Frequency Response: 1% (sine wave) Output Waveforms: Sine, Square
OSCILLOSCOPE Recommend: HP 1741A or HP 181A with 1801A and 1820C plug-ins	Display: Storage/Variable Persistence Bandwidth: d-c to 10 MHz. Vert. Deflection Range: 20 mV to 10 V/div Storage Write Speed: 5 cm/μ sec minimum Mode: 2 Channel, chopped
D-C POWER SUPPLY Recommend: HP 6214 or HP 6224B	Output: 10 V, regulated; 15 MA.
ECG GENERATOR/CALIBRATOR Recommend: Parke-Davis 3175	Output Level: 1 mV Range: 60 and 120 BPM calibrated outputs
DIGITAL VOLTMETER Recommend: HP 3466A	Capable of 300 mV DC + 1% measurements
TEST CABLES/COMPONENTS Recommend:	
(1) HP 11086A	BNC-BNC Cable
(2) HP 10501	BNC-Clipleads Cable (Alligator Clips must be added---4 required).
(1) HP 0757-0465	100 K ±1% Resistor.
(1) HP 0757-0401	100 Ω ±1% Resistor.
(3) HP 0698-3159	26 K Resistor.
(1) HP 0757-1094	1.5 K Resistor.
(1) HP 0160-3552	1 uF Capacitor.
(1) HP 0757-0438	5 K Resistor.
(2) HP 0757-0442	10 K Resistor.
(1) HP 8120-3164	Signal Cable, ECG Output
(1) HP 1251-7127	Coaxial Adaptor, BNC to Phone Jack
(1) HP 14489B	Patient Cable
(1) HP 14151A	Electrode Lead Set
(1) HP 14445A	ECG Electrodes
(1) HP 0160-4511	220 pF Capacitor.
(1) Hp 0698-5552	1 K Resistor.
(1) HP 0698-6366	800 Ω Resistor.

3.4.1.2 ECG Amplifier Gain - Manual Control.

This check verifies that the gain range of the ECG amplifier is adjustable from 250 to 3600. If this check fails, refer to the ECG troubleshooting information in Section V. Perform the check as follows:

1. Connect the test equipment as shown in Figure 3-12A.

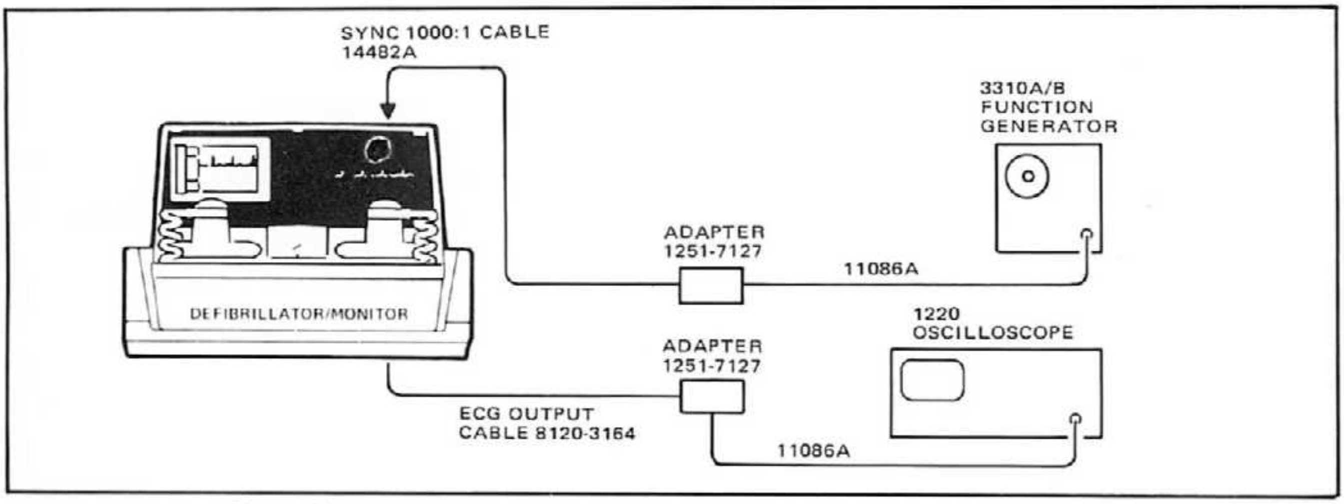


Figure 3-12A. ECG Amplifier Gain and Frequency Response Test Setup.

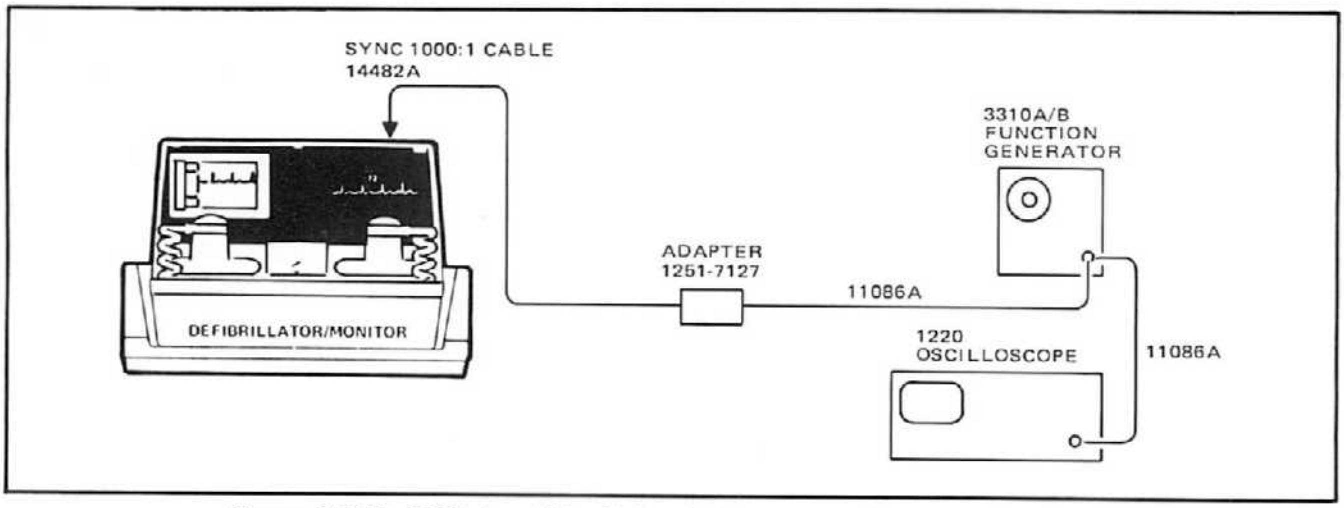


Figure 3-12B. ECG Amplifier Gain and Frequency Response Test Setup.

2. Set the defibrillator controls as follows:

   (a) ECG SOURCE Control - LEADS I position.
   (b) ECG SIZE Control - Fully clockwise, but not past the "AUTO" detent.
   (c) INTENSITY Accessory Compartment - To obtain adequate viewing level.

3. Adjust the test equipment as follows:

   (a) Function Generator
       Frequency - 5 Hz.
       Function - Sine Wave

Output Level - 1 V p-p (measure with the oscilloscope at the output of the function generator while the function generator is connected to the 1000:1 divider circuit. Then reconnect the oscilloscope as shown in Figure 3-12A.

(b) Oscilloscope Channel A
Vertical Sensitivity - 1 V/cm
Time Base - 50 ms/cm

4. A setting of the ECG SIZE control to the full clockwise position should provide an overall gain of at least 3600. The 1 mV sine wave signal at the input of the defibrillator should produce greater than 3.6 V p-p when measured on the 1V ECG output connector of the defibrillator.

5. Rotate the ECG SIZE control to the full counterclockwise position, noting whether smooth change of amplitude occurs on the oscilloscope.

6. Change the oscilloscope vertical sensitivity to 0.05 V/cm. Observe the sine wave display on the oscilloscope. The signal amplitude should be 250 mV p-p or less.

3.4.1.3 ECG Amplifier Gain - Auto Mode

1. Connect the test equipment as shown in Figure 3-12A.

2. Set the defibrillator ECG SIZE control to the AUTO position, ECG SOURCE to LEADS I position.

3. Adjust the test equipment as follows:

(a) Function Generator
Frequency - 5 Hz.
Function - Sine Wave
Output Level - 0.5V p-p (measure with the oscilloscope at the output of the function generator while the function generator is connected to the 1000:1 divider circuit. Then reconnect the oscilloscope as shown in Figure 3-12.

(b) Oscilloscope
Vertical Sensitivity - 0.1 V/cm at start
Time Base - 50 ms/cm

4. Connect Channel B of the oscilloscope to the function generator (Determine that the channel A and B deflections are equal).

5. Start with a function generator output of 0.5 V pp (0.5 mV ECG input). Confirm that the CRT display or recorder shows between 0.8 and 1.6 cm amplitude sine wave.

6. Increase the function generator amplitude slowly and watch the display go through four discrete gain changes (5 stages including the starting stage). Keep increasing amplitude until the display just goes over 3.2 cm pp. Input should now be 5.1 V ±20% on the function generator (5.1 mV ±20% at ECG Input).

7. Decrease amplitude slowly and watch the display go back through four discrete gain changes.

NOTE: It takes 2 seconds for the AUTO GAIN circuitry to respond to a decrease in signal level.

8. Continue decreasing amplitude until the display is just below 1.6 cm p-p for 2 seconds. Function generator input should now be 0.64 V p-p ±20%.

3.4.1.4 Baseline Offset - ECG Lead Input

1. Connect the test equipment as shown in Figure 3-13.

2. Place the ECG source switch in LEADS I position.

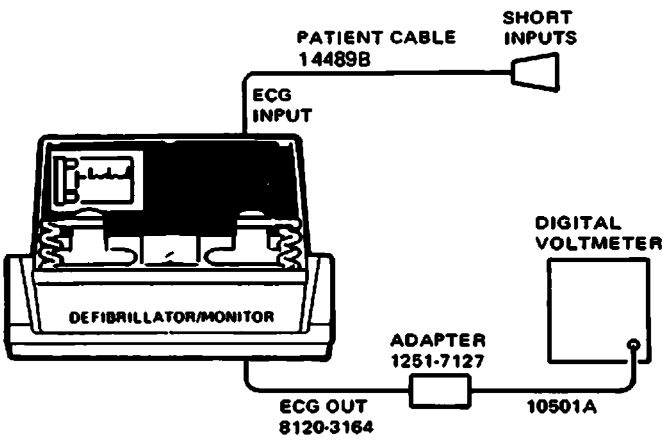


Figure 3-13. ECG Amplifier Baseline Offset (Leads).

3. Turn the ECG SIZE control from MIN to MAX position while observing the digital voltmeter.

4. The voltmeter should not change more than 300 mV (<Δ300mV) from MIN to MAX gain with all three input leads shorted together.

3.4.1.5 Baseline Offset - Paddles Input

Perform the check as follows:

1. Remove the cable from the ECG input connector and connect the test equipment as shown in Figure 3-14.

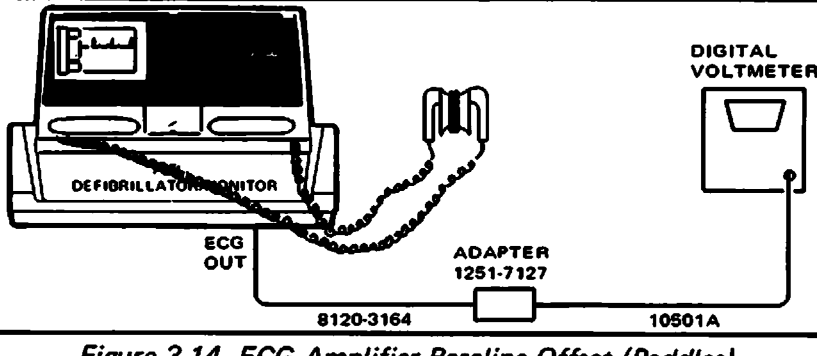


Figure 3-14. ECG Amplifier Baseline Offset (Paddles).

2. Switch the ECG source switch to the PADDLES position.

3. With the paddles pressed firmly together, vary the ECG SIZE control from MIN to MAX. The reading on the DVM should not vary more than 300 millivolts.

3.4.1.6 ECG Amplifier Frequency Response, Leads Input

Perform the check as follows:

1. Connect the test equipment as shown in Figure 3-12A.

2. Adjust the test equipment as follows:

(a) Function Generator
Frequency - 5 Hz.
Function - Sine Wave
Output Level - 1V p-p

(b) Oscilloscope
Vertical Sensitivity - 0.2 V/cm
Time Base - 50 ms/cm

3. Set the ECG SOURCE Switch to LEADS I position.

4. Set the ECG SIZE control to obtain a 5 cm deflection on the oscilloscope (1 V p-p). The defibrillator CRT display should have 1 cm deflection, if not, refer to the Adjustment part of this section, and adjust accordingly. Use a short length of chart paper for measurement.

5. Change the function generator to 0.5 Hz.

6. Observe the oscilloscope for a minimum deflection of 3.5 cm. (3dB down). The CRT display should not be less than 0.7 cm.

7. Slowly increase the function generator frequency to 40 Hz while observing the peak-to-peak deflection on the oscilloscope and the CRT display. The deflection should remain greater than 3.5 cm on the oscilloscope and 0.7 cm on the CRT display.

NOTE: If the defibrillator is equipped with a recorder, refer to 3.4.2. for recorder frequency response tests (since the test set-up is the same).

3.4.1.7 ECG Amplifier Frequency Response Check - Paddle Input

1. Switch the ECG SOURCE to PADDLES.

2. Connect the test equipment as shown in Figure 3-15.

3. Adjust the test equipment as follows:

(a) Function Generator
Frequency - 5 Hz.
Function - Sine Wave
Output Level - 1 V p-p

(b) Oscilloscope
Vertical Sensitivity - 0.2 V/cm
Time Base - 50 ms/cm

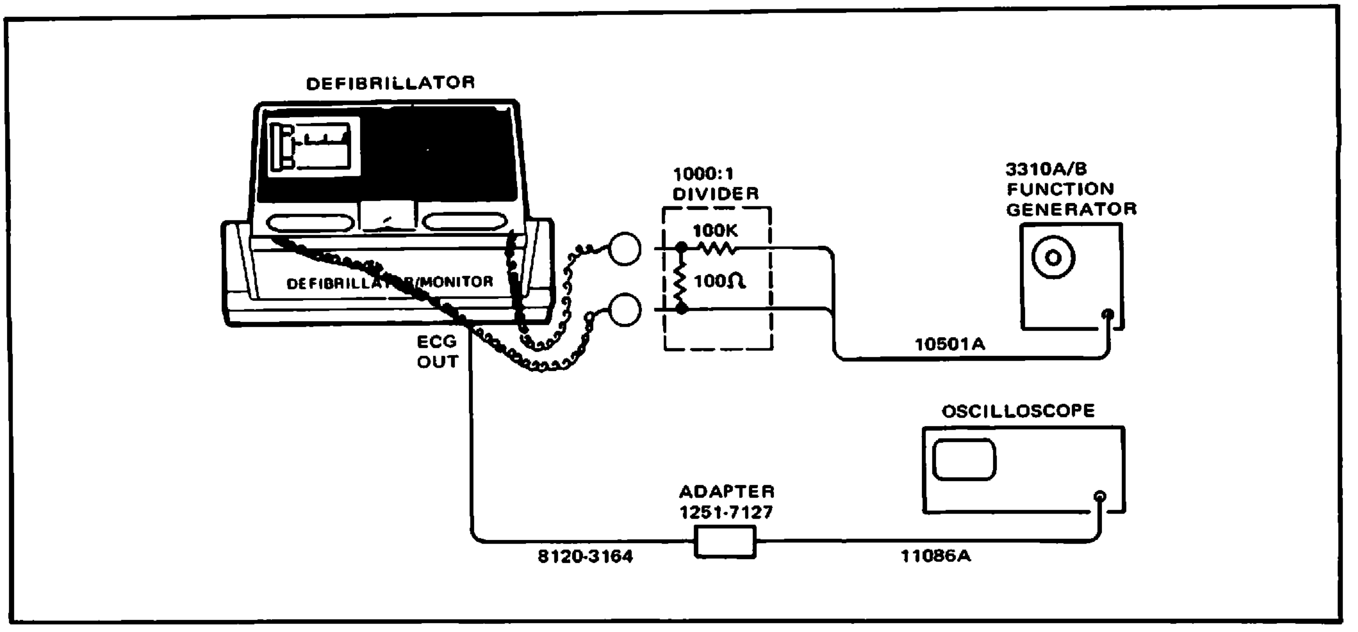


Figure 3-15. ECG Amplifier Frequency Response Setup (Paddles).

4. Perform steps 3 through 6 of 3.4.1.6.

3.4.1.8 Input Offset Tolerance (DC) - ECG LEAD INPUT.

1. Connect the test equipment as shown in Figure 3-16.

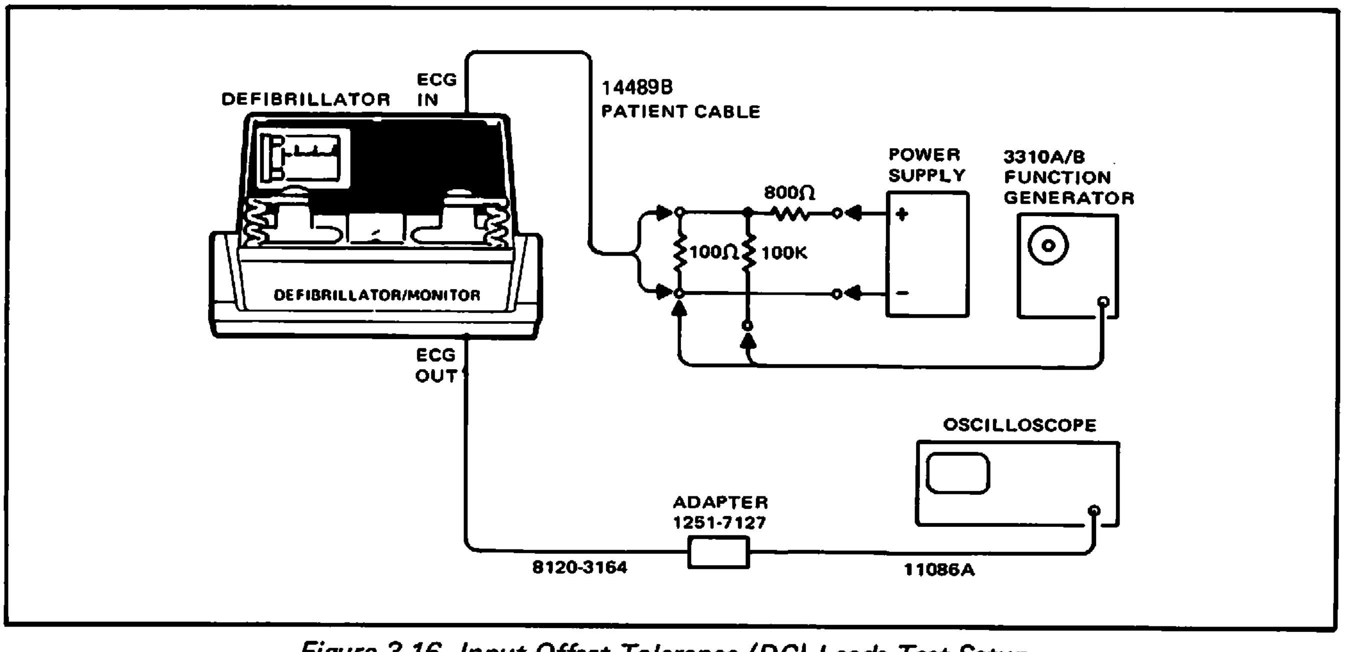


Figure 3-16. Input Offset Tolerance (DC) Leads Test Setup.

2. Adjust the test equipment as follows:

(a) Function Generator
Frequency - 5 Hz.
Function - Sine Wave
Output Level - 1 V p-p measured using oscilloscope

(b) Power Supply
Output Level - 10.0 volts measured using an oscilloscope.

(c) Oscilloscope
Time Base - 50 ms/cm
Vertical Sensitivity - As necessary for set-up
0.2 V/cm for measurement

3. With the power supply connected but turned off, adjust the defibrillator ECG SIZE control for a 1 cm p-p waveform on the defibrillator display.

4. Turn the power supply on. After approximately 10 seconds, the sine wave viewed on the oscilloscope should show no evidence of clipping and the amplitude should not be reduced by more than 20%.

5. Reverse the polarity of power supply inputs to the test circuit (negative to the 800 Ω resistor, positive to bottom of the 100 Ω resistor).

6. The sine wave viewed on the oscilloscope should conform to step 4 above.

3.4.1.9 Input Offset Tolerance (DC) - Paddle input

1. Connect the test equipment as shown in Figure 3-16. Instead of connecting to the ECG INPUT, connect to the paddles as shown in Figure 3-15.

2. Adjust the test equipment as follows:

(a) Function Generator
Frequency - 5 Hz.
Function - Sine Wave
Output Level - 1 V p-p measured using oscilloscope

(b) Power Supply
Output Level - 10.0 volts measured using an oscilloscope

3. With the positive terminal connected but turned off, adjust the defibrillator ECG SIZE control for a 1 centimeter p-p waveform on the defibrillator display.

4. Turn the power supply on. The sine wave viewed on the oscilloscope should conform to 3.4.1.8, step 4.

5. Reverse the polarity of the power supply inputs to the test circuit (negative to the 800 Ω resistor, positive to bottom of the 100 Ω resistor.

6. The sine wave viewed on the oscilloscope should conform to 3.4.1.8, step 4-5.

3.4.1.10 ECG Amplifier Noise, Leads Input

This procedure checks the maximum allowable ECG Amplifier noise referred to the input. First the ECG Amplifier Gain is set at 4000 as follows:

1. Connect the test equipment as shown in Figure 3-12A.

2. Adjust the test equipment as follows:

   (a) Function Generator
   Frequency - 5 Hz.
   Function - Sine Wave
   Output Level - 1 V p-p (measure with the oscilloscope at the output of the function generator while the function generator is connected to the 1000:1 divider circuit. Then reconnect the oscilloscope as shown in Figure 3-12A.

   (b) Oscilloscope Channel A
   Vertical Sensitivity - 1 V/cm
   Time Base - 50 ms/cm

3. Adjust the ECG SIZE control for 4 V on the oscilloscope (ECG Source switch LEADS I position).

NOTE: For the remainder of the tests do not change the ECG SIZE control setting. If unable to get 4000 gain at maximum setting, set to a known lower value and reduce allowable noise levels proportionly.

4. Connect the equipment as shown in Figure 3-17.

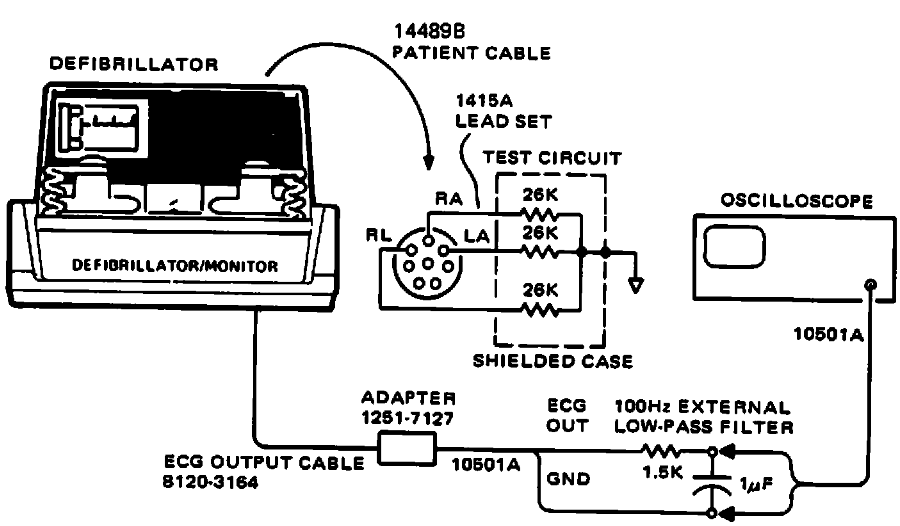


Figure 3-17. ECG Amplifier Noise, Leads Input Test Setup.

5. Set the oscilloscope controls as follows:

(a)	Vertical Sensitivity	.05 V/div
(b)	Time Base	0.5 sec/div
(c)	Triggering	Free Run
(d)	Mode	Storage

6. Use the store function of the oscilloscope and adjust the controls to allow reading peak to peak excursions without blooming of the trace.

7. The peak to peak noise on the oscilloscope should not exceed 113 mV which corresponds to 10 Vrms referred to the input at the ECG gain of 4000.

NOTE: The monitor ECG NOISE specification calls for a 12 dB per octave external filter to simulate the response of an external chart recorder connected to the ECG output of the monitor. The filter used here is a 6 dB per octave filter which will yield a slightly higher noise level because of the slower frequency rolloff, and is hence a more conservative verification of the noise specification as well as being easier to construct.

3.4.1.11 ECG Amplifier Noise, Paddles Input

This procedure checks the maximum allowable ECG amplifier noise referred to the input using paddles connection as SOURCE.

1. If not already done, set the ECG Amplifier Gain as in 3.4.1.10, steps 2 and 3.

2. Connect the equipment as shown in Figure 3-18. Put ECG source to paddles.

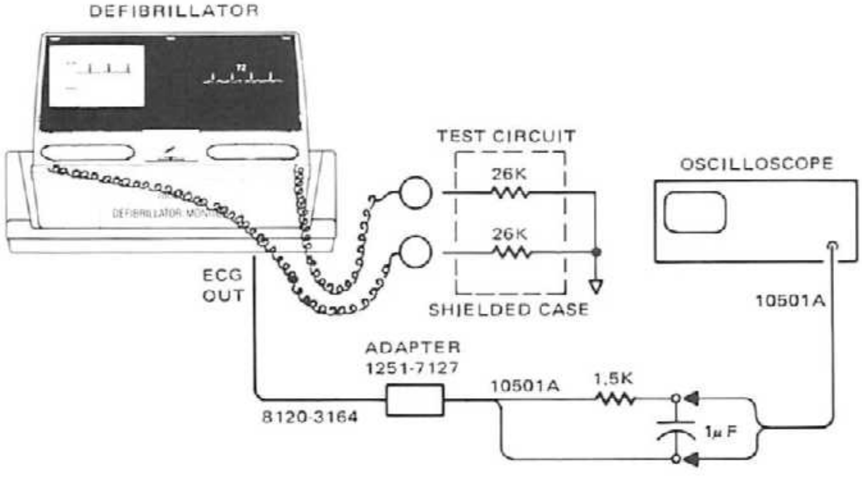


Figure 3-18. ECG Amplifier Noise, Paddle Input Test Setup.

3. Follow the same procedure as with LEADS source in steps 5,6 and 7. The paddles SOURCE and leads SOURCE noise specification are the same.

3.4.1.12 ECG Calibration Check

1. Determine the exact gain of the highest auto gain stage. This is done by applying a very small known ECG signal input and measuring the output. (With small or no signal present the auto gain is automatically set at maximum).

2. Connect the equipment as shown in Figure 3-12A.

3. Carefully set the function generator at 0.5 V pp, 5 Hz as measured on a calibrated oscilloscope. This puts 0.5 mV p-p to the ECG input. Call this V1.

4. Measure the 1V ECG output. Call this V2, which will be approximately 1.25 V p-p.

5. The auto gain will be G = V2/V1.

6. Now set the oscilloscope controls:

(a)	Vertical sensitivity	0.5 V/div
(b)	Time Base	1 sec/div
(c)	Positioning	On graticle line at bottom of screen
(d)	Triggering	Free run
(e)	Mode	Storage

7. As the trace moves across the CRT screen, press the CAL button. Call the leading edge deflection voltage V3. Calculate the calibration amplitude thus:

Cal Amplitude = V3/G

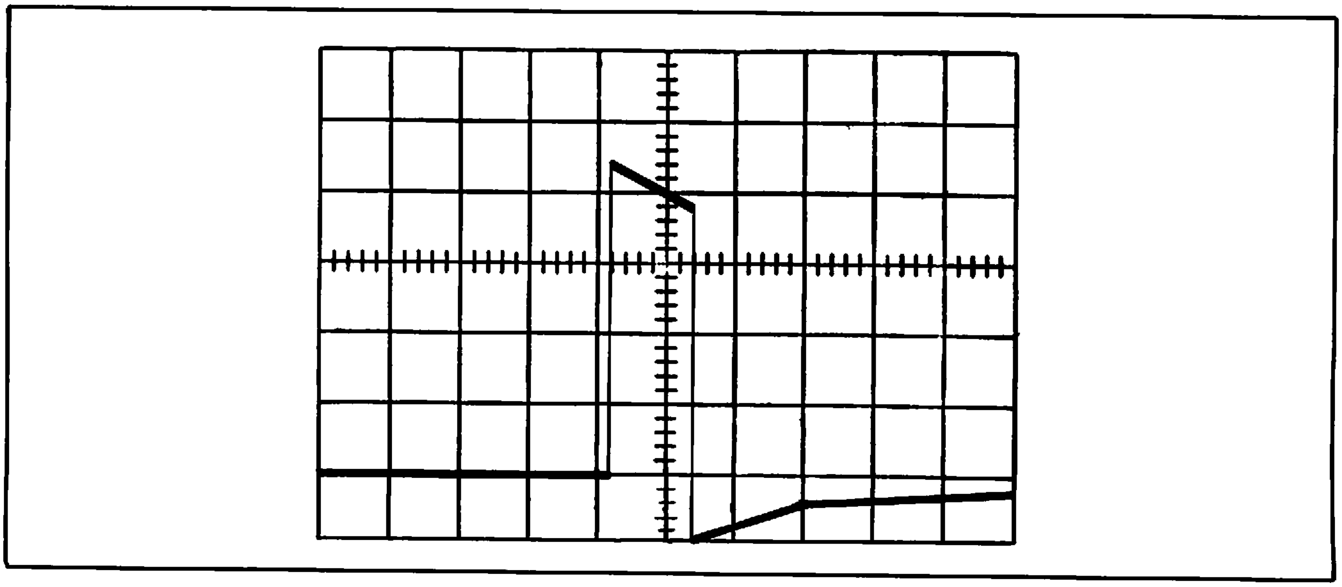


Figure 3-19. Calibration Step Waveform.

8. The CAL step amplitude should be 0.975 to 1.025 mV. Refer to Section 3.3.6 for adjustment procedure.

3.4.1.13 Common Mode Rejection (CMR) Leads Source

This procedure verifies that the monitor will provide 112 dB of common mode rejection of unwanted interference signals with the internal 50/60 Hz NOTCH FILTER and 100 dB with the NOTCH FILTER switched out. This with up to 5 KΩ of electrode impedance imbalance and using the ECG LEADS source (LEADS I position).

1. Connect the equipment as shown in Figure 3-12.

2. Set the function generator controls as follows:

   (a) Frequency — 5 Hz

   (b) Output Level — 1 V p-p

   (c) Function — Sine Wave

3. Set the oscilloscope controls as follows:

   (a) Vertical Sensitivity — 1V/div

   (b) Time Base — 50 ms/div

4. Adjust the defibrillator ECG SIZE control for 4 V p-p on the oscilloscope (4000 gain). Leave this ECG Gain setting for the remainder of the test.

5. Connect the equipment as shown in Figure 3-20, connecting the function generator ground to the defibrillator ground jack (at rear).

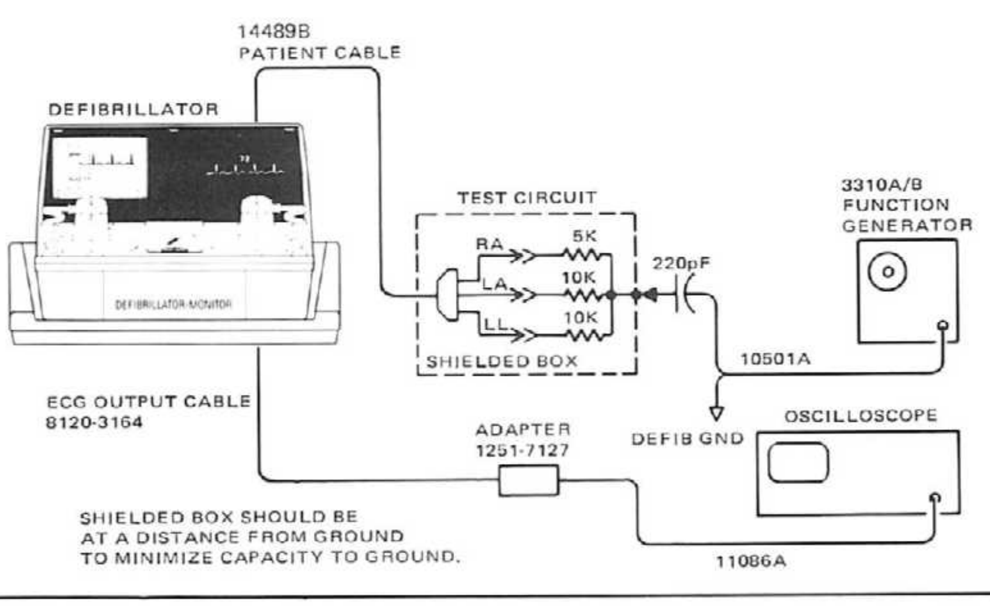


Figure 3-20. Common Mode Rejection Test Setup (Leads).

6. Set the function generator controls as follows:

   (1) Frequency 60 Hz (50 Hz if this is the power line frequency and the Notch Filter is set accordingly)

   (2) Output Level 30 V p-p

   (3) Function Sine Wave

7. Set the oscilloscope controls as follows:

   (a) Vertical Sensitivity 0.1 V/div

   (b) Time Base 0.5 sec/div

   (c) Triggering Line or Free Run

8. With the NOTCH FILTER switched IN, the oscilloscope reading should not exceed 0.30/V p-p (-112 dB). With the NOTCH FILTER switched OUT, the reading should not exceed 1.2 V p-p (-100 dB). Recheck with the RA and LA connections reversed. See Section 3.3.11 for NOTCH FILTER switch location and selection instructions.

NOTE 1: Use the STORE function of the oscilloscope. Adjust controls to allow reading of the peak to peak excursions without blooming of the trace.

NOTE 2: The NOTCH FILTER switched OUT position can be simulated by using 40 Hz as a common mode frequency since the FILTER is ineffective at that frequency.

3.4.1.14 Common Mode Rejection (CMR), Paddles Source

This procedure verifies that the monitor will provide 104 dB of common mode rejection of unwanted interference signals with the internal 50/60 Hz NOTCH FILTER and 84 dB with the NOTCH FILTER switched OUT. This is with up to 1 KΩ of imbalance between paddle connections.

1. Set the ECG Amplifier Gain to 4000 as covered in 3.4.1.13, steps 2-4 (ECG SOURCE in Paddles Position).

2. Connect the equipment as shown in Figure 3-21 and set the controls as in 3.4.1.13, steps 6 and 7, except set the oscilloscope vertical sensitivity for desired viewing amplitude.

3. With the NOTCH FILTER switched IN the reading should not exceed 0.76 V p-p (104dB). With the NOTCH FILTER switched OUT the reading should not exceed 7.57 V p-p (84dB). Recheck the paddle connections reversed.

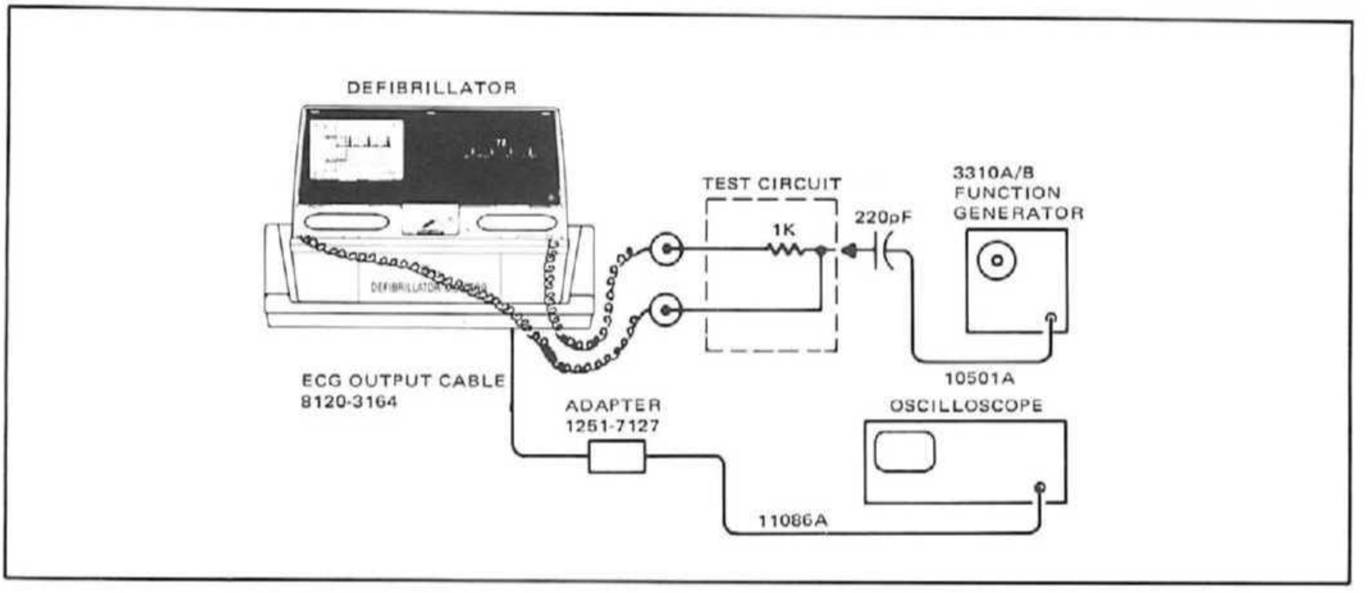


Figure 3-21. Common Mode Rejection Test Setup (Paddles).

3.4.1.15 Heart Rate Accuracy

1. Connect the test equipment as shown in Figure 3-22.

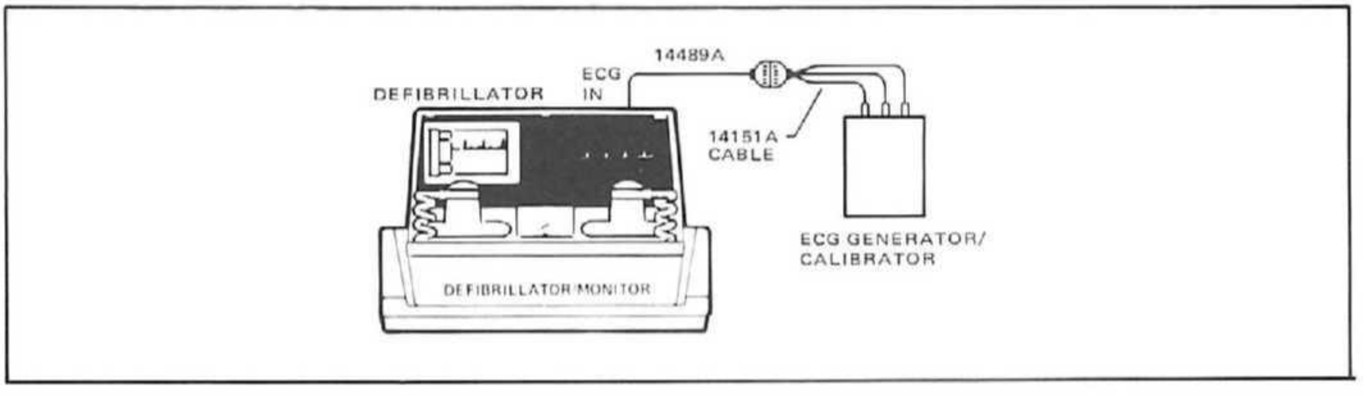


Figure 3-22. Heart Rate Accuracy Test Setup.

2. Turn the defibrillator ON, ECG SOURCE to LEADS I position.

3. Turn the ECG generator ON and adjust the defibrillator ECG SIZE control to display 1 cm R-wave deflection on the monitor.

4. Check the heart rate digital display in the calibrated 60 BPM and 120 BPM switch positions of the ECG Generator. The heart rate accuracy specification is ± 5% or 2 BPM (whichever is greater).

3.4.1.16 Heart Rate Alarm Limits

1. Connect the test equipment as shown in Figure 3-12.

2. Put the function generator on square wave. Adjust for 1V p-p output at 0.5 Hz. Adjust the ECG SIZE control for reliable counting. The circuit counts both positive and negative going excursions of the square wave, therefore the heart rate count will be:

Heart rate = frequency setting x 60 x 2 = 60 BPM

3. Turn the ALARM switch ON. Vary the frequency between 30 BPM (0.25 Hz) and 150 BPM (1.25 Hz) the alarm should not sound. Vary the frequency slightly below 0.25 Hz so that the heart rate digits drop below 30. The alarm should sound and the recorder should run. Likewise when the heart rate indication exceeds 150 BPM, the alarm sounds and the recorder starts.

4. Check the alarm delay time from the time the heart rate changes until the alarm sounds. This should be 3-8 seconds depending on the heart rate average.

3.4.2 Recorder Section

3.4.2.1 Test Equipment Requirements

Test equipment, for performing recorder specification checks, is listed in Table 3-5.

TABLE 3-5

TEST EQUIPMENT REQUIREMENTS FOR RECORDER SPECIFICATION CHECKS

REQUIREMENT	NECESSARY QUALIFICATIONS
FUNCTION GENERATOR Recommend HP 3310A/B	Output Level: 30 V pp Open Circuit Frequency Range: 0.25 to 60 Hz Frequency Response: 1% (sine wave) Output Waveforms: Sine, Square
OSCILLOSCOPE Recommend: HP 1741A or HP 181A with 1801A and 1820C plug-ins	Display: Storage/Variable Persistence Bandwidth: dc to 10 MHz Vert. Deflection Range: 20 mV to 10 V/div Storage Write Speed: 5 cm/μ sec minimum
ECG GENERATOR/CALIBRATOR Recommend: Parke-Davis 3175	Output Level: 1 mV Range: 60 and 120 BPM calibrated outputs
TEST CABLES/COMPONENTS Recommend:	
(2) HP 11086A	BNC-BNC Cable
(2) HP 10501	BNC-Clipleads Cable (Alligator Clips must be added----4 required).
(1) HP 14482A	Sync Cable (1000:1)
(1) HP 8120-3164	Signal Cable, ECG Output
(2) HP 1251-7127	Coaxial Adaptor, BNC to Phone Jack
(2) HP 14489B	ECG Cable
(1) HP 14151A	Electrode Lead Set

3.4.2.2 Recorder Frequency Response

Perform the check as follows:

1. Connect the test equipment as shown in Figure 3-12A.

2. Adjust the test equipment as follows:

(a) Function Generator
Frequency - 5 Hz
Function - Sine Wave
Output Level - 1 V p-p

(b) Oscilloscope
Vertical Sensitivity - 0.2 V/cm
Time Base - 50 ms/cm

3. Set the ECG SIZE control to obtain a 5 cm. deflection on the oscilloscope (1 V p-p). Turn the Recorder ON to RUN. Measure the peak to peak excursion of the sine waves. This should be about 10 mm. If not, consult the Troubleshooting Secton.

4. Change the function generator to 0.5 Hz. Again run a short strip of paper. The minimum allowable deflection is 70.7% of the 5 Hz reference value.

5. Change the function generator to 1 Hz. Run the recorder. Slowly increase the frequency to 20 Hz. The deflection amplitude should remain between 90 and 110% of the 5 Hz reference value.

6. Run the recorder while increasing the frequency from 20 Hz to 40 Hz. The deflection amplitude should remain between 70 and 110% of the 5 Hz reference value.

3.4.2.3 Recorder Gain Accuracy, Linearity, and Overshoot

1. Place the unit in the Service Mode as follows:

(a) Turn the unit OFF. Pull up on the BEEPER volume control under accessory door.

(b) Turn the unit ON and quickly push down on the BEEPER volume control.

(c) The unit should then display a test pattern on the CRT display, the Recorder, and the 1 V ECG V output as shown in Figure 3-23.

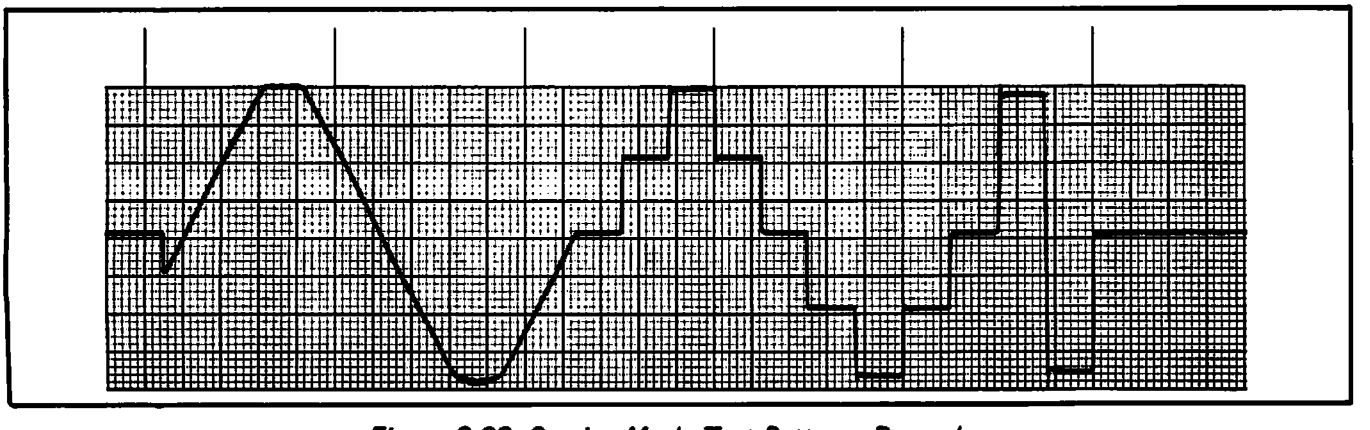


Figure 3-23. Service Mode Test Pattern, Recorder.

2. The test pattern includes a series of exact 1 V steps in the positive direction then the negative direction followed by a positive 2 V step then a negative 2 V step.

3. The Gain Accuracy is specified as ±5% at 10 mm therefore the positive and negative 1 V step should produce 10 mm ± 0.5 mm (at 25 degrees C).

4. Linearity specification is ±1% of full scale. Full scale is considered to be 40 mm, therefore 0.4 mm is the maximum deviation allowable on any of the steps of the test pattern.

5. Carefully examine all of the test steps for overshoot. Maximum overshoot allowed is 10% on any step.

3.4.2.4 Recorder Chart Speed

Perform the check as follows:

1. Connect the test equipment as shown in Figure 3-12, except delete the oscilloscope connections.

2. Set the function generator exactly on 1 Hz square wave.

3. Run the recorder and adjust the ECG SIZE control for a viewable trace.

4. There should be one square wave cycle per major division (25 mm) on the chart. Allowable deviation is ±5% (23.75 to 26.25 mm).

3.4.3 Defibrillator Section

3.4.3.1 Test Equipment.

Test equipment required for performing defibrillator specification checks is listed in Table 3-6.

TABLE 3-6

TEST EQUIPMENT REQUIREMENTS FOR DEFIBRILLATOR SPECIFICATION CHECKS

REQUIREMENTS	NECESSARY QUALIFICATIONS
OSCILLOSCOPE Recommend: HP 1741A or HP 181A with 1801A and 1820C plug-ins	Display: Storage/Variable Persistence Bandwidth: dc to 10 MHz Vert. Deflection Range: 50 mV to 1 V/div Storage Write Speed: 5 cm/μsec minimum
ENERGY METER Recommend: Dempsey Model 429	Capable of 5 to 400 Joule damped sinusoidal Waveform measurements with ±2% of full scale accuracy. Load Resistance 50 Ω ±1/2%
STOPWATCH OR TIMER	Capable of measuring 2 to 12 second events with hand start/stop actuation to 1/4 sec. accuracy

3.4.3.2 Energy Accuracy.

1. Connect the equipment as shown in Figure 3-24.

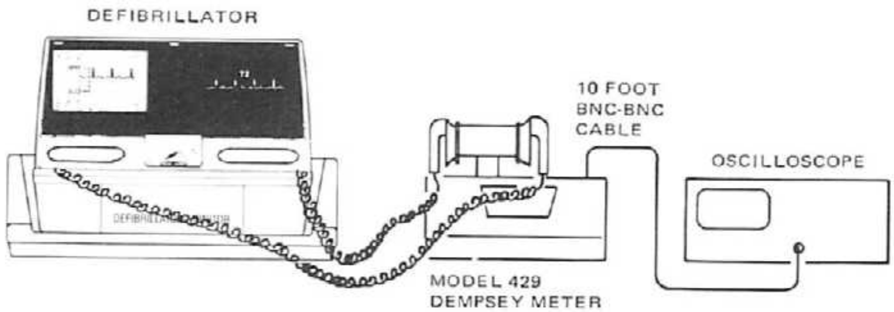


Figure 3-24. Energy Accuracy Test Setup.

2. Set the oscilloscope as follows:

Channel Selector	- Channel A
Sweep Mode to	- Single
Trigger to	- INT
Trigger Slope	- +
Time/Division	- 1 ms/div
Vertical Sensitivity	- 0.5 volt/division or as appropriate
Press Trigger Reset While	- charging

3. Set the ENERGY SELECT control to each of the positions indicated in the table below, press the CHARGE button and allow the unit to charge. The CHARGE DONE LED will light at the end of each charge cycle. Firmly press the paddles to the energy meter and press both DISCHARGE buttons simultaneously. Record the energy level measured.

4. If the unit is equipped with an Annotating Recorder (78670A), refer to the printed information for conformance to the delivered energy waveform information.

5. Record the peak voltage amplitudes of the damped sinusoidal waveform for later calculation of Current Amplitudes (see section 3.4.3.3., step 3).

NOTE: The 78670A and 78671A should be operated on battery only when performing this test. If the power base is used, multiple ground paths through power line cords can produce some misleading waveforms.

Energy Select Setting	Delivered Energy Joules Meter	Energy Select Setting	Delivered Energy Joules Meter
5	5 ± 4	70	70 ± 10.5
10	10 ± 4	100	100 ± 15
20	20 ± 4	150	150 ± 22.5
30	30 ± 4.5	200	200 ± 30
50	50 ± 7.5	300	300 ± 45
		360	360 ± 54

3.4.3.3 Delivered Energy Waveform Information (Recorder Printout)

1. If the recorder printout was not taken at the same time as steps 3.4.3.2, Energy Accuracy, repeat steps 3.4.3.2, noting delivered energy on the energy meter and the recorder printout information.

2. Compare the delivered energy as read on the energy meter against delivered energy printed on the recorder chart. The printed data should be within 15% or 5 Joules (whichever is greater) of the actual energy displayed on the energy meter.

3. The energy meter acts as a 1000:1 voltage divider and outputs this signal to the oscilloscope. Using this voltage and the 50 Ω impedance of the energy meter, the peak current can be calculated thus:

$$I \text{ peak} = \frac{\text{Energy meter output voltage X1000}}{50}$$

Calculate these current values and compare with the printed current values. The printed data should be within 8% or 2 amps (whichever is greater) of the calculated values.

4. If the printed current values are not within specifications, it will be necessary to first perform the defibrillator output energy calibration (Section 3.3.13), setting the energy output as close to the set energy (5% or less) as possible; then perform the self test accuracy adjustment (Section 3.3.15).

5. Compare the calculated current peak at 360 Joules with the specification value. It should be 57 to 64 amps for 360 Joules.

3.4.3.4 Self Testing Accuracy

1. Place the unit in the Service Mode as follows:

(a) Turn the unit OFF. Pull up on the BEEPER Volume control knob under accessory door.

(b) Turn the unit ON and quickly push down on the BEEPER Volume control

(c) The unit should then display a test pattern on the CRT display.

2. Make sure the paddles and the paddle contacts in the storage pockets are clean and free of contaminants. This is to assure good electrical contact, and avoid paddle surface damage on discharge.

3. Place the paddles firmly in their storage positions.

4. Put the ENERGY SELECT switch in the 100 Joule position. Charge and discharge the unit.

5. The LCD display should flash the test discharge energy of 90-110 Joules and if the unit is equipped with an Annotating Recorder (78670A) it should print out the test energy.

6. Place the ENERGY SELECT switch in the 360 Joule energy position. Charge and discharge the unit. The LCD should display 324-396 Joules.

3.4.3.5 Defibrillator Capacitor Charge Time

1. Install a fully charged battery of known good condition or connect the defibrillator to a Model 78668A Power Base. The A-C line voltage to the Power Base must be 110 to 120 volts.

2. Use a stop watch or similar device to measure the time from pressing the CHARGE button until the unit's CHARGE DONE light comes on.

3. The table below notes the allowable charging times:

ENERGY SETTING	ALLOWABLE CHARGE TIME BATTERY	POWER BASE
360	8-10 sec	6-8 sec

4. If the allowable charging time is exceeded, refer to Section 3.3.14 for adjustment procedure.

3.4.4 Synchronizer Section

3.4.4.1 Test Equipment.

Test equipment required to perform the specification checks on the synchronizer is listed in Table 3-7.

TABLE 3-7

TEST EQUIPMENT REQUIREMENTS FOR SYNCHRONIZER SPECIFICATION CHECKS

REQUIREMENT	NECESSARY QUALIFICATIONS
OSCILLOSCOPE Recommend: HP 1741A or HP 181A with 1801A and 1820C plug-ins	Display: Storage/Variable Persistence Bandwidth: dc to 10 MHz Vert. Deflection Range: 0.5V to 2 V/div Storage Write Speed: 5 cm/μ sec min. Mode: 2 channel, chopped
ECG GENERATOR/CALIBRATOR Recommend: Parke-Davis 3175	Output Level: 1 mV Range: 60 and 120 BPM calibrated outputs
ENERGY METER Recommend: Dempsey Model 429	Capable of 5 to 400 Joule damped sinuousoidal Waveform measurements with ± 2% of full scale accuracy. Load Resistance 50 ohm ± 1/2%
TEST CABLES/COMPONENTS Recommend: (2) HP 11086A (1) HP 8120-3164 (1) HP 1251-7127 (1) HP 14489B (1) HP 14151A	 BNC-BNC Cable Signal Cable, ECG Output Coaxial Adaptor, BNC to Phone Jack ECG Cable Electrode Lead Set

3.4.4.2 R-wave/Sync Pulse/Discharge Delay

1. Connect the test equipment as shown in Figure 3-25.

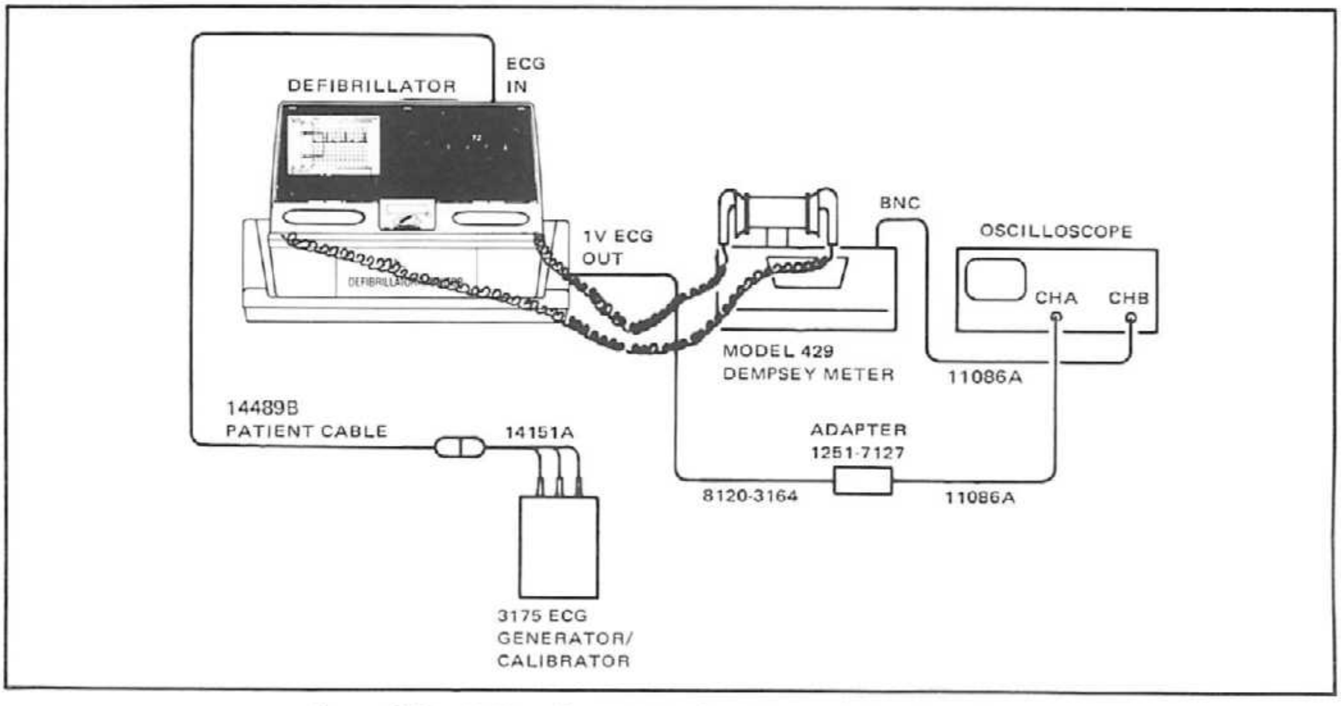


Figure 3-25. R Wave/Sync Pulse/Discharge Delay Test Setup.

2. Provide power to the defibrillator and turn the ENERGY SELECT control to the monitor - ON position.

3. Turn the ECG generator simulator on (ECG SOURCE in LEADS I position).

4. Set the oscilloscope controls as follows:

Channel A	Vertical Sensitivity	0.5 V/div
Channel B	Vertical Sensitivity	2 V/div
Display Mode	Chopped	
Sweep Mode	Normal	
Sweep Trigger	Internal, Channel A	
Sweep Rate	0.1 sec/div	
Trigger Slope	+	

5. Observe the ECG output signal. Adjust the ECG Size Control for about 1 V on the R-wave.

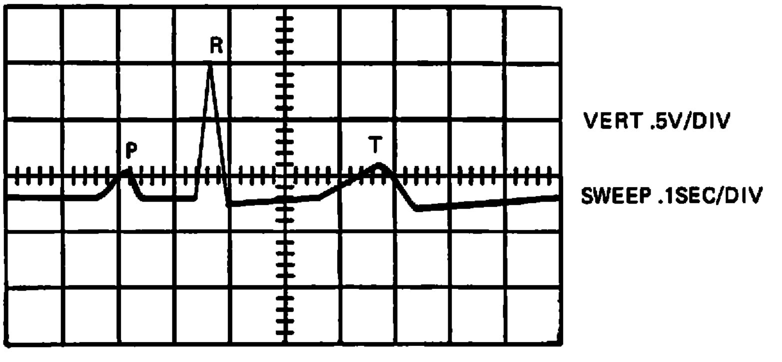


Figure 3-26. ECG Output Waveform.

6. Reset the oscilloscope controls:

Channel A	Vertical Sensitivity	1 V/div
Sweep Rate		20 ms/div

7. Adjust the trigger sensitivity so that the sweep trigger does not trigger on the P-wave but triggers on the positive slope of the R-wave as shown in Figure 3-27.

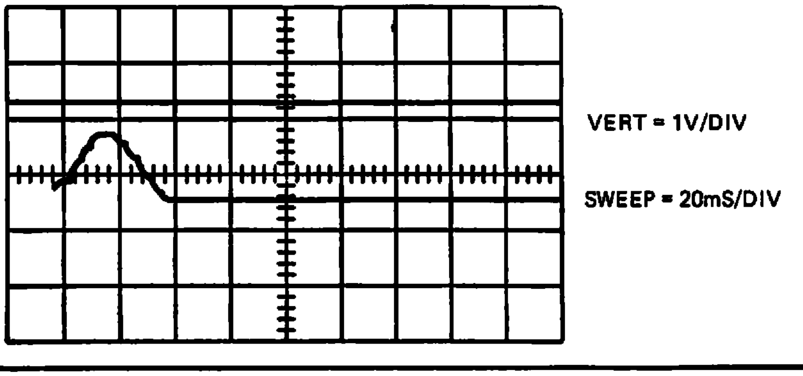


Figure 3-27. R Wave.

8. Press the SYNC/DEFIB switch to the SYNC position and release. The Sync/Marker pulse should appear within 20 ms of where the peak of the R-wave had been displayed. The Sync pulse obscures all but the first rise of the R-wave display as shown in Figure 3-28.

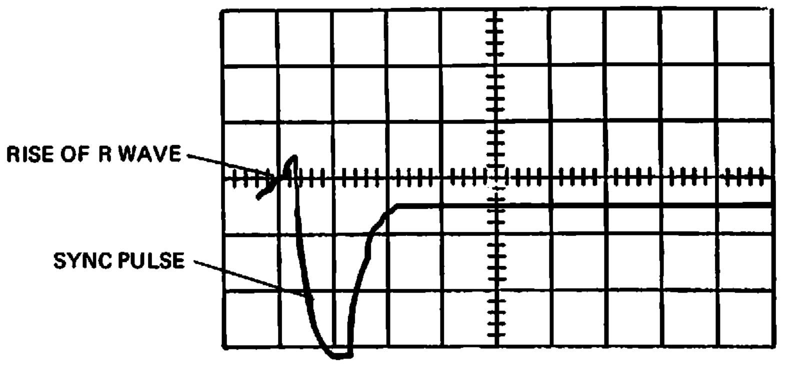


Figure 3-28. Sync Pulse Superimposed on R Wave.

9. Push the SYNC/DEFIB switch over to the DEFIB position and release. Verify that the Sync pulses are no longer present. Push the switch back to SYNC position.

10. Turn the ECG generator OFF-ON-OFF quickly and verify that a single R-wave will result in a Sync pulse. Set the ECG generator to VARIABLE BPM and slowly adjust the rate control to both limits and verify that Sync pulses are available at all beat rates.

11. Set the oscilloscope to SINGLE SWEEP. Slow the ECG generator to the slowest rate. Set the defibrillator ENERGY SELECT to 360 Joules and press the CHARGE button.

(a) After the CHARGE DONE indicator comes on, press the oscilloscope SWEEP RESET button, press the paddles firmly against the energy meter contacts and press the DISCHARGE buttons. This will probably require assistance since the time is short between Sync pulses. Alternatively, leave the ECG generator OFF until the oscilloscope sweep is reset, the defibrllator paddles in contact with the energy meter, and DISCHARGE buttons pressed; then turn ON the ECG generator.

(b) The defibrillator discharge must occur within 30 ms of the Sync Marker pulse as shown in Figure 3-29.

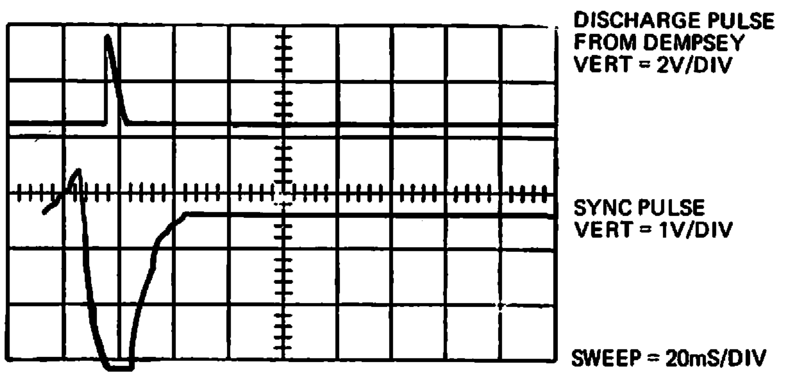


Figure 3-29. R Wave/Sync Pulse/Discharge Pulse Relationship.

3.4.5 PADDLE CONTACT INDICATOR

3.4.5.1 Test Equipment

Test equipment required to perform specification checks on the paddle contact indicator is listed in Table 3-8.

TEST EQUIPMENT REQUIRED FOR PADDLE CONTACT INDICATOR	
Requirement	Necessary Qualifications
Resistor	61.1 ohm, 1%
Resistor	250.0 ohm, 1%

3.4.5.2 Paddle Contact Indicator Test

1. Turn the instrument ON to MONITOR and remove the paddles from the storage pockets. The first light bar (closest to the handle) on the PCI indicator should light and blink on and off.

2. Connect a 61.1 ohm resistor between paddle electrodes. All the light bars should be lit.

3. Connect a 250.0 ohm resistor between paddle electrodes. Only two light bars should be lit.

NOTES

PRELIMINARY INSTRUCTIONS

This section contains general service information for the 78670A and 78671A Defibrillator/Monitor. Included in this section are mechanical disassembly procedures, circuit board removal procedures and general service and circuit information.

Disassembly Precautions

For your own safety, observe the following precautions before starting the disassembly procedures.

> WARNING - HIGH VOLTAGE
>
> THIS INSTRUMENT STORES HIGH VOLTAGE AND ENERGY. DEFECTIVE COMPONENTS MAY PRESENT HIGH VOLTAGE AND/OR EXPLOSION HAZARDS. ALWAYS OBSERVE THE FOLLOWING PRECAUTIONS WHEN SERVICING THIS UNIT.

1. Wear Safety glasses.

2. Ensure that energy storage capacitor is discharged by observing that LCD reads zero and charged indicator is OFF.

3. Remove the battery.

4. Before servicing energy storage capacitor, see capacitor discharge procedure, section 4.2.4.2

> CAUTION
>
> READ THE FOLLOWING PRECAUTIONS THOROUGHLY BEFORE PERFORMING ANY OF THE DISASSEMBLY PROCEDURES. SERIOUS DAMAGE TO THE INSTRUMENT CAN RESULT IF THE PRECAUTIONS ARE NOT STRICTLY FOLLOWED.

1. The CMOS logic family of integrated circuits can be damaged by an uncontrolled static discharge. Before handling any of the circuit boards, firmly grasp the instrument ground to eliminate any static charge difference between yourself and the instrument.

2. The analog ECG board (A3) has a floating ground section which is isolated from the remainder of the board. Never handle this section of the board - oils, dirt, dust, etc., deposited on this section can cause leakage paths which can degrade ECG circuit isolation and performance.

3. The plastic front panel on these instruments scratches easily. Avoid rough handling of the panel.

4. Handle all circuit boards by the edges; CMOS circuits operate with currents in the microampere range and leakage paths caused by skin oils, dirt, dust, etc., can cause inaccurate circuit performance.

SECTION IV
MAINTENANCE

4.1 MECHANICAL DISASSEMBLY

In order to gain access to the internal components, for service or repairs, it is necessary to open the instrument case. The case consists of two sections. The recorder, CRT and all circuit boards except the power supplies are located in the upper section. The low voltage and defibrillator capacitor charging supplies, all defibrillator high voltage circuits and components, and the battery are located in the lower section.

4.1.1 Tools Required

- Medium posidrive screwdriver
- 1/4" nutdriver

4.1.2 Procedure

1. Remove the battery.

2. Lay the instrument on its top, preferrably on a protective pad.

3. Refer to Figure 4-1.

4. Remove the two screws indicated by Number 1 and the six screws indicated by Number 2.

5. The two screws indicated by Number 3 are accessed through holes in the case bottom, but are located in the battery compartment. After the screws are loose, reach through the battery opening and remove the screws.

6. Hold the instrument case together and carefully turn it over.

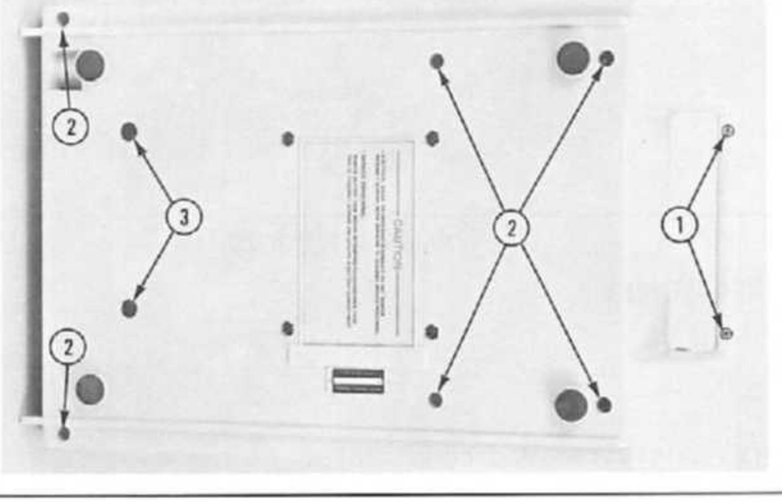


Figure 4-1.

7. Lift the top section off, turn it upside down, and place it on the bench to the right of the lower section. The upper and lower sections are connected by wiring. See Figure 4-2.

8. A metal shield covers the circuit boards in the upper section. To remove the shield (see Figure 4-3):

(a) Remove the four screws indicated by Number 1.

(b) Remove the two hex standoffs indicated by Number 2.

DO NOT remove the hex standoffs at the rear of the shield.

(c) Lift the shield out of the case.

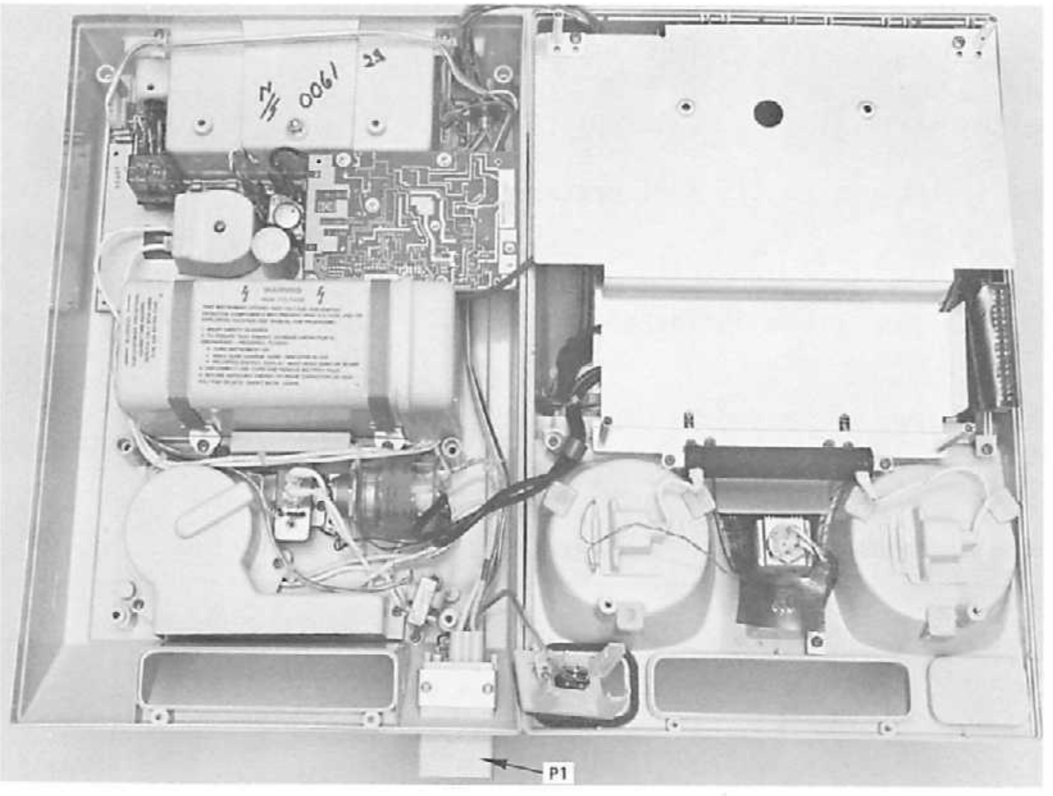


Figure 4-2. (78670A)

4.2 MECHANICAL REASSEMBLY

4.2.1.A Procedure

1. Replace all previously removed components.

2. Verify system operation.

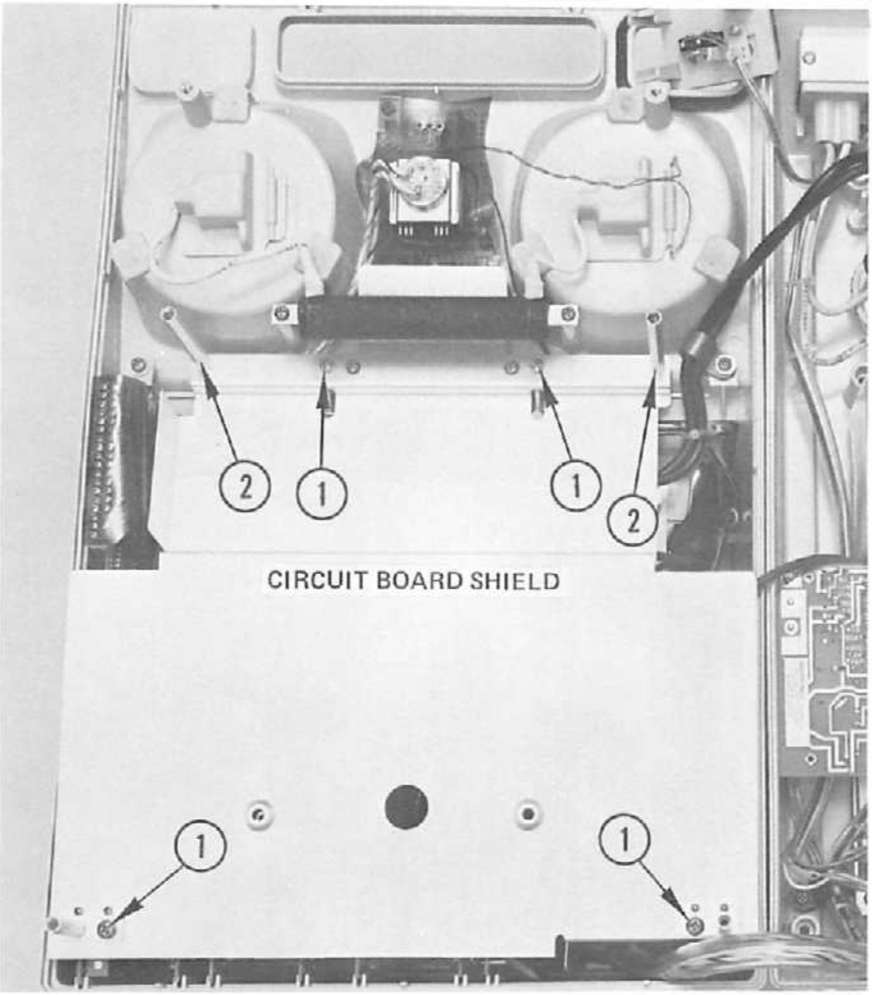


Figure 4-3. (78670A)

3. Reinstall metal shield and mounting screws.

4. Visually check that all wiring is properly placed and that none passes over any mounting bosses.

5. Close upper case over lower case - use caution that intercable lays properly - especially at the left rear corner.

6. Make sure all tabs that project down from the upper case engage correctly around perimeter.

7. Check engagement of cable housings at openings.

8. Turn unit over onto its top while holding together and reinstall the screws.

9. Reinstall battery.

4.2.1 Replacing the Low Voltage Power Supply Board

4.2.1.1 Procedure

1. Remove the battery.

2. Open the case as described in section 4.1.

3. Remove the five hex nuts (A) that secure the L.V. power supply board. See Figure 4-4.

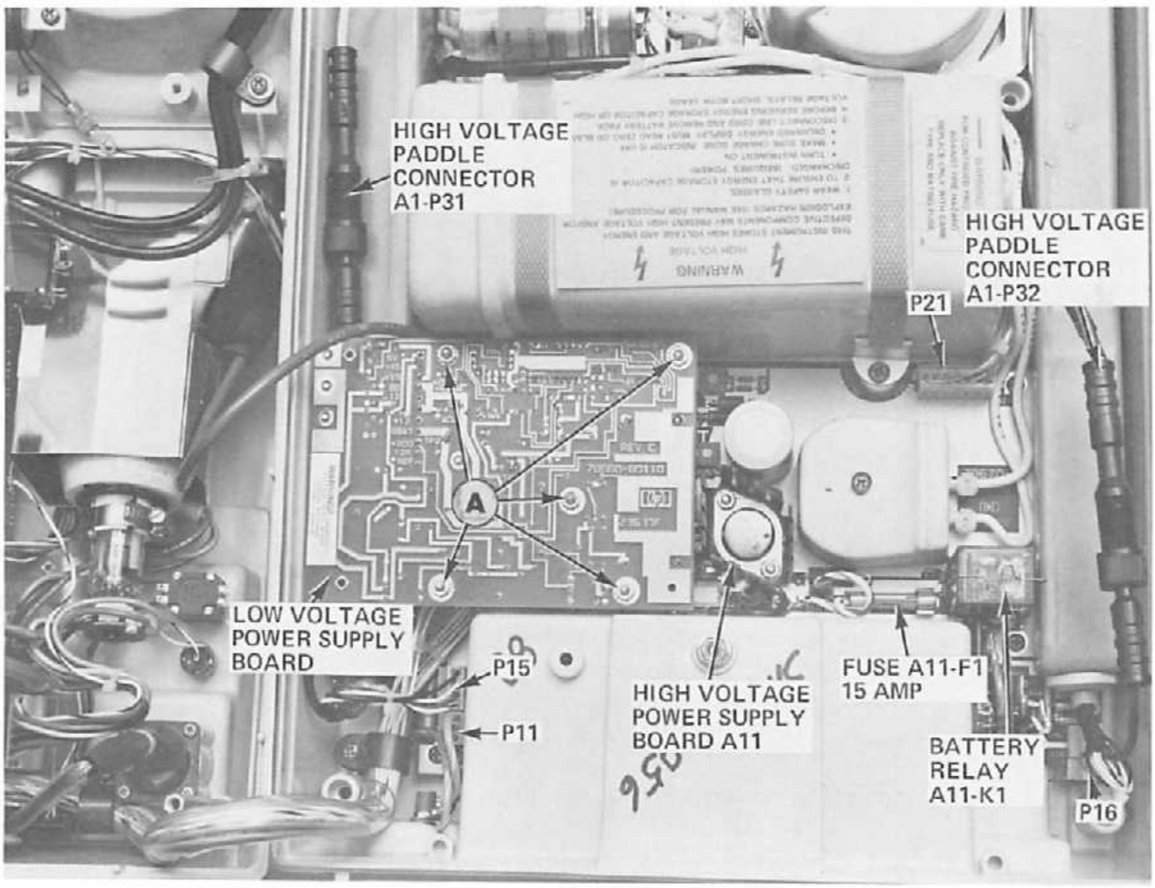


Figure 4-4. (78671A)

4. Lift the board free and disconnect P23. See Figure 4-5.

5. Remove the H.V. cable from the CRT. See Figure 4-5.

6. Replace board and assemble in reverse order.

7. Reassemble per section 4.2.

2.2.2 Paddle/Cable Assembly Replacement

(78671A and 78670A/A03) with non-interchangeable paddles.

These assemblies may be replaced individually. The procedure for replacing the cable within the housing is identical for both sides. Both cable housings are secured with double-sided adhesive foam tape, but the left side housing has an additional mounting clamp. When the cable housings are removed from the case, considerable pressure may have to be applied. The foam tape may split, leaving an adhesive surface stuck to the case and the cable housing. THIS MUST BE COMPLETELY REMOVED BEFORE APPLYING NEW TAPE. The tape adhesive has very high tack and does not come off easily by mechanical means. Certain solvents are useful but caution must be exercised in selecting one that does not attack the base material. The instrument case is polycarbonate, so acetone, MEK and similar solvents must NOT be used. Isopropyl alcohol does not attack the plastic and will loosen the adhesive if kept saturated for 2-3 minutes. If in doubt about the solvent, moisten a small area inside the case with the solvent. Rub the area with your finger. If the spot feels sticky, don't use it.

4.2.2.1 Tools/Parts Required

Medium size posidrive screwdriver

Long nose pliers

Solvent such as isopropyl alcohol

5/16" nut driver

Adhesive foam tape (PN 0460-1242)

4.2.2.2 Procedure

1. Open the case as outlined in section 4.1.

NOTE: It is possible to replace cables without removing the cable housings, but it is not an easy job.

2. See Figure 4-4. At the rear of each cable housing is a 4 pin connector, P15 and P16, and part way along the side is a high voltage connector, P31 and P32. Disconnect the cables for the side you wish to replace. Unscrew the ring from the H.V. connector body and pull apart.

3a. Apex side cable housing removal: See Figure 4-4. Remove the five hex nuts that secure the low voltage power supply board. Turn the board over and disconnect the cable from the board (P23) (see Figure 4-5)

3b. Sternum side cable housing removal: Disconnect P16 near the rear of the cable housing (see Figure 4-4). Remove the two screws (A) (see Figure 4-6), that secure the cable housing clamp.

4. Grasp the front end of the cable housing and apply upward pressure until the housing comes free from the case.

5. See Figure 4-7. Unscrew the ring nut from the strain relief at the rear of the housing and slide it over the connectors. The 4 pin connector is a tight fit but it will clear. Pull the cable from the housing.

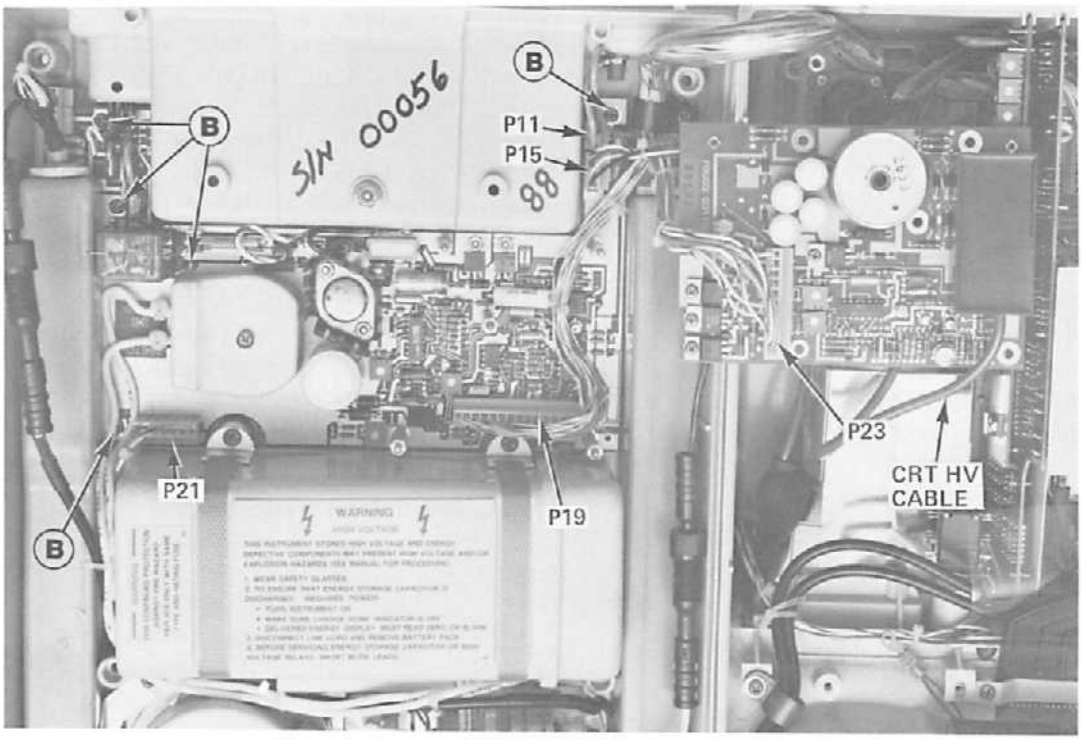


Figure 4-5.

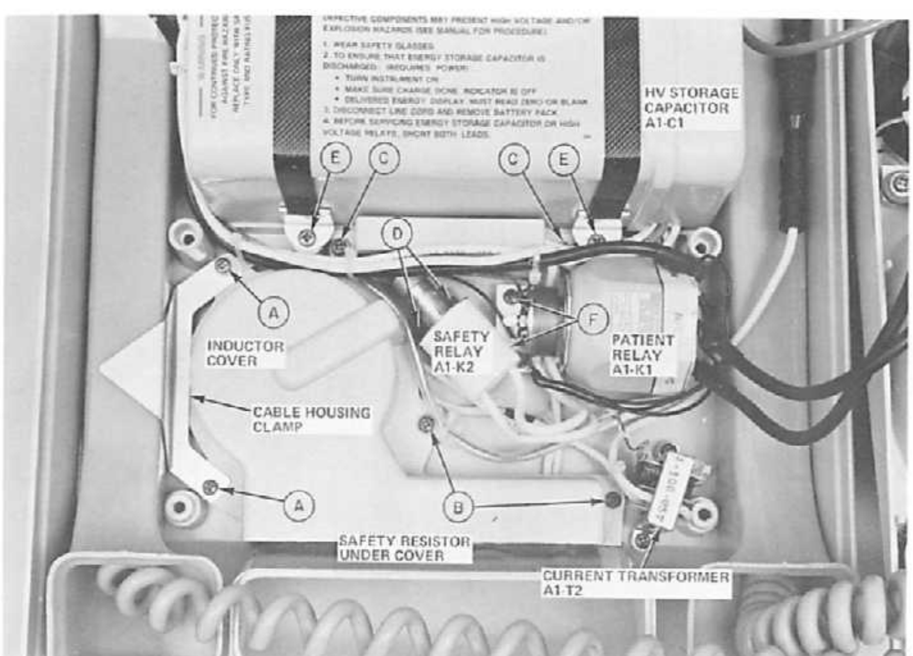


Figure 4-6.

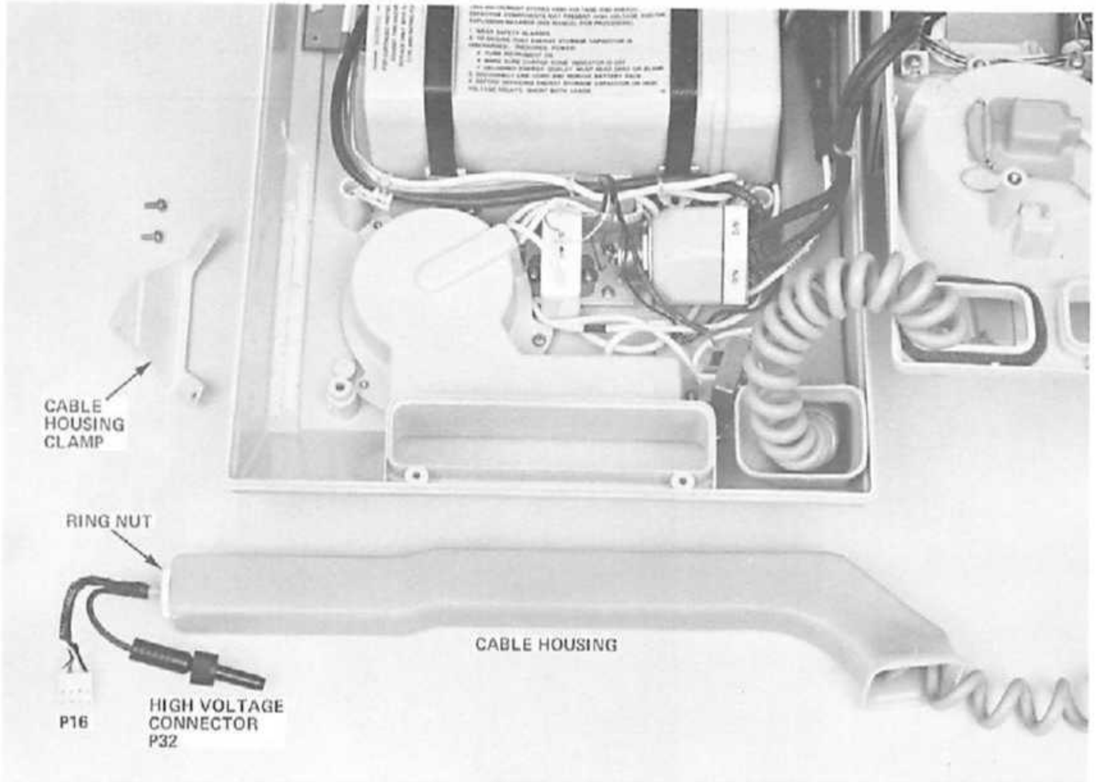


Figure 4-7.

6. When installing the new cable, be sure to run the cable through the opening in the top half of the case before inserting into the housing.

7. See Figure 4-8. Place the connector end of the cable into the large end of the housing. The square flange on the strain relief will usually align itself, but a second try may be necessary.

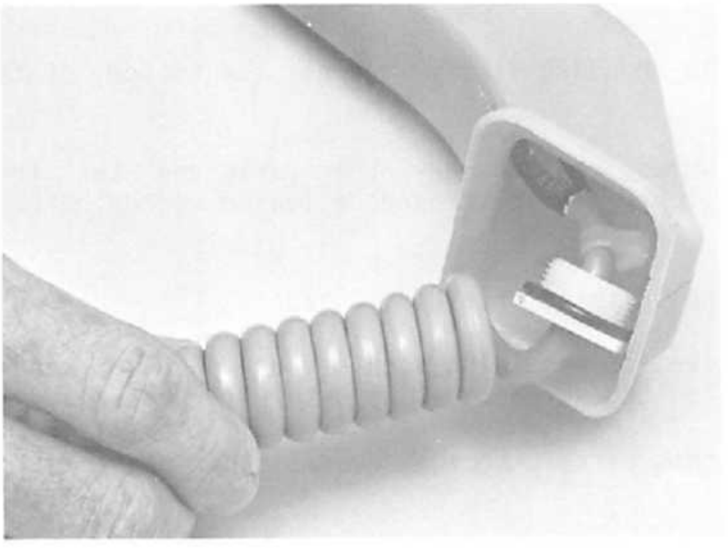


Figure 4-8.

8. The cable is a snug fit so it must be pushed through the housing. Push the cable until the H.V. connector contacts the rear of the housing. Use the long nose pliers to get the connectors through the hole (see Figure 4-9).

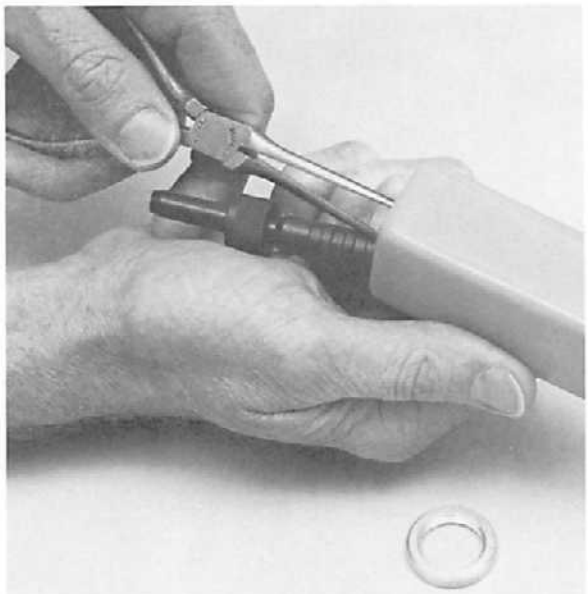


Figure 4-9.

9. Continue to push the cable until the threaded part on the strain relief extends through the hole. Tighten the ring nut on the strain relief finger tight. DO NOT USE PLIERS.

10. Be certain the plastic surfaces are clean before applying the adhesive foam tape. Place the tape on the bottom of the cable housing.

11. The cable housing must be in the correct position before pressure is applied. Place the housing against the side of the case with the open end contacting the front of the case.

12. Press the cable housing firmly against the bottom of the case to set the adhesive.

13. Connect the cables, replace any other parts and test the paddle for proper operation of the switches, indicator and delivered energy before closing case.

4.2.3 Replacing the Defibrillator H.V. Board

NOTE: A posidrive screw-holding screwdriver, or other screw holding device, is helpful when replacing the screws that hold this circuit board.

In order to remove this circuit board, several other parts must be removed.

4.2.3.1 Procedure

1. Remove the battery.

2. Open the case as outlined in section 4.1.

3. Unplug the paddle and ECG output connectors (see Figure 4-4, P11, P15, and P16).

4. On the 78671A and 78670A, option A03, the sternum cable in-line high voltage connector, P32, must be disconnected and the sternum cable housing removed. Unscrew the collar and pull the connector apart (Figure 4-4).

5. Remove the two screws (A, Figure 4-6) that secure the cable housing clamp. Lift the housing out and set it aside. See Section 4.2.2.2 for details on cable housing removal.

6. Remove the five hex nuts that secure the low voltage power supply board. Lift the board out and lay it aside. It is not necessary to disconnect the cables (see Figure 4-4).

7. Remove the battery relay (A11-K1).

8. Remove the five hex posts (see Figure 4-5).

9. Disconnect the four push-on lugs near the relay and the two wires from the battery compartment, near the center of the board.

10. Disconnect P19, the P40 and P41, H.V. output leads from the H.V. rectifier assembly (See Figure 4-5). Disconnect P21 and P11.

11. Remove the four screws (B) that secure the board. Lift the board out.

4.2.4 Replacing H.V. Capacitor

4.2.4.1 Tools Required

- Medium posidrive screwdriver
- Long nose pliers with strong jaws
- Safety glasses

These capacitors are supplied with quick connect lugs.

4.2.4.2 Procedure

(Before removing the screws, stuff tissue paper in the hex shaped holes in the case bottom. Place tape over the holes to hold the paper in place. This will keep the hex nuts from falling out of the case.)

> WARNING
>
> Before performing service on this component, the capacitor terminals should be shorted to prevent electrical shock. It is advisable to leave a jumper cable on the terminals since this capacitor is capable of recovering a charge.

1. Open the instrument case as outlined in section 4.1.

2. See Figure 4-6. Remove the two capacitor clamp screws (E). Lift off H.V. terminal cover.

3. Before removing any wires from the capacitor, draw a diagram to ensure proper connection when the new capacitor is installed.

4. After replacing the capacitor, test the unit before reassembling the case. After reassembling the unit, remove the paper from the holes.

4.2.5 Safety Relay Replacement

NOTE: There are two different styles of relay available, but they are interchangeable and the procedure is the same for either type.

4.2.5.1 Tools Required

- Medium size posidrive screwdriver
- Soldering iron
- Safety glasses

4.2.5.2 Procedure: Before removing the screws, stuff tissue paper in the hex shaped holes in the case bottom. Place tape over the holes to hold the paper in place. This will keep the hex nuts from falling out of the case.

1. Open the case as outline in section 4.1.

2. Remove two capacitor clamp screws (E) (Figure 4-6) and lift it off the capacitor cover.

WARNING
Short out the capacitor leads and connect a JUMPER wire across the capacitor terminals to prevent the possibility of electrical shock.

3. Remove the two screws (A) and cable housing clamp. Remove the two inductor cover screws (B), and lift off the cover. This exposes the safety resistor.

4. At this point, draw a diagram to ensure everything gets connected properly when the new part is installed. Clip ty-wraps when necessary.

5. Unsolder the snubber wire from the safety resistor A1-R1. Disconnect the other snubber wire from the H.V. capacitor.

6. Unsolder the orange and yellow wire from the safety relay coil terminals.

7. Remove the two screws (C) that secure the H.V. snubber. Remove the two safety relay screws (D).

8. Remove the safety relay wire from the lower H.V. capacitor terminal. Lift the relay out.

9. Put the new relay in place and route the wires from the H.V. snubber. Replace the screws in the snubber.

10. Connect the wires. Install ty-wraps as required.

11. Test for proper operation before closing case.

12. After reassembling the unit, remove the paper from the holes.

4.2.6 Patient Relay Replacement

4.2.6.1 Tools Required

- Posidrive screwdriver
- Soldering iron
- Safety glasses
- Diagonal pliers
- Small Ty-wraps

> WARNING
>
> Patient relay is a pressurized unit and poses POSSIBLE explosion hazard. To prevent possible eye damage, safety glasses should always be worn while performing this service.

4.2.6.2 Procedure: Before removing the screws, stuff tissue paper in the hex shaped holes in the case bottom. Place tape over the holes to hold the paper in place. This will keep the hex nuts from falling out of the case.

1. Open the defibrillator case as outlined in section 4.1.
2. Remove the metal circuit board shield.
3. Disconnect the paddle ECG leads from the ECG Analog Board (J28).

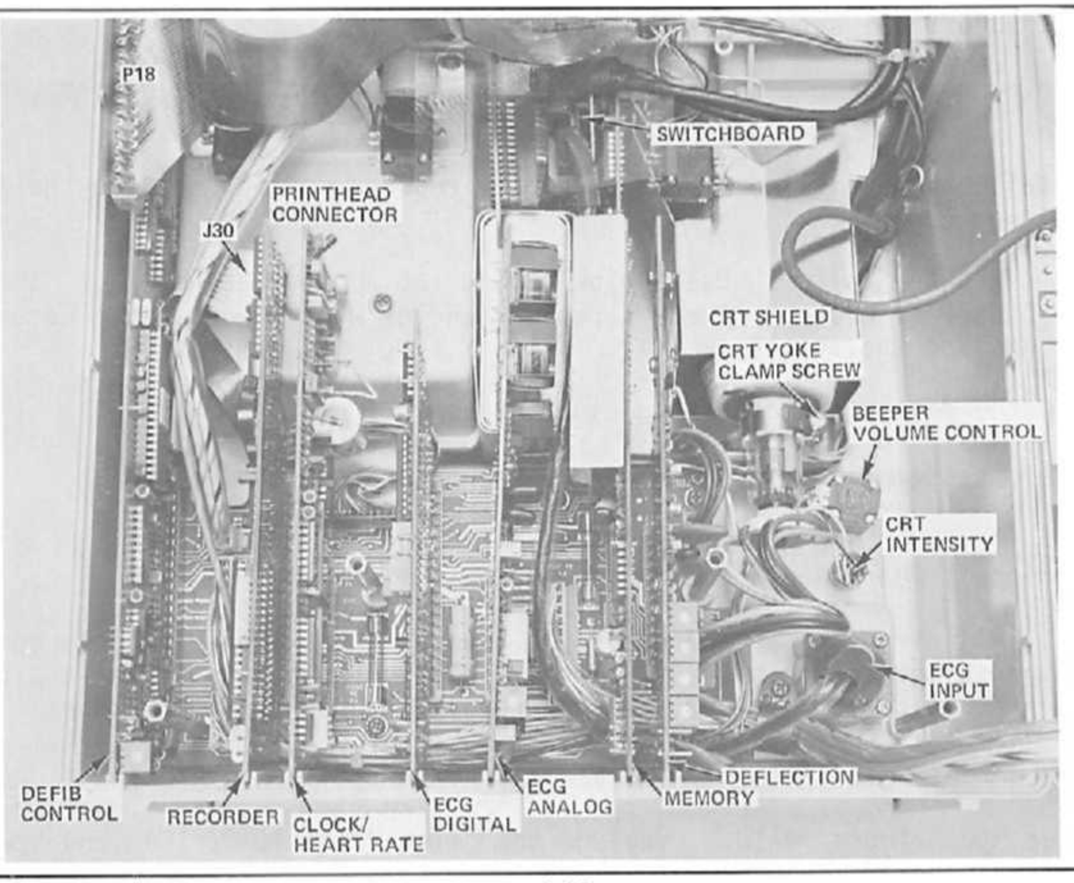


Figure 4-10.

4. Remove the screws securing the inductor cover. Figure 4-6 shows the Model 78671A in which the two screws labelled (A) also fasten the sternum paddle cable housing clamp. Remove these screws labelled (A) and (B) and lift off the inductor cover.

5. Remove the capacitor clamp screws ((E) Figure 4-6) and lift off the capacitor cover. Short the capacitor as described in Section 4.2. Draw a diagram of the relay wires to aid reassembly.

6. Refer to 4-6. Unsolder the red and brown wires from the patient relay coil terminals.

7. Cut the shrink tubing from the terminal on the inductor where the patient relay high voltage lead is attached and unsolder the lead.

8. Disconnect the other patient relay high voltage lead from the H.V. capacitor (quick disconnect lug).

9a. Units with non-interchangeable paddles (Model 78671A and 78670A/opt A03): Disconnect the HV leads to the paddles at the connectors P31 and P32. (Figure 4-4).

9b. Units with interchangeable paddles: Use a pin extractor, HP P/N 8710-0614 (AMP 305-183) to remove the HV leads from the paddles connector P1, Pins 1 and 2. (Figure 4-2).

Note: These wires are not interchangeable. Be sure to install the replacement relay with identical connections.

10. Remove the two screws (F) that secure the patient relay bracket. Lift the relay out.

11. Install the new relay. Make sure no wires are wedged between the relay body and the lower case.

12. Reconnect the wires. Use shrink tubing of appropriate size on the inductor terminal. Use ty-wraps to secure cable bundles when necessary. Reconnect all cables. Replace the shields.

13. Test the defibrillator before closing case.

14. After reassembling the unit, remove the paper from the holes.

4.2.7 Circuit Board Replacement

NOTE: All circuit boards are plug-in, except the two power supply boards which are located in the bottom half of the case. Only two boards in the top section of the case need special attention, the others will present no problems.

4.2.8 Recorder Board Assembly Replacement

1. Refer to Figure 4-10. Unplug the flex circuit (P18) and remove the defibrillator control board.

2. A flat ribbon cable, from the recorder printhead, plugs into a small edge connector on the recorder board (J30).

3. Carefully remove the recorder board assembly and pull the cable from the connector, (J30).

4. When replacing the board, connect the flat cable before plugging in the board. The single, wide conductor in the ribbon cable goes toward the rear of the case.

4.2.9 ECG Analog Board Replacement

1. There are two cables which attach to this board. Unplug the paddles ECG connector (P28).

2. Lift the ECG Analog Board up slightly to provide clearance and unplug the 15 contact cable connector (P42) coming from the switchboard and place it out of the way.

3. Disconnect the flex circuit (P18) from the Defibrillator Control Board and place it out of the way.

4. Pull the ECG board up and out of the unit.

5. When replacing the ECG board, ensure that the plastic cover halves are in place over the metal shield section of the board.

4.2.10 Switchboard Replacement

1. Remove the ECG Analog Board as described in 4.2.9. Disconnect the ECG input connector, J26, from the switchboard.

2. Remove the memory and deflection boards, Figure 4-10.

3. Remove the ECG source knob (Refer to 4-2-16).

4. Use a 5/16 inch nutdriver to remove the nut from the switch mounting bushing. Remove the screw from the right angle mounting bracket on the switchboard.

5. Pull the switchboard back into a position where the connector attached to the LED's can be unplugged. This is a locking type connector and the locking side must be pried out while exerting a pulling force.

6. Install replacement in reverse order.

4.2.11 CRT Replacement

4.2.11.1 Tools Required

— Medium size posidrive screwdriver — 3/32" hex key
— Small flatblade screwdriver

NOTE: This procedure requires removal of the plastic overlay panel. This part scratches easily, so care should be exercised during the following operations. Remove the knobs as described in section 4.2.14.

It is possible to remove the plastic overlay panel without removing all of the knobs. However, some manipulation of the panel is necessary.

> WARNING
>
> During the following procedure, HANDLE THE CRT WITH CAUTION. Wear protective safety glasses. The cathode ray tube contains high vacuum and breakage can result in flying glass. Do not strike or scratch the tube or subject it to more than moderate pressure during handling. Always handle the tube by the main body, never by the neck alone.

4.2.12 Front Panel Removal

4.2.12.1 Tools Required

- Small flat blade screwdriver

4.2.12.2 Procedure

1. The front panel is secured by three plastic tabs spaced across the top of the panel. Insert the flat blade screwdriver between the tab and the panel, and carefully pry the panel loose (see Figure 4-11 and 4-12).

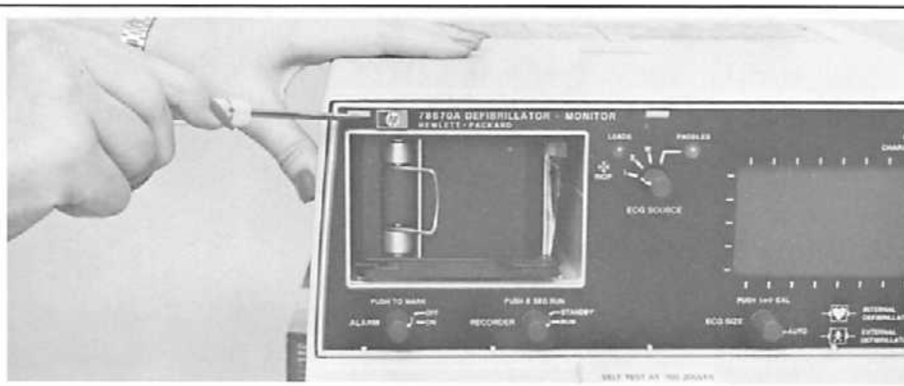


Figure 4-11.

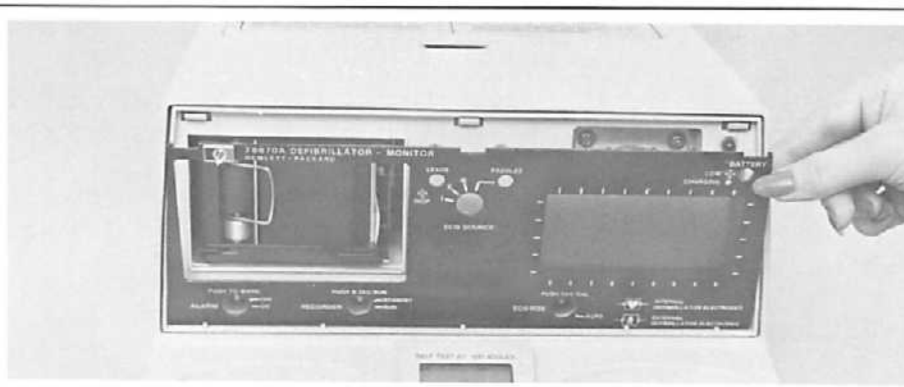


Figure 4-12.

2. Remove the battery.
3. Open the case as outlined in section 4.1.
4. Remove the metal circuit board shield.
5. Disconnect the H.V. lead from the side of the CRT. Unplug the connector from the rear of the CRT.

6. Loosen, but do not remove the yoke clamp screw (see Figure 4-15). Remove four screws (two above and two below) from the face of the CRT (see Figure 4-13).

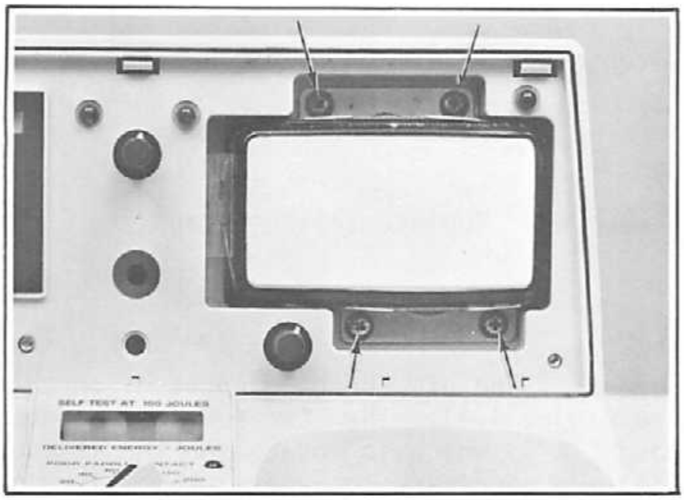


Figure 4-13.

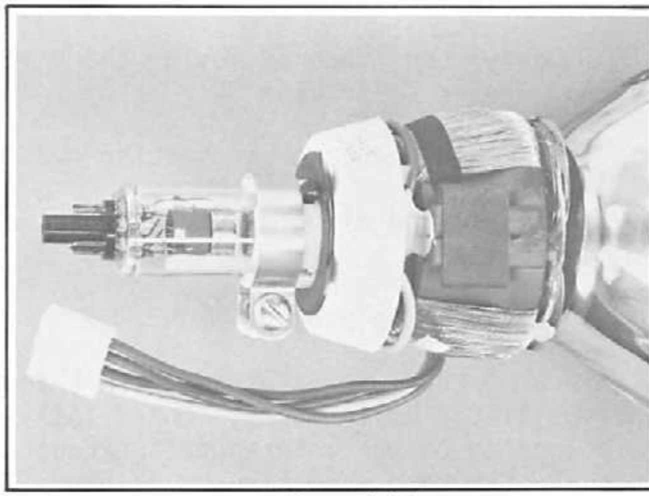


Figure 4-14.

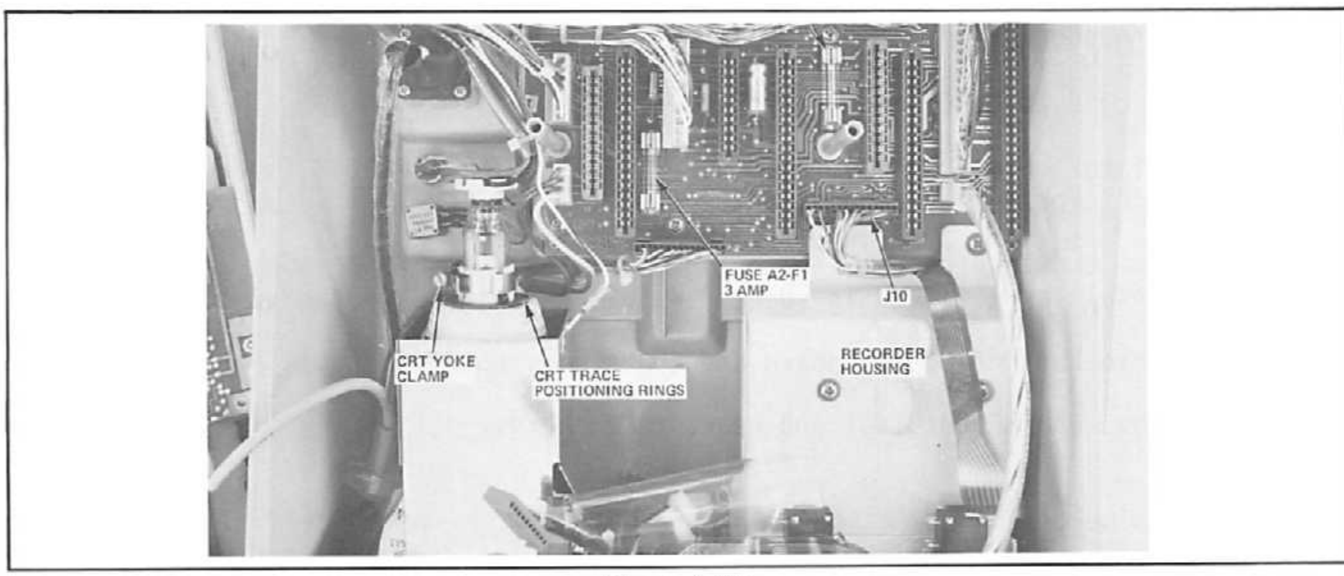


Figure 4-15.

7. Hold the yoke with one hand and slide the CRT out of the yoke and out through the front panel. It is not necessary to remove the CRT shield.

8. Slide the new CRT in place. Install the four screws at the face of the tube.

9. Slide the yoke as far toward the front of the CRT as it will go. Tighten the clamp screw. DO NOT OVERTIGHTEN.

10. Connect the high voltage lead and plug the connector to the rear of the CRT.

11. Plug in the battery and turn the monitor on to be sure the tube operates properly.

12. Install the front panel. Place the edge of the panel under the bottom tabs and press the top into place under each top tab.

13. Set the minimum and maximum intensity adjustments as described in section 3.

14. Check to see that the trace on the CRT lines up properly with the marks on the panel. If it does not, loosen the yoke clamp screw and rotate the yoke until proper alignment is achieved. Tighten the screw.

15. Center the trace by moving the trace centering levers on the yoke (see Figure 4-15). Refer to section 3.

16. Assemble the case per section 4.2.

17. Install and align any knobs that were removed. Replace the knob caps.

4.2.13 Fuse Replacement

There are three fuses used in this instrument. One of these is located on the defibrillator H.V. supply board (A11) (see Figure 4-4). The two remaining fuses are located on the interconnect circuit board (A2), which is located on the inside top of the case (see Figure 4-15). It will be necessary to remove some circuit boards to gain access to the fuses.

4.2.13.1 Procedure

1. Open the case as described in section 4.1.

2. Defibrillator H.V. supply fuse, A11-F1, 15A P/N 2110-0048 (see Figure 4-4). Remove relay K1 for easier access to fuse.

3. Fuses on the interconnecting board A2-F1 and A2-F2, 3 amp P/N 2110-0003. Remove the shield as outlined in section 4.1.2 (see Figure 4-3 and 4-10).

   F1: Remove the deflection board and the memory board.

   F2: Remove the ECG digital and heart rate boards.

4.2.14 Knob Removal

4.2.14.1 Tools Required

- 3/32" hex key

4.2.15 ECG Size, Recorder, Alarm and ECG Source Knobs

4.2.15.1 Procedure

1. Insert your thumbnail or a small screwdriver into the recessed area at the front of the knob and pry off the cap.

2. The knobs are secured to the control shafts by collets. Insert the hex key through the front of the knob. Hold the knob to prevent rotation, and use the hex key to loosen the collet by turning one full turn counterclockwise (see Figure 4-16).

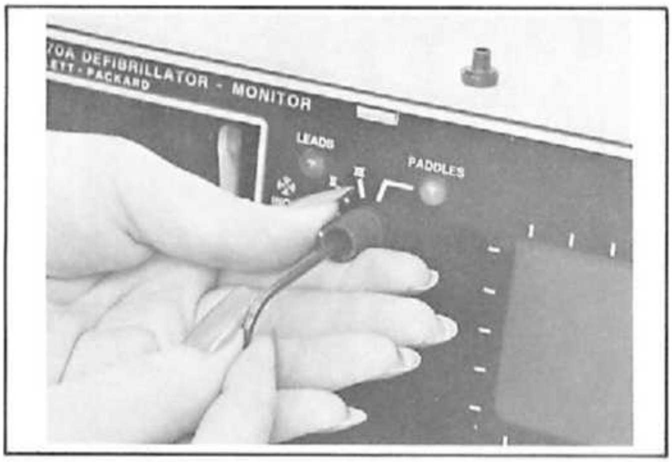


Figure 4-16.

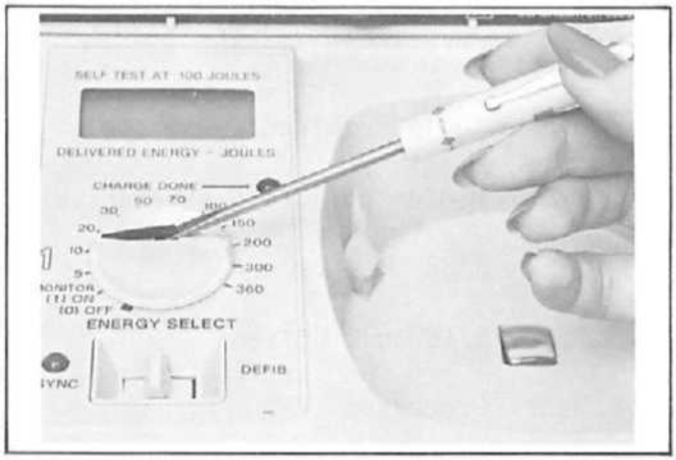


Figure 4-17.

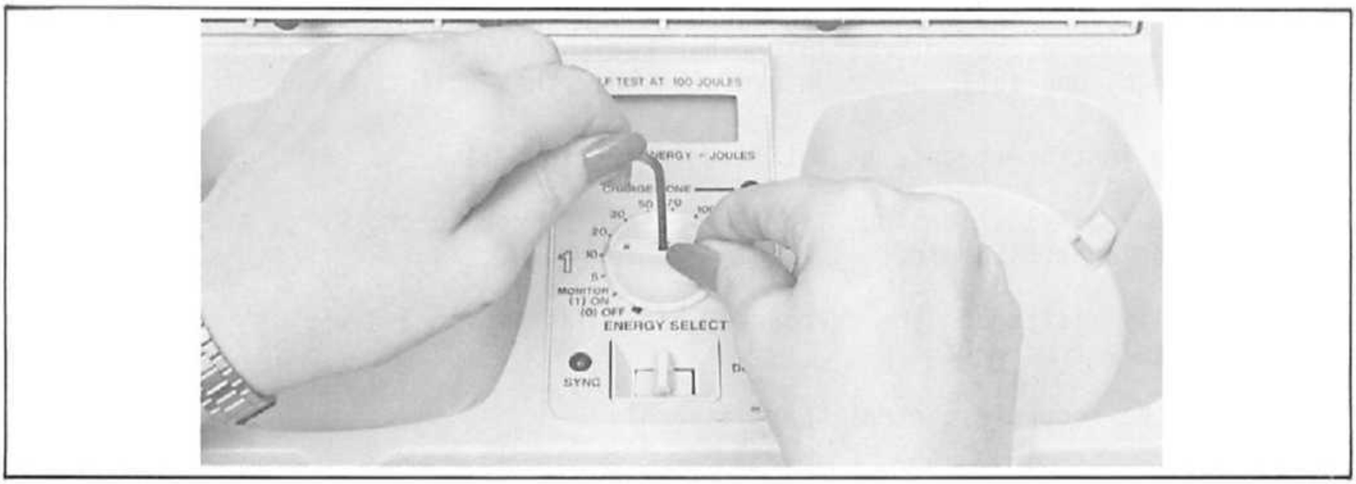


Figure 4-18.

3. Pull the knob from the shaft. If the knob hangs up on the shaft, it may be necessary to insert the hex key back into the end of the knob and tap it very gently to force the collet to release.

4.2.16 Knob Replacement

4.2.16.1 Procedure

1. There are no flats on the switch shafts; so when replacing the knob, it must be properly aligned as the collet is tightened.

2. Tighten the ECG Size, Recorder and Alarm knobs to 4 in/lb (this may be approximated by tightening the collet until snug and then turning it an extra turn). Be sure to hold the knob to avoid breaking the stops in the switch.

4.2.17 Energy Selection Knob

1. The pointer is an insert and is removed by prying up at the tail-end with your thumbnail or a small screwdriver (see Figure 4-17).

2. The knob is removed and reinstalled as described in section 4.2.14 and 4.2.15, except to tighten to 10 in/lb or 1/2 extra turn after snug (see Figure 4-18). Test to be sure the knob does not slip on the shaft.

4.2.18 Recorder Replacement

4.2.18.1 Tools Required:

- Medium posidrive screwdriver
- 3/32" hex key
- 5/16" nut driver

4.2.18.2 Procedure

1. It is necessary to loosen the two controls located directly below the recorder. Pry off the caps on the front of the knobs. The knobs are secured to the shafts by collets. To loosen the collets insert hex key through the front of the knob. Turn the collet nut one full turn counterclockwise, then pull the knob from the shaft

2. Open the instrument case as outlined in section 4.1.

3. See Figure 4-10. Unplug the flex circuit connector, P18, and remove the defibrillator control board.

4. Carefully lift out the recorder board assembly and unplug the recorder printhead cable from J30.

5. Remove the recorder control board assembly.

6. Remove the memory board, the ECG digital board and the heart rate board.

7. Unplug the cables from ECG analog board and remove the board (see section 4.2.9).

8. Use the 5/16" nutdriver to loosen the two controls directly below the recorder housing. It is not necessary to remove the nuts from the controls.

9. Unplug the recorder cable from J10 (see Figure 4-15).

10. See Figure 4-19. Remove the five screws (A), that secure the recorder housing (two in back and 3 in front). DO NOT REMOVE THE TWO SCREWS NEAR THE CENTER OF THE HOUSING. Lift the recorder assembly from the instrument. Figure 4-19 is shown without wiring for clarity.

11. The recorder is secured to the housing by four screws (see Figure 4-20). Lay the recorder housing on a flat surface with the screws up. Be careful not to damage the QRS Beeper speaker which is on the opposite side of the housing.

12. Remove the four screws and carefully pull the recorder out of the housing. The speaker wires will not allow it to be completely removed with the cable attached. Unplug the cable from the recorder mounted circuit board. At this point, the stylus and printhead are accessible. The stylus can be replaced with the recorder mounted in the instrument. The procedure is described in section 7 of

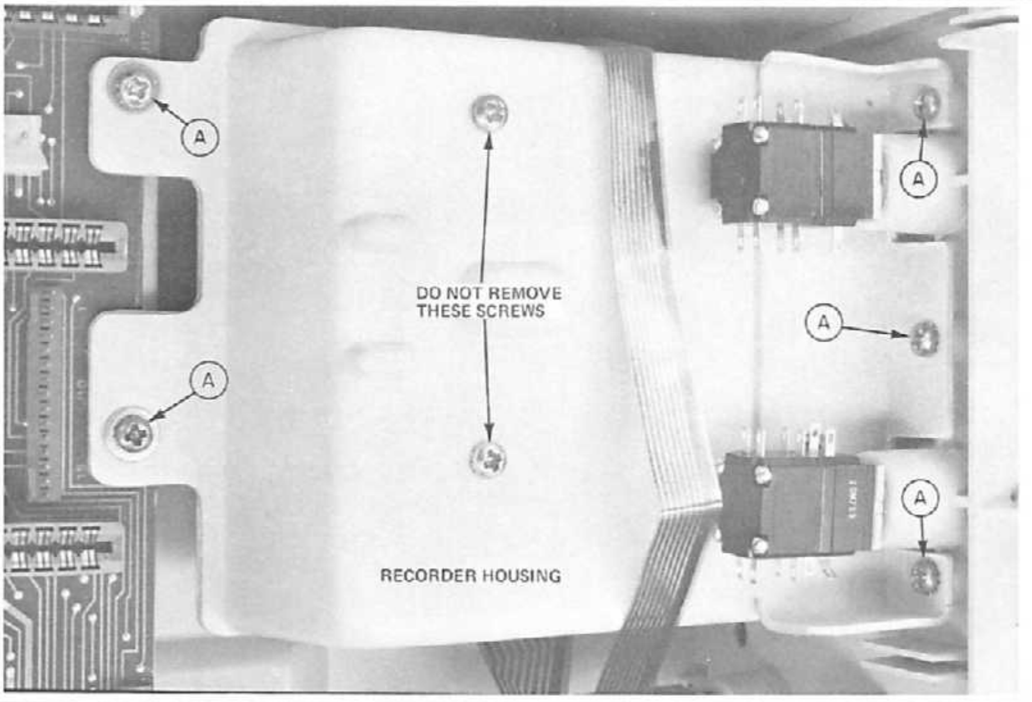


Figure 4-19. (Shown without wiring for clarity).

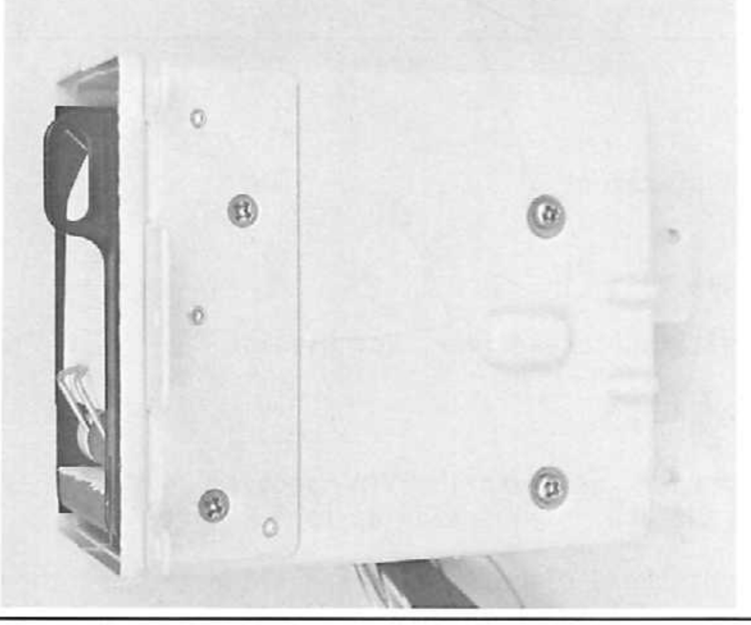


Figure 4-20.

the Operator's Guide, so it will not be repeated here. However, stylus replacement is very easy with the recorder out of its housing (see Figure 4-21).

Instructions for replacing the recorder in the instrument follows the printhead replacement procedure.

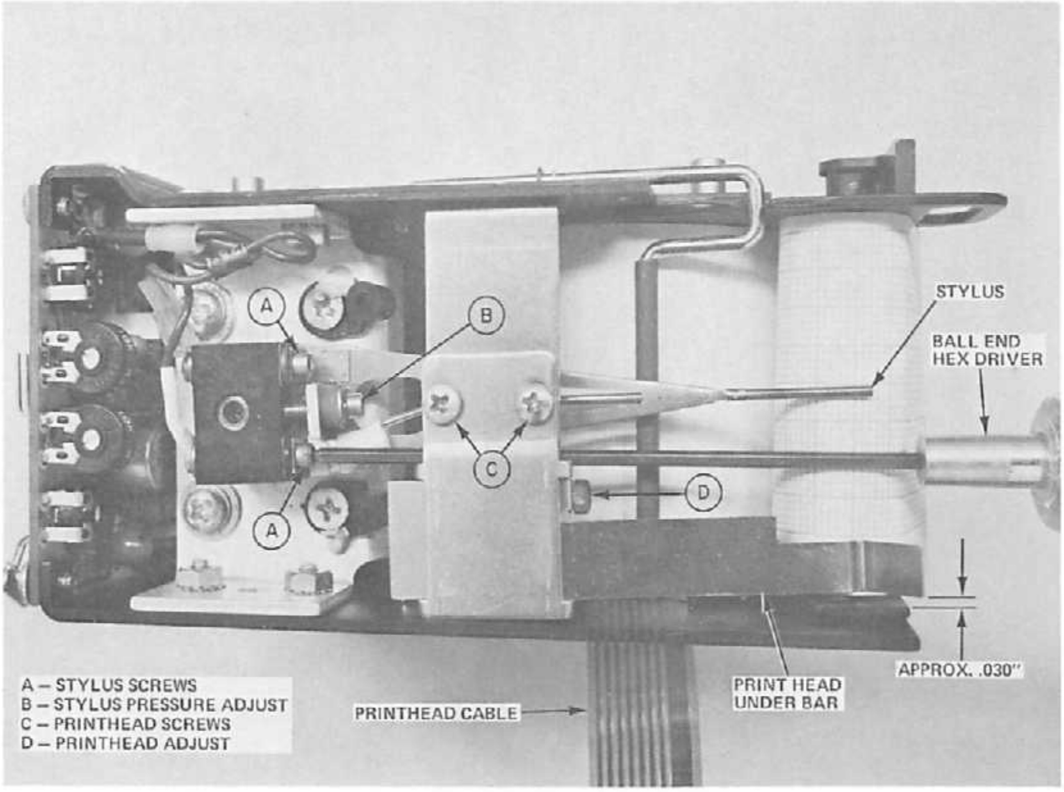


Figure 4-21.

4.2.19 Printhead Replacement

4.2.19.1 Tools Required

Small phillips screwdriver, No. 0 point

4.2.19.2 Procedure

1. Remove the recorder as described in section 4.2.17. Place the recorder mechanism on a flat surface, stylus side up (see Figure 4-21).

2. Loosen the two printhead clamp screws and slide the printhead bar assembly out from under the clamp. Pull the printhead and flat cable out of the housing.

3. When installing the new printhead, be sure to leave a small gap (.030" to .040") between the printhead bar and the edge of the paper carrier. Align the bar so it is parallel to the edge of the recorder and tighten the clamp screws. There is a groove in the printhead adjustment screw. A small projection from the printhead bar assembly fits in this groove. Be sure the protection is engaged in the groove when replacing the printhead.

4. The printhead may be adjusted before reassembly (See procedure below). Connect the recorder and install the circuit boards. Load a roll of paper into the recorder.

4.2.20 Printhead Adjustment

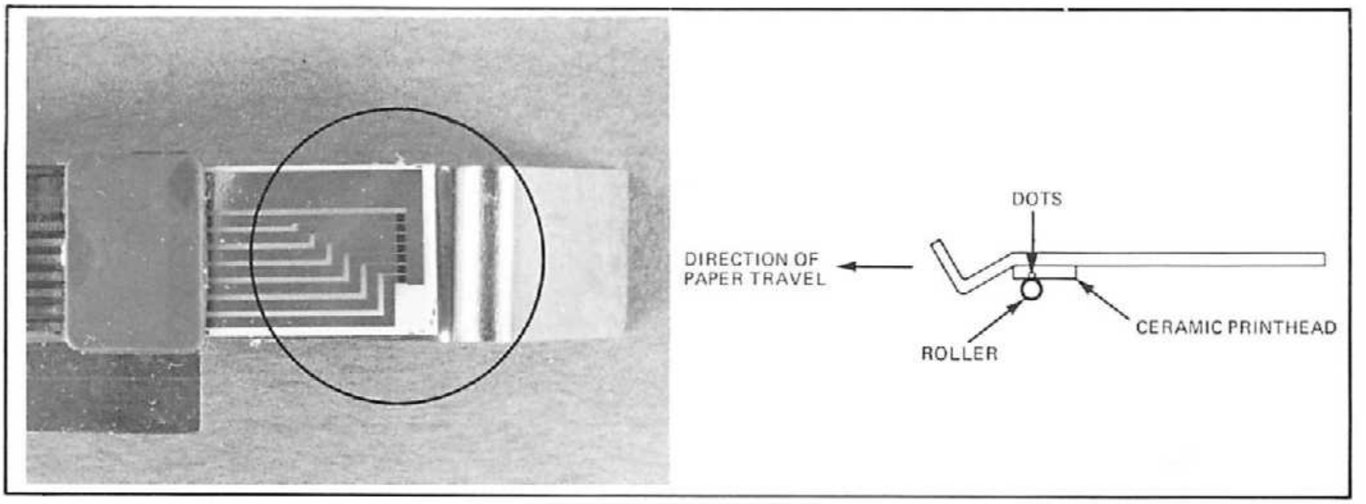


Figure 4-22. Detail of Print Head.

Only one adjustment is required to position the printhead. The printhead adjustment screw is accessed through the front of the recorder. After a printhead is replaced, it is likely that no annotation will be printed. It may require several turns of the adjustment screw to bring the printhead into the correct position. Check to be sure the ribbon cable is properly inserted into connector J30 on the recorder control board before attempting printhead adjustment.

4.2.20.1 Procedure

1. The printhead is a ceramic block which is attached to the stainless bar (see Figure 4-22).

2. The printhead dots are in a row running across the printhead. The row is located approximately .060 from the front edge of the ceramic block. The row of dots must be centered above the roller for proper operation. The adjustment screw moves the printhead to place the dots over the roller (see Figure 4-21).

3. Turn the monitor on and press the 8 second run switch to obtain a printout.

4. Examine the printout with a 10 x magnifier. The density of the dots should be uniform over the entire area of the dot. (Note: The dots are square). If the dots are darker at the leading edge and lighter at the trailing edge, the printhead is behind the roller. Turn the adjustment screw counterclockwise to move the printhead forward.

5. If the dots are lighter at the leading edge and darker at the trailing edge, the printhead is in front of the roller. Turn the adjustment screw clockwise to move the printhead back.

NOTE: When making adjustments, turn the screw no more than 1/2 turn at a time. After each adjustment, run the recorder and examine the dots with a magnifier.

6. When you are satisfied that the printhead is correctly positioned, install the recorder in its housing.

4.2.21 Recorder Assembly Installation

4.2.21.1 Procedure

1. Place the recorder in the 78670A or 78671A upper case and position the recorder cables where they will be out of the way.

2. Lift the two recorder controls and slide the recorder housing into position. Replace the five screws that secure the housing.

3. Tighten the control nuts and replace the knobs (see section 4.2.16).

4. Plug in the ECG Analog board (A3) and plug in the cables.

5. Plug in the recorder control/cable to A2-J10.

6. Plug in the digital ECG board and the Clock/Heart Rate board. Carefully plug the printhead cable into J30 on the recorder board. (The wide conductor goes toward the rear of the instrument case). Install the circuit board.

7. Install the defibrillator control board and connect the flex circuit P18. Plug in the deflection and memory boards, if they were removed.

8. Test the recorder before installing the circuit board shield.

4.2.22 QRS Beeper Speaker Replacement

(Order speaker P/N 9164-0133 and ring gasket 0905-0889)

1. The speaker is mounted to the top of the recorder housing. The housing must be removed in order to gain access to the speaker. Refer to section 4.2.18.

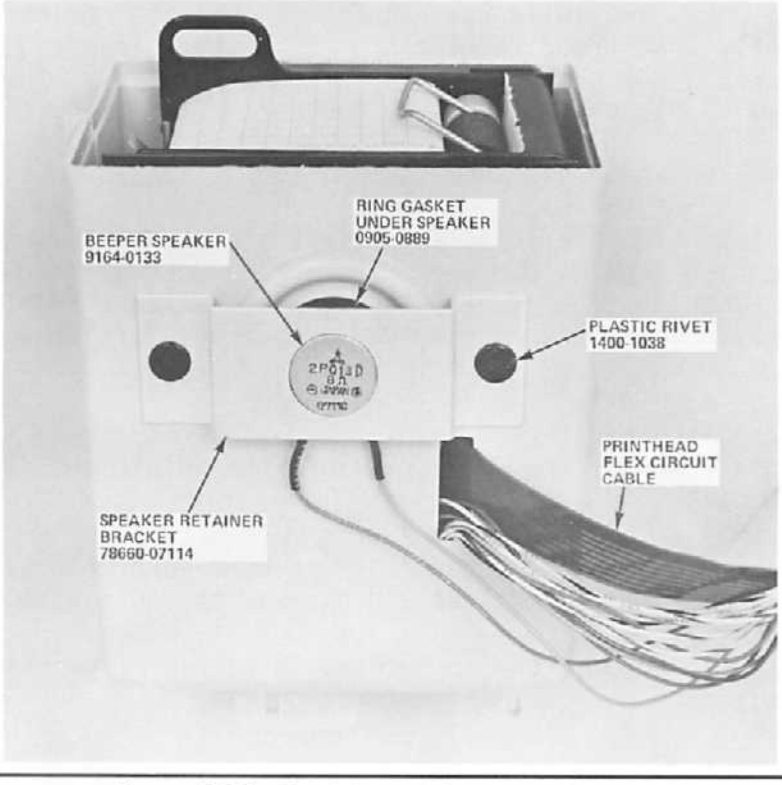


Figure 4-23. Top View of Recorder Housing.

2. Remove the recorder mechanism from the housing. Refer to Section 4.2.18.2, paragraph 11 and 12. Press out the two plastic rivets that secure the speaker bracket. These rivets must be pressed out from inside the recorder housing.

3. The speaker is secured to the recorder housing by a ring of double-side adhesive foam tape. When the old speaker is removed, the tape may separate leaving a layer stuck to the recorder housing.

4. The mounting surfaces must be free of all tape residue and grease. Wipe these surfaces with isopropyl alcohol and allow to dry for a few minutes.

5. Peel the protective paper from one side of the adhesive foam ring. DO NOT TOUCH THE ADHESIVE SURFACE. Position it on the recorder housing. When the ring is correctly positioned, apply gentle but firm pressure all the way around to set the adhesive.

6. Peel the protective backing from the other side of the ring and position the speaker. Apply pressure to the speaker magnet and hold for about one minute to set the adhesive. Not too much pressure or you may damage the speaker (see Figure 4-23).

7. Solder the speaker wires. Position the speaker bracket and install the plastic rivets. Install the recorder in the housing. Proceed with the installation as outlined in section 4.2.21.

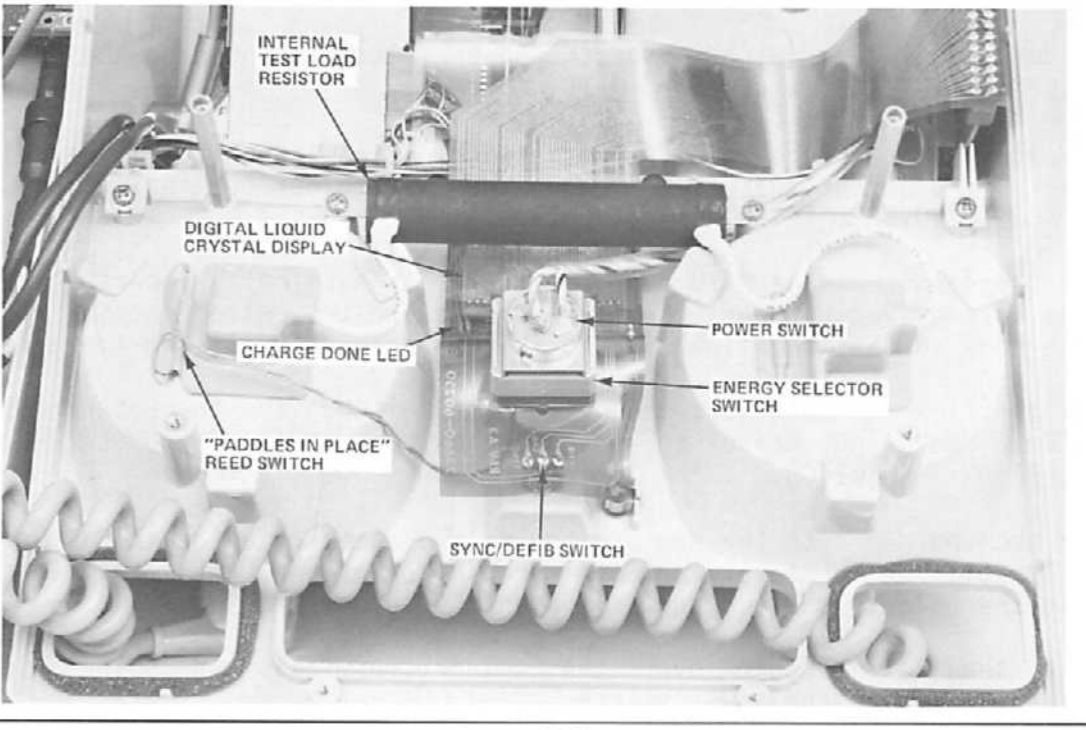


Figure 4-24.

4.2.23 "Paddles in Place" Reed Switch Replacement

(Reed switch 0490-0194, cover 78660-40034, adhesive gasket 78660-40035)

1. This switch is mounted under the apex paddle pocket. The switch is mounted under a plastic cover which is secured to the paddle pocket by a double-side adhesive foam gasket (see Figure 4-24).

2. Use a pocket knife to pry the plastic cover from the paddle pocket. Unsolder the wires from the reed switch.

3. Solder the wires to the new switch.

4. In order to mount the replacement cover, the paddle pocket must be free of all residue from the old adhesive foam gasket. Remove with a pocket knife or screwdriver and wash the surface with isopropyl alcohol.

5. Wash the mounting surface of the cover with alcohol. Peel the protective cover from one side of the adhesive foam gasket. DO NOT TOUCH THE ADHESIVE SURFACE.

6. Place the reed switch in the cavity in the cover and place the adhesive surface of the gasket on the plastic cover. Apply firm but gentle pressure to set the adhesive. Be careful not to damage the reed switch.

7. Peel the protective cover from the other side of the gasket and place the cover in position over the paddle pocket terminal. Press around the edges to set the adhesive.

4.2.24 ENERGY SELECTOR Switch Replacement

1. Remove the ENERGY SELECTOR Knob (see section 4.2.17).

2. This switch is mounted to the lower front panel but is electrically connected to the flex circuit (see Figure 4-24). Exercise caution when removing the switch from the flex circuit. Unsolder the flex circuit with the switch in place (see step 4).

3. Unsolder the 2 heavy wires from the power switch mounted on the rear of the ENERGY SELECTOR.

4. The following procedure requires a small soldering iron with a fine point. Use solder wick or a solder sucker to loosen the six solder terminals from the flex circuit. DO NOT OVERHEAT THE FLEX CIRCUIT.

5. After the solder has been removed from all six terminals, insert a scribe or a fine blade screwdriver between the flex circuit and the switch body. Work across the switch body so that the flex circuit is removed evenly all the way across.

6. After the flex circuit is removed from the switch, lay the upper case housing on its side. Use a nut driver to loosen the switch. NOTE THE ORDER THE HARDWARE IS INSTALLED ON THE SWITCH.

7. Place the hardware on the new switch in the same order as it was on the old switch. It will be necessary to move the switch around until the locating lug engages in the hole in the housing. Tighten the nut.

8. Place the flex circuit over the solder terminals and solder in place. Reconnect the wires to the power switch.

4.2.25 Other Components Mounted on the Flex Circuit

1. These include the SYNC and CHARGE DONE LED's, the SYNC/DEFIB switch and the LCD (see Figure 4-25).

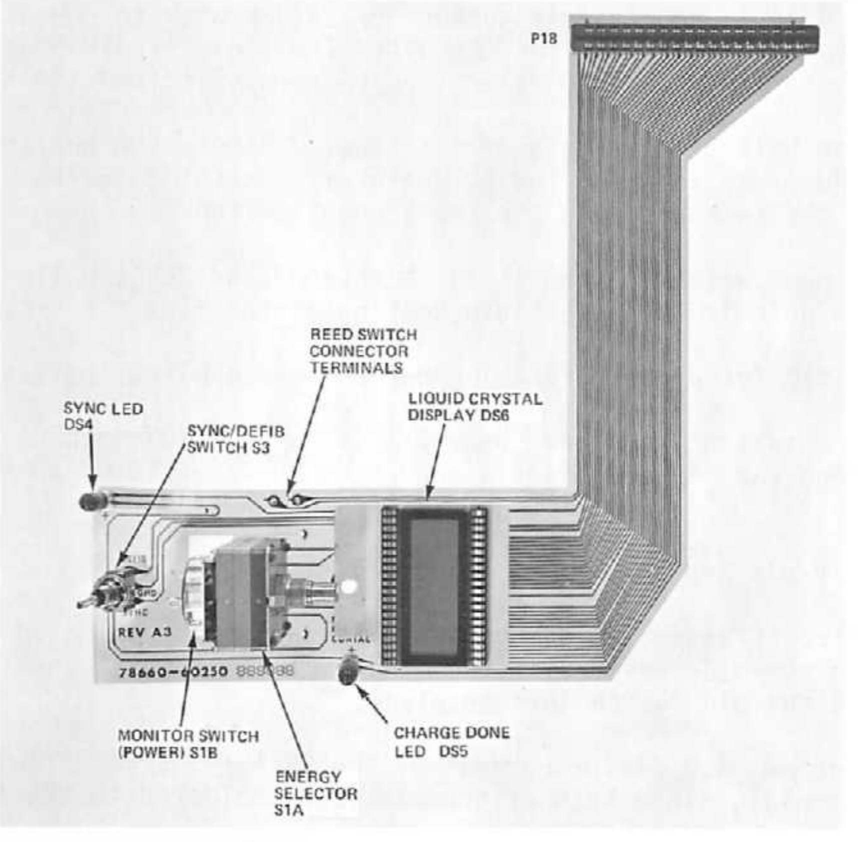


Figure 4-25. Flex Circuit Assembly(A-16).

2. Refer to section 4.2.24 concerning procedure for unsoldering components from the flex circuit.

3. When replacing LED's, note polarity. The longest LED wire is positive. Always install any panel mounted part before soldering to the flex circuit.

4.2.26 SYNC/DEFIB Switch Replacement

- Switch 3101-2398
- Energy switch decal

4.2.26.1 Tools Required

Soldering iron and solder sucker

5/16" nut driver

4.2.26.2 Procedure

1. The SNYC/DEFIB switch bezel is secured by the ENERGY SELECT switch decal. It is possible to remove the switch bezel by lifting the lower end of the decal. However, a spare decal is good insurance.

2. After the bezel is removed, pull the plastic knob off the switch lever.

3. Open the unit as outlined in section 4-1.

4. See Figure 4-24. Use a solder sucker or solder wick to unsolder the switch. Be careful not to overheat the flex circuit. The flex circuit must be loose from all three switch terminals before attempting to remove it from the switch.

5. Turn the top half of the case on its side. Remove the nut that secures the switch. Note the order in which the hardware is assembled on the switch. It must be installed in the same order on the replacement switch.

6. Install the new switch. After it is tightened, solder the flex circuit to the switch. Do this quickly to prevent overheating of the flex circuit.

7. Test the switch for proper operation before reassembling the case.

8. Install the switch knob and bezel. If the ENERGY SELECT decal must be replaced, exercise care in alignment around the ENERGY SELECTOR switch.

4.2.27 Flex Circuit Replacement (Refer to Figure 4-25)

1. The flex circuit assembly is supplied with all parts soldered in place. The installation can be made easier if the SYNC/DEFIB switch is unsoldered from the flex circuit and the old switch left in place.

2. Refer to section 4.2.24 for removal of the ENERGY SELECTOR switch and Section 4.2.28 on LCD removal, since both of the parts are soldered to the flex circuit.

3. The CHARGE DONE and SYNC LED's are each secured by one screw. Unplug the reed switch cable from the flex circuit.

4.2.28 Liquid Crystal Display Replacement

The LCD holder is soldered to the flex circuit. Figure 4-24 shows the flex circuit as it appears when installed. Figure 4-25 is the flex circuit assembly.

No soldering is necessary to change the LCD but caution should be exercised when working with the flex circuit since it can be damaged by careless handling.

4.2.28.1 Tools Required

- Medium size posidrive screwdriver

READ THIS ENTIRE SECTION BEFORE PROCEEDING

4.2.28.2 Procedure

1. Open the instrument as outlined in section 4-1 and remove the circuit board shield. Unplug the flex circuit from the Defib Control board (P18). Unplug the two wire connector from the mother board that contains the power switch wires.

2. Remove the two screws that secure the internal test load resistor. It is not necessary to remove the wires. Lift the resistor and position it over the handle opening (see Figure 4-26).

3. Remove the two screws from the LCD clamp (Figure 4-26) and the single LCD holder screw, located directly behind the ENERGY SELECTOR switch (Figure 4-27).

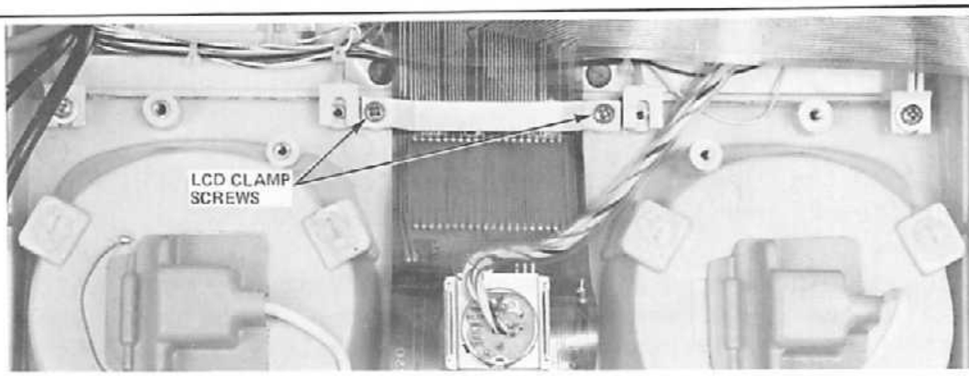


Figure 4-26.

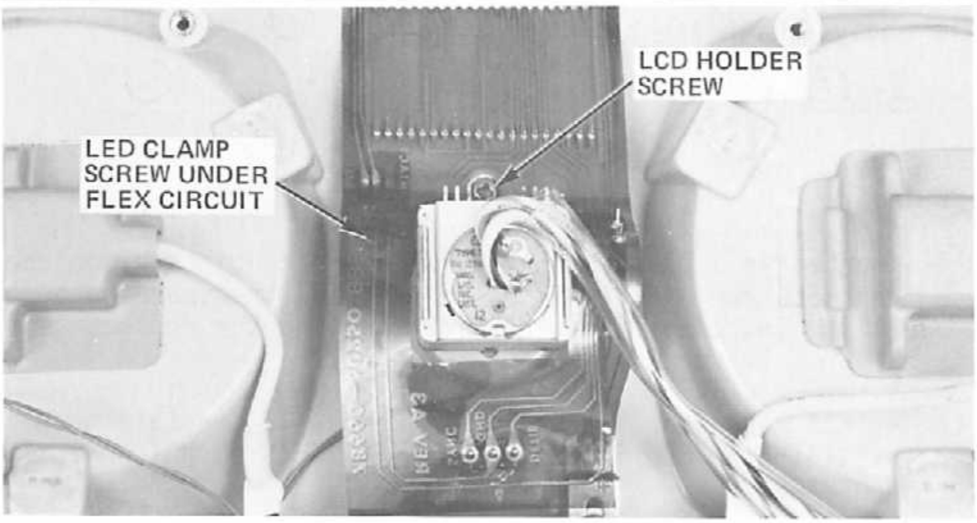


Figure 4-27.

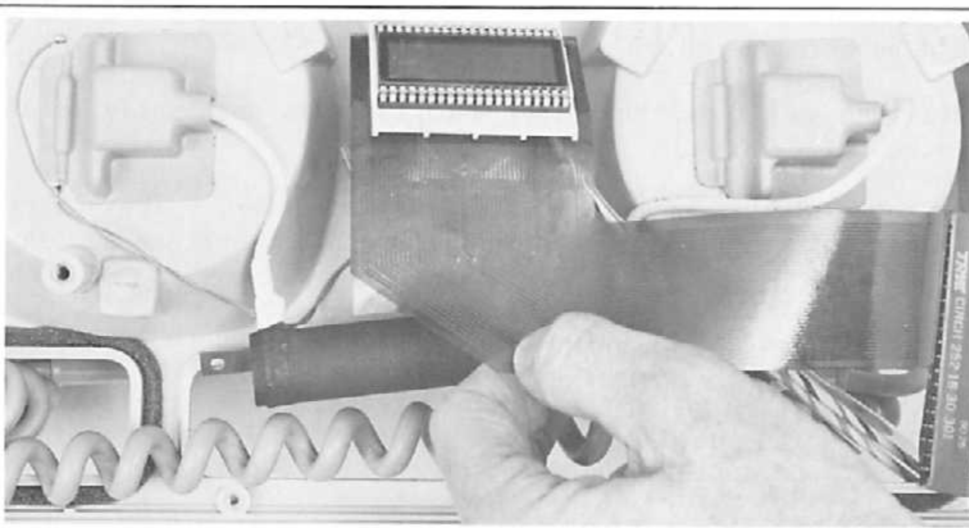


Figure 4-28.

4. Just to the left of the ENERGY SELECTOR switch is the CHARGE DONE LED. There is a screw in front of the LED that must be removed. It will be necessary to bend the flex circuit to allow passage of a screwdriver. Start at the forward edge and bend the flex circuit down. DO NOT ATTEMPT TO BEND IT UP. Remove the screw and carefully pull the LED from the front panel. DO NOT pull the flex circuit.

5. The LCD holder has a projection at the top edge which slides under a tab on the back of the front panel. Without attempting to lift the flex circuit, slide the LCD holder toward the ENERGY SELECTOR switch, until the LCD holder is off the tab on the panel.

6. Carefully fold the flex circuit back over the ENERGY SELECTOR switch to expose the LCD holder (see Figure 4-28).

7. If trouble was experienced with the display and it has been determined that the problem lies in the LCD, examine the LCD holder to be sure the contacts are centered on the LCD. Gently push the LCD from side to side but not so far that the end of the LCD goes beyond the end contact and allows the contact to drop.

8. When reinstalling the LCD holder, be certain the projection on the top of the LCD holder is engaged with the tab on the panel.

4.2.29 LCD Replacement

4.2.29.1 Procedure

1. The LCD is mounted in a glass sandwich with the contacts along the top on both sides. These contacts are a thin film, and nearly transparent, but can be seen under the proper lighting conditions. Avoid touching the contact surface with the fingers.

2. Since the glass sandwich has an abrupt edge, a special technique must be employed when installing an LCD in the holder. IF THIS IS NOT DONE, THE LCD HOLDER CONTACTS WILL BE DAMAGED.

3. When replacing an LCD, one method is to use the new LCD to push the old one out of the holder. As long as a gap is not allowed to form between the two LCD's, no problem should be encountered.

4. When installing an LCD in the holder when there is no display in place, use the following procedure:

(a) Obtain two strips of hard plastic such as mylar. These strips should be about .005 inches thick, no wider than the LCD contact surface and an inch or more longer than the LCD.

(b) Slide a strip under each set of LCD holder spring contacts.

(c) Slide the LCD in under the plastic strips. The strips should be between the LCD contacts and the holder contacts. When the LCD has been inserted all the way into the holder and centered between the contacts, pull the plastic strips out.

5. Before the new LCD is installed, it must be correctly oriented. The three 8's are toward the right side of the display when installed in the unit. When the unit is open and the flex circuit folded back over the ENERGY SELECTOR switch, the 8's go toward your left.

6. Peel the protective plastic cover from the LCD if this has not been done. Check the surface of the display for dirt or fingerprints before assembling the unit. Check the display for proper operation before closing the case.

4.2.30 LED Replacement, Front Panel

4.2.30.1 Procedure

The ECG Source and low battery indicator LED's can be replaced without disassembling the case.

1. Remove the front panel as described in Section 4.2.12.

2. Carefully pull out the LED assembly far enough to access the shrink tubing covering the soldered connection. Cut and remove the shrink tubing. Unsolder the LED assembly.

3. Observe the polarity of the replacement LED. The wiring color code is as follows:

INDICATOR	POSITIVE (LONG) LEAD CONNECTION
ECG Paddles	Orange
ECG Leads	Yellow
Low Battery	Wht/Blu

4. Install the new LED being sure to replace the shrink tubing (1/16 inch 0890-0732 is recommended).

4.3 RECHARGEABLE NICKEL CADMIUM BATTERY - B1

Many nickel cadmium batteries are needlessly replaced each year because service personnel did not understand their characteristics. Most storage batteries require a certain amount of maintenance, and the nickel cadmium battery is no exception. However, their maintenance requirements are quite different from an automobile battery, for example.

4.3.1 General Description

The battery (B1) used in the portable defibrillator is a 10-cell, 2.0 AH sealed nickel cadmium type. It is charged with a constant current source of 200 mA and can sustain overcharging indefinitely at this rate. The internal construction and chemistry of the battery is such that oxygen generated during overcharging rapidly diffuses through the cell and recombines at the negative plate. Consequently, there is no excessive pressure build-up in the cells and the excess energy is converted to heat; a fully-charged battery will be warm to the touch when kept on overcharge. Since no detrimental effects occur because of overcharging, the unit should be kept charging whenever practical.

4.3.2 Charge Retention

The nickel cadmium battery has a relatively high self discharge rate, when compared to other types of batteries. Charge retention depends on the storage temperature and the age and condition of the battery. The self discharge rates for new batteries are listed below:

Temperature	Self Discharge/Month
0°C (32°F)	10%
20°C (68°F)	30%
40°C (104°F)	70%

4.3.3 Charging

The heat generated during normal overcharge however, necessitates that the battery not be charged when the ambient temperature exceeds 45°C. The battery should not be charged when the ambient temperature is below 5°C. Charging below this temperature may cause build-up of excessive pressure, with a resultant venting of the cells. Venting will cause loss of electrolyte and gradual loss of battery capacity.

4.3.4 Voltage Depression (Memory)

Nickel cadmium batteries that are left on continuous charge, for long periods of time, suffer from a voltage depression pheomenon. The terminal voltage, under load, will be about 1 volt less than that of a battery in good operating condition. The apparent effect is reduced battery capacity, sometimes referred to as memory.

Under conditions of long continuous charge, the crystals of active material within the plates of the cells, begin to increase in size. As the crystals grow larger, the surface area of active material in contact with the electrolyte decreases. The effect is an increase in internal resistance of the battery. This will be exhibited as premature flashing of the low battery warning light.

4.3.5 What To Do About It

The effects of voltage depression can be eliminated by exercising the battery every 3 months. This can be accomplished by turning on the monitor for about 3 hours, and allowing the battery to discharge. An alternate method is to connect the battery to a test load (HP 78620-60860). Connect a voltmeter to the test load and monitor the discharge. Discharge the battery until the voltage falls below 10 volts. DO NOT ALLOW THE VOLTAGE TO FALL BELOW 9.0 VOLTS, or cell reversal may occur. Use Model 78660-67300 adapter to connect the battery to the test load. The test load will become quite warm during this procedure.

4.3.6 Cell Reversal

Cell reversal, due to deep discharge, can occur whenever the battery voltage drops low enough (i.e., below 9 volts) to cause one of the cells to reach zero volts. The current flowing through the battery pack will then tend to reverse-charge this (weakest) cell. Reverse charging generates hydrogen and oxygen which will cause a rise in internal pressure and possible subsequent venting if the pressure increases sufficiently. The cells have resealable vents, and only a small amount of electrolyte escapes during venting. However, after 10 or more venting incidents, the affected cell will begin to lose capacity and reach reversal earlier.

To minimize this possibility, cells are closely matched in capacity during manufacturing. This ensures that the loss of the weakest cell will be followed shortly by the collapse of the remaining cells. Therefore, when the weakest cell is fully discharged, the remaining cells have so little capacity that current flow is not enough to seriously reverse-charge the weakest cell. This matching of cell capacity makes it imperative that individual cells never be replaced. In the event of a weak battery, the entire battery pack must be replaced. As a further precaution, turn the unit off, or plug in whenever the trace starts to dim or has disappeared.

4.3.7 Battery Replacement

As a battery ages, its capacity will be reduced. If the LOW BATTERY warning starts flashing after only 2 hours of monitoring, and the voltage is not depressed due to long term continuous overcharging, the battery is showing signs of weakening. A fully charged battery should be capable of sustaining at least two hours of monitoring before the trace dims. If the battery is incapable of meeting this minimum, it should be replaced. However, test the battery before replacing. See section 3.2.3.7.

4.3.8 Storage of Nickel Cadmium Batteries

Batteries that are stored for several months without recharging will occasionally develop a short circuit in one or two cells, which renders the battery useless.

If the batteries must be stored, they should be charged about once a month if stored at normal room temperature. The recharge interval may be extended to about three months if the batteries are stored in a refrigerator. In this case, allow the battery to warm up for several hours before charging.

After removal from storage, the battery should be deep discharged and recharged once or twice to restore its capacity.

4.4 RECORDER STYLUS REPLACEMENT (1530-0359)

4.4.1 Tools Required

5/16" hex driver (8710-1196)
Stylus force gauge (8750-0345)

4.4.2 Procedure

1. Remove the battery and place the instrument with the front panel facing up.

2. Refer to section 3.3.17.1 and the right hand illustration. Loosen the stylus pressure adjust screw. Remove the two stylus mounting screws. Grasp the stylus assembly and pull it from the recorder.

3. Reverse the procedure to install the new stylus.

4. Perform stylus pressure adjustment as outlined in Section 3.3.17.

SECTION V
TROUBLESHOOTING

5.1 INTRODUCTION

This portion is divided into two sections. The first section is board level and major component level.

The second section is component level troubleshooting by board or circuit.

5.2 BOARD LEVEL

5.2.1 System Problems

SYMPTOM	SUSPECT AREA	CHECKS
System Dead. Battery voltage normal or power base operation.	Fuse A2-F1 and F2	Check fuses on mother board (A2)
	Battery relay, A11-K1	
	V Ref on defib H.V. board (A-11)	TP-5 to ground 5.4 volts +/-2% (see section 3 for calibration procedure)
	Power switch/wiring	
	Power base	See section 7
	Low voltage power supply (A12)	Troubleshoot low voltage power supply board (A12)
Defibrillator charge time may vary at same energy setting. Strange LCD and recorder readout. Not repeatable.	Noise caused by HV arc HV charger board, A11. Rectifier assembly A13.	Be sure contacts are seated.
	A11-T1	Look for H.V. arcing during charge.

5.2.2 Defibrillator H.V. Problems

SYMPTOM	SUSPECT AREA	CHECKS
Will not charge; LCD shows zeros	SW. BAT No. 2 fuse	Check fuse A2-F2 mother board (A2)
	Defib supply fuse	A11-F1 on defib charger board (A11)
	Defib control board (A10)	
Will not charge. LCD blank	Defib charger board (A11)	If +12 volts not present on P17 Pin 11 when CHARGE switch pressed.
	ENERGY SELECTOR switch binary coding	Place ENERGY SELECTOR in MONITOR position. CHARGE DONE LED should flash when CHARGE switch pressed and released.

Will not discharge in DEFIB mode.	Patient relay drive Defib control board (A-10)	Voltage across patient relay coil should go from zero to approx +12 volts at discharge.
Will not discharge in SYNC mode or will not go into SYNC.	Defib control board (A-10) ECG digital board (A4) SYNC switch or flex circuit (A16)	
Will not discharge in SYNC mode but SYNC LED flashes	Defib control board (A-10)	
	Flex circuit (A-16) SYNC LED	Check through to LED
LCD shows approx 5-10 Joules but unit continues to charge when set to 10J	Defib control board (A-10) Safety relay drive	Pull fuse A11-F1. Check on P28 Pin 4. Should rise to approx +12 volts when CHARGE switch is pressed.
CAUTION: (1) SHORT HV CAP TERMINALS BEFORE CONTACT, TO BLEED CHARGE. (2) RECONNECT LEADS TO T1 BEFORE CHARGING DEFIBRILLATOR.	Safety relay, A1-K2	Pull fuse A11-F1. REMOVE COVER FROM HV DEFIB CAP (A1-C1). DISCONNECT OHMMETER ACROSS HV CAP LEADS NORMAL READING, 10KΩ. WHEN CHARGE SWITCH CLOSED, SHOULD SHOW CAPACITOR CHARGE THRU OHMMETER FOR 5 SEC P5 ERROR SIGNAL, THEN 10KΩ A5 SAFETY RELAY RECONNECTS SAFETY LOAD.
Defib continues to charge. LCD shows zero or low value.	Shorted H.V. capacitor A1-C1. (A loud bang during charge usually indicates a shorted cap).	Ohmmeter check as above. Shorted cap indicates less than 10KΩ.
	Defib H.V. board (A11) or H.V. rectifier	
	Safety relay	Test as noted above.
Unit charges to safety cutoff. LCD indication may be zero or exceed highest energy setting.	Defib control board (A10)	
	Defib H.V. board (A11)	If P17 Pin F is zero volts.
Charge time excessive.	Low battery	Substitute

Audible chirp when charging.	Power base	Check V raw under defib charger load. Should be greater than 10 volts. See section 7
	Charge time calibration (A11-R34)	See section 3 for calibration procedure.
Oscilloscope discharge waveform from energy meter is RC decay instead of damped sine wave.	Shorted defib inductor (A1-L1)	Replace
Inaccurate, inconsistant defib output	Patient relay A1-K1	Inspect for internal discoloration or very bright flash on discharge. WARNING: WEAR EYE PROTECTION. EXPLOSION HAZARD.
	Defib H.V. Board (A11)	
Very high peak current. High delivered energy.		Shorted inductor A1,L1.

5.2.3 LCD Readout Problems

SYMPTOM	SUSPECT AREA	CHECKS
No 8's at turn-on on LCD	Defib control board (A10)	
No LCD or recorder digits	Defib control board (A10)	
Missing digit or segment in LCD	Defib control board (A10)	
	LCD holder	Attempt to adjust. See section 4 on LCD replacement.
	LCD	Check for cracks or improper position in LCD holder.
LCD blurry	Defib control board (A10)	

	Memory board (A5)
	Flex circuit
Missing LCD digit but recorder message O.K.	Defib control board (A10)

5.2.4 ERROR Messages on LCD

(When there's an error mesage, the LCD's will flash the error number and energy alternately).

SYMPTOM	SUSPECT AREA	CHECKS
P0 error	Defib control board (A10)	U10 bus (Port 0)

NOTE: This error may not show up as P0 error on the LCD's because the bus has been effected.

SYMPTOM	SUSPECT AREA	CHECKS
P0 error	Defib control board (A10)	U10 pin 14 or 25
P1 error	Defib control board (A10)	U14 2.5V ref
	Power supply board (A12)	+5V
	Defib H. V. board (A11)	+5.4V ref
P2 error	Defib control board (A10)	U11 A/D converter
P3 error. Cap overcharged	Defib H.V. board (A11)	Vcap monitoring circuit
P4 error	H.V. defib section	Leakage to ground
	H.V. cap	Shorted H.V. cap
	Patient relay	Arcing in relay
P5 error. Can't charge	Safety relay or drivers	Safety relay doesn't open
	Defib H.V. board (A11)	PWM charging circuit
	H.V. cap	Cap leaking charge
P6 error	Patient relay	Arcing in relay
P7 error. Unexpected energy detected on cap	Safety relay	Stuck open
	Defib control board (A10)	Safety relay driver
	Defib H.V. board (A11)	Safety relay driver

P8 error. Can't charge	Low battery	
P9 error	Defib control board (A10)	R72 adjusted out of range.
	H.V. cap	Out of tolerance

5.2.5 CRT Display Problems

SYMPTOMS	SUSPECT AREA	CHECKS
Heart rate digits missing or bad digits	Clock/Heart Rate boards (A7)	
	Deflection board (A6)	
	Memory board (A5)	
	Recorder board (A8)	
Heart rate digits flash. Characters printed on recorder wider than normal.	Recorder board (A8)	
Wrong heart rate displayed and printed	ECG digital board (A4)	
	Recorder board (A8)	
Vertical jitter on CRT digits. Distortion on recorder trace.	L.V. power supply board (A12)	Check -12 volt supply
Modulation on trace edge, trace shrinks, CRT digits deformed	L.V. power supply board (A12)	Check + and -15 volt supplies
Trace shrinks and moves to center of CRT. Edges of trace fold inward. Fuzzy, out-of-focus, jittery trace. Modulation up and down	L.V. power supply board (A-12)	Check +5 volt supply. (5.0 to 5.1 volts with all boards in place). If out, adjust A12-R14 See section 3.

NOTE: If the 5 volt supply is out of regulation, all other supplies may be out as well.

No vertical deflection on ECG trace	Deflection board (A6)	
	Deflection yoke	Measure resistance. See interconnect schematic, Figure 6-2.
Asymetrical vertical deflection.	Deflection board (A6)	
Vertical crossover distortion	" "	
No horizontal deflection	" "	
Asymetrical horizontal deflection	" "	
Beam does not turn off (no retrace blanking)	" "	
Cannot control intensity	" "	
No brightness	CRT filament	Turn power OFF. If dot appears on CRT, CRT and anode H.V. are O.K.
	+200 volt supply	Measure at P3 Pin A
	Anode high voltage	Remove CRT anode connector and arc to CRT shield. WARNING: 5000 VOLTS
No CRT trace or digits	" " "	
Brightness and trace length varies. Spikes on trace	" " "	
No ECG signal on CRT (CRT digits and recorder ECG O.K.)	Memory board (A5)	
ECG trace breaks up	Memory board (A5)	

5.2.6 Recorder Problems

SYMPTOM	SUSPECT AREA	CHECKS
Recorder will not run or will not shut off	Recorder control board (A8)	

SYMPTOM	SUSPECT AREA	CHECKS
Recorder will not run or will not shut off	Recorder control board (A8)	
	Recorder run switch/cable recorder	
Recorder will not run. Slight movement when MARK switch pressed. No movement when 8 second run switch pressed	Recorder	Recorder fully closed.
	Recorder board (A8)	
Automatic recorder run on defib charge, does not operate.	Recorder control board (A8)	
	Defib control board (A10)	
No recorder ECG trace heart rate and CRT digits normal	Pen heat adjust	See Section III
	Recorder control board (A8)	
	Stylus	Replace. See Section IV of this manual
Stylus moves with recorder off	Recorder control board (A8)	
Stylus does not move with recorder on	Recorder control board (A8)	
	Memory board (A5)	
Stylus pinned or large stylus offset	Recorder control board (A8)	
	Memory board (A5)	
Stylus vibrates at approx 60 Hz	Recorder board (A8)	
Poor recorder performance (frequency response - overshoot)	Recorder	Replace if CRT trace is good.
No ECG signal on recorder or EXT ECG output. CRT trace O.K.	Memory board (A5)	
	Recorder control board (A8)	

No annotation, poor quality printing, missing dots. LCD normal.	Recorder	Recorder fully closed.
	Printhead adjustment	See section 4 for alignment procedure.
	Printhead	Unplug P30. Check between common and each printhead element. Aprox. 80 Ω.
No annotation. LCD does not operate.	Defib control board (A10)	
Printhead dots printed on power up or power down.	Recorder control board (A8)	
Wrong "SET TO" energy message printed	Recorder control board (A8)	
Strange messages or missing dots	Recorder control board (A8)	
	Printhead cable connector (J30)	Check connector
Wrong language or relative time printed instead of real time or no delivered energy or peak current information printed.	Check position of switches on clock/heart rate board	See section 2.4.1
	Clock/heart rate board (A7)	
Recorder prints TEST ENERGY with paddles out of pockets.	Defib control board (A10)	
	Reed switch or wiring short.	Unplug P18. Continuity check reed switch with paddles out of pockets.
Recorder prints delivered energy with paddles in pockets, at any energy setting.	Reed switch or wiring open circuit.	Same as above but with paddles in pockets.
Light or no printing		Printhead alignment recorder not properly closed.

5.2.7 Indicator Malfunction

SYMPTOM	SUSPECT AREA	CHECKS
LOW BATTERY LED function does not work	Defib control board (A10)	

Battery LED on all the time without power base	defib control board(A 10)	
LOW BATTERY function. LED does not flash but lights when unit is on power base.	" " "	
Defib will not discharge in SYNC mode or will not go into SYNC.	Defib control board (A10)	
	ECG digital board (A4)	
	Sync switch or flex circuit	
Defib will not discharge in SYNC mode but SYNC LED flashes	Defib control board (A10)	
Sync LED does not flash but defib discharges in SYNC mode	Defib control board (A10)	
	Flex circuit, SYNC LED	Check through to LED
Leads and Paddles LED's does not operate. No CAL signal.	ECG analog board (A3)	
As above except CAL O.K.	ECG analog board (A3)	
Malfunctions or delivered energy or peak current annotation problems.	Defib control board (A10)	
No CAL signal. Leads and paddles LED do not operate.	Analog ECG board (A3)	
No CAL signal. Leads and paddles LED's O.K.	Cal switch and wiring	
No QRS beep or alarm signal.	Memory board (A5)	

5.2.8 ECG Signal Problems

SYMPTOM	SUSPECT AREA	CHECKS
No Leads ECG signal CAL and paddles ECG O.K.	ECG leads and connector wiring	
	Leads/Paddles switch	

No ECG signal from leads or paddles. CAL signal O.K. Leads and paddles LED's operate.	ECG analog board (A3)	
No ECG signal from paddles. Leads ECG and CAL signal O.K.	Patient relay A1-K1	
	Leads/paddles switch, wiring	
No external ECG output. Recorder ECG O.K.	Memory board (A5)	
No external ECG output or recorder ECG. CRT ECG O.K.	Memory board (A5)	

5.2.9 Real Time Clock Problems

SYMPTOM	SUSPECT AREA	CHECKS
Clock inaccurate or does not operate	Clock/heart rate board (A7)	
Cannot enter time set mode.	Clock/heart rate board (A7)	Read instructions for time set mode very carefully. See section 3.
Time/date cannot be set correctly.	Clock/heart rate board (A7)	

5.2.10 Control Problems

SYMPTOM	SUSPECT AREA	CHECKS
Alarms switch or alarms problems	Clock/heart rate board (A7)	
	Memory board (A5)	
	Alarm switch and wiring	
	Speaker, wiring	If tone does not sound at turn-on or in service mode.
Recorder controls	Recorder board (A8)	
Mark Switch	Clock/heart rate board (A7)	
8-second run switch	Switch and wiring	

5.2.11 Service Mode

SYMPTOM	SUSPECT AREA	CHECKS
Will not enter service mode	Defib control board (A10)	
	Service switch and wiring	Unplug P11 from mother board, A2. Check for switch operation. See interconnect schematic in Figure 6-2.
No service ramp-step waveform on CRT or recorder	Memory board (A5)	
	ECG Digital board (A4)	
Ramp waveform is nonlinear	Memory board (A5)	
	Deflection board (A6)	

5.2.12 Battery and/or Power Base Problems

SYMPTOM	SUSPECT AREA	CHECKS
Reduced monitoring time until BATTERY LED flashes.	Battery	Replace or deep discharge battery. See section 3 on Battery Capacity Check.
	V Ref shutdown on defib H.V. board (A11)	Measure TP-5 to ground. 5.29 to 5.51 volts. See section 3 for calibration procedure (A11-R100)
Battery does not charge with unit on power base.	Battery	Fully charged battery should measure approx 13.5 volts.
	Power base	See section 7
	Defib control board (A10) LED	

5.3 COMPONENT LEVEL

5.3.1 ECG Monitor

SOURCE	OBSERVED CONDITION											
CRT ECG signal	Y	Y	Y	N	N	N	N	-	-	N	N	N
Recorder ECG signal	N	N	Y	-	-	Y	Y	Y	Y	N	N	N
Ext ECG signal	Y	N	N	-	-	-	-	-	-	N	N	N
Beeper (when CAL is pushed)	-	-	-	-	-	-	-	-	-	N	Y	N
CRT Service Ramp-step signal	-	-	-	Y	Y	N	N	-	-	N	N	N
Operation of CAL in service (and in AUTO GAIN)	-	-	-	Y	N	-	-	-	-	-	-	-
CRT Horiz sweep	-	-	-	-	-	-	-	N	N	N	Y	Y
CRT Digits	-	-	-	-	-	Y	N	Y	N	-	-	-
Go to Line	1	2	3	4	5	6	7	8	9	10	11	12

1. RECORDER PCA - A8 or Recorder
2. MEMORY PCA - S/H opamp U18D or S/H switch U14B
3. MEMORY PCA - opamp U18A; cabling from mother board to ECG output jack A1-J34
4. ECG ANALOG PCA - A3
5. ECG DIGITAL PCA - A4
6. MEMORY PCA - S/H opamp U17A; S/H switch U14C
7. DEFLECTION PCA - A6
8. MEMORY PCA - Ramp generator U17B,C; Ramp sync U3A
9. DEFLECTION PCA - A6
10. MEMORY PCA - 1MHz osc; divider chain U5,6,7
11. MEMORY PCA - A5
12. ECG DIGITAL PCA-A4

5.3.2 ECG Analog Board (A3)

5.3.2.1 ECG Section

SOURCE	OBSERVED CONDITION					
CAL signal	No	Yes	No	Yes	Yes	Yes
ECG from Leads	--	--	Yes	Yes	No	No
ECG from paddles	--	--	Yes	No	Yes	No
Leads/Paddles LED's operate	No	No	Yes	--	--	Yes
Go to Line	1	2	3	4	5	6

	SYMPTOM	SUSPECT AREA	CHECKS
1.	No CAL signal. Leads/paddles LED's do not operate	Power supplies	+12 and -12 R. (J8 Pins 10 and L). 5 Volt regulators A3-U53 and U54.
2.	CAL signal O.K. Leads/paddles LED's do not operate	Isolation transformer A3-T1 and T2, U51B, U52A, U52B, Q51, Q52	Check for broken transformer leads. 62.5 KHz clock signal J8 Pin 2. Drive signals to T2. +5D J8 Pin 9.
3.	No CAL signal. ECG signals and leads/paddles LED's O.K.	CAL switch/wiring	
4.	No ECG signal from paddles. Leads ECG and CAL signals O.K.	Patient relay, leads/ paddles switch, A1-S2	Paddle connectors
5.	No Leads ECG signal CAL and paddles ECG O.K.	Leads/paddles switch A1-S2	Lead connectors and cables
6.	No ECG signal from leads or paddles. CAL signal O.K. Leads/paddles LED's operate.	T2 defective or broken connection to T2. ECG amplifier	Follow the ECG test procedure outlined below.

5.3.2.2 ECG Differential Amplifier Test Procedure

INSTRUCTION	NORMAL OBSERVATION	POSSIBLE CAUSE FOR ABNORMAL OBSERVATION
1. Measure isolated power supply voltage.	Isolated Vcc + 4.2 V isolated Vee - 4.2 V	Chopper power supply and driver circuits.
2. Select "LEADS" for ECG SOURCE. Short "LEADS" inputs together.	Voltage at junction of R12, R13 and R23 approx zero to +/-20 mV. Voltage at junction of R31, R32 and R29 approx zero to +/-20 mV. U2 Pin 6 approx +0.8 V.	If voltage O.K., go to 3. If voltage not O.K. go to 4.
3. Disconnect shorts. Short junction of R12, R13 and R23 to +Vcc. Short junction R31, R32 and R24 to -Vee.	Floating side of T2 should be square wave approx/less than +/-4.2 V P-P 32 usec period.	If observation normal, U55. If observation abnormal, U3.
4. Short C13.	U2 pin 6 = 0 volt +/-15 mV	If voltage abnormal, U2. If voltage normal check differential amplifier transistors Q1 thru Q6. Check bias voltages.

5.3.2.3 Bias Voltage Check Procedure on Differential Amplifier

1. Disconnect J27 ribbon cable. Connect J27 pins 11 and 13 to float ground.

2. Short across R18.

3. Apply power and wait at least one minute to allow the amplifier to stabilize.

4. If all transistors (A1 thru Q6) are operating properly, the bias voltages should be as noted below:

Q1 base and Q6 base	-10 mV
Q1 emitter and Q6 emitter	-0.5 V
Q2 base and Q5 base	Vcc-0.55 V
Junction of R12, R13 and R23	-0.8 V

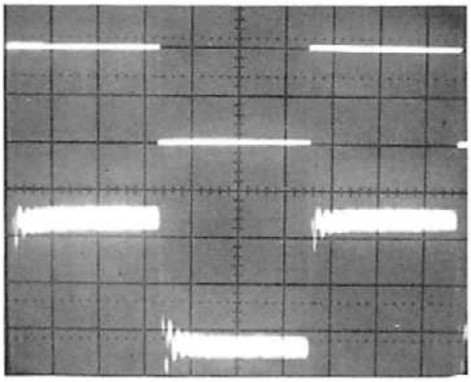
Junction of R31, R32 and R24	-0.8 V
Q3 emitter and Q4 emitter	-0.2 V
Q2 collector and Q5 collector	-0.4 V

If all bias voltages are correct, probable cause is LEADS/PADDLES switch A1-S2.

5.3.2.4 Paddle Contact Indicator Section

1. Put instrument in service mode. (Refer to paragraph 3.4.2.3).
2. Lock paddles in storage pockets.
3. Check for the following waveforms

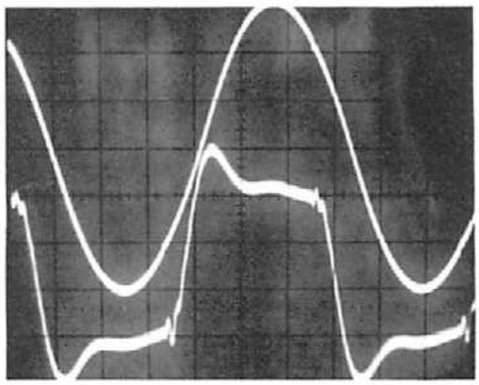
TP 51
5V
U58-1
10mV



5µS Sweep 64.9 ohms across paddles

Figure 5-1A

U58-8
1V
U58-7
0.1V



5µS Sweep 64.9 ohms across paddles

Figure 5-1B

5.3.3 Digital ECG Board (A-4)

CONDITION			INSTRUCTION
1.	+5 Volts on +5D.	NO	Check L.V. power supply board (A-12).
2.	Is +5A normal.	NO	Check U53 and U54 on analog board (A3).

With no ECG input, J9 Pin N should be biased at zero +/-50 mV. This should drop to approx -250 mV when the CAL switch is pressed.

3.	CAL signal on J9 Pin N when CAL switch pressed.	NO	Check CAL switch A1-S5, cabling and ECG analog board (A3).
		YES	Switch to service mode.
4.	Was service waveform visible.	YES	Go to line 7
		NO	Check U6 Pin 6

5.	4 mS clock signal U6 Pin 6.	NO	Check memory board as for 4 mS clock signal.
		YES	Go to line 6
6.	Reset pulses at U6 Pin 4.	NO	Go to line 7
		YES	Go to line 15

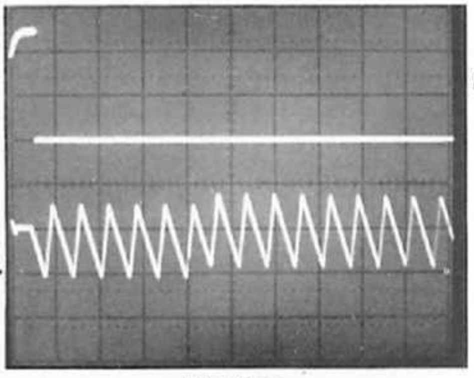


Figure 5-2A

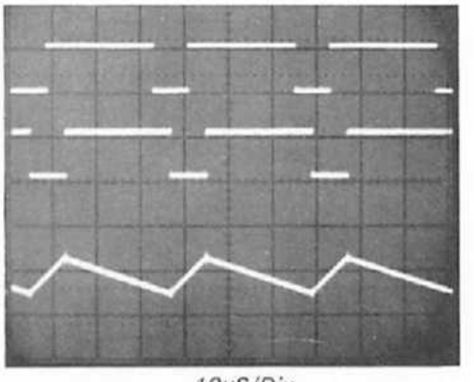
A/D = 128


Figure 5-2B

7.			Ground TP1
8.	Reset pulses at U6 Pin 4.	YES	Diconnect ground from TP-1
		NO	Go to line 16
9.	4 uS clock at U1 Pin 11. (See Figure 5-3).	NO	Check memory board (A5) for clock signal
		YES	Continue

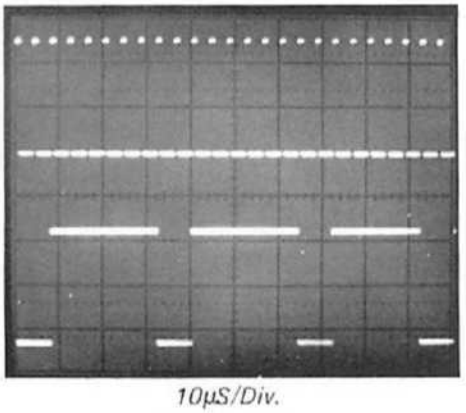
A/D = 128


Figure 5-3A

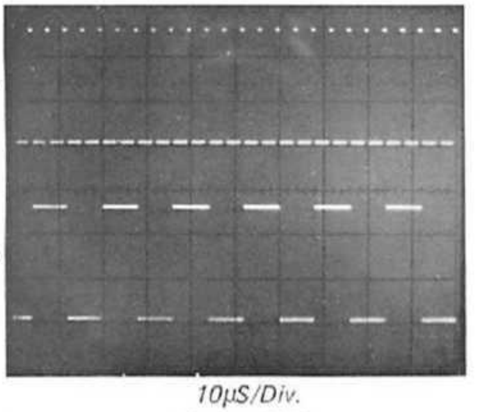
A/D = 255


Figure 5-3B

TP4 should be biased at zero volts +/-40 mV. CAL pulse is approx -210 mV.

10.	CAL pulse at TP4.	NO	Replace U4.
		YES	Continue

11.		Put instrument in SERVICE mode and MANUAL GAIN.
12. Is there a CAL signal at TP-5 of the correct magnitude.		(Less than 160 mV at MIN GAIN. Greater than 3.18 V at MAX GAIN).
	NO	Go to line 18
	YES	Continue
13.		Switch to AUTO GAIN.
14. Is there a CAL pulse of correct magnitude on TP5 for each of the 5 gain stages.		Range is 0.5 to 2.0 V +/-20%
	YES	Go to line 27
	NO	Go to line 23
15. Are there "tickle" pulses at TP1. (4 mS spacing. After reset greater than 10 ms spacing).	NO	Replace U6
	YES	Continue
16. Check U3C and U3D		Connect U3 Pin 12 to ground or +5D and note output on U3 Pin 10.
17. Output follows input.	NO	Replace U3
	YES	Q3 or C1 defective
18.		Check logic level on U6 Pins 27, 28 and 29 (should be 101).
19. Logic levels correct.	YES	Go to line 25
	NO	Continue
20. Is U6 Pin 36 high.	NO	Defective AUTO/MANUAL switch or cabling.
	YES	Continue
21. Does operation of CAL switch pull U6 Pin 37 high and low.	YES	Replace U6
	NO	Continue
22. Is operation of CAL switch seen at J9 Pin 12.	YES	Replace Q2
	NO	Defective CAL switch or cabling.
23. Is ACG (U6 Pins 29, 28 and 27) stepping thru this sequence.		100, 011, 010, 001, 000 then repeat.
	YES	Go to line 25
	NO	Continue

24. Is U6 pin 36 low.	NO	Defective AUTO MANUAL switch or cabling.
	YES	Go to line 21
25.		Short TP5 to junction of R20, R21 and R22.
26. TP5 zero +/-15 mV.	YES	U2 defective
	NO	U5 defective
27.		Short U5 Pins 6 and 7 together.
28. U5 Pin 7 at approx 2.5 Volts.	NO	Replace U5
	YES	Continue
29. Is there V/F conversion from TP5 to U6 Pin 39. (Period should be 32 uS +/-4 uS at U6 Pin 39).	NO	Go to line 35
	YES	Continue
30.		Connect U5 Pin 5 to TP6 (analog ground)
31. Is TP3 high.	NO	U6 defective
	YES	Continue
32. Is U3 low.	NO	U3 defective
	YES	Disconnect U5 Pin 5 from TP6. Connect U5 Pin 5 to Pin 4. Continue.
33. Is TP-3 low.	NO	U6 defective
	YES	Continue
34. Is U3 Pin 3 high.	NO	U3 defective
	YES	Board is operating
35. Does the waveform at U6 Pin 30 appear correct. (See Figure 5-4 and schematic 6-4).	NO	U6 defective
	YES	Continue

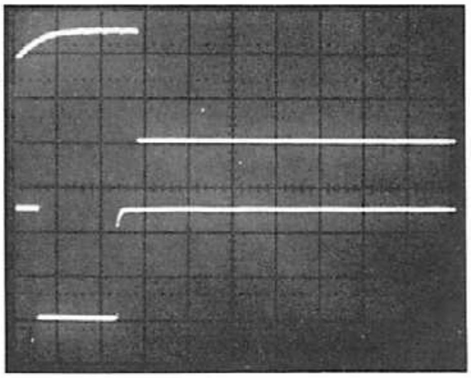


Figure 5-4

36. U5 Pin 1 = 0 +/-15 mV.	YES	Continue
	NOS	Ground U6 Pin 24 and go to line 38
37. Does the waveform at at U6 Pin 24 appear correct. (See Figure 5-4 and schematic Figure 6-4)	NO	U6 defective
	YES	Q5 defective
38. Is U5 Pin 1 at zero +/-15 mV.	YES	Go to line 40
	NO	Short U5 Pin 1 to Pin 2. Continue
39. Is U5 pin 1 at zero +/-15 mV.	YES	U5 defective
	NO	Replace Q5, remove short from U5 Pin 1 to Pin 2. Ground U6 Pin 24 and go to line 38.
40. U5 Pin 14 high. (greater than 3.5 V)	NO	U5 defective
	YES	Short U5 Pin 13 to Pin 14. Continue.

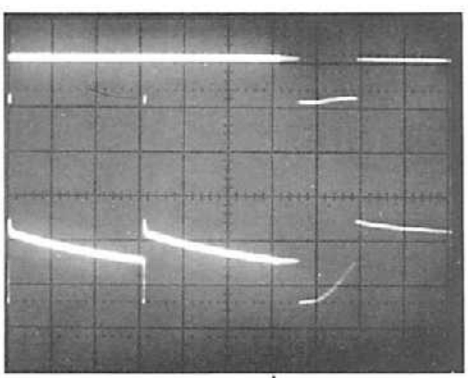


Figure 5-5

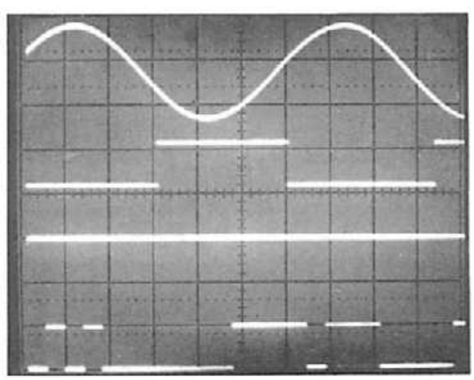


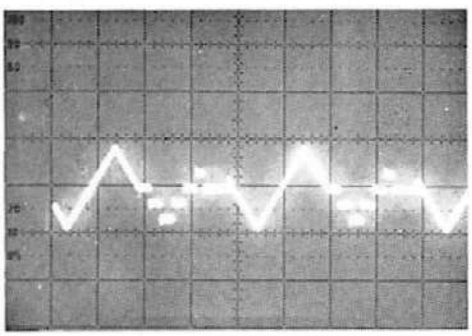
Figure 5-6

Figure 5-6 demonstrates the operation of the auto baseline circuit. In the upper pair, a sine wave signal is applied to the ECG input. In the lower pair, no external signal is applied.

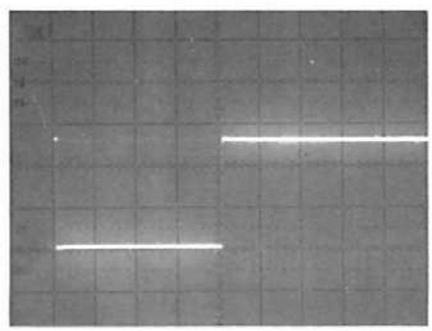
41. Is U5 Pin 14 low. (less than -3.5 V)	NO	U5 defective
	YES	Connect oscilloscope to U1 Pin 13.
42. Does U1 oscillate with period of 16 uS.	NO	U1 defective
	YES	Q4 defective

5.3.4 Memory Board (A5)

SYMPTOM	SUSPECT AREA	CHECKS
No ECG signal on CRT (Recorder ECG O.K.) (CRT HR digits O.K. Refer to Figure 5-7A	A5-U14 s/h switch	Place in service mode for ramp-step waveform Check for ramp-step waveform at U14C pin 10.
	A5-U17 s/h opamp	Check for same waveform at U17A pin 1.

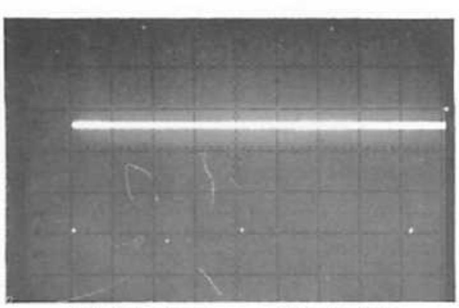


TP4, 1 msec, 2 Volts/Div.
Figure 5-7A

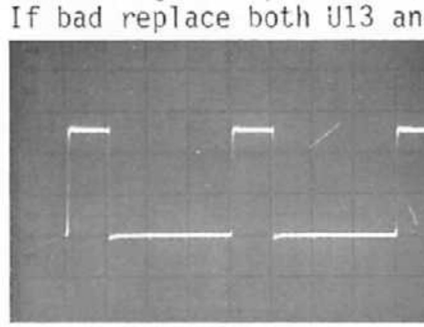


U9, Pin 18, 1usec, 2 Volts /Div.
Figure 5-7B

SYMPTOM	SUSPECT AREA	CHECKS
No service ramp-step waveform on CRT or recorder	A5-U9 RAM	Check waveforms at U9
	A5-U4	If waveforms on U9 pins 18,20 bad, check U4 pins 11,12,14,15.
	A5-U13 D/A, U17	Check waveforms at U13 pins 5-1 and voltages on pins 3,13,14. If bad replace both U13 and U17.

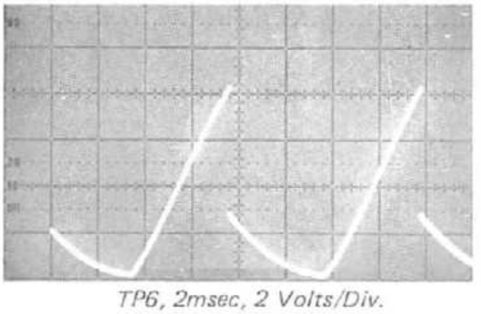


U9, Pin 18, 1 usec, 2 Volts/Div.
Figure 5-7C



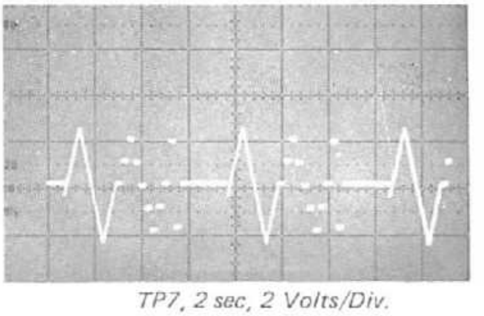
U9, Pin 20, 1 usec, 2 Volts/Div.
Figure 5-7D

Ramp waveform not linear	A5-U14,15 strobe	Connect 2Hz triangle waveform to leads input (or check with service ramp step waveform making observation during ramp). Check that all data lines toggle at different rates.
	A5-U9 RAM	If recorder output is good in REAL TIME mode but bad in DELAY mode, RAM is bad or signals to RAM are incorrect.
	A5-U13 D/A, A5-U17	
No horizontal sweep (CRT digits ok)	A5-U2 Oscillator	Check waveform at U2 pin 4,5 for 1mHz 5V p-p.
	A5-U1 Johnson Counter	Check waveform at U1 pins 1,2, for 1 usec active high 5 volt pulses every 4 usec.
	A5-U8 or FIXED/MOVING trace switch	Switch to FIXED trace mode. If trouble clears, suspect U8. Check waveforms on U8 in MOVING trace mode.
	Address counters A5-U5B, U6B, U7B	Check waveform at U5,6,7 pins 11,12,13. Note-binary dividers starting with period of 8usec at U5 pin 11.
	1025 counter	Check waveform at U5,6,7 pins 3,4,5,6. Note-binary dividers producing 5 volt square waves starting with period of 8 usec at U5 pin 3.
	A5-U17	Check waveform at U17 pin 7 for 16 ms square wave 24V p-p.
	A5-R28,CR6	Check for same waveform at junction CR5,CR6 6.5 V p-p
Horizontal ramp nonlinear	A5-R20,C11,12	Check waveform at U17 pin 10 for 6.5 V ramp.
	A2-U17	Check waveform at TP6 for 6.5 V ramp.



TP6, 2msec, 2 Volts/Div.

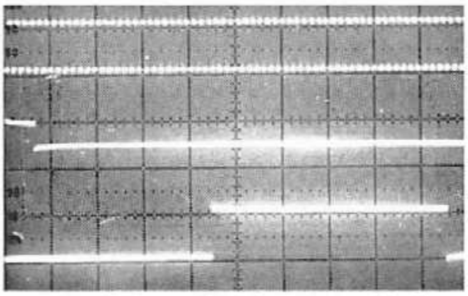
Figure 5-7E



TP7, 2 sec, 2 Volts/Div.

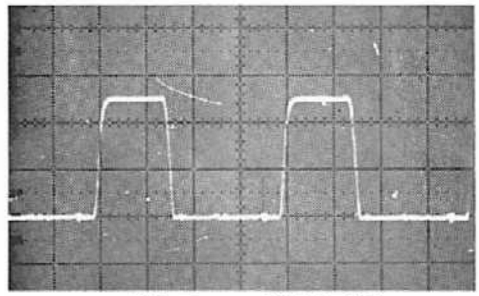
Figure 5-7F

No EXT ECG output (Recorder output O.K.)	A5-U18	Check waveform at U18 pin 1 (TP7) Figure 5-7F
	cabling	Unplug P11 from EXT ECG jack to HV Charger PCA. Check for ramp step waveform at L1 on HV CHARGER PCA (near EXT ECG jack).
No R wave beep or alarm signal	A5-U3	Check waveform at U3 pin 5 for 128 usec active high 5 volt 500 Hz pulses.



U3A, 200usec, 5 Volts, Upper, Pin 2; Middle, Pin 5; Lower Pin 7.

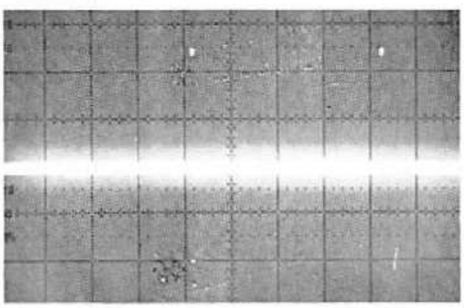
Figure 5-7G



TP1, 1 usec, 2 Volts/Div.

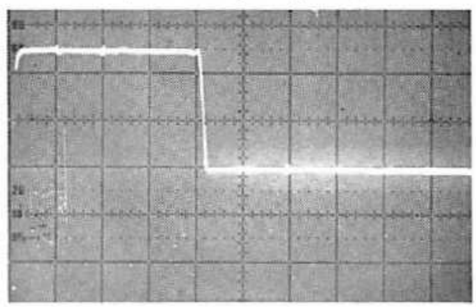
Figure 5-7H

	A5-U2	Check waveform at U2 pin 2 for same waveform inverted.
No signal on recorder or EXT ECG output (CRT O.K.)	A5-U10	Place in service mode for ramp step waveform. Check waveforms at U10 pins 11, 12, 13(TP1 &TP2).



TP2, 1 msec, 2 Volts/Div.

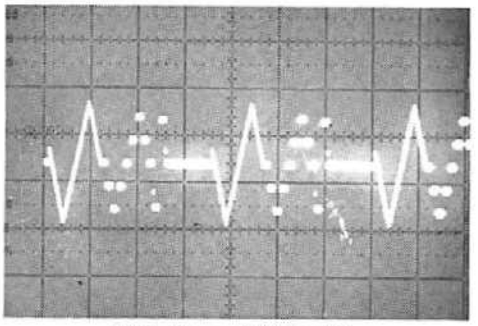
Figure 5-7J



TP2, 1 usec, 2 Volts/Div.

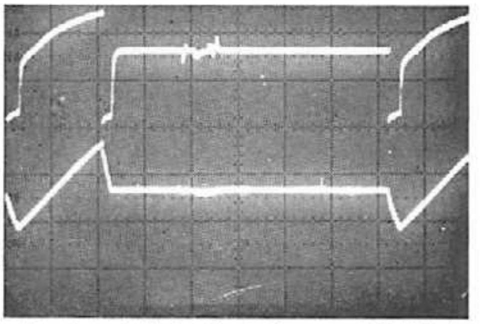
Figure 5-7K

	A5-U14	Check waveform at TP4 for ramp step (0.5 usec/div 3.5 V p-p).(See Figure 5-7A).
	A5-U18	Check for same waveform at TP5 (1 sec/div 5 V p-p). (Fig. 5-7L)



TP5, 2 sec, 2 Volts/Div.

Figure 5-7L



Deflection Board U1A, Pin 1, 2 msec, 10 Volts(upper)
R-32, 2 msec, 2 Volts (lower)

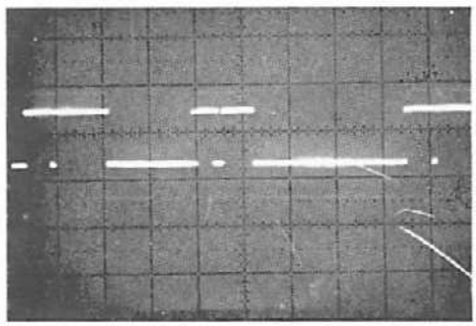
Figure 5-7M

5.3.5 Deflection Board (A6)

Many of these tests require the DEFLECTION PCA, A6, to be inserted in the unit through an extender board.

SYMPTOM	SUSPECT AREA	CHECKS
No vertical gain	Opamp A6-U1D	Check for waveform at U1 pin 14.
	YOKE	Measure resistance of yoke. See schematic Figure 6-2.
	A6-R13	Check for waveform on R13.
Asymetrical vertical gain	Transistor A6-Q2, Q3 Q4, Q5	Check for positive only or negative only excursions at collector Q4, Q5 to ground.
Vertical crossover distortion	Transistor A6-Q1	With no signal input-measure voltage from base Q2 to base Q3-should be 1.0 volts.
No horizontal gain	Opamp A6-U1A (Fig. 5-7M)	Check waveform at U1 pin 1
Asymetrical horizontal deflection	Transistor A6-Q7, Q8	Check for positive only or negative only excursions on R19.
Horizontal crossover distortion	Transistor A6-Q6	With no signal input-measure voltage from base Q7 to base Q8 should be 1.2 volts.
No brightness	CRT filament	Turn power off. If dot appears briefly on CRT, the anode HV and CRT are O.K.
	+200 V supply	Measure voltage at P3 Pin A (+180 to +210 volts).

R13 or R19 burned out	Check power supply voltages.	Replace resistor and U1.
	Intensity pots	Measure cathode and grid volts
	Anode high voltage WARNING: +5000 VOLTS	Remove anode connector and arc to CRT shield.
Beam doesn't turn off	Opamp A6-U1C (Fig. 5-7N)	Check waveform at U1 pin 8
Can't lower intensity	Opamp A6-U1B	Check waveform at U1 pin 7



Deflection Board U1C, Pin 8, 2 msec, 20 Volts/Div.

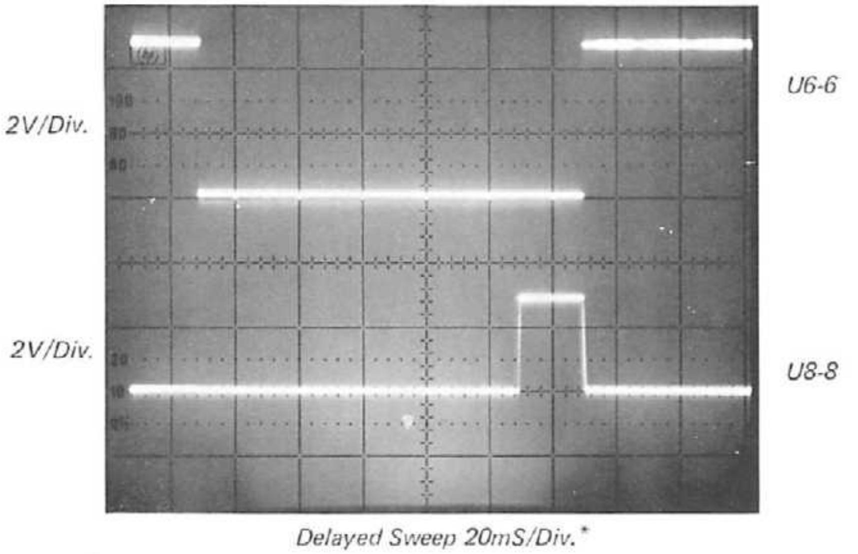
Figure 5-7N

5.3.6 Clock/Heart Rate Board (A7)

SYMPTOM	SUSPECT AREA	CHECKS
1.Clock inaccurate or does not operate.	Clock battery A7-BT1	Battery voltage should be greater than 2.5 volts.
2. New battery voltage pulled below 2.9 volts.	C10, C16, C26, C27, C28, C29, shorted and SCR latched IC's U7, U8.	Remove jumper wire, W1. Connect microampmeter between TP4 and TP5. Typical current less than 10 uA at room temperature (may be as high as 60 uA).
	U6, U7, A8-U1 connection to mother board, A2.	TP1 for 2048.00 Hz +/-0.005 Hz at 25 degree C.
3. Clock not running or cannot be adjusted.	Y1, C8, C9, U7	Externally trigger oscilloscope on power switch. U6 Pin 6 should go low for 120 or 600 msec. One second after power on. (See Figure 5-8).
	A8-U1, A8-Y1, A7-U6, A7-U5, A15-U1, A15-U2	Connection between A8-U1 Pins 35 and U6 Pin 6.

(For the following checks have oscilloscope set as previously described).

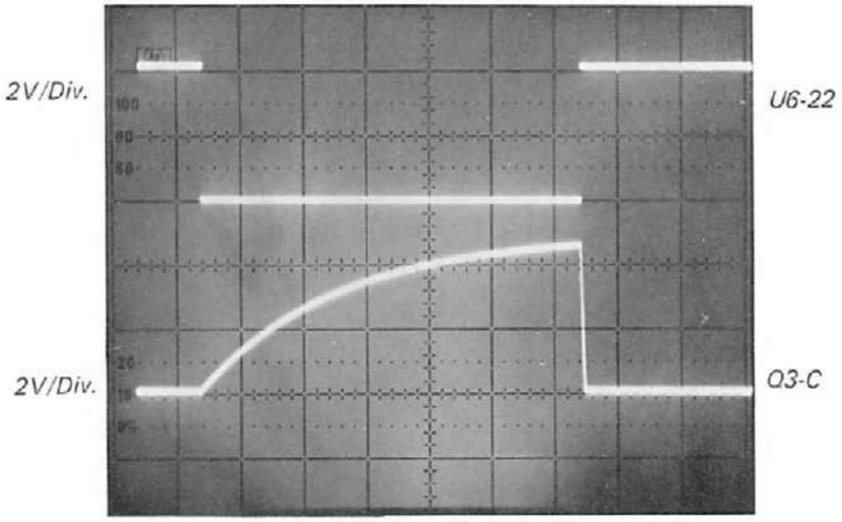
If level does not change, go to step 4.		U8 Pin 6 should to high (2.9 V) for 20 or 600 mS. (See Figure 5-8).
	Q6, R53, R54, U6	Q6 collector should be low when U8 Pin 6 is high.
4. U8 Pin 6 is stuck high (2.9 V) or low (0 V).	U6, if U8 Pin 6 does not charge and U6 does not go low at all.	U6 Pin 22. If U8 is high, U6 Pin 22 should go low for 20 mS. If U8 Pin 6 is low, U6 Pin 22 should go low for 600 mS.
5. U8 Pin 6 is not high or low, or U6 Pin 22 goes low for a time different from 20 or 600 mS.	Q3, R47, R31	Look at U6 Pin 22 simultaneously with the following: (a) base of Q3 should be +0.6 V when U6 Pin 22 is high and near zero when U6 is low.
	C3, C18, R28, R27	(b) Collector Q3 should be as shown in Figure 5-9.



*Delayed Sweep 20mS/Div.**

**Approximately one second has elapsed before start of sweep*

Figure 5-8

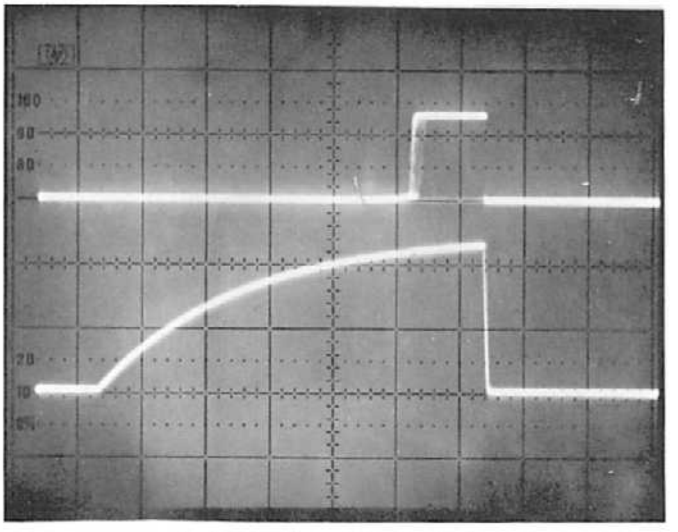


*Delayed Sweep 20mS/Div.**

**Approximately one second has elapsed before start of sweep*

Figure 5-9

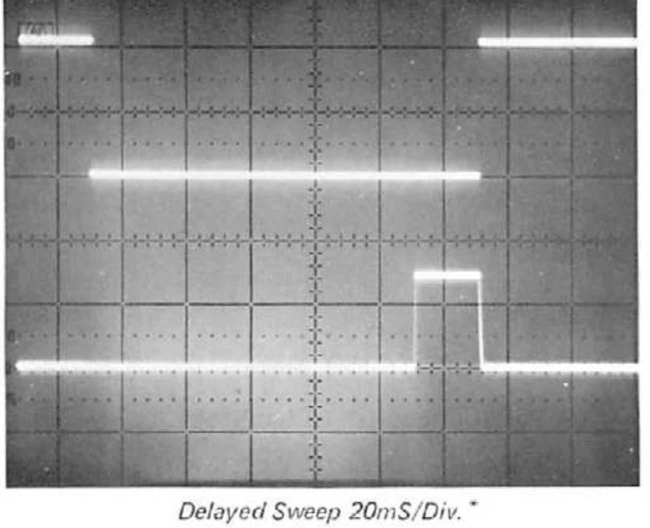
6. "Sleep" line P12 Pin H stuck low.	Connections A1 to A2 and A2 to A7.	
		Q4 and Q5 have parallel connected collectors so that one could fail without being able to tell which one.
	Q4, Q5, R25, R26, R27, R28, R50, R51	Q4, Q5 collectors should be +5 volts when instrument is idle and 0 volts when Q3 collector is above 4.5 volts.
		Place shorting jumper across base and emitter of Q2. Collector should be 2.6 volts.
	If close but not correct, replace any of R18, R20, R21 and Q2.	With jumper in place, measure across R21. It should be 0.5263 times the measured voltage of 5 volt supply.
	Q2, R18, U8	Remove jumper. Check Q2 collector. Should be 2.6 volts when Q3 collector is about 4.5 volts. (See Figure 5-10).
	CR13, R24, C12, R23	Voltage across C12. Should be at system battery voltage.
	U9, CR2, CR8, R23, R22, R19, U8.	DC voltage between TP2 and TP3 should be 2.490 volts



Delayed Sweep 20mS/Div.*

Figure 5-10

	+/- 0.0005 volts (use 5-1/2 digit DVM). Adjust R40.
	If not, replace R22.
	Turn off power. TP2 should be about 0.6 volts.
U8	Replace jumper base to emitter Q2. U8 Pin 6 should be high (2.9 V). Remove jumper. U8 Pin 6 should be low.
C11, R53	On power up, 100 mS after U6 Pin 22 goes low, U8 pin 6 should go high for about 20 mS. (See Figure 5-11).
R48, CR15, C19, R48 If after replacing these components, U7 Pin 5 still does not follow, replace U7.	U7 Pin 5 (chip select) should follow 20 mS pulse at U8 Pin 6.



Delayed Sweep 20mS/Div.*

Figure 5-11

Trigger on edge of pulse on U6 Pin 22. Look at U7 Pins 1-4, 6, 8, 9 and their corresponding lines U6 Pins 1-5, 20, 23. Compare the waveforms with those in Figure 2-31 and 2-32 of the Theory of Operation. If the waveforms at U6 are bad, replace U6, possibly A8-U1. If the waveforms are good at U6, and bad at U7, replace any of R39, R52 and the capacitor and Schottky diode on the affected line (any of CR9-14, C20-25). If waveforms are good at U7,

SYMPTOM	SUSPECT AREA	CHECKS
		replace U7. If clock still does not work, replace any of U6, A8-U1, A15-U1. Check connections on mother board A2.

5.3.7 Recorder Board (A8)

NOTE: Recorder control board (A8) and Heart Rate board (A7) have some interaction with circuit boards A4, A5, A6, A10, A15. Interconnection is through mother board (A2).

SYMPTOM	SUSPECT AREA	CHECKS
Recorder won't run or won't shut off, no digits on CRT, alarms don't work or won't enter Time/Date set mode.	A8U1 microcomputer	+5 volts at U1 Pins 5, 26, 40. Zero volts at U1 Pin 7. +5 volts at U1 interrupt line, Pin 6. 400 kHz pulses at U1 Pins 11 and 9 if oscillator running. If not, replace Y1, C12, C13, U1.
	A8 tickle circuit A8U5, Q6, Q7, Q8 U4 Pin 11	Check A8U1 or A15U1 Pin 4 for negative going pulses as in Figure 5-12. If pulses are seen, any of U4, Q7, CR6, C9, R24, R25, CR4 could be bad. Check U4 pins 11, 12 as described below in "No annotating or missing dots." If U4 good, check base of Q7 for pulses synced with U4 Pin 11 as in Figure 5-13. If no pulses at base of Q7, replace C9, R24, R25, CR6, Q7. If pulses seen at U1 Pin 4 are wrong duty cycle and/or frequency, replace C10, R20, R22, R23. Short base to emitter of Q7. U1 Pin 4 should now appear as in Figure 5-12. If not, check U5B Pin 2. Should be 2.5 volts. If not, replace R18, R19, CR14 C11. If it oscillates as in Figure 5-14 or oscillates with a 50% duty cycle at approx 25 Hz, replace CR11.

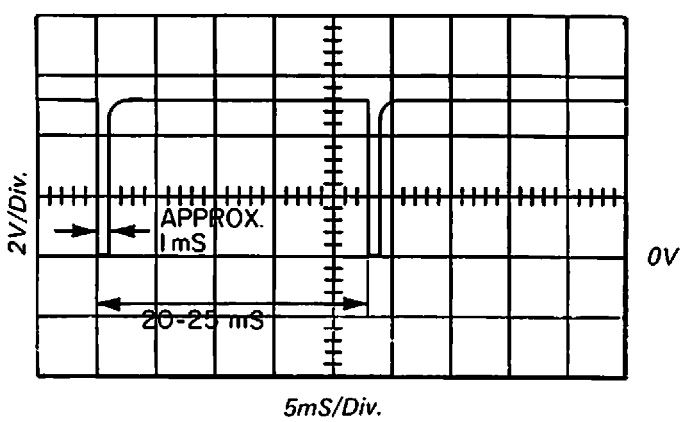


Figure 5-12

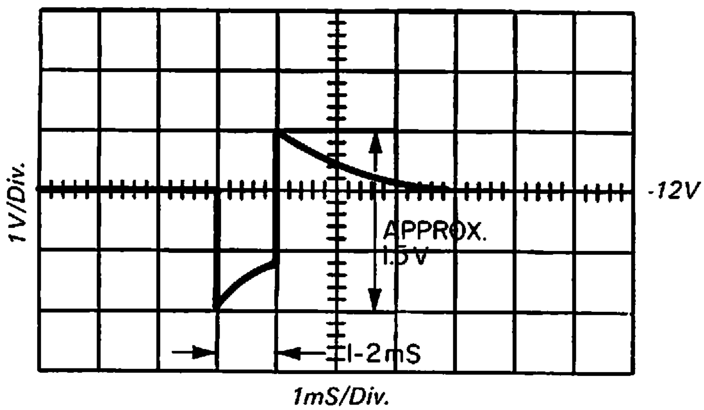


Figure 5-13

If it does not oscillate at all, with base and emitter Q7 shorted together, short U5 Pin 3 to ground. Pin 1 should be at -12 volts. Short Pin 3 to +5. Pin 1 should be at +5 volts. If not replace U5.

When U5 Pin 1 is at +5, Q6 collector (U1 Pin 4) should be low (0 volts), when U5 Pin 1 is at -12 volts, Q6 collector should be at +15. If not, replace Q6, R20, R21, CR10.

A8Q8, A10, A8 or A15 U1 Pin 4 held low.

Check level of "sleep" line from A10. If held low, repair A10 or A2.

If "sleep" high, check voltage across R26. If not close to zero, replace Q8, R27

Short "sleep" line to ground collector of Q6 should also be at ground. If not, replace R26, Q6.

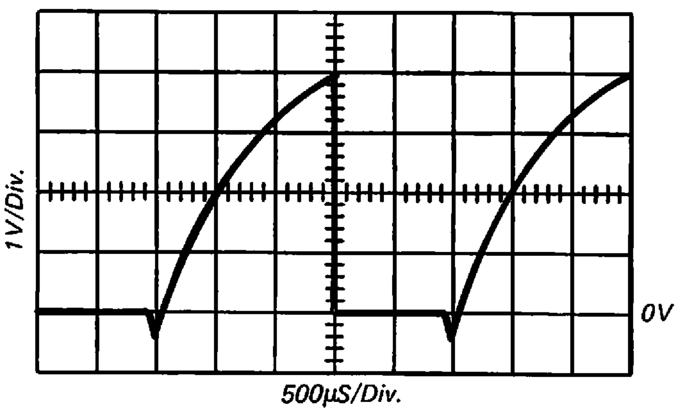


Figure 5-14

After oscillations are obtained (see Figure 5-12), remove short from Q7 base-emitter. Trigger oscilloscope on power switch. Look at U1 Pin 4 (Q6 collector) on power up.

Should be low for approx 100 mS after power up. If not, replace C11, C18, R19, CR14.

5.3.7.1 Annotation (78670A only)

SYMPTOM	SUSPECT AREA	CHECKS
Dots printed on power up.	Printhead protection network A8Q9, Q10	+15 volts at emitter Q10. Trigger scope on power switch. Look at collector Q9. See Figure 5-15. If collector Q9 stays at +15,

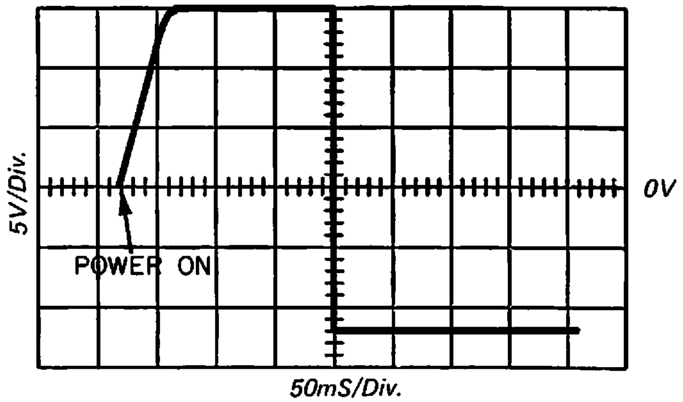


Figure 5-15

replace any of Q9, C21, R47.

If collector stays at -12, replace any of Q9, Q10, R48, R47, C21.

If collector Q9 stays high, much less than 100 mS, replace CR14, R46, R47, C21, C20.

If Q9 collector waveform is good, and +15 does not appear at the collector of Q10, with the printhead connected, replace Q10.

Dots printed on power down.	Same as above	Same as above. See Figure 5-16 for power down waveform at collector Q9. If waveform is good, replace Q10. If not, replace CR15, C20. If collector Q9 stays low for much longer than 50 mS, replace C20, CR15.
No annotation	Same as above	Same as above.
	Recorder	Be sure recorder door is fully closed.
Missing dots	Printhead adjustment	Check alignment. See section 4.2.20 for procedure. (Note: One full turn of the adjustment screw can move the printhead out of the print area.

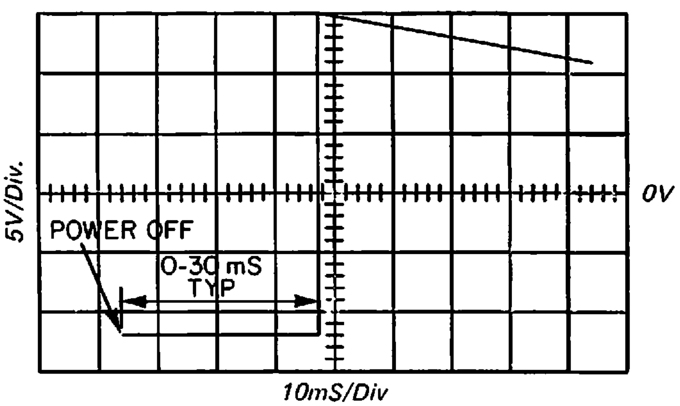
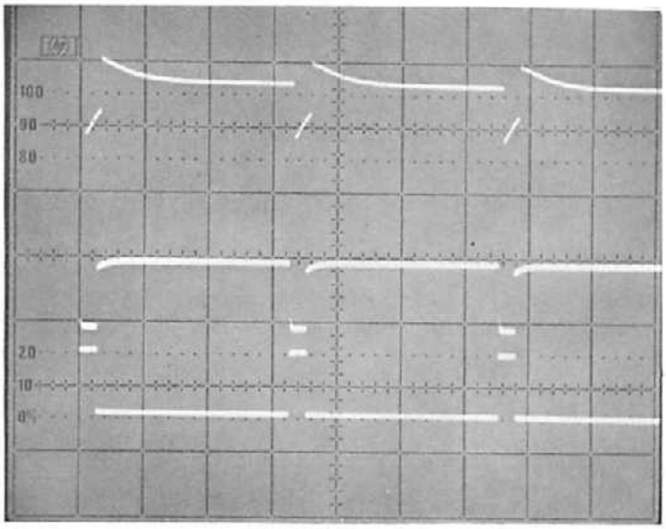


Figure 5-16

Flex cable connector A8-J30	Reinsert cable. Replace connector.
A8U2	When trying to print, inputs to U2 Pins 1-6 should be inverted at outputs (Pins 16-10). If not, replace U2.

5V/Div.
5V/Div.
5V/Div.



5mS/Div.

Figure 5-17

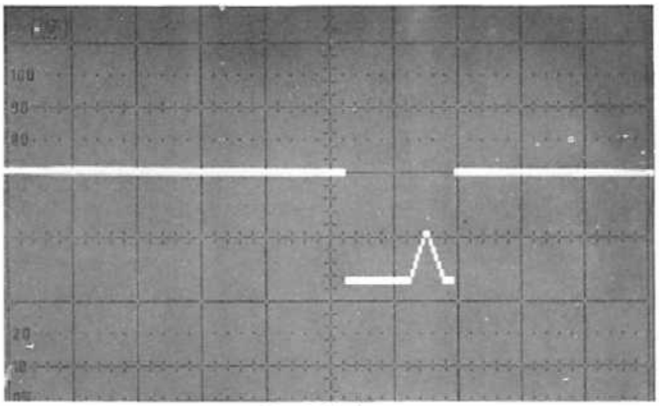
Enable circuits A8C1, R1, R2, R3, CR1, A8U4	Look at junction of R1, R2 R3, CR1 with 10 MΩ scope probe. See Figure 5-17, upper trace for waveform. If waveform at U4 Pin 11 (Figure 5-17, center trace) good, replace C1, R1, R2, R3, CR1. If U4 Pin 12 good, Pin 11 bad, replace U4.
A8U3, U4	When common lines of U3 and U4 are low (see Figure 5-17, lower trace) outputs of U3 and U4 (U3 pins 10, 4, 11, 3 and U4 pins 4, 10, 3) should be inverted from the inputs, (U1 Pins 12-18). If not, replace U3 or U4.
Printhead failure	Measure resistance at flex cable end between common (wide conductor) and printhead elements (narrow conductors). Should be 78-97 Ω on all 7 resistors.

		Check for intermittent failure of flex cable at overlay termination due to bending while inserting cable into connector.
Wrong "SET TO ENERGY" printed. No discharge information printed.	A8, A10	Check continuity of LCD lines (A8 Pins 27-30) from A8 to A10. Check for shorts.
Strange messages printed or missing dots.	A8U1 Pins 6, 27-30	Check for intermittent shorts.
	Printhead cable connector A8-J30	Check connection, reinsert or replace.
Wrong language, or relative time printed instead of real time, or no delivered energy or peak current information printed.	A7S1 and R5-8, A7U1	Check operation of switches. S1 should short A7U1 Pins 2, 4,17, and 23 to ground when closed. Logic high when open. If good, replace A7U1. (See section 2.3.12 for switch operation).
Poor quality printing	Printhead adjustment	Check printhead resistance as above. Adjust printhead as in Checks and Adjustments, Section 3.

5.3.7.2 CRT Digits

SYMPTOM	SUSPECT AREA	CHECKS
No CRT digits. Possibly bright dot in center of CRT. Baseline trace visible.	A8,A7	Check chip selector line for high level, A8U1 Pin 35,
	A7U5d	A7U5d, A7U1, Pin 6.
	A7U1, U2, U3, U4	Check for pulses at U1 Pins 13-16, 18-22, 1. If none, replace U1.
Or bad digits		Check that waveform at U4 pins 5 and 7 are identical. Pins 3 and 1 are identical. If not, replace U4.
		Check for signal at U2 and U3 Pin 4. If none, replace U2 or U3. See Figures 5-18 and 5-19.

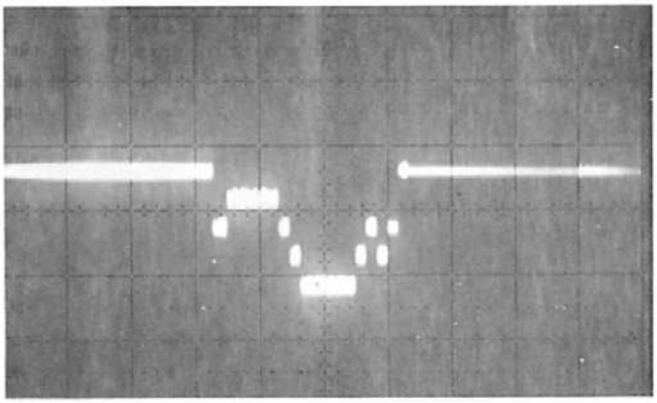
0.5V/Div.



2mS/Div.

Figure 5-18

0.1V/Div.



500µS/Div.

Figure 5-19

Beam blanked		Check intensity line A7U1 Pin 21. When low, CRT beam is blanked. Line should go high during signal. (Figure 5-18 and 5-19). If not, replace A7U1. Check A5 memory board.
	A5-memory board	
	A-6 deflection A-8/A-7/A-2	If no baseline trace. Also Check A8U1 to A7U1, U6 connection A8U1 Pins 21-25.
Digits flash, characters printed wider than normal.	A8, A5	Check 16 mS line A8U1 Pin 39,from memory board PCA A5. Should be square wave with 16.4 mS period.
Wrong heart rate displayed and printed.	A4-ECG digital board	A4 not detecting R-waves correctly.

	A8, A4 A15	Check R-wave line A8U1 Pin 1 from A4 for negative going pulses. When using ECG simulator, pulses should coincide with QRS complex. If pulses good, replace A8U1.

5.3.7.3 Switch Functions

SYMPTOM	SUSPECT AREA	CHECKS
Alarm switch, alarms	Alarm switch, cable A7 clock board	Check A7U1 Pin 5 for transitions when actuating switch. If none, replace R10, R13 switch, cabling.
	A7U1	Check if U1 Pin 3 is low during alarm condition. If not, replace R9, U1.
	A5 memory board	Check for approx 500 Hz pulses at A8 edge pin D ("Beep").
	A7U5A, A7U5B, A7U5C, A7Q1, R11, R12, C7 CR1	Check if outputs U5 (Pins 4,10,11) are inverted from "Beep" signal during alarm condition. If not, replace U5. If output U5A, B and C are good, then check collector Q1 for sync'd transistions. If none, replace R11, R10, Q1. If collector Q1 is good, replace C7, CR1.
	Speaker	Replace speaker, check for system interconnect short to ground on A8 edge Pin E ("SPKR").
	Recorder/Speaker cable	Check connections to speaker.

Recorder run switch doesn't work or recorder won't run or won't shut off	Switch, cable, A8, recorder board	Check A8U1, Pin 31 for transitions when switch actuated. If good, replace U1. If not, replace R29, C19 switch, cable.
	Recorder	Check recorder as described below.
Mark switch same	Same as above	Check U1 Pin 32 for transitions as above. R29, C18 switch, cable. If good, replace U1.
8-SEC RUN switch Same as above	Same as above	Check U1 Pin 33 for transitions as above. C29, C17 switch cable. If good, replace U1.
Service switch (won't enter Time/ Date set mode)	Same as above	Check U1 Pin 37 for transitions as above. R29, C16, switch, cable If good replace U1.

5.3.7.4 Recorder

SYMPTOM	SUSPECT AREA	CHECKS
Recorder won't run or won't shut off. Digits on CRT good, printing good when recorder runs.	A8Q3, Q4, R13-17, R41, A8 or A15 U1 Pin 19	Check U1 Pin 19 for transitions when MARK button pressed (to run recorder). If none, replace R13, R41, U1.
		Check collector and base of Q3 for transitions (+ BAT, to 0 volts on collector). If none, replace Q3, CR5, R14, R17.
		Check collector and base Q4 for transitions (+ BAT, -5 volts on collector). If none, replace Q4, R15.
		Check A8 edge Pin 1 for transitions (0 volts to approx +6 volts when recorder is connected). If none, replace C3, CR8, R16.
	Recorder	Replace

Stylus moves with recorder off	A8Q5, Q3, Q4	Check gate Q5 for 0 volts. If positive, replace CR7, R41. If negative, check Q3, Q4, U1 as above. Replace Q5.
Stylus won't move with recorder on	A5-memory board	Check for signal at A8 edge Pin U
	A8Q5, Q3, Q4	Check if gate Q5 is at -5 volts. If at -12 volts, replace R42. If more positive than -4 volts, check Q3, Q4 U1 as above. Replace Q5, replace R10, R11.
Stylus pinned or large stylus offset	Q1, Q2, U5a	Check collector Q1 at +5 volts. Collector Q2 at -12 volts, no signal. If not, replace Q1 or Q2, R4-9.
		Replace U5, R10, R11
	CR12, R43, R44	Check anode CR12 for -5.6 volts. If not, replace CR12, R43, R44.
	A5 memory board	Check signal from A5-memory.
		Board has approx 2.56 volt DC offset.
Stylus vibrates approx 60 Hz	A8CR13	Replace
Recorder won't run Slight movement on pressing MARK switch. No movement on pressing 8-SEC RUN switch.	Recorder cable	
Automatic run on charge does not operate.	A8, A10	Check LCD lines A8U1 Pins 27-30 for continuity, shorts to ground, etc.
Automatic run, on charge, does not operate.	A8, A10	Check LCD lines A8U1 Pins 27-30 for continuity, shorts to ground, etc.
		Check A8Q3, Q4, U1 as described above.
Poor performance frequency response and overshoot.	Recorder	If CRT trace is good, replace recorder

5.3.8 Defibrillator Control Board (A10)

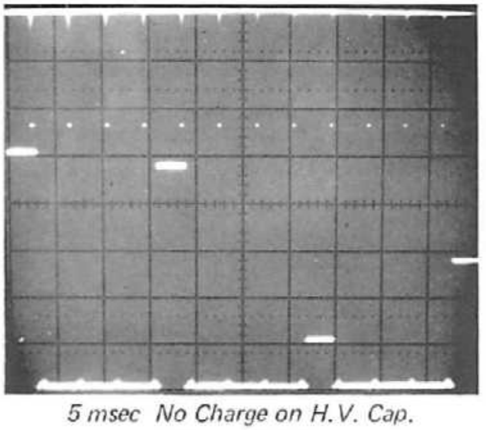
5.3.8.1 Error Messages

Error messages on LCD (when there's an error message, the LCD's will flash the error number and energy alternately).

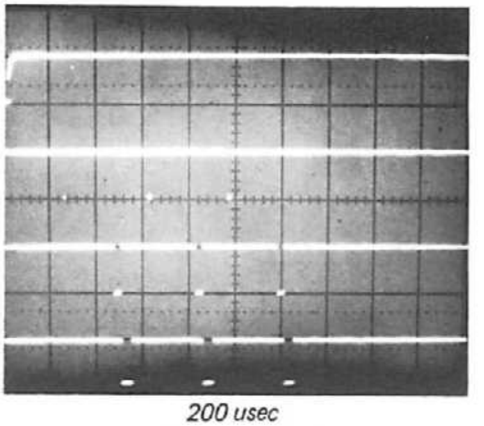
SYMPTOM	SUSPECT AREA	CHECKS
P0 error	U10 or U4	U10 bus (Port 0)

Note: This error may not show up as P0 error on the LCD's because the bus has been effected.

SYMPTOM	SUSPECT AREA	CHECKS
P0 error	Defib control board (A10)	U10 pin 14 or 25
P1 error	U14	2.5 V ref
	Power supply board (A12)	+5 V
	Defib H.V. board (A11)	+5.4 V ref
	U12 or U13B	Compare waveform with Figure 5-20



5 msec No Charge on H.V. Cap.
Figure 5-20



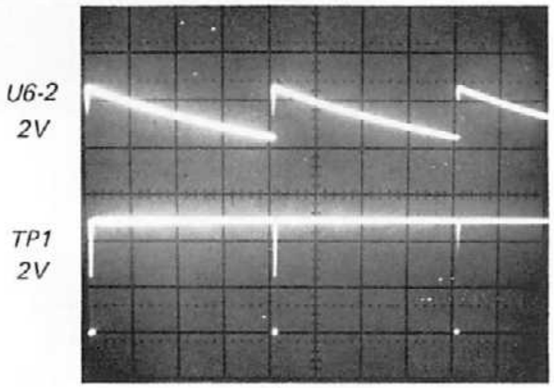
200 usec
Figure 5-21

SYMPTOM	SUSPECT AREA	CHECKS
P2 error	U11, A/D converter	U11, pin 19 300 KHz
		Compare waveform with Figure 5-21
P3 error. Cap overcharged.	Defib HV board (A11)	Vcap monitoring circuit

P4 error. Imbalance detected between Vcap 1 and Vcap 2	HV defib section	Leakage to ground
	HV cap	Shorted HV cap
	Patient relay	Arcing in relay
P5 error. Can't charge	Safety relay can't open.	U1 pin 13 <0.5 V
	Defib HV board (A11)	PWM charging circuit
	HV cap	Cap is leaking or shorted
P6 error	Patient relay	Arcing in relay
P7 error. Unexpected energy detected on cap	Safety relay stuck open	U1 pin 3 near SW BATT 2 voltage
		U1 pin 13 <1.5 V
	Defib HV board (A11)	Safety relay driver
		PWM charging circuit
P8 error. Can't charge	Low battery	
P9 error	Defib control board (A10)	R72 adjusted out of range
	HV cap	Out of tolerance

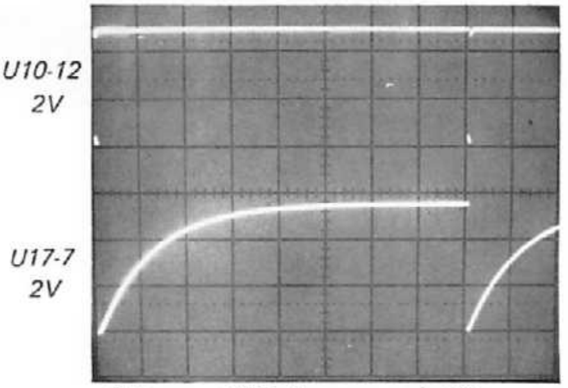
5.3.8.2 LCD Display

SYMPTOM	SUSPECT AREA	CHECKS
No "HP", "888" or "P" errors at turn-on.	Microprocessor (U10) or "Tickle Ckt" (U6)	Compare waveforms with Figure 5-22



1 msec

Figure 5-22



0.5 msec 64.9 ohms across paddles.

Figure 5-23

5.3.8.3 Paddle Contact Indicator

SYMPTOM	SUSPECT AREA	CHECKS
With 64.9 ohms across paddles, bar display has less than 9 LED's lit	U2 or U1B	Compare waveforms with Figure 5-23
	ECG Analog board (A3)	5.4 Vdc at J17, pin B
	Patient relay	Short C25 on ECG analog board (A3). Should measure less than 3 ohms across paddles

5.3.9 Defibrillator Charger Board (A-11)

SYMPTOM	SUSPECT AREA	CHECKS
P4 error. No defib charge (no sound, no LCD count at any energy setting).	Mother PCB	Check fuse, SW BAT 2 A11-F1 greater than 10 volts both ends of ground is normal.
P5 error after	Defib charger (A11)	If fuse blown, check Q5, Q2 and Q1 output transistors for shorts.
	Relay A11-K1	If less than 10 volts with battery, check K1 circuit If less than 10 volts with Power Base, check J47. If greater than 10 volts, check Power Base V-Reg circuit (See Section VII of this manual). J19, pin 8 should drop to less than 1.0 volt during CHARGE if normal. If greater than 1.5 volts, check defib control board (A10) CHARGE circuits and cables. TP8 should be at low voltage. If not, Low Battery Shutdown is keeping Q9 on.

Check for low V-Bat or V-REG.

If normal, check J19, pin 11 for 5.4 V +/-2% (5.29 to 5.51 volts).

If normal, check U1B circuit.

U3, pin 9 climbs from approx 0.5 volts to greater than 2.0 volts normally during CHARGE.

If less than 1.0 volts, check Q9 and C105 for shorts.

A11-U3

Normal TP9 from 4.6 to 5.4 volts.

If less than 4.6, check for no Vc on pin 15 or short circuit load on this +5 V reference.

Check U3, pin 7 for 8 kHz sawtooth waveform, replace U3 if missing.

Before charging, U3, pin 2 should be approximately 2.5 volts, pin 1 at 0 volts. During charge, pin 1 should rise to less than 2.5 volts or safety shutdown will occur.

Check R35 for open circuit or cold solder at pads, which cause immediate current shutdown, pin 4.

Normal: U3 pin 9 climbs to greater than 2.0 volts and TP3 output approximately 10 volts p-p during charge.

If no output, measure resistance, TP3 to ground. If short, check Q1. If 500-600 ohms, replace U3 (open circuit output).

If 10 volts p-p and duty cycle approximately 90%, check Q2 for open base. Or Q2 and Q5 collectors for V-raw. Possible open circuit to F1. Normal

		waveforms Fig. 5-25A through D, Fig. 5-26A and B. Or check Q5 for open base.
No sound, no error code.	Apex paddle circuit	Check J15, paddle switch operation.
No defib charge. Very faint sound.	Defib HV components	If LCD count-up, possible open circuit to HV defib cap. ========================== WARNING: HIGH VOLTAGE ========================== DANGER: T1 OUTPUT HV LEADS CONNECT TO POTENTIALLY LETHAL HV DEFIB CAPACITOR. SHORT HV CAPACITOR. TERMINALS BEFORE TESTS. Normal: Resistance at HV cap terminals approximately 10 kilohms (safety load resistor) CAUTION: RECONNECT HV T1 LEADS TO HV CAPACITOR BEFORE CHARGING DEFIBRILLATOR. If no LCD count-up, possible HV transformer or rectifier short. Note Figures 5-24, A to D vs E. Also, HV leads to each other and ground over 20M ohms with DMM if VDMM less than 5 volts.
Defib charges to low energy settings only, with frequent recharge after reaching preset. May time out with P5 error if unable to reach higher settings after 10 sec.	HV safety relay	Charges to 5 joules with frequent refresh but unable to reach 10 joules: probable failure of safety relay to open J21, pin 4 normally greater than 9 volts during charge. If not: check Q4 operation, drive to relay coil. Check J19 pin 16 normally less than 2.5 volts during charge. If not, check defib control board (A10).

FOR FIGURES 5-24 THROUGH 5-30 REFER TO PAGES 5-45/5-46 (FOLD-OUT)

		If higher values of energy, but still limiting, check for possible safety relay arcing during charge (may give P5 or P3 error). A long attempt to charge should produce noticeable heat on safety resistor plastic cover.
	HV circuit	Possible HV transformer arc. Note R35 normal vs shorted transformer or HV rectifier waveforms. See Fig. 5-24, A to D vs E. Also, HV leads to each other and ground should be over 20 M ohms with DMM if VDMM less than 5 volts (may get P5 or P3 error if layer arcing, P4 error if arcing to ground).
	HV monitor circuits	Check with energy meter at lower energy settings. If out of calibration, adjust A10-R72, recheck at high energy level. Refer to Section III for procedure. U3 pin 2 voltage greater than pin 1 voltage (approximately 2.5 volts normal). If voltage at pin 2 equals pin 1 at less than 360 joules, check error amp circuit, R141 and R142.
No defib charge. Near normal sound but little or no LCD count-up. Charger shut off after about 10 seconds with P5 error.	HV circuit	Check for HV shorts: HV defib capacitor (usually follows loud bang when capacitor shorts during charge). Flyback waveform slope normal. See Fig. 5-24, A to D normal, E if short.
	HV defib cap A1-C1	============================ WARNING: HIGH VOLTAGE ============================ Uncover defib capacitor ============================ SHORT HV CAPACITOR TERMINALS WITH SCREWDRIVER BEFORE MEASUREMENTS OR DISCONNECT TO DISCHARGE HV. ============================

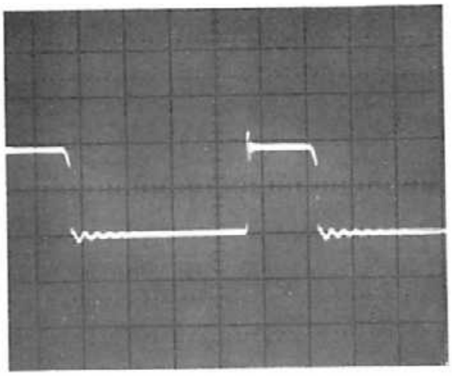
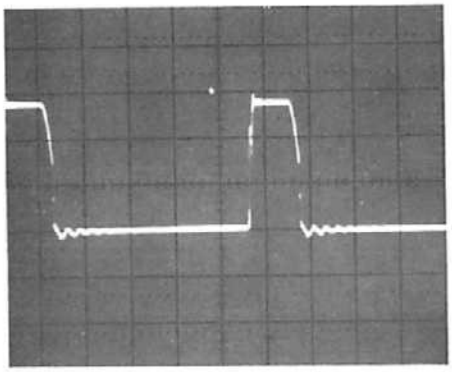
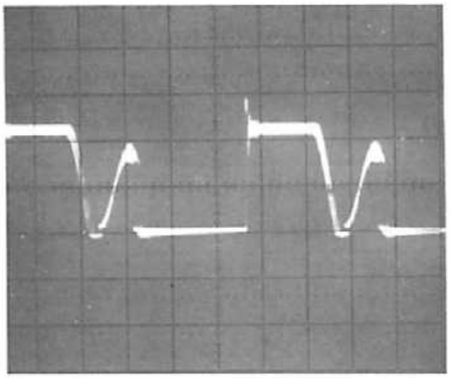


Figure 5-25
Flyback charging waveform,
TP1, 20V/ Div., 20 usec/Div.

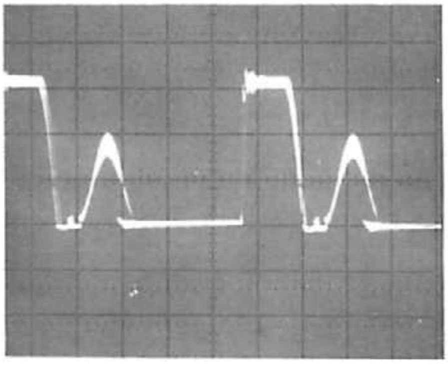
A: Battery only
Approx. 100 J on LCD



B: Battery only
Approx 300 J on LCD



C: Power Base
A Approx. 100 J on LCD



D: Power Base
Approx. 300 J on LCD

		Check resistance between HV capacitor terminals. 10 K ohms is normal. If short, remove leads to isolate short and replace defective part.
	HV transformer A11-T1	If not HV capacitor, measure HV leads to HV transformer-rectifier. Should measure over 20 M ohms wire-to-wire and either wire-to-ground if DMM ohms test voltage less than 5 volts.
Inaccurate/inconsistant output, especially at high energy settings. Maybe P4 errors.	HV circuit	Perform calibration procedure with defib energy meter (refer to Section III). If output still non-linear or erratic, may be due to shunt leakage to ground, in either HV lead.
	Patient relay A1-K1	============================ WARNING: EYE PROTECTION REQUIRED. ============================ Inspect HV patient relay, replace if badly discolored internally or if very bright discharge flash.
Above high energy problems and/or some P6 errors (10% drop in V_{HV}).	Patient relay A1-K1	Same check as above.
	Safety relay A1-K2	Best check is to look at both HV metering amplifier output on dual channel storage scope during charge to 360 joules. Normal are smooth lines to 360 on LCD, than horizontal traces until discharge by operator or timeout. Sudden changes indicate probable arcs in HV relay.
	HV transformer	Same as above checks.
	Monitor circuits	Check monitor circuit for intermittents, including A10 (defib control board) components, including A10-R72 for poor wiper contact.

Inaccurate/inconsistant output only at low energy setting. May show P3 error.	I-Pk circuit	Standby saturation of output to defib control board (A10). Test defib at 100 J while measuring voltage J18 pin 9 to pin 10. Should read schematic values after defib, slowly drift down. If there is drift up to over 6 volts, check U4a, Q21 for excess leakage.
	U3 shutdown circuit	Check U3 pin 9 charge start waveform. If voltage rise much faster than 1/3 second, check Q9, C105 circuit.
Incorrect charge time to 360 joules. May show P5 or P8 error.	Defib inverter	Normal charge time: 7 sec on Power Base, 9 seconds with fully charged battery. Perform calibration. Refer to Section III. Check either battery or Power Base if one is OK, other is not. If audible on/off, check low battery/V-reg circuits. If normal times at lower energy, very long at 360, check waveform at TP1 for possible HV transformer short -- see Figure 5-24E. If very little decrease in charge time from 1/2 to 1/4 turn position of R34, 1/2 of U3 output may be inoperative. Waveform TP3 should go from approximately 50% to 90% duty cycle if fuse A11-F1 is pulled. If 50% max, replace U3. Figure 5-27.
No I-Pk or delivered energy reading.	I-Pk circuit	Operate in internal test mode, 100 J. Measure voltage at J19, pin 9 to pin 10 after 50 ohm discharge. Compare with voltage on schematic, Section VI (A11). If normal, check defib control board (A10) operation.

		If absent, check waveform back through circuit to determine loss and faulty parts (U1A, Q21, U4A, Q6, I-Pk XFMR). (Figure 5-28 through 5-30).
I-Pk and delivered energy inconsistant.	I-Pk circuit	Perform voltage and waveform checks listed above.
		If normal, check defib control board (A10) operation.
		If irregular output, check for proper A11-Q6 reset.
		Observe HV patient relay. Replace if badly discolored or very bright discharge flash at 360 joules - possible EMI source.
I-Pk always high		Do above voltage and waveform checks.
		If normal, check defib control board (A10) operation.
		If J19 pin 9 to pin 10 voltage is greater than 5 volts, check back through circuit for point of voltage clamp, faulty part.
HV patient relay will not discharge	Patient relay circuit	Charge reaches preset energy level, but discharge paddle switches will not discharge system.
	SYNC/DEFIB switch	System is in SYNC mode, with no ECG leads input waveform.
		Relay drive circuit Q3, CR8, J21, etc. defect. Check waveforms, Figure 5-28.
		Check discharge switch voltages, J15, J16, J19.
		Defib control PCB (A10). No input pulse, J1 pin 13.
		Charge stops before preset level is reached.
		Check for low battery voltage.

		Check inputs to U3 error amplifier.
Dempsey discharge waveform is RC decay instead of damped sine wave.	Defib inductor	Measure DC resistance of defib inductor. Should be greater than 9 ohms. ================================ WARNING: HIGH VOLTAGE. ================================
Entire unit dead, ECG and defib	V-ref, shutdown	Battery voltage normal. (12 volts nominal). Check A2-F1 and F2 on mother board (A2). Check power switch on ENERGY SELECTOR. Check TP5 for 5.4 volts +/-2%. If high, adjust R132 for 5.4 V, TP4 to J19 pin 10. If high over whole R132 range, check U5 circuit.
Short monitor time and/or reduced defib count before LOW BATTERY indication and/or shutdown.	V-ref, shutdown	Check battery, See Section III
	Low battery	Perform voltage ref check noted above. Check LOW BATT LED drive circuit, defib control board (A10).
Monitor OK. No defib charge.		Check U1B circuit.
Battery does not charge (cold after overnight, on charge, may also be noted if no current to battery.	V-Bat circuit	Approx 0.6 volt across CR9 normal. Check battery for cell reversal. Fully charged battery open circuit voltage should be appproximately 13.5 volts.
	A11-CR9	If greater than 1.0 volts across CR9, then CR9 open. If less than 0.5 volts across CR9, no Power Base output (pull P48 and test) See Section VII.

		Open circuit to battery. Short circuit, line to ground (isolate by connector discon-nects).
No CHARGING BATTERY LED. Power Base on.	V-BATT circuit	J48 greater than 10 volts normal, then open circuit to LED. Defective LED. If J48 is less than 10 volts, check for dead or shorted battery (unplug battery). No Power Base output (pull P48 and test). See Section VII. Q22 circuit.
Monitor and defib dead.	Battery or V-reg Power Base circuits	J44, 10 to 13 volts normal range with battery. 11.5 to 13.5 volts normal range with Power Base. Check J19 pin 3 for about the same voltage. Power switch on. If not, check fuse A2-F2. Also check A2-F1 on mother board (A2). If voltage normal, check Low battery shutdown/V-ref circuit A11-U5, U1B. If J44 less than 10 volts. If battery only, check battery and P43, P44 jumper con-nections, PCB wiring. If Power Base only, check it. See Section VII for Power Base information.

After replacing a component in the defibrillator high voltage circuit that also involves the discharge current transformer, T2. No discharge energy is displayed or printed. (The patient relay would be a good example.		If the single turn loop of wire was removed from the transformer, it was wound in the wrong direction when it was replaced. The transformer output pulse must be positive. This can be checked with an oscilloscope on J21 pin 7.
Very high peak current and high delivered energy.	Shorted inductor, A1-L1.	

5.3.10 Low Voltage Power Supply (A12)

SYMPTOM	SUSPECT AREA	CHECKS
Unit is dead on battery power.	Battery	Replace battery pack or use Power Base.
Unit does not beep on turn-on. LED's LCD, self test does not work, or unit will operate but will not charge.	Battery dead or not in unit.	
	Blown fuses	Check fuse A2-F1.
	A2-F1	
	A11-F1	A11-F1
Vertical jitter, offset motion of heart rate digits, distortion of recorder trace.	-12 volt supply	Remove loads. Remove the recorder board, recorder cable, the deflection board; troubleshoot the -12 and -15 volt supplies.
Modulation of the trace edges. Heart rate digits are deformed, trace shrinks.	+/-15 volts	Remove loads; as above. Check +/-15 volt supplies.
Trace shrinks and moves to the center. Edges of trace fold inward. Fuzzy, out-of-focus, jittery trace. Modulation up and down.	+5 volts	Check the 5 volt output. If unregulated, remove all PC boards. Check the drive and power switch, Q3.

Note: If the 5 volt supply is not regulated, the rest of the supplies will not be in regulation. The 5 volt supply must be within the range of 5.0 to 5.2 volts, with the PC boards in place. The 5 volt supply can be as high as 5.35 volts when no other boards are in place.

The following symptoms assume that the 5 volt supply is operating normally.

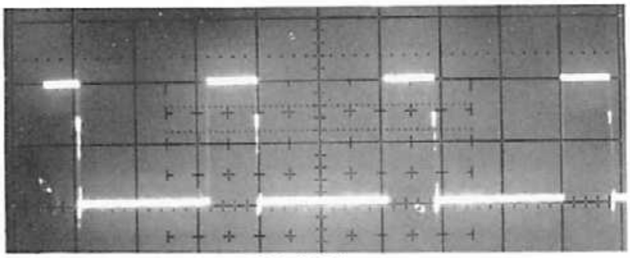
No CRT trace	5 kV supply	R12
Brightness varies, trace width varies. Trace length varies.	5 kV clamp	CR4, 8, 15, VR2 thru VR6.
Spikes on CRT trace.	5 kV supply	T1 H.V. secondary. H.V. multiplier failure.
System dead	L.V. supplies	Fuse A2-F1 on mother board (A2). Verify +12 volts at TP2.

Note: The following symptoms assume all power supply outputs are very low but are not all zero.

System dead	A12-	Connect oscilloscope to U1 Pin 11 with power on. If scope indicates DC offset +12 volts or zero volts or 30% duty cycle. Replace U1.
	Q3	Remove Q3 and test U1, as above. If 60% duty cycle, U1 is O.K., test Q3. (See Figure 5-31).
		Connect voltmeter to U1 Pin 16. If not 4.85 to 5.05 volts, replace U1.
	Q1, Q2	Check TP1. If 60% duty cycle, Q1 and Q2 O.K. (See Figure 5-31).
	U1 Pin 2	Must read approx 2.5 volts. (See Figure 5-32).
	U1 Pin 3	50 mS spikes

	U1 Pin 7	3 volts, 60 uS sawtooth. (See Figure 5-33)

5V/Div.



A12-U1 Pin 14 Figure 5-31

20µS/Div.

	U1 Pin 10	Less than 0.6 volts
	U1 Pin 16	4.85 to 5.05 volts
		If not, replace U1.
		Examine the board for overheated parts. If any of the inductors, L2, L3 or L4 exhibit signs of overheating, the problem lies somewhere else in the unit.
		If the 5 volt supply is out of tolerance, the 15 volt and H.V. supplies will be out of tolerance in the same direction. However, if one of the other supplies is overloaded, it does not necessarily mean the remaining supplies will be out of tolerance.
		Turn the adjustment pots counterclockwise to increase the voltage.
Out of focus trace	+200V	Rectifiers CR8, CR4, zeners VR2, VR3, VR6.
		Check for long component leads on bottom of board shorting to circuit board shield.

Power Suppy Output Voltage

	Min.	Max.
+5V	5.05	5.15
+15	14.50	15.50
-15	-14.50	-15.50
+12R	11.50	12.50
+12 (adjust)	11.96	12.04
-12V	-11.50	-12.50
+200	+180	+210

+5 kV (use 1000 megohm probe. Should read 4.2 kV +/-200 V).

5.3.10.1 Pulse Width Modulator (A12-U1)

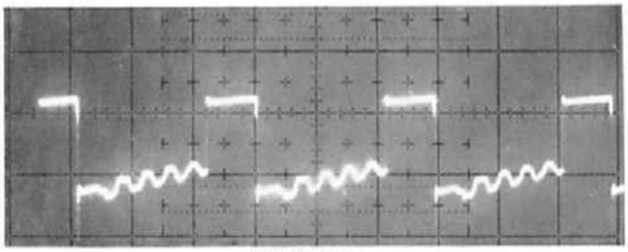
PIN	NORMAL OPERATING VOLTAGE
1	Approximately 2.5 volts DC
4	Less than 200 mV average
7	Sawtooth 3 volt p-p approx 60 uS period
9	TP3 (see Figure 5-16)
11-14	Duty cycle controlled rectangular wave (see Figure 5-31)
12-13	Supply voltage
15	Supply voltage
16	+5 volts ref. 4.85 to 5.05

If supply voltage is normal and pin 16 is zero, replace U1.
If DC out of supply is very low, check to see if both PWM output transistors are producing an output. Pins 11 and 14.

Check low battery detector

PIN	NORMAL OPERATING VOLTAGES
2	+4.46 Volts
3	Greater than 4.46 volts
6	Greater than 4.46 volts
7	Supply voltage
Base Q4	0.6 volts
Collector Q4	Vce sat. less than 0.5 volts.

5V/Div.

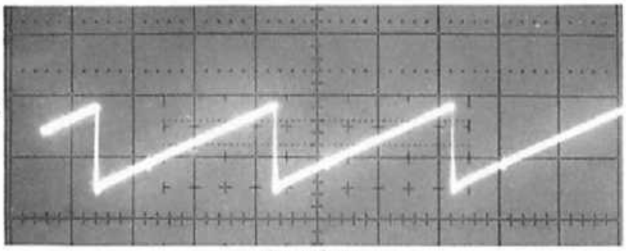


A12-TP-1

20µS/Div.

Figure 5-32

2V/Div.

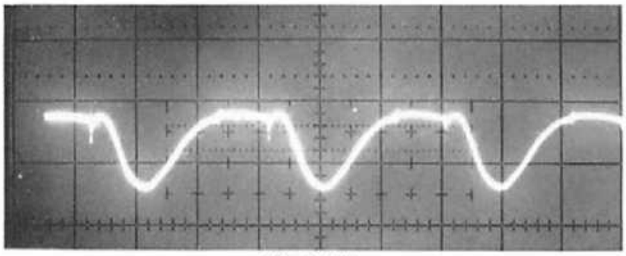


A12-U1 Pin 7

20µS/Div.

Figure 5-33

1V/Div.

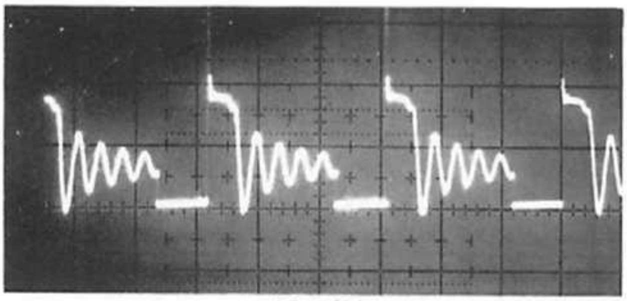


A12-TP-3

20µS/Div.

Figure 5-34

20V/Div.

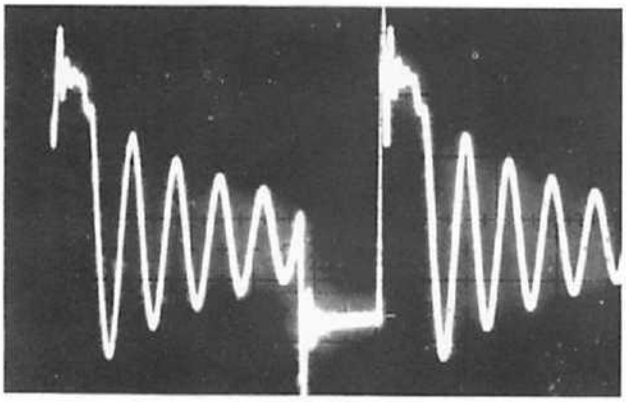


A12-TP-5

20µS/Div.

Figure 5-35

200V/Div.



A12-T1 Pin 4 Flyback Transformer Secondary

10µS/Div.

Figure 5-36

REFERENCE DESIGNATORS

A	assembly
B	motor
BT	battery
C	capacitor
CP	coupler
CR	diode
DL	delay line
DS	device signaling (lamp)
E	miscellaneous electronic part
F	fuse
FL	filter
HR	heater
J	jack
K	relay
L	inductor
M	meter
MP	mechanical part
P	plug
Q	transistor
R	resistor
RT	thermistor
S	switch
T	transformer
TB	terminal board
TC	thermocouple
TP	test point
V	vacuum tube photocell, etc.
W	cable
X	socket,
XDS	lampholder
XF	fuseholder
Y	crystal
Z	network

ABBREVIATIONS *

A	amperes
ACC	accessories
AFC	automatic frequency control
Al	aluminum
AMP	amplifier
as ord	as ordered
Be Cu	beryllium copper
BFO	beat frequency oscillator
bh	binder head
bp	bandpass
brs	brass
c/s	cycles/second (see Hz)
CALIB	calibration
ccw	counterclockwise
cd pl	cadmium plate
cer	ceramic
ch	channel
cmo	cabinet mount only
coef	coefficient
com	common
comp	composition
conn	connector
CRT	cathode-ray tube
cw	clockwise
dB	decibel
dep C	deposited carbon
DISP	display
DPDT	double-pole double-throw
DPST	double-pole single-throw
EIA	tubes or transistors meeting Electronic Industries Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by stock numbers
elect	electrolytic
encap	encapsulated
F	farad(s)
fet	field effect transistor
fh	flat head
FIG	figure
fil hd	fillister head
flm	film
FR	front
fwd	forward
fxd	fixed
G c/s	gigacycles per second (see G Hz)
Ge	germanium
GEN	generator
G Hz	gigacycles per second
gl	glass
grd	ground(ed)
h	henry(ies)
hex	hexagonal
Hg	mercury
Hz	cycle per second
impg	impregnated
incd	incandescent
ins	insulation(ed)
ips	inches per second
k, K	kilo (1000)
Kc, k c/s	kilocycles (see k Hz)
KEPS	hex rut with lockwasher
k Hz	kilocycles/second
lin	linear taper
lkwash	lockwasher
log	logarithmic taper
lp flt	low-pass filter
m	milli (10^{-3})
mA	milliamperes
mam	milliammeter
M	mega (10^{6})
M c/s	megacycles (see M Hz)
met flm	metal film
mfr	manufacturer
mH	millihenry
M Hz	megacycles/second
minat	miniature
mom	momentary
mtg	mounting
mV	millivolt
mW	milliwatt
my	mylar - (Dupont de Nemours)
n	nano (10^{-9})
NC	normally closed
Ne	neon
NETWRK	network
Ni Pl	nickel plate
NO	normally open
NPN	negative positive negative
NPO	negative positive zero (zero temperature coefficient)
nsr	not separately replaceable
obd	order by description
od	outside diameter
ov hd	oval head
ox	oxide
pc	printed circuit board
PEMS	circular press fitted nut
pF	picofarad (10^{-12} farads)
PH	phone
ph brz	phosphor bronze
Phl hd	Phillips head
piv	peak inverse voltage
pk	peak
PNL	panel
PNP	positive negative positive
poly	polystyrene
por	porcelain
pos	position(s)
pot	potentiometer
pp	peak-to-peak
PREAMP	preamplifier
prec	precision (temperature coefficient, long term stability, and/or tolerance)
pt	point
rec	recorder
rect	rectifier
rev	reverse
rf	radio frequency
rh	round head
rmo	rack mount only
rms	root-mean-square
rot	rotary
s-b	slow-blow
scon	semiconductor
Se	selenium
sect	section(s)
SEMS	machine screw with washer
SEQ	sequential
Si	silicon
sil	silver
sl	slide
SPDT	single-pole double-throw
spl	special
SPST	single-pole single-throw
sst	stainless steel
SWTCH	switch
Ta	tantalum
td	time delay
Ti	titanium
tog	toggle
tol	tolerance
trim.	trimmer
twt	traveling wave tube
µor U	micro (10^{-6})
µA	microamperes
µF	microfarads
µV	microvolts
V	volt(s)
vac	vacuum
Vacw	volt(s) alternating current working
var	variable
Vdcw	volt(s) direct current working
W	watt(s)
w/	with
w/o	without
wiv	reverse working voltage
ww	wirewound
Ω	ohm

* Electric Accounting Machines (EAM) capitalize all abbreviations

Table 6-1. Manufacture's Code.

MFR NO.	MANUFACTURER NAME	ADDRESS		ZIP CODE
0003J	NIPPON ELECTRIC CO			
00853	SANGAMO ELEC CO S CAROLINA DIV	PICKENS	SC	29671
01121	ALLEN-BRADLEY CO	MILWAUKEE	WI	53204
01281	TRW INC SEMICONDUCTOR DIV	LAWNDALE	CA	90260
01295	TEXAS INSTR INC SEMICOND CMPNT DIV	DALLAS	TX	75222
0192B	RCA CORP SOLID STATE DIV	SOMERVILLE	NJ	08876
02111	SPECTROL ELECTRONICS CORP	CITY OF IND	CA	91745
03508	GE CO SEMICONDUCTOR PROD DEPT	SYRACUSE	NY	13201
03888	KDI PYROFILM CORP	WHIPPANY	NJ	07981
04222	AVX CERAMICS CORP	MYRTLE BEACH	SC	29577
04713	MOTOROLA SEMICONDUCTOR PRODUCTS	PHOENIX	AZ	85062
07263	FAIRCHILD SEMICONDUCTOR DIV	MOUNTAIN VIEW	CA	94042
12617	HAMLIN INC	LAKE MILLS	WI	53551
13606	SPRAGUE ELECT CO SEMICONDUCTOR DIV	CONCORD	NH	03301
17856	SILICONIX INC	SANTA CLARA	CA	95054
19701	MEPCO/ELECTRA CORP	MINERAL WELLS	TX	76067
20932	EMCON DIV ITW	SAN DIEGO	CA	92129
24546	CORNING GLASS WORKS (BRADFORD)	BRADFORD	PA	16701
25088	SIEMENS CORP	ISELIN	NJ	08830
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA	CA	95051
27777	VARO SEMICONDUCTOR INC	GARLAND	TX	75040
28480	HEWLETT-PACKARD CO CORPORATE HQ	PALO ALTO	CA	94304
32293	INTERSIL INC	CUPERTINO	CA	95014
34649	INTEL CORP	MOUNTAIN VIEW	CA	95051
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS	MA	01247
71590	CENTRALAB ELEK DIV GLOBE-UNION INC	MILWAUKEE	WI	50501
72136	ELECTRO MOTIVE CORP SUB IEC	WILLIMANTIC	CT	06226
75042	TRW INC PHILADELPHIA DIV	PHILADELPHIA	PA	19108
75915	LITTELFUSE INC	DES PLAINES	IL	60016
84411	TRW CAPACITOR DIV	OGALLALA	NE	69153

6.3 ORDERING INFORMATION

NOTE: Occasionally, electronic items in the replacement parts list will be found to carry standard commercial identification numbers but which also are indicated as being manufactured by HP. These components have been selected to meet specific operational criteria. The use of these components purchased through normal commercial channels may result in degradation of the operation performance or reliability of the unit.

To order a replacement part, address order or inquiry to the local Hewlett-Packard Sales/Service Office (see list of addresses at the rear of this manual) and supply the HP part number of the item from the listing.

To order a part not listed in a table, provide the following information:

1. Model number of the instrument.

2. Complete serial number of the instrument.

3. Description of the part including function and location.

To order a part from a manufacturer other than Hewlett-Packard Company, provide the complete part description and the manufacturer's part number from the listing. Manufacturer's codes are listed in Table 6-1.

SECTION VI
REPLACEABLE PARTS

6.1 INTRODUCTION

This section of the service manual includes schematic diagrams and identifies major assemblies, subassemblies, and components of both defibrillators to aid in ordering replacement parts. Each entry in these tables includes the reference designation, HP part number, check digit, quantity used within the referenced assembly, a brief description of the part, the NEC code of the manufacturer of the part and the part number assigned by the manufacturer. Wherever possible, parts lists for the assemblies are printed on the same page as the schematic diagram and component location drawing or on immediate adjacent pages.

6.2 REFERENCE DESIGNATIONS

The parts listings use an alphabetical-numerical (alpha-numeric) method of listing the end item, assemblies, subassemblies and circuit components. These items are defined as follows:

1. An END ITEM is the instrument with all the supplied accessories. The END ITEM is made up of assemblies to aid in the location of parts.

2. Each assembly and subassembly is assigned an "A" number (A1, A2, A3, etc). Assemblies and subassemblies that can be purchased have part numbers in the part number column of the table; those that cannot be purchased do not have part numbers in the columns.

3. Components within the assembly and subassembly circuits are assigned circuit reference designators (C1 capacitor, R1 resistor, etc). These parts are prefaced by the assembly number (A1C1, A2C2, A1R1, A2R2, etc), to indicate the assembly on which the part is located.

An example of the alpha-numeric numbering method used to identify assemblies, subassemblies and circuit components is shown below:

A1	R	1
ASSEMBLY NO.	COMPONENT ALPHA DESIGNATION	COMPONENT NUMERIC DESIGNATION

The complete reference designations is read as the first resistor (R1) of the first assembly (A1).

SECTION VII
ACCESSORIES

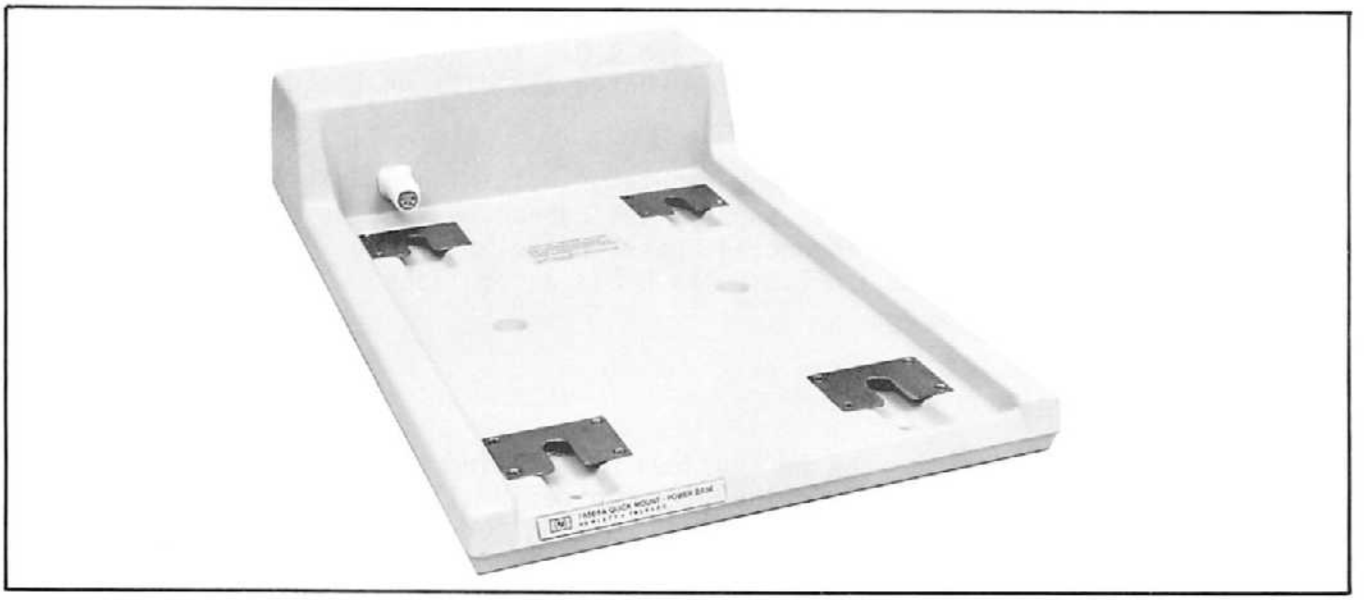


Figure 7-1. Quick-Mount Power Base.

7.1 78668A Quick-Mount Power Base

This accessory allows the 78670A and 78671A defibrillators to operate from the AC power line. All power supplies to the defibrillator, are connected when it is installed on the power base.

The power base supplies:

1. Regulated 12.5 volts DC for all monitor and control functions.

2. Unregulated V-Raw DC for defibrillator charging.

3. Current - limited DC for charging the defibrillator battery.

In case of loss of power line voltage, a fast shutdown circuit automatically transfers the defibrillator power lines back to its internal battery.

7.1.1 Theory of Operation - AC Circuits (Figure 7-4)

The AC input circuit is the customary dual winding 115/230 VAC configuration, selected by S1, protected by CB1 and CB2. C13 reduces the effects of fast rise power line transient spikes. A thermal fuse is part of the T1 secondary winding.

7.1.2 Regulated Voltage Circuit

DC for this circuit is from the bridge rectifier (CR11) and filter capacitor (C11), with R1 as a bleeder resistor. U11 is a 5 amp, adjustable voltage series pass regulator I.C. R4 and R5 set the output voltage. CR3 is a protection diode and C2, C3, C15 and C16 are stability bypass capacitors. Fast shutdown, to about 1.3 volts DC is accomplished by pulling U11 ADJUST terminal to ground.

7.1.3 Raw Voltage and Battery Charge Circuit

DC for these circuits is from CR12, C12 and R10. Voltage is supplied directly to the high-current, defibrillator capacitor charge circuits on the defibrillator H.V. board (A11).

This DC source also powers the current regulator U1, with R9 giving a nominal 0.20 A battery charge current. This supply is connected to the battery when the defibrillator is on the AC-connected Power Base. CR4 and CR5 are protection diodes. Fast shutdown to about 2.3 volts DC is accomplished by pulling U1 ADJUST terminal to ground.

7.1.4 Low Line Voltage Circuit

Both U1 and U11 regulators can be shutdown by pulling their ADJUST terminals to ground. This allows the battery relay, in the defibrillator, to switch to battery operation in less than 100 msec, instead of waiting for the slower discharge of the 10,000 uF filter capacitors, C12 and C11.

CR1, CR2 and C1 form a full wave rectifier circuit for the transformer output. R8 and R7 form a divider/bleeder. If the 115 VAC input remains over about 50 VAC, Q1 conducts, keeping Q3 and Q2 nonconducting. A further drop to about 40 VAC switches both Q3 and Q2 into saturation, clamping the voltage adjust terminals of the two regulators to ground.

7.1.4.1 Disassembly

1. Remove the defibrillator from the power base. Remove the power line cord.

2. Place the power base upside down. Remove the 6 screws indicated in Figure 7-2.

3. Lift the electronics section from the plastic base.

4. The circuit board may be removed with capacitors C11 and C12 attached. Remove the two hex nuts just in front of the finned heat sink and loosen the capacitor clamps.(Figure 7-3).

> Note: If the capacitors C11 or C12 are removed, be sure the terminal screws are tight when the unit is assembled.

> **WARNING**
>
> The two filter capacitors, C11 and C12, store enough energy to vaporize the tip of a screwdriver. Allow at least 3 minutes for the capacitors to discharge before shorting the capacitors or removing circuit components.

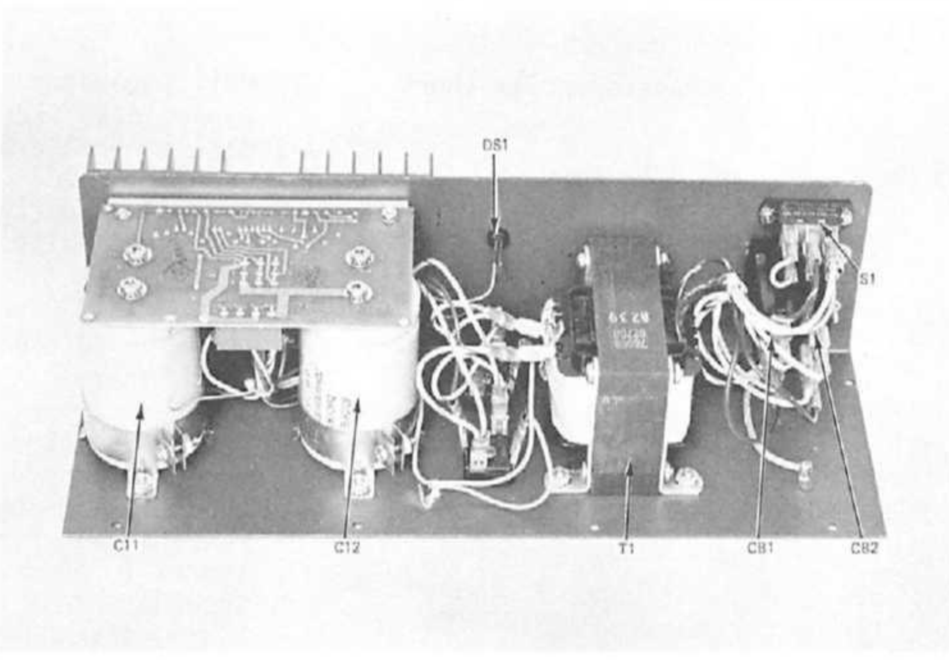


Figure 7-2. Quick-Mount Power Base, (Bottom View).

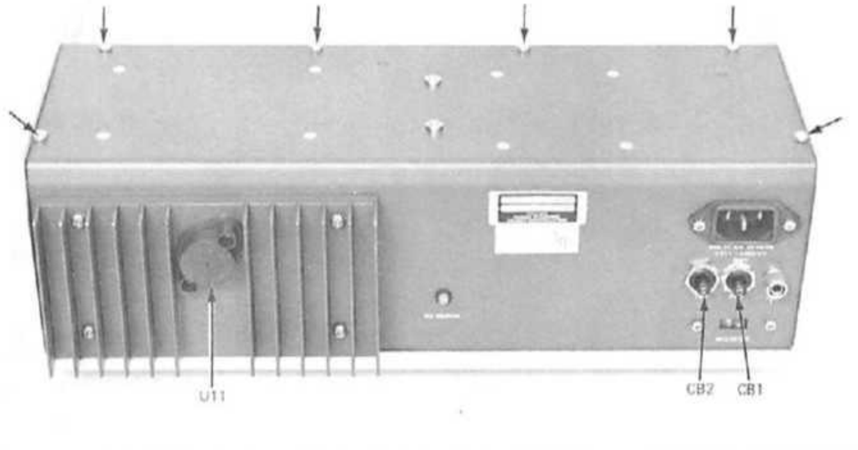


Figure 7-3. Quick-Mount Power Base Inner Circuitry.

7.1.5 Troubleshooting Power Base

SYMPTOM	SUSPECT AREA	CHECKS
Circuit breakers open (CB1-CB2)	C11, C12 short	Disconnect and make resistance check.
	U11, C15, C16 short	Pull P55. Check for shorts including to chasis.

	Transformer T1 short	Pull secondary connectors. Reset circuit breakers. Connect to AC. Normal secondary voltage approx 20 volts.
Low output voltage	Line voltage selector switch	Switch in 230 volt position for 115 volt line.
No output on all supplies. (Circuit breakers may or may not be open)	S1, CB1, CB2 Thermal fuse in T1 open	Measure voltage through transformer. Check T1 winding resistance. Primary approx 10 ohms each. Secondary less than 1 ohm. Disconnect secondary wiring before making resistance check.
V-Raw less than 15 volts (no load)	CR12, C12	Check voltage at J55 Pin 2. Check wave-form V-Raw under load.
V BAT less than 12 volts	Defective or discharged battery.	Check battery
	Q3 ON	Check low line. Shut down circuit voltage.
	R9, R11, CR4, CR5	Check for shorted diodes or open resistors.
	C1	Check for short.
	U1	Defective or shorted tab to heat sink.
Defib battery relay A11-K1, does not immediately transfer to battery at power loss.	Low line voltage shut down circuit	Check AC on/AC off, DC voltages in circuit.
Defib BATTERY LED does not immediately turn-off with power line voltage loss.	Same as above	

Power Base Trouble Shooting

These measurements made with 115V AC 60Hz input.

Test Point	Voltage	Condition
T1 Secondary	Approximate 20VAC	No Load
Across C11 and C12	Approximate 28VDC	No Load
Voltage across C2 (U11 Output, V Reg)	12.5V Nominal	No Load
J54 Pin 4 to Pin 1 (battery charger output)	Approximate 28VDC Approximate 14 to 16VDC	No Load with battery load
J54 Pin 3 to Pin 1 (V Raw)	Approximate 28VDC Approximate 26VDC	No Load Monitor Only

Fast turn-off circuit activated by pulling the cord. All measurements referenced to on board ground (negative terminal of C11 and C12). Nominal voltages are listed and may vary slightly.

ON	Fast Turn-Off	
11.5V	0.12V	C1 Positive terminal
11.3V	0.12V	U11 Adj Terminal
28V	.02V	U1 Adj Terminal
.04V	0.7V	Q1 Collector
.04V	0.7V	Q2 Base
.04V	0.7V	Q3 Base

NOTES

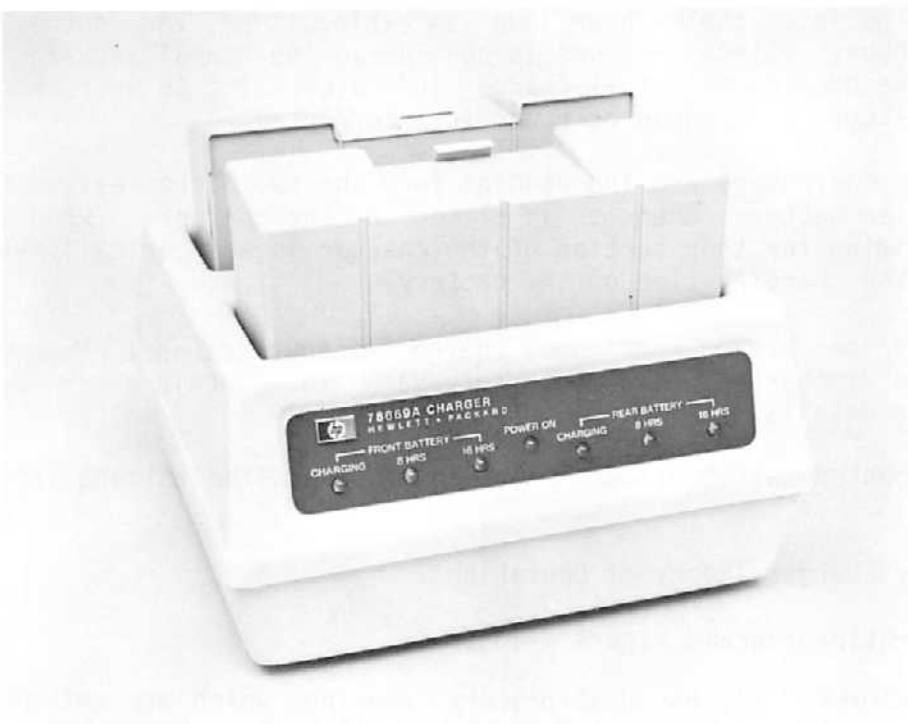


Figure 7-5. 78669A Battery Charger.

7.2 BATTERY CHARGER 78669A

7.2.1 Description

This instrument charges batteries for the Model 78670A or 78671A Defibrillators. It will charge one or two batteries at a time. No power switch is included in this instrument. Charging begins whenever a battery is inserted.

7.2.2 Charging

Batteries are inserted into the cavities on top of the charger. The plugs in the charger cavity contact the jacks in the battery housing and charging begins. The batteries are inserted with the tab at the rear of the battery toward the center of the charger. If a battery is inserted backwards, no contact takes place.

7.2.3 Indicator Lamps (See Figure 7-5).

The green lamp labelled "POWER ON" in the center of the panel glows when the line cord is plugged in, indicating the instrument has A.C. power.

On each side of the front panel are 3 indicators that give the status of the battery charging cycle. A green CHARGING indicator lamp glows when a battery is plugged in, to indicate that the charger is supplying current to the battery. This lamp will glow as long as the battery is plugged into the charger.

The 2 remaining yellow lamps indicate the time the battery has been charging. The first lamp lights at approximately 8 hours after charging begins. At the end of a second 8 hour period, the 8 hour lamp is extinguished and another lamp lights indicating 16 hours. Since 16 hours is considered the normal recharge time, the 16 hour lamp can be considered a full charge indicator. The 16 hour lamp will remain on until the battery is removed or power is interrupted.

The charge time indicators are independent for the two batteries and timing begins for a particular battery when it is placed in the charger. When a battery is removed, the timing for that section of the charger is automatically reset to zero, regardless of the charging time on the battery.

The battery may be left on continuous charge, without damage. However, batteries should be deep discharged at 3 month intervals to maintain their capacity. See Section III for details.

A rear panel mounted switch allows selection of power line voltage 115-230 volts.

7.2.4 Battery Charger Theory of Operation

(Refer to Schematic Diagram, Figure 7-13).

The power transformer T1, has dual primary windings which are switched in series for 230 volt operation or parallel for use on 115 volts. Each winding is fused to comply with UL and European requirements.

A full wave bridge rectifier, CR1 thru CR4, rectifies the low voltage of the transformer secondary to provide DC for the control circuits and for battery charging.

Since the battery charging and indicator circuits are identical for each channel, only one will be described. Only the power supply and timing oscillator are common to both channels.

7.2.5 Current Source

Nickel-cadmium batteries require a constant current for charging. U1 is connected as a current source. The current is determined by R1. U1 will go into current limit when the voltage drop across R1 equals 1.25 volts.

$$I \text{ charge} = 1.25/R1 = 1.25/6.2 = .202 \text{ amperes}$$

When the current drawn through R1 exceeds approximately 160 mA, Q1 conducts current to light DS-1, indicating current is being drawn by the battery. Under no load conditions, the charger output is approximately 30 volts DC.

7.2.6 Timing Circuit Voltage Regulator

When Q1 conducts current, it furnishes power to the 12 volt regulator U4. This regulator provides a regulated voltage to the C-MOS timing circuits and the 8 and 16 hour LED indicators.

7.2.7 Timing Oscillator

U7 contains an R-C oscillator and a divide by 1024 circuit. This circuit operates when a battery is plugged into the charger, with the +12 volts applied through CR7 or CR8. C3 and R4 are the timing elements. The oscillator runs at a cycle period of about 27.8 mS at U7 Pin 1. The output of U7 is available at TP-1 and has a one cycle period of approximately 28.5 seconds.

See timing diagram Figure 7-6, and schematic.

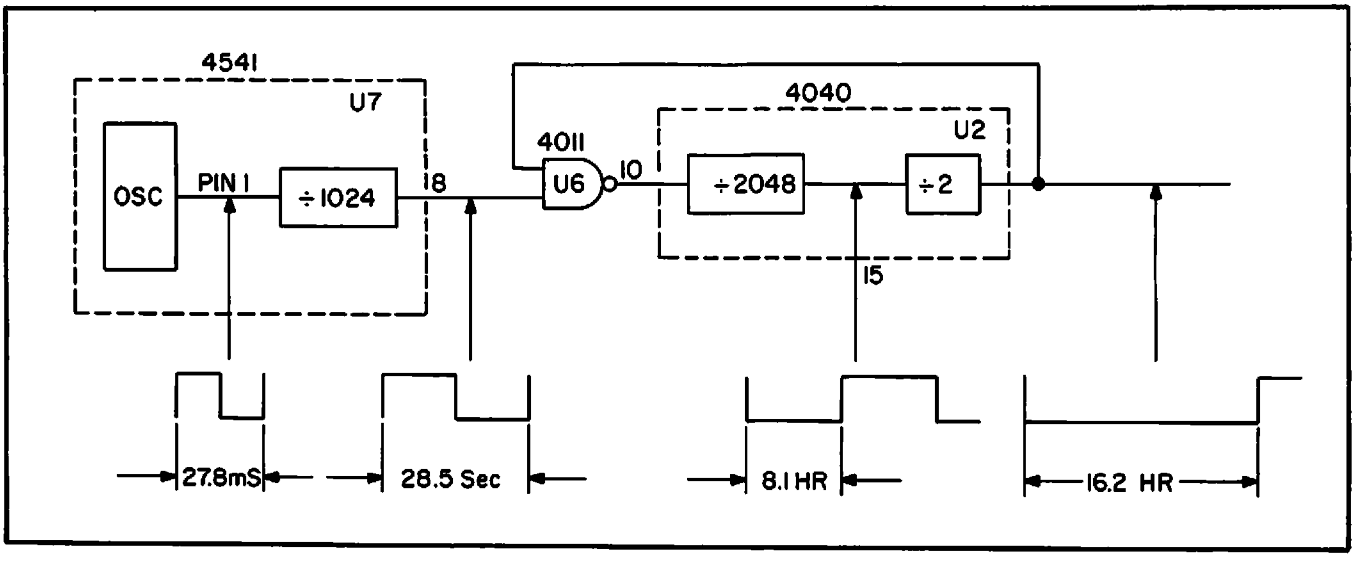


Figure 7-6. Timing Diagram.

7.2.8 Clock Gate

U6B is a nand gate which passes the 28.5 second clock signal when enabled by +12 volts on Pin 6. At the end of 16 hours, Q2 collector is pulled to ground which removes the clock signal from U2.

7.2.9 Divide By 2048 and Divide By 4096 Counters

U2 is a 12 bit binary counter with divide by 2048 and divide by 4096 outputs selected for 8 and 16 hours. After approximately 8.1 hours, the divide by 2048 output goes high, turning on Q3 which lights the 8 hour LED indicator, DS3. At 16.2 hours, the divide 2048 output goes low and the 4096 output goes high with Q2 lighting the 16 hour LED, DS2, and removing the clock signal so that U2 will hold its count.

7.2.10 Counter Reset Gate

When the battery is removed, the +12 volts is removed from the input to U6A. This causes the gate output to go high. Resetting the counter, U2, to zero and extinguishes the 8 or 16 hour LED if it is on.

7.2.11 Maintenance

There are no adjustments in this instrument. Therefore, the only reason for disassembly will be for repair.

7.2.12 Disassembly

The molded plastic case consists of an upper and lower section. Both case sections are removed for service.

1. Top cover removal. See Figure 7-7.

(a) Unscrew the four banana plugs located in the battery cavities. These plugs have a metric hex nut section but can be removed with a 1/4 inch nut driver.

(b) Lift the rear of the top cover about 1/2 inch, just above the heat sink. Slip your fingers under the edge of the front panel and spring it forward to clear the LED's. Lift off the cover.

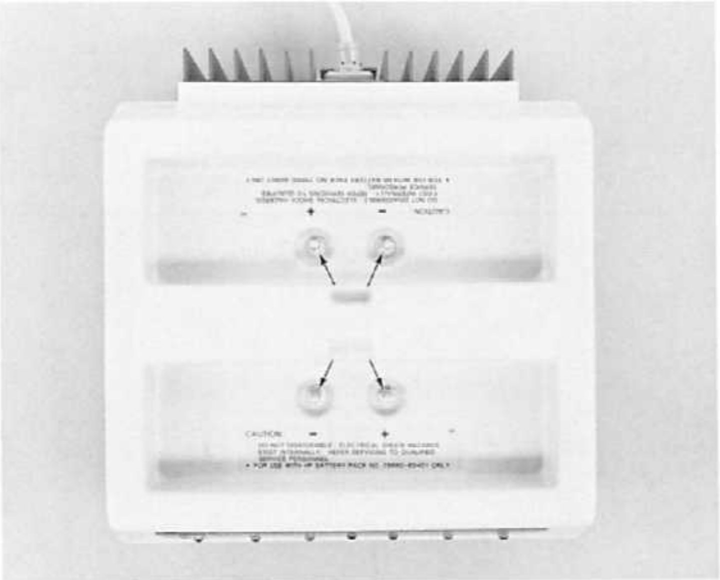


Figure 7-7. Top Cover Removal.

2a. Bottom cover removal. See Figure 7-8.

(a) Lay the battery charger on its top. Use a small posidrive screwdriver to remove the four rubber feet.

2b. Lift off the bottom cover.

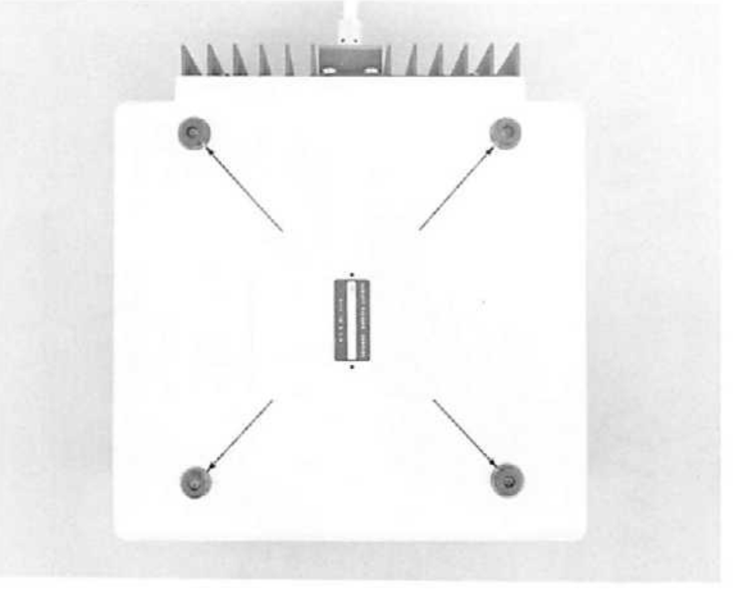


Figure 7-8. Bottom Cover Removal.

3. Circuit board removal.

NOTE: All nuts used in the structure are captive PEM nuts except the two used on the current regulators, U1 and U5.

(a) Remove the finned heat radiator by removing the four screws shown in Figure 7-9.

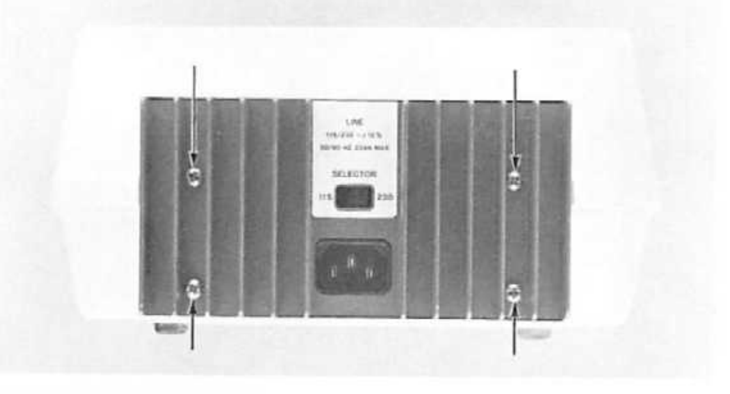


Figure 7-9. Removing Heat Radiator.

(b) Place the unit on its back where the heat sink was removed.

(c) See Figure 7-10. Remove the two screws, A, to loosen the LED board. It remains attached to the main circuit board by a short flat jumper cable.

(d) Unscrew the two hex posts, B.

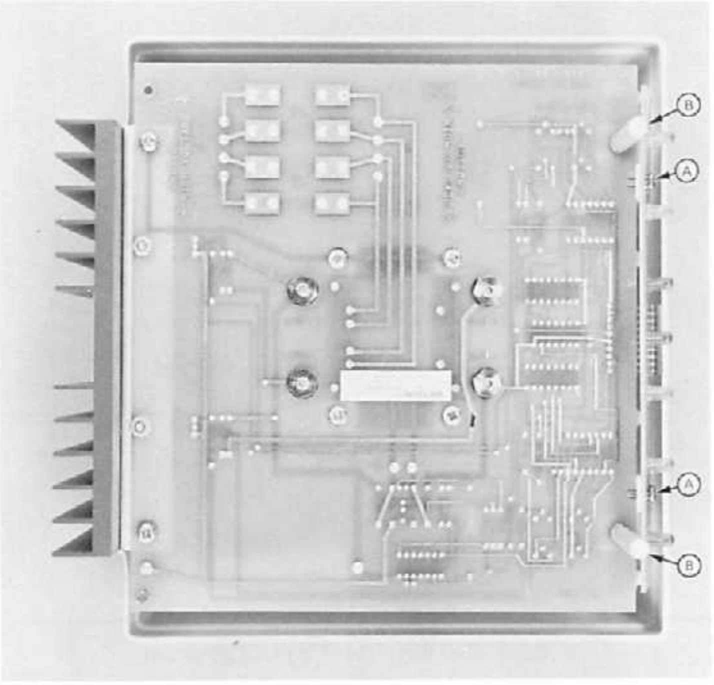


Figure 7-10. Battery Charger With Top Cover Removed.

(e) Refer to Figure 7-11. Remove the 4 screws shown in the illustration. The bottom sheet metal is now free. The transformer remains attached to the circuit board.

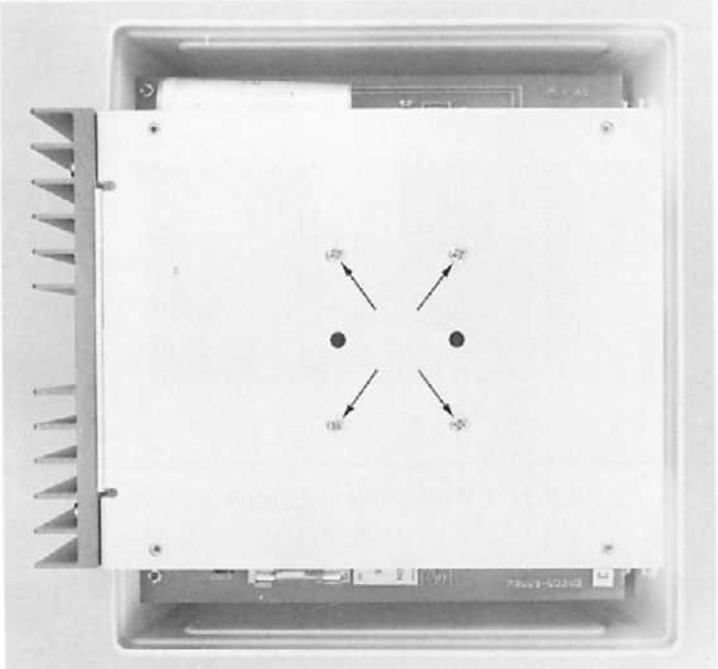


Figure 7-11. Battery Charger With Bottom Cover Removed.

4. The power cord connector bracket remains attached to the circuit board. See Figure 7-12. The transformer is secured to the main board by four screws and the electrical contacts are soldered into the board.

5. Assembly is done in the reverse order.

NOTE: When replacing the top cover, spring the front panel forward to clear the LED's.

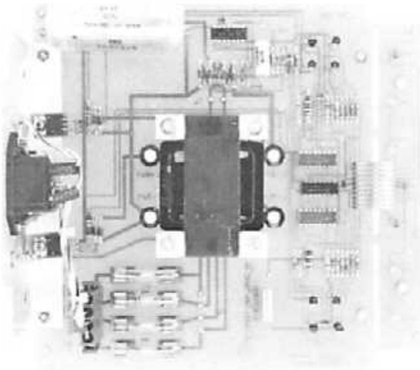


Figure 7-12. Battery Charger Circuit Board.

7.2.13 Troubleshooting Battery Charger

7.2.13.1 Equipment Required:

DVM or VOM

SYMPTOM	CHECK
Unit plugged into AC power. Power LED does not light	1. Line AC outlet 2. Defective power cord. 3. Line voltage selector switch in wrong position. 4. Blown fuse 5. Defective transformer, T1 6. Defective LED
Charging LED does not light when battery is plugged in.	1. Open battery (no load on charger) 2. U1 or U5 3. Q1 or Q4 4. R1 or R11 5. U4 or U8

NOTE: A battery load may be simulated by connecting a 70-75 ohm resistor in place of the battery. Power dissipation is approximately 3 watts.

The following symptoms concern the 8 and 16 hour LED's. A battery or resistor must be connected across the charger terminals to power the charge time indicator circuits. These tests assume the battery has been on charge for at least 16 hours. The battery should be warm to the touch if charging is taking place.

SYMPTOM	CHECK
8 and 16 hour LED's do not light on either side. Batteries warm after 16 hours charge. Charging LED's light.	Connect DC voltmeter to TP1. Voltage should switch between zero and Vcc (approximately 12 volts) at about 14 second intervals. If this switching action does not occur, check Vcc. U7 defective.
8 and 16 hour LED does not operate on one side only. Battery is warm. Charging LED lights.	U4 or U8 U2 or U3

The 8 and 16 hour LED's may be checked by connecting a battery or resistor load to the charger and grounding the collector of the transistor driver for the LED under test. DO NOT GROUND the LED cathode.

To check the LED driver transistor, connect a 22K resistor between Vcc and the base of the transistor. The LED should light.

8 and 16 hour LED's do not light on one side only. Charging LED does not light on that side. Battery is warm.	Q1 or Q4
8 and 16 hour LED's do not light on one side only. Charging LED does not light. Battery is cold.	U1 or U5

See Figure 7-13.

7.3 RECHARGEABLE NICKEL CADMIUM BATTERY - B1

Many nickel cadmium batteries are needlessly replaced each year because service personnel did not understand their characteristics. Most storage batteries require a certain amount of maintenance, and the nickel cadmium battery is no exception. However, their maintenance requirements are quite different from an automobile battery, for example.

7.3.1 General Description

The battery (B1) used in the portable defibrillator is a 10-cell, 2.0 AH sealed nickel cadmium type. It is charged with a constant current source of 200 mA and can sustain overcharging indefinitely at this rate. The internal construction and chemistry of the battery is such that oxygen generated during overcharging rapidly diffuses through the cell and recombines at the negative plate. Consequently, there is no excessive pressure build-up in the cells and the excess energy is converted to heat; a fully-charged battery will be warm to the touch when kept on overcharge. Since no detrimental effects occur because of overcharging, the unit should be kept charging whenever practical.

7.3.2 Charge Retention

The nickel cadmium battery has a relatively high self discharge rate, when compared to other types of batteries. Charge retention depends on the storage temperature and the age and condition of the battery. The self discharge rates for new batteries are listed below:

Temperature	Self Discharge/Month
0°C (32°F)	10%
20°C (68°F)	30%
40°C (104°F)	70%

7.3.3 Charging

The heat generated during normal overcharge however, necessitates that the battery not be charged when the ambient temperature exceeds 45°C. The battery should not be charged when the ambient temperature is below 5°C. Charging below this temperature may cause build-up of excessive pressure, with a resultant venting of the cells. Venting will cause loss of electrolyte and gradual loss of battery capacity.

7.3.4 Voltage Depression (Memory)

Nickel cadmium batteries that are left on continuous charge, for long periods of time, suffer from a voltage depression pheomenon. The terminal voltage, under load, will be about 1 volt less than that of a battery in good operating condition. The apparent effect is reduced battery capacity, sometimes referred to as memory.

Under conditions of long continuous charge, the crystals of active material within the plates of the cells, begin to increase in size. As the crystals grow larger, the surface area of active material in contact with the electrolyte decreases. The effect is an increase in internal resistance of the battery. This will be exhibited as premature flashing of the low battery warning light.

7.3.5 Reconditioning Charge/Discharge Cycle

The effects of voltage depression can be eliminated by exercising the battery. This can be accomplished by the following procedure:

1. Charge battery for 16 hours.

2. Remove the defibrillator from the Quick-Mount Power Base.

3. Turn ENERGY SELECT switch to MONITOR ON position.

4. Allow the battery to discharge until the LOW BATTERY light flashes.

DO NOT LEAVE THE UNIT ON FOR A LONG PERIOD AFTER THE BATTERY LOW LIGHT FLASHES, or cell reversal may occur.

An alternate method is to connect the battery to a test load (HP 78620-60860). Connect a voltmeter to the test load and monitor the discharge. Discharge the battery until the voltage falls below 10 volts. DO NOT ALLOW THE VOLTAGE TO FALL BELOW 9.0 VOLTS, or cell reversal may occur. Use Model 78660-67800 adapters to connect the battery to the test load.

7.3.6 Cell Reversal

Cell reversal, due to deep discharge, can occur whenever the battery voltage drops low enough (i.e., about 9 volts) to cause one of the cells to reach zero volts. The current flowing through the battery pack will then tend to reverse-charge this (weakest) cell. Reverse charging generates hydrogen and oxygen which will cause a rise in internal pressure and possible subsequent venting if the pressure increases sufficiently. The cells have resealable vents, and only a small amount of electrolyte escapes during venting. However, after 10 or more venting incidents, the affected cell will begin to lose capacity and reach reversal earlier.

To minimize this possibility, cells are closely matched in capacity during manufacturing. This ensures that the loss of the weakest cell will be followed shortly by the collapse of the remaining cells. Therefore, when the weakest cell is fully discharged, the remaining cells have so little capacity that current flow is not enough to seriously reverse-charge the weakest cell. This matching of cell capacity makes it imperative that individual cells never be replaced. In the event of a weak battery, the entire battery pack must be replaced. As a further precaution, turn the unit off, or plug in whenever the trace starts to dim or has disappeared.

7.3.7 Battery Replacement 78660-60401

As a battery ages, its capacity will be reduced. If the LOW BATTERY warning starts flashing after only 2 hours of monitoring, and the voltage is not depressed due to ng term continuous overcharging, the battery is showing signs of weakening. A lly charged battery should be capable of sustaining at least 2-1/2 hours of nitoring. If the battery is incapable of meeting this minimum, it should be placed. However, test the battery before replacing. See Section 3.2.3.7.

3.8 Storage of Nickel Cadmium Batteries

he batteries must be stored, they should be charged about once every three months if stored at nor- l room temperature. After removal from storage, the battery should be deep discharged and recharg- once or twice to restore its capacity.

SECTION VIII
OPTIONS

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr.Part Number
				PERTAINS TO THESE INSTRUMENTS 78670A AND 78671A		
A01				78671A (Only)		
	OPTION A01			DELETE RECORDER		
	0460-1678	6	+	ADHESIVE TAPE	28480	04601678
	0470-0573	2	+	ADH-LOCTITE 222	28480	0470-0573
	1400-1038	7	4+	FASTENER	28480	1400-1038
	1400-1038	7	2-	FASTENER	28480	1400-1038
	9270-0980	7	3-	RECORDER PAPER	28480	9270-0980
	5952-6866	2	1-	OPERATING CARD	28480	5952-6866
	5952-6868	4	1+	OPERATING CARD	28480	5952-6868
	78660-40032	2	1+	FILLER PAD	28480	78660-40032
	78660-61605	6	1-	CBL AY-RECORDER	28480	78660-61605
	78660-61616	9	1+	CBL AY-SPEAKER	28480	78660-61616
	78671-07200	6	1-	FRONT PANEL	28480	78671-07200
	78671-07201	7	1+	FRONT PANEL	28480	78671-07201
	78671-27204	2	1+	PANEL-FILLER	28480	78671-27204
A02				78671A (Only)		
	OPTION A02			DELETE RECORDER AND HEART RATE		
	0470-0573	2	+	ADH-LOCTITE 222	28480	0470-0573
	1400-1038	7	4+	FASTENER	28480	1400-1038
	1440-1038	7	2-	FASTENER	28480	1400-1038
	9270-0980	7	3-	RECORDER PAPER	28480	9270-0980
	5952-6866	2	1-	OPERATING CARD	28480	5952-6866
	5952-6868	4	1+	OPERATING CARD	28480	5952-6868
	78660-40032	2	1+	FILLER PAD	28480	78660-40032
	78660-60200	5	1-	PC AY-RECRD CTRL	28480	78660-60200
	78660-60210	7	1-	PC AY-HEART RATE	28480	78660-60210
	78660-61605	6	1-	CBL AY-RECORDER	28480	78660-61605
	78660-61616	9	1+	CBL AY-SPEAKER	28480	78660-61616
	78671-07200	6	1-	FRONT PANEL	28480	78671-07200
	78671-07201	7	1+	FRONT PANEL	28480	78671-07201
	78671-27204	2	1+	PANEL-FILLER	28480	78671-27204
C01						
	OPTION C01			ADD 78669A SPARE BATTERY CHARGER		
	78669A		1+	AUX BATT CHGR	28480	78669A
C02						
	OPTION C02			DELETE 78668A QUICK-MOUNT POWER BASE		
	78668A		1-	QUICK-MOUNT POWER BASE	28480	78668A
C03						
	OPTION C03			78670A (Only)		
	14412D		1+	ADD ANT/POST PADDLE	28480	14412D
				PADDLE ASSY-APEX		
	C04					
C04				78670A (Only)		
	OPTION C04			ADULT INTERNAL PADDLES		
	14990B		1+	HANDLE SET-INTERNAL	28480	14990B
	14993A		1+	ELECTRODE SET-ADULT	28480	14993A

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
C05				78670A (Only)		
	OPTION C05			PEDI INTERNAL PADDLES		
	14990B		1+	HANDLE SET-INTERNAL	28480	14990B
	14992A		1+	ELECTRODE SET-PEDI	28480	14992A
C06				78670A (Only)		
	OPTION C06			INFANT INTERNAL PADDLES		
	14990B		1+	HANDLE SET-INTERNAL	28480	14990B
	14994A		1+	ELECTRODE-INTERNAL INFANT	28480	14994A
C07				78670A (Only)		
	OPTION C07			DELETE STANDARD PADDLES		
	14983A		1-	PADDLE SET-DEFIBRILLATOR	28480	14983A
L01						
	OPTION L01			FRENCH LABELS		
	7121-0763	7	1-	LABEL-INFO	28480	7121-0763
	7121-2424	1	1+	LABEL-INFO	28480	7121-2424
	7121-0764	8	1-	LABEL-INFO	28480	7121-0764
	7121-1675	2	1+	LABEL-INFO	28480	7121-1675
	7121-0765	9	1-	LABEL-WARNING	28480	7121-0765
	7121-1675	3	1+	LABEL-WARNING	28480	7121-1676
	7121-0767	1	1-	LABEL-WARNING	28480	7121-0767
	7121-1677	4	1+	LABEL-WARNING	28480	7121-1677
	7121-0768	2	1-	LABEL-INFO	28480	7121-0768
	7121-1678	5	1+	LABEL-INFO	28480	7121-1678
	7121-0773	9	1-	LABEL-WARNING	28480	7121-0773
	7121-1683	2	1+	LABEL-WARNING	28480	7121-1683
	7121-0774	0	1-	LABEL-WARNING	28480	7121-0774
	7121-1684	3	1+	LABEL-WARNING	28480	7121-1684
	7121-0775	1	1-	LABEL-WARNING	28480	7121-0775
	7121-1685	4	1+	LABEL-WARNING	28480	7121-1685
	7121-0776	2	1-	LABEL-WARNING	28480	7121-0776
	7121-1686	5	1+	LABEL-WARNING	28480	7121-1686
	7121-0777	3	1-	LABEL-INFO	28480	7121-0777
	7121-1687	6	1+	LABEL-INFO	28480	7121-1687
	7121-3918	0	1-	LABEL-INFO	28480	7121-3918
	78670-84510	2	1+	LABEL-DEFIB CONTROL	28480	78670-84510
	7121-3921	5	1-	LABEL-INFO	28480	7121-3921
	78670-84513	5	1+	LABEL-APEX PADDLE	28480	78670-84513
	7121-3922	6	1-	LABEL-INFO	28480	7121-3922
	78670-84514	6	1+	LABEL-OPERATING INSTRUCTIONS	28480	78670-84514
	7121-4004	3	2-	LABEL-TWIST PADDLE	28480	7121-4004
	78670-84517	9	2+	LABEL-TWIST PADDLE	28480	78670-84517
	L01			78670A (Only)		
	7121-3920	4	1-	LABEL–STERNUM PADDLE	28480	7121-3920
	78670-84512	4	1+	LABEL-STERNUM PADDLE	28480	78670-84512
	7121-3924	8	1-	LABEL-INFO	28480	7121-3924
	78670-84515	7	1+	LABEL-CHARGE	28480	78670-84515
	7121-4142	4	1-	LABEL-INFO	28480	7121-4142
	78670-84518	0	1+	LABEL-PADDLE CONTACT	28480	78670-84518
	78670-07200	5	1-	PANEL-FRONT	28480	78670-07200
	78670-07201	6	1+	PANEL-FRONT	28480	78670-07201
	5952-6866	2	1-	OPERATORS CARD	28480	5952-6866
	5952-6874	2	1+	OPERATORS CARD	28480	5952-6874
	78670-91998	5	1-	OPERATING GUIDE	28480	78670-91998
	78670-91996	3	1+	OPERATING GUIDE	28480	78670-91996
	7120-6767	1	1+	LABEL-LATCHED/UNLACTED	28480	7120-6767
	7121-2503	7	1-	LABEL-CAUTION	28480	7121-2503
	7121-2502	6	1+	LABEL-CAUTION	28480	7121-2502
	7121-1373	7	1+	LABEL-INFO	28480	7121-1373

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
				78671A (Only)		
	7121-4003	2	1-	LABEL-STERNUM PADDLE	28480	7121-4003
	78670-84516	8	1+	LABEL-STERNUM PADDLE	28480	78670-84516
	78671-07200	6	1-	PANEL-FRONT	28480	78671-07200
	78671-07202	8	1+	PANEL-FRONT	28480	78671-07202
	5952-6868	4	1-	OPERATORS CARD	28480	5952-6868
	5952-6875	3	1+	OPERATORS CARD	28480	5952-6875
	78671-91998	6	1-	OPERATING GUIDE	28480	78671-91998
	78671-91996	4	1+	OPERATING GUIDE	28480	78671-91996
L02						
	OPTION L02			GERMAN LABELS		
	7121-0484	9	1+	LABEL-INFO	28480	7121-0484
	7121-0763	7	1-	LABEL-INFO	28480	7121-0763
	7121-2424	1	1+	LABEL-INFO	28480	7121-2424
	7121-0764	8	1-	LABEL-INFO	28480	7121-0764
	7121-1693	4	1+	LABEL-INFO	28480	7121-1693
	7121-0765	9	1-	LABEL-WARNING	28480	7121-0765
	7121-1694	5	1+	LABEL-WARNING	28480	7121-1694
	7121-0767	1	1-	LABEL-WARNING	28480	7121-0767
	7121-1695	6	1+	LABEL-WARNING	28480	7121-1695
	7121-0768	2	1-	LABEL-INFO	28480	7121-0768
	7121-1696	7	1+	LABEL-INFO	28480	7121-1696
	7121-0773	9	1-	LABEL-WARNING	28480	7121-0773
	7121-1701	5	1+	LABEL-WARNING	28480	7121-1701
	7121-0774	0	1-	LABEL-WARNING	28480	7121-0774
	7121-1702	6	1+	LABEL-INFO	28480	7121-1702
	7121-0775	1	1-	LABEL-WARNING	28480	7121-0775
	7121-1703	7	1+	LABEL-WARNING	28480	7121-1703
	7121-0776	2	1-	LABEL-WARNING	28480	7121-0776
	7121-1704	8	1+	LABEL-WARNING	28480	7121-1704
	7121-0777	3	1-	LABEL-INFO	28480	7121-0777
	7121-1705	9	1+	LABEL-INFO	28480	7121-1705
	7121-3918	0	1-	LABEL-INFO	28480	7121-3918
	78670-84520	4	1+	LABEL-DEFIB CONTROL	28480	78670-84520
	7121-3921	5	1-	LABEL-INFO	28480	7121-3921
	78670-84523	7	1+	LABEL-APEX PADDLE	28480	78670-84523
	7121-3922	6	1-	LABEL-INFO	28480	7121-3922
	78670-84524	8	1+	LABEL-OPERATING INSTRUCTIONS	28480	78670-84524
	7121-4004	3	2-	LABEL-TWIST PADDLE	28480	7121-4004
	78670-84527	1	2+	LABEL-TWIST PADDLE	28480	78670-84527
				78670A (Only)		
	7121-3920	4	1-	LABEL-STERNUM PADDLE	28480	7121-3920
	78670-84522	6	1+	LABEL-STERNUM PADDLE	28480	78670-84522
	7121-3924	8	1-	LABEL-INFO	28480	7121-3924
	78670-84525	9	1+	LABEL-CHARGE	28480	78670-84525
	7121-4142	4	1-	LABEL-INFO	28480	7121-4142
	78670-84528	2	1+	LABEL-PADDLE CONTACT	28480	78670-84528
	78670-07200	5	1-	PANEL-FRONT	28480	78670-07200
	78670-07203	8	1+	PANEL-FRONT	28480	78670-07203
	78670-60200	7	1-	PC ASSY-RECORDER	28480	78670-60200
	78670-60201	8	1+	PC ASSY-RECORDER	28480	78670-60201
	5952-6866	2	1-	OPERATORS CARD	28480	5952-6866
	5952-6872	0	1+	OPERATORS CARD	28480	5952-6872
	78670-91998	5	1-	OPERATING GUIDE	28480	78670-91998
	7120-7941	5	1+	LABEL-LATCHED/UNLATCHED	28480	7120-7941
	7121-2503	7	1-	LABEL-CAUTION	28480	7121-2503
	7121-2536	6	1+	LABEL-CAUTION	28480	7121-2536
				78671A (Only)		
	7121-4003	2	1-	LABEL-STERNUM PADDLE	28480	7121-4003
	78670-84526	0	1+	LABEL-STERNUM	28480	78670-84526
	78671-07200	6	1-	PANEL-FRONT	28480	78670-07200
	78671-07204	0	1+	PANEL-FRONT	28480	78671-07204
	5952-6868	4	1-	OPERATORS CARD	28480	5952-6868
	5952-6873	1	1+	OPERATORS CARD	28480	5952-6873
	78671-91998	6	1-	OPERATING GUIDE	28480	78671-91998
	0520-0065	1	8+	PHMS 2-56 x .25	28480	0520-0065

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
L03						
	OPTION L03			DUTCH LABELS		
	7121-02763	7	1-	LABEL-INFO	28480	7121-02763
	7121-2424	1	1+	LABEL-INFO	28480	7121-2424
	7121-0764	8	1-	LABEL-INFO	28480	7121-0764
	7121-2207	8	1+	LABEL-INFO	28480	7121-2207
	7121-0765	9	1-	LABEL-WARNING	28480	7121-0765
	7121-2208	9	1+	LABEL-WARNING	28480	7121-2208
	7121-0767	1	1-	LABEL-WARNING	28480	7121-0767
	7121-2198	6	1+	LABEL-WARNING	28480	7121-2198
	7121-0768	2	1-	LABEL-INFO	28480	7121-0768
	7121-2197	5	1+	LABEL-INFO	28480	7121-2197
	7121-0773	9	1-	LABEL-WARNING	28480	7121-0773
	7121-2192	0	1+	LABEL-WARNING	28480	7121-2192
	7121-0774	0	1-	LABEL-WARNING	28480	7121-0774
	7121-2191	7	1+	LABEL-WARNING	28480	7121-2191
	7121-0775	1	1-	LABEL-WARNING	28480	7121-0775
	7121-2190	6	1+	LABEL-WARNING	28480	7121-2190
	7121-0776	2	1-	LABEL-WARNING	28480	7121-0776
	7121-2189	5	1+	LABEL-WARNING	28480	7121-2189
	7121-0777	3	1-	LABEL-INFO	28480	7121-0777
	7121-2188	4	1+	LABEL-INFO	28480	7121-2188
	7121-3918	0	1-	LABEL-INFO	28480	7121-3918
	78670-84530	6	1+	LABEL-DEFIB CONTROL	24840	78670-84530
	7121-3921	5	1-	LABEL-INFO	28480	7121-3921
	78670-84533	9	1+	LABEL-APEX PADDLE	28480	78670-84533
	7121-3922	6	1-	LABEL-INFO	28480	7121-3922
	78670-84534	0	1+	LABEL-OPERATING INSTRUCTIONS	28480	78670-84534
	7121-4004	3	2-	LABEL-TWIST PADDLE	28480	7121-4004
	78670-84537	3	2+	LABEL-TWIST PADDLE	28480	78670-84537
	L03			78670A (Only)		
	7121-3920	4	1-	LABEL-STERNUM PADDLE	28480	7121-3920
	78670-84532	8	1+	LABEL-STERNUM PADDLE	28480	78670-84532
	7121-3924	8	1-	LABEL-INFO	28480	7121-3924
	78670-84535	1	1+	LABEL-CHARGE	28480	78670-84535
	7121-4142	4	1-	LABEL-INFO	28480	7121-4142
	78670-84538	4	1+	LABEL-PADDLE CONTACT	28480	78670-84538
	78670-07200	5	1-	PANEL-FRONT	28480	78670-07200
	78670-07204	9	1+	PANEL-FRONT	28480	78670-07204
	78670-60200	7	1-	PC ASSY-RECORDER	28480	78670-60200
	78670-60201	8	1+	PC ASSY-RECORDER	28480	78670-60201
	5952-6866	2	1-	OPERATORS CARD	28480	5952-6866
	5952-6876	4	1+	OPERATORS CARD	28480	5952-6876
	78670-91998	5	1-	OPERATING GUIDE	28480	78670-91998
	7121-2503	7	1-	LABEL-CAUTION	28480	7121-2503
	7121-2505	9	1+	LABEL-CAUTION	28480	7121-2505
				78671A (Only)		
	7121-4003	2	1-	LABEL-STERNUM PADDLE	28480	7121-4003
	78670-84536	2	1+	LABEL-STERNUM PADDLE	28480	78670-84536
	78671-07200	6	1-	PANEL-FRONT	28480	78671-07200
	78671-07206	2	1+	PANEL-FRONT	28480	78670-07206
	5952-6868	4	1-	OPERATORS CARD	28480	5952-6868
	5952-6877	5	1+	OPERATORS CARD	28480	5952-6877
	78671-91998	6	1-	OPERATING GUIDE	28480	78671-91998
	0520-0065	1	8+	PHMS 2-56 x .25	28480	0520-0065
N01						
	OPTION N01			CSA		
	7120-6645	4	1+	LABEL-CSA	28480	7120-6645
	7121-2526	4	1+	LABEL-INFO	28480	7121-2526
	7121-3922	6	1-	LABEL-OPERATING INSTRUCTIONS	28480	7121-3922
	7121-3923	7	1+	LABEL-OPER. w/FRENCH WARNING	28480	7121-3923

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
N02						
	OPTION N02			VDE/IEC		
	0590-0565	3	2+	NUT-HEX DBL-CHAM	28480	0590-0565
	1251-5964	9	1+	CONN-SGL CONT	28480	1251-5964
	1510-0038	8	1-	BINDING POST-SGL	28480	1510-0038
	7120-7115	5	1+	LABEL-VDE ID	28480	7120-7115
	7121-0763	7	1-	LABEL-INFO	28480	7121-0763
	7121-2424	1	1+	LABEL-INFO	28480	7121-2424
	5955-7825	1	1+	INST SHT-MFR RES	28480	5955-7825
	78670-00849	4	1+	WASHER	28480	78670-00849
	14151A		1-	CABLE-LEAD SET	28480	14151A
	14463A		1+	CABLE-TRUNK	28480	14463A
	14481B		1+	CABLE-PATIENT	28480	14481B
	14489B		1-	CABLE AY-ECG	28480	14489B
L01				78668A POWER BASE		
	OPTION L01			FRENCH LABELS		
	7121-0841	2	1-	LABEL-WARNING	03211	7121-0841
	7121-1689	8	1+	LABEL-WARNING	03211	7121-1689
	7121-0842	3	1-	LABEL-IDENT	28480	7121-0842
	7121-1690	1	1+	LABEL-IDENT	28480	7121-1690
	78668-84506	0	1+	LABEL-SELECTOR	28480	78668-84506
L02	78668-84507	1	1+	LABEL-LINE	28480	78668-84507
	OPTION L02			GERMAN LABELS		
	7121-0841	2	1-	LABEL-WARNING	03211	7121-0841
	7121-1707	1	1+	LABEL-WARNING	03211	7121-1707
	7121-0842	3	1-	LABEL-IDENT	28480	7121-0842
	7121-1708	2	1+	LABEL-IDENT	28480	7121-1708
L03						
	OPTION L03			DUTCH LABELS		
	7121-0841	2	1-	LABEL-WARNING	03211	7121-0841
	7121-2186	2	1+	LABEL-WARNING	03211	7121-2186
	7121-0842	3	1-	LABEL-IDENT	28480	7121-0842
	7121-2185	1	1+	LABEL-IDENT	28480	7121-2185
N01						
	OPTION N01			CSA		
	7120-6645	4	1+	LABEL-CSA	03211	7120-6645
	7121-1841	4	1+	LABEL-WARNING	03211	7121-1841
	78668-62700	2	1-	TRANSFORMER	28480	78668-62700
	78668-62703	5	1+	XFMR-CSA TESTED	28480	78668-62703
N02						
	OPTION N02			VDE/IEC		
	0590-0565	3	2+	NUT-HEX DBL-CHAM	28480	0590-0565
	1251-5964	9	1+	CONN-SG. CONT	28480	1251-5964
	1510-0038	8	1-	BINDING POST-SGL	28240	1251-0038
	7120-7115	5	1+	LABEL-VDE ID	03211	7120-7115
	7121-2424	1	1+	LABEL-INFO	03211	7121-2424
	5955-7825	1	1+	INST SHT-MFR RES	28480	5955-7825
	78620-00849	4	1+	WASHER	28480	78620-00849
N05						
	OPTION N05			UK CONFIGURATION		
	0890-0312	4	1+	SHRINK TUBING .250	28480	0890-0312
	1400-0023	8	1+	CLAMP-CABLE	28480	1400-0023
	1400-0307	1	1+	TIE WRAP	28480	1400-0307
	1400-1254	9	3+	CLIP-WIRE HARNESS	28480	1400-1254
	1450-0622	8	1+	LAMPHOLDER	28480	1450-0622
	1450-0623	9	1+	LAMP-MINIATURE	28480	1450-0623
	7124-1964	8	1+	LABEL-MADE USA	28480	7124-1964
	78668-40001	0	1-	CASE	28480	78668-40001
	78668-27100	3	1+	CASE-MODIFIED	28480	78668-27100
	78668-61604	3	1+	CABLE-PILOT LITE	28480	78668-61604
	78668-61605	4	1+	CABLE-PILOT LITE	28480	78668-61605
	78668-84502	8	1+	LABEL-POWER BASE ON	28480	78668-84502
	78668-84503	9	1+	LABEL-115/240V	28480	78668-84503
	78668-84504	0	1+	LABEL-240V	28480	78668-84504
Z02						
	OPTION Z02			100 VOLT OPERATION		
	7120-5716	8	1+	LABEL 100/200	03211	7120-5716
	78668-62700	2	1-	TRANSFORMER	28480	78668-62700
	78668-62701	3	1+	TRANSFORMER	28480	78668-62701

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
900						
	OPTION 900			UK POWER CORD		
	8120-1351	0	1+	PWR CBL-85 1363	28480	8120-1351
	8120-3493	5	1-	POWER CORD	28480	8120-3493
	5001-2043	4	1-	CLAMP-PWR CORD	28480	5001-2043
	07807-05060	7	1+	CORD RETAINER	28480	07807-05060
901						
	OPTION 901			AUSTRALIAN POWER CORD		
	1251-3921	4	1+	POWER PLUG-AUST	28480	1251-3921
	8120-1369	0	1+	CBL-ASSY ASC-112	28480	8120-1369
	8120-3493	5	1-	POWER CORD	28480	8120-2393
	5001-2043	4	1-	CLAMP-PWR CORD	28480	5001-2043
	07807-05060	7	1+	CORD RETAINER	28480	07807-0506
902						
	OPTION 902			EUROPEAN POWER CORD		
	8120-1689	7	1+	CBL ASSY 3 COND	28480	8120-1689
	8120-3493	5	1-	POWER CORD	28480	8120-3493
	5001-2043	4	1-	CLAMP-PWR CORD	28480	5001-2043
	07807-05060	7	1+	CORD RETAINER	28480	07807-05060
906						
	OPTION 906			SWISS POWER CORD		
	8120-2104	3	1+	CBL-ASSY	28480	8120-2104
	8120-3493	5	1-	POWER CORD	28480	8120-3493
	5001-2043	4	1-	CLAMP-PWR CORD	28480	5001-2043
	07807-05060	7	1+	CORD RETAINER	28480	07807-05060
L01				78669A BATTERY CHARGER		
	OPTION L01			FRENCH LABELS		
	7121-0771	7	1-	LABEL-INFO	03211	7121-0771
	7121-2237	4	1+	LABEL-INFO	03211	7121-2237
	7121-0772	8	2-	LABEL-WARNING	03211	7121-0772
	7121-1682	1	2+	LABEL-WARNING	03211	7121-1682
	7121-0773	9	1-	LABEL-WARNING	03211	7121-0773
	7121-1683	2	1+	LABEL-WARNING	03211	7121-1683
	7121-1685	4	2+	LABEL-WARNING	03211	7121-1685
	78669-07200	2	1-	PANEL-OVERLAY	28480	78669-07200
	78669-07201	3	1+	PANEL-OVERLAY FR	28480	78669-07201
L02						
	OPTION L02			GERMAN LABELS		
	7121-0771	7	1-	LABEL-INFO	03211	7121-0771
	7121-2236	3	1+	LABEL-INFO	03211	7121-2236
	7121-0772	8	2-	LABEL-WARNING	03211	7121-0772
	7121-1700	4	2+	LABEL-WARNING	03211	7121-1700
	7121-0773	9	1-	LABEL-WARNING	03211	7121-0773
	7121-1701	5	1+	LABEL-WARNING	03211	7121-1701
	7121-1703	7	2+	LABEL-WARNING	03211	7121-1703
	78669-07200	2	1-	PANEL-OVERLAY	28480	78669-07200
	78669-07202	4	1+	PANEL-OVERLAY GR	28480	78669-07202
L03						
	OPTION L03			DUTCH LABELS		
	7121-0771	7	1-	LABEL-INFO	03211	7121-0771
	7121-2238	5	1+	LABEL-INFO	03211	7121-2238
	7121-0772	8	2-	LABEL-WARNING	03211	7121-0772
	7121-2193	1	2-	LABEL-WARNING	03211	7121-2193
	7121-0773	9	1-	LABEL-WARNING	03211	7121-0773
	7121-2192	0	1+	LABEL-WARNING	03211	7121-2192
	7121-2190	8	2+	LABEL-WARNING	03211	7121-2190
	78669-07200	2	1-	PANEL-OVERLAY	28480	78669-07200
	78669-07203	5	1+	PANEL-OVERLAY DU	28480	78669-07203

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
N01	OPTION N01			CSA		
	7120-6645	4	1+	LABEL-CSA	03211	7120-6645
	7121-0771	7	1-	LABEL-INFO	03211	7121-0771
	7121-1841	4	1+	LABEL-WARNING	03211	7121-1841
	7121-2215	8	1+	LABEL-INFO	03211	7121-2215
	8120-1378	1	1-	CBL-ASSY 18/3	28480	8120-1378
	8120-1992	5	1+	CBL-ASSY 8 FT	28480	8120-1992
	78660-60240	4	1+	LABEL	28480	78660-60240
	78669-60240	2	1-	PC-AY BAT CHGR	28480	78669-60240
	78669-60241	3	1+	PC-AY CSA CHGR	28480	78669-60241
N02	OPTION N02			VDE-IEC CONFIGURATION		
	7120-7115		1+	LABEL-VDE ID	03211	7120-7115
	OPTION 900			UK POWER CORD		
	8120-1351	U	1+	PWR CBL-B5 1363	28480	8120-1351
	8120-1378	1	1-	CBL-ASSY 18-3	28480	8120-1378
901	OPTION 901			AUSTRALIAN POWER CORD		
	1251-3921	4	1+	POWER PLUG-AUST	28480	1251-3921
	8120-1396	0	1+	CBL-ASSY ASC-112	28480	8120-1369
	8120-1378	1	1-	CBL-ASSY 18/3	28480	8120-1378
	8120-1689	7	1+	CBL-ASSY 3 COND	28480	8120-1689
906	OPTION 906			SWISS POWER CORD		
	8120-1378	1	1-	CBL-ASSY 18/3	28480	8120-1378
	8120-2104	3	1+	CBL ASSY	28480	8120-2104
Y01	90898RZ	6	1	TNG FILM UMATIC	28480	90898RZ
Y02	90898RV	4	1	TNG FILM VHS	28480	90898RV
Y03	90898RW	5	1	TNG FILM BETA	28480	90898RW

NOTES