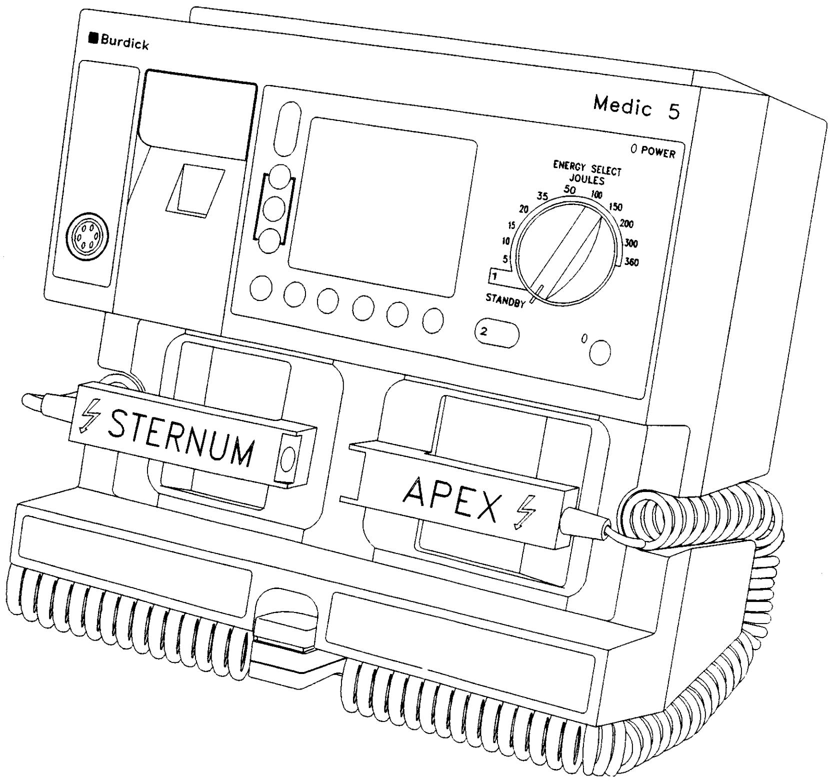
Service manual



Medic 5 Defibrillator

Service Manual Part No. 086405
Revised 6-96

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TO RESPONSIBLE SERVICE PERSONNEL:

The contents of this document are not binding. If any significant differences between the product and this document are encountered regarding service work, contact Burdick, Inc. for further information.

We reserve the right to modify products without amending this document or advising the user.

We recommend using authorized Burdick personnel for all service and repairs, and the use of Burdick exchange parts or genuine spare parts. Burdick will not otherwise assume responsibility for the materials used, the work performed, or for any possible consequences thereof.

This product has been carefully designed to provide a high degree of safety and dependability. However, we can not guarantee against the deterioration of components due to aging and normal wear.

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1 General information

About the Medic 5

The *Medic 5* is a portable emergency system which integrates a defibrillator, monitor, and recorder. It may be powered either from the internal, rechargeable battery or from the AC power line. The defibrillator delivers a damped, sinusoidal waveform ranging from 5 to 360 Joules. The defibrillator automatically disarms if any of the following conditions are true: there is no discharge within 30 seconds after ready indication, the energy select switch is turned to standby or ECG position, or an internal fault is detected.

The monitor features a non-fade display capable of freezing the waveform, setting heart rate alarm limits, and showing other relative information. Also, it has a full range of gain and lead selections.

The built-in thermal printer creates permanent records of the monitor trace. Each record is annotated with the date, time, lead group, sensitivity, heart rate, Joules selected, Joules delivered, and current modes. When a charge is initiated, the printer automatically writes a real time, selectable waveform until either the energy is delivered or the recording is stopped manually.

Basic system description

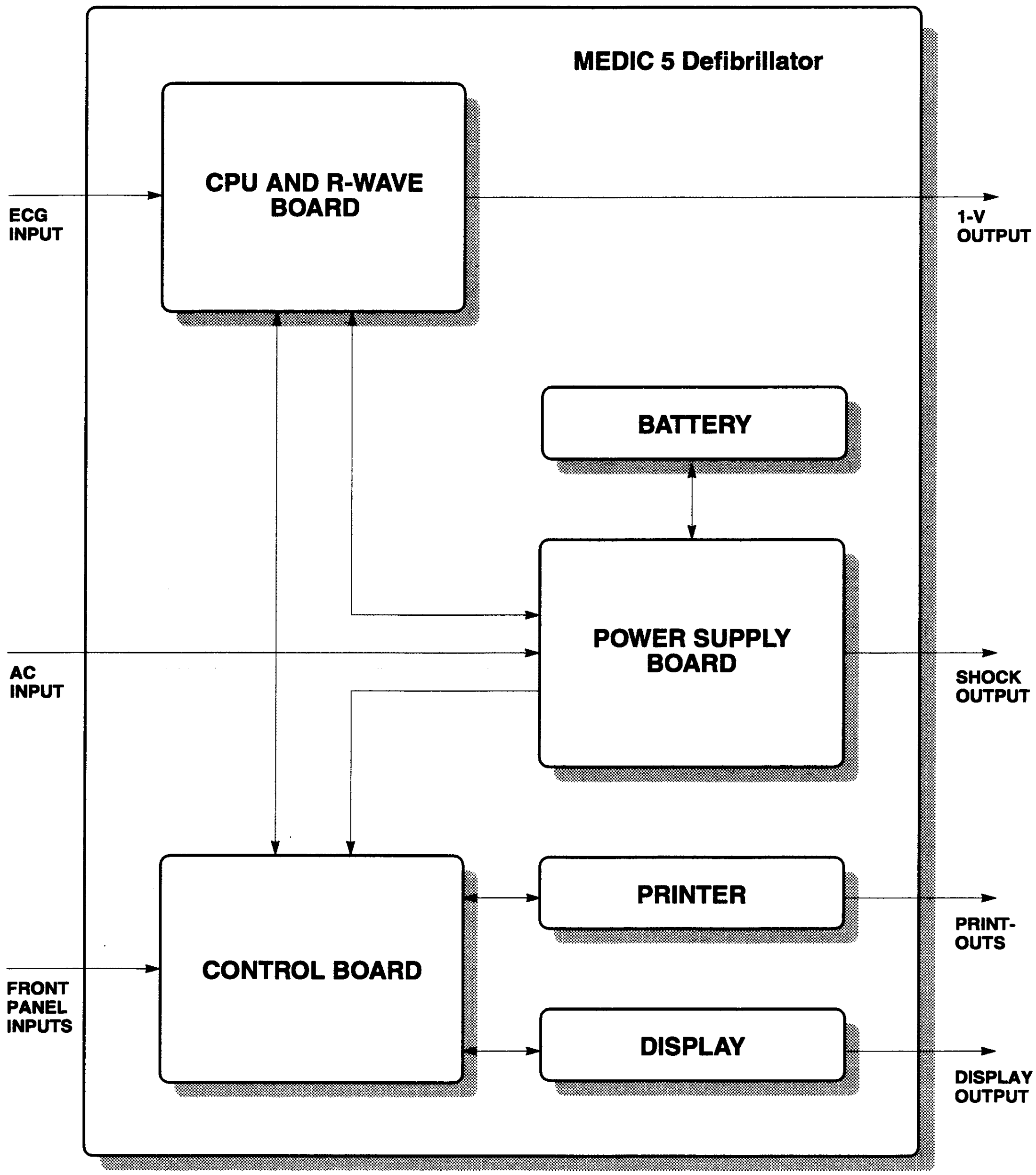
The main circuitry is incorporated on three circuit boards: the Power Supply board, the CPU and R-Wave board, and the Control board. See Fig. 1, pg. 2.

The Power Supply board generates all of the system power supplies and controls battery charging. It also generates and controls the high voltages required for defibrillation.

The CPU and R-Wave board contains the main logic for the system. It acquires and amplifies the ECG signal, detects R-waves, and communicates with the peripheral components to operate the defibrillator.

The Control board circuitry controls the thermal array printhead and liquid crystal display.

Figure 1
Basic system block diagram



Specifications

The *Medic 5* specifications are as follows:

SPECIFICATIONS	
Defibrillator:	
waveform:	damped sinusoid
energy select:	external: 5, 10, 15, 20, 35, 50, 100, 150, 200, 300, and 360 Joules; internal: 5, 10, 15, 20, 35, and 50 Joules
charge time:	< 10 seconds (to 360 J)
ready signal:	continuous audio tone, visible indicator
disarm:	occurs on selecting ECG, STANDBY; or 30 seconds after reaching full charge
paddles:	interchangeable between external adult and pediatric, internal and disposable; automatic range limit for internal
ECG amplifier:	
input:	Separate paddle and lead amplifiers. Lead amplifier accepts 3- or 5-lead patient cable.
lead selection:	I, II, III, avR, avL, avF, CHEST
leakage current:	< 20 µA (patient); < 20 µA (chassis)
common mode rejection:	> 85 dB at 60 Hz (lead amp); > 85 dB at 60 Hz (paddle amp)
frequency response:	0.05–100 Hz (lead amp), 0.5–35 Hz (paddle amp)
filters:	0.5–25 Hz, 50-/60-Hz notch
gain:	2.5, 5, 10, or 20 mm/mV
Monitor:	
Size:	5-inch flat screen, 4 seconds of data and alphanumerics
Sweep speed:	25 mm/s, trace held with FREEZE key
Annotation:	lead, gain, filter

SPECIFICATIONS (continued)	
Heart rate:	30–300 bpm, pace pulse enhancement, QRS beeper with volume control
Alarms:	high and low limits, adjustable over entire range
Recorder:	
type:	thermal array
paper size:	50-mm wide, 40-mm grid
paper speed:	25 mm/s
annotation:	date, time, lead, gain, heart rate, filter, auto disarm, energy selected/delivered, low and high alarm
Electrical:	
AC input:	115 V (99–132 V) ac, 230 V (207–253 V) ac, 50 or 60 Hz
battery type:	sealed lead-acid
battery capacity:	2.5 hours monitoring, 50 discharges minimum
power consumption:	2.5 A (115 V), 1.4 A (230 V) peak current draw; 21 W typical (monitor only); 25 W typical (recorder on)
Physical:	
dimensions:	36-cm wide, 34-cm high, 25-cm deep, (14″ by 13.5″ by 10″)
weight:	10.8 kg (23.8 lbs) including paper roll
Environmental:	
temperature:	0°C to 45°C (operating), –40°C to 70°C (storage)
humidity:	95% non-condensing
atmospheric pressure:	700–1060 hPa (operating), 500–1060 hPa (storage)
conforms to:	CSA 22.2, No. 125

Section

2 Service

What you will need

You will need only standard electronics tools to perform board-level repairs. Test equipment must be in good condition and calibrated regularly. We recommend the following:

- ✔ digital multimeter
- ✔ leakage meter / safety analyzer
- ✔ joule meter / defibrillator energy analyzer
- ✔ anti-static workstation

Before you begin

A few words of caution are in order. Before you perform any service on the defibrillator, be aware of:

- **High voltage.** Be *very* careful when working inside the defibrillator. You will encounter dangerously high voltages at the storage capacitor and display. Also, watch out for high voltage near the fuse, power inlet, and power transformer. Always unplug the defibrillator, disconnect the battery pack, and discharge the storage capacitor before taking it apart. You can internally dump the capacitor charge at any time by rotating the energy select switch on the front panel.

- **Static electricity.** The CMOS (complimentary metal-oxide semiconductor) chips on the defibrillator's circuit boards are extremely sensitive to static electricity. Also, the printhead and display are sensitive to static. To minimize the risk of damage, use a grounding strap and work on an antistatic surface.

- **Recording paper.** Use the proper recording paper. Do not use wax-coated or blush-coated paper in the defibrillator. It will damage the printhead. Use only Burdick-approved thermal paper.

Performance checks

Performance checks help you determine whether or not the *Medic 5* is operating properly.

Testing the defibrillator

Test the performance of the defibrillator as follows:

1. Ensure a pair of adult external paddles are connected and stored securely in paddle storage area.
2. Set the energy select switch to the 100 Joules position.
3. Press 2 CHARGE (charge) on the apex paddle or 2 CHARGE (charge) on the front panel.
4. An intermittent tone sounds as the unit charges. When the tone becomes continuous, "READY" appears on the display and the defibrillator is fully charged. This should occur within 10 seconds.
5. Within 30 seconds (before the energy is automatically dumped), press 3 DISCHARGE (discharge) on both paddles simultaneously.
6. After the discharge, the display indicates the Energy Delivered to the test load.
7. The recorder strip will annotate the following: type of discharge, Joules delivered, time, and date. *If it takes more than 10 seconds to fully charge the defibrillator, or a delivered energy of less than 90 J or more than 110 J is indicated, service is required.*

Testing the battery

Burdick recommends a battery test at least once every 3 months as follows:

1. Make sure the defibrillator has been connected to a working AC outlet for 24 hours.
2. Unplug the defibrillator and turn the energy select switch to 1 ECG.
3. Measure how long it takes before the battery runs down and the monitor automatically turns off. *If it takes less than two and a half hours, replace the battery.*

Caution! If you are unable to replace the battery right away, inform potential operators that the defibrillator *will not function* unless it is properly connected to an AC power source.

4. Reconnect the defibrillator to an AC outlet and let the battery charge for at least 8 hours before using again.

Testing the display

You can test the display pixels (picture elements) as follows:

1. Rotate the energy select switch to STANDBY.
2. Carefully open the enclosure as described on page 28.
3. Locate S1, a 4-switch DIP (dual in-line package), on the CPU and R-Wave board. Set switch #3 to OFF.
4. Rotate the energy select switch to 1 ECG.
5. The display cycles through the following test patterns: full flood, checkerboard, 1-pixel vertical lines, 1-pixel horizontal lines, 2-pixel vertical lines, and 2-pixel horizontal lines. Each pattern appears for about 5 seconds. The cycle repeats continuously; and the patterns shift down and right by one pixel with each repetition.

   Note: When the display test mode is active, all other functions are disabled.

6. Observe the patterns as they cycle. Missing or incorrectly lit pixels indicate that the display needs to be replaced. (Refer to the procedure on page 29.)
7. To exit from the test mode, rotate the energy select switch to STANDBY and set S1, switch #3, back to ON.

Service menus

The *Medic 5* has several special menus for service personnel. These menus let you adjust the printhead strobe, test the printer assembly, print a service log, and select the waveform display mode.

- **To see the service menus:** Hold down the STOP key while turning the energy select switch to 1 ECG.

Adjusting the printhead strobe

Because individual printheads vary in resistance, you must adjust the printhead strobe whenever the CPU & R-Wave board or printhead is replaced.

To adjust the printhead strobe:

1. Enable the service menus by holding down (STOP) while turning the energy select switch to 1 ECG.
2. Use the [UP] and [DOWN] keys to select a printhead resistance range which corresponds to the value written on the printhead. For example, if the printhead is marked R=323, select the 320–339 range.
3. Press [ENTER].
4. Rotate the energy select switch back to STANDBY.

Testing the printer assembly

To test the printer assembly:

1. Enable the service menus by holding down (STOP) while turning the energy select switch to 1 ECG.
2. Press (NEXT).
3. Press [SPEED] to check paper speed. The *Medic 5* prints a series of parallel lines. Press [OFF] to stop printing.

   Use a metric ruler (not the paper grid) to measure the distance between the lines. All lines should be 5 mm apart, with 25 mm (±1 mm) between the longer lines. If they are not, refer to "Adjusting the paper speed" on pg. 10.
4. Press [RAMP] to check print density and continuity. The *Medic 5* prints a series of slanted lines. Press [OFF] to stop printing.

   Visually inspect the lines. Fading at the top or bottom means the printhead is misaligned. Individual dots or groups of dots which do not print indicate a problem with the printhead control circuitry or the printhead itself. Also, make sure the printhead is clean (see "Maintaining the printhead" on pg. 42).
5. Rotate the energy select switch back to STANDBY.

Printing the service log

The service log tells you how often the defibrillator was discharged, disarmed, and charged. It provides information about the battery, including the number of low and cutoff conditions. Also, the service log tells you how long the defibrillator was operated on AC power and on battery power.

To print the service log:

1. Enable the service menus by holding down (STOP) while turning the energy select switch to 1 ECG.
2. Press (NEXT) twice.
3. Press [PRINT].

   Also, you can reset the service log as follows:
   Press [clrDFB] to clear discharge, disarm, and charge cycles.
   Press [clrBAT] to clear battery low and battery cutoff counters.
   Press [clrHRS] to clear battery hours, AC hours, and total hours.
4. Rotate the energy select switch back to STANDBY.

Selecting the waveform display mode

You can select either fixed or scrolling waveforms for display on the screen. Fixed waveforms remain stationary. They are drawn from left to right, giving the appearance of motion. Scrolling waveforms move continuously across the screen. The default mode is fixed waveforms.

To change the waveform display mode:

1. Enable the service menus by holding down (STOP) while turning the energy select switch to 1 ECG.
2. Press (NEXT) three times.
3. Select [SCROLL] or [FIXED].
4. Rotate the energy select switch back to STANDBY.

Calibrations

Whenever you replace a circuit board or major assembly, you must do the appropriate calibrations. For example, if you replace the printer or Control board, you should adjust the paper speed. If you replace the CPU and R-Wave board, adjust the zero offset and gain. If you replace the Power Supply board, adjust the 24-volt supply and energy accuracy.

Adjusting the 24-volt supply

1. Connect the defibrillator to the AC power line. Make sure the front panel power indicator lights up.
2. Turn the energy select switch to 1 ECG.
3. Connect a multimeter between ground and the end of R27 closest to T1 on the Power Supply board.
4. The multimeter should read between 24.0 and 24.5 V DC. If not, adjust R28 on the Power Supply board until the reading is correct. Refer to Fig. 4, pg. 14 for the location of R28.

Adjusting the paper speed

1. Enable the service menus by holding down STOP while turning the energy select switch to 1 ECG.
2. Press NEXT.
3. Press SPEED. After the *Medic 5* prints ten parallel lines, press OFF to stop printing.
4. Use a metric ruler (not the paper grid) to measure the distance between nine lines. The distance should be 200 mm (±10 mm). If not, adjust R3 on the Control board until the measurement is correct. Refer to Fig. 2, pg. 12 for the location of R3.
5. Rotate the energy select switch back to STANDBY.

Adjusting the zero offset

1. Connect a multimeter between pin 14 of U42 and ground.
2. Short together pins 1–5 at JP1.

3. The multimeter should read between 2.46 and 2.54 V DC. If not, adjust R224 on the CPU and R-Wave board until the reading is correct. Refer to Fig. 3, pg. 13 for the location of R224.

Adjusting the gain

1. Connect the patient cable to a calibrated 1-mV source (safety analyzer or defibrillator energy analyzer).
2. Select [SENSORS]. Then, press (NEXT) to display the leads menu. Select [II].
3. Press (NEXT) twice to display the gains menu. Select [10].
4. Press (PRINT) to start a real time printout and inject a 1-mV pulse.
5. Press (STOP) to quit printing. Check the printout to see if the pulse is 10 mm (±0.5 mm). If it is not, adjust R127 on the CPU and R-Wave board until the pulse is correct. Refer to Fig. 3, pg. 13 for the location of R127.

Adjusting the energy output

1. Ensure a pair of adult external paddles are connected and properly attached to a calibrated joule meter / defibrillator energy analyzer.
2. Set the energy select switch to the 20 Joules position.
3. Press (2 CHARGE) (charge) on the apex paddle. An intermittent tone sounds as the unit charges. When the tone becomes continuous, the defibrillator is fully charged. This should occur within 10 seconds.
4. Within 30 seconds (before the energy is automatically dumped), discharge the defibrillator into the joule meter by pressing (3 DISCHARGE) (discharge) on both paddles simultaneously.
5. Ensure that the joule meter reading is 20 joules (±8%). If not, adjust R72 on the Power Supply board until the meter reading is correct. Refer to Fig. 4, pg. 14 for the location of R72.
6. Next, check the energy delivered display to make sure it reads 20 joules. If not, adjust R143 on the Power Supply board until the display reading is correct. Refer to Fig. 4, pg. 14 for the location of R143.

7. Repeat this procedure for each energy level. Verify that the joule meter readings are in the following ranges: 5-J level = 3.4–6.6 J; 10-J level = 8.4–11.6 J; 15-J level = 13.4–16.6 J, all other levels = ±8%.

Figure 2
Control board adjustments

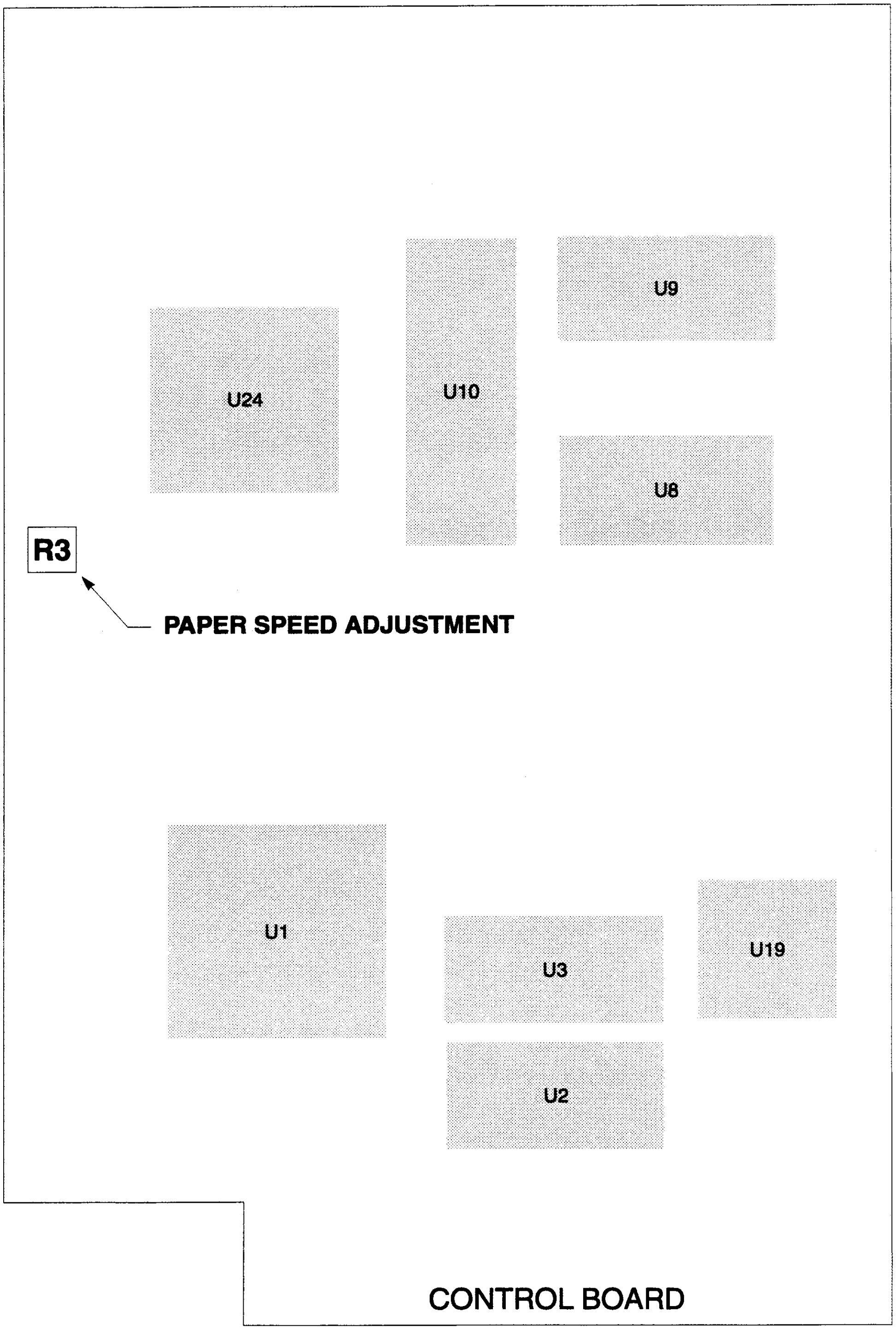


Figure 3
CPU and R-Wave board adjustments

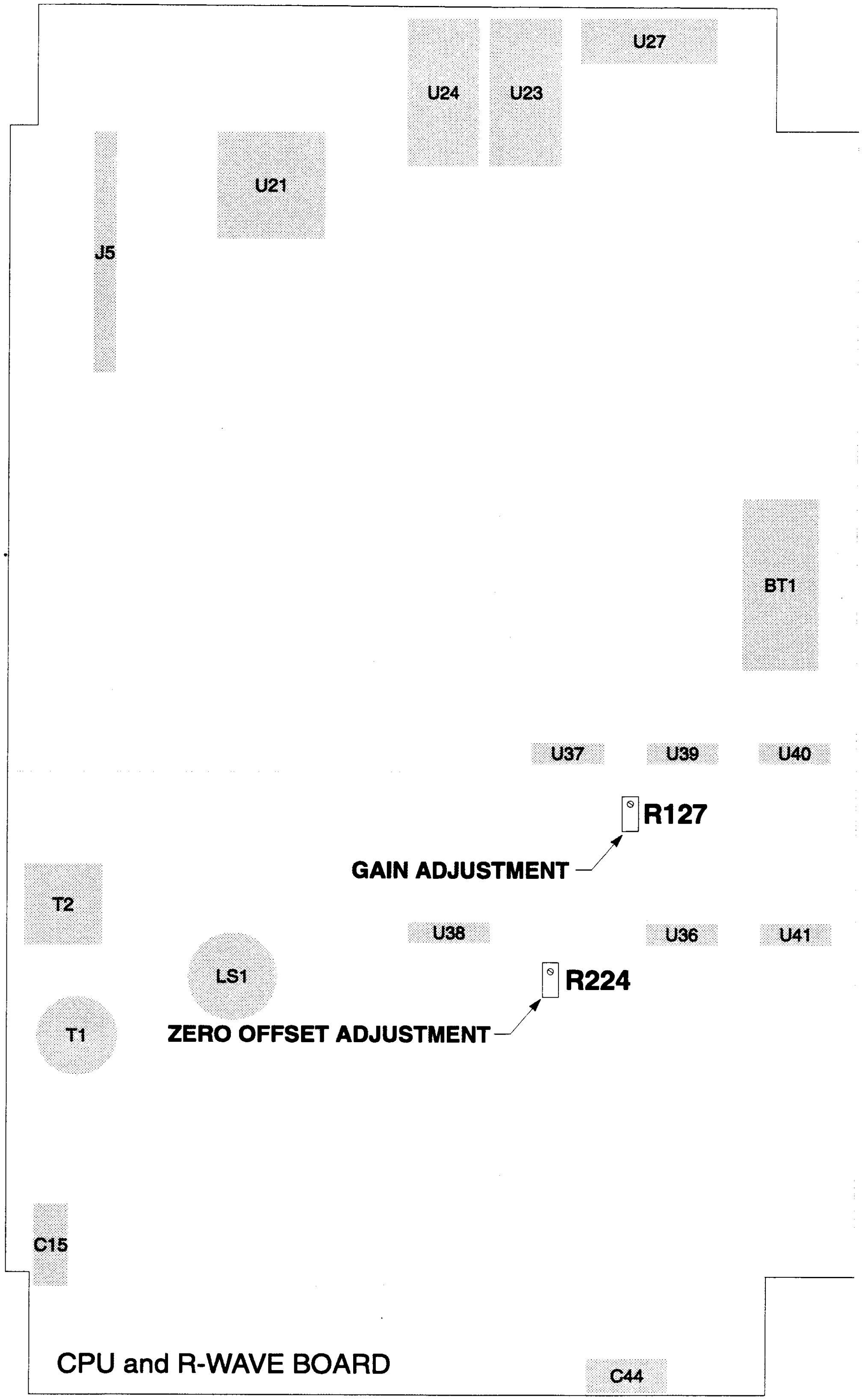
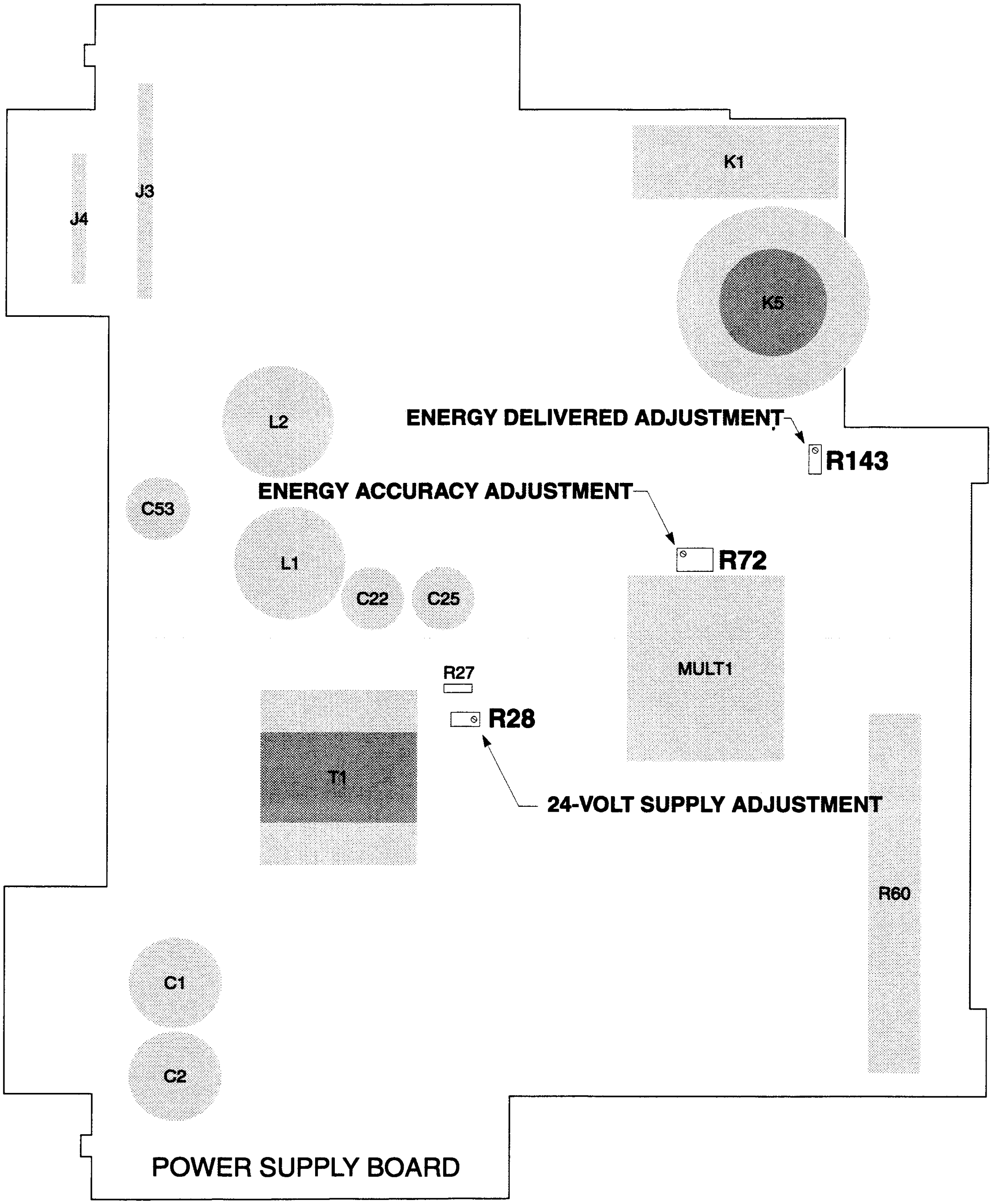


Figure 4
Power Supply board adjustments



Section

3 Problem solving

Troubleshooting

Past experience shows that many service calls are due to improper operator technique and broken cables. Before you take apart the defibrillator, make sure that these things are not causing the problem. Also, don't overlook the *Operator's Manual*. It contains useful information!

The following tables should help you trace problems to a particular assembly.

Part A

GENERAL		
Symptom:	**Possible cause:**	**Procedure:**
Medic 5 will not turn on	- battery is depleted or disconnected	- replace or connect as necessary
	- power line cord defective or disconnected	- connect, repair, or replace as necessary
	- power line fuse F1 or F2 open	- replace blown fuse on power supply board
	- power supply circuits are defective	- check for: +24 V at J4, pin 4 +12 V at J4, pin 9 +5 V at J4, pin 5 +8 V at J3, pin 18 –8 V at J3, pin 21 - replace power supply board if voltages are incorrect
	- defective energy selector switch	- check switch contacts and replace if necessary
	- defective control board	- check for power-on signal at J4, pin 1 - check Q19 - if rotary switch is OK, replace control board

GENERAL (continued)		
Symptom:	**Possible cause:**	**Procedure:**
Power supply voltages are correct, but liquid crystal display does not operate	- loose or broken cables	- secure all cables between the LCD and circuit board
	- defective CPU and R-wave board	- check U56, pin, 7 for transition from low to +5 V - replace U23 - replace board
	- faulty LCD module	- swap with known good module
	- defective control board	- replace board
Medic 5 turns on, but sounds a continuous tone	- paddle buttons stuck or defective	- replace paddles
	- defective CPU and R-wave board	- check to see if LED D80 is blinking. Refer to error code table for definition - replace board

Part B

DEFIBRILLATOR		
Symptom:	**Possible cause:**	**Procedure:**
Medic 5 does not charge	- energy select switch is in the ECG position	- rotate switch to desired energy level
	- paddles are removed or defective	- connect or replace paddles
	- fuse F3 is open	- replace
	- faulty CHARGE button on front panel or paddles	- replace membrane switch or paddles
	- faulty interconnecting cable	- replace cable between CPU and R-wave board and power supply board
	- defective CPU and R-wave board	- if CHARGE signal is present at J3, pin 4, on power supply board, replace CPU and R-wave board - if analog voltage at U28, pin 6, is correct, replace board

DEFIBRILLATOR (continued)		
Symptom:	**Possible cause:**	**Procedure:**
Medic 5 does not charge (continued)	- defective power supply board	- check overcharge circuit for approx. 24 V at U10, pin 7. Replace board if incorrect
	- dump relay K4 does not open	- check for 24 V across relay coil. If correct, replace relay.
	- storage capacitor is short-circuited	- check and replace if faulty
	- high voltage multiplier is faulty	- replace
Medic 5 does not charge to more than 50 Joules	- internal paddles are connected	- use external paddles
Medic 5 does not discharge	- *Medic 5* is still charging	- wait for READY indication
	- incorrect use of paddle DISCHARGE buttons	- both buttons must be pressed simultaneously. In SYNC mode, both must be pressed until next QRS detection
	- charge has been dumped	- re-charge (defibrillator must be fired within 30 seconds)
	- loose or broken paddle connections	- replace if voltage does not switch to +5 V at JP2, pin 2 and pin 3, when paddle buttons are pressed
	- transfer relay is defective	- check for 24 V across relay coil when DISCHARGE buttons are pressed. If correct, relay is faulty
	- fault in redundant transfer circuit	- check for SHOCK and REDSHK to power supply board. Replace CPU and R-wave board if incorrect
	- defective power supply board	- replace board if unit takes longer than 10 seconds to charge
	- gain setting is too low in SYNC mode	- select an appropriate gain to allow QRS detection

DEFIBRILLATOR (continued)		
Symptom:	**Possible cause:**	**Procedure:**
incorrect delivered energy reading on external analyzer	- *Medic 5* is incorrectly calibrated	- re-calibrate
	- discharge inductor faulty or poor connections	- replace or repair connections
	- poor connections in high voltage circuitry	- check and re-seat all internal connections

Part C

RECORDER		
Symptom:	**Possible cause:**	**Procedure:**
recorder does not operate	- faulty motor controller	- check voltage at JP4, pins 1 and 2, on Control board. Replace board if voltages are incorrect.
	- faulty interface cables	- check connections and replace if necessary
	- faulty DC motor	- check voltage at JP4, pins 1 and 2, on Control board. Replace motor if voltages are correct.
	- defective CPU and R-wave board	- replace board if voltage at JP1, pin 1, does not switch to +5 V when recorder is started
recorder speed is incorrect	- calibration is required	- adjust R3 on Control board
	- faulty motor controller	- replace control board
poor trace quality	- printhead is dirty	- clean
	- printhead resistance is incorrect	- adjust accordingly
characters are missing	- faulty printhead controller	- replace control board

Part D

MONITOR		
Symptom:	**Possible cause:**	**Procedure:**
waveform does not appear on monitor or recorder	- incorrect ECG gain setting	- select appropriate gain
	- incorrect lead group is selected	- select appropriate group
	- incorrect lead amplifier is selected	- select either sensor or paddle input source
	- patient cable is defective	- replace
	- defective CPU and R-wave board	- replace board if no ECG signal at U37, pin 7
trace is noisy	- improper patient prep	- refer to *Operator's Manual* for correct placement of sensors
	- poor sensor/paddle contacts	- refer to *Operator's Manual*
	- incorrect line filter setting	- select 50 or 60 Hz as appropriate
	- patient cable is defective	- replace
	- defective CPU and R-wave board	- check filter and gain circuits
no QRS beep	- gain is set too low	- select an appropriate gain
	- volume is set too low	- adjust accordingly
	- defective CPU and R-wave board	- check QRS detection circuits

Connector pinouts

You can use the following tables to help locate signals during trouble-shooting:

Part A

EXTERNAL	
Connector:	**Description:**
ECG OUT	analog 1-V output jack
PATIENT	ECG patient cable connector
PADDLE	paddle connector
BATTERY	internal battery connector
AC INLET	power cord connector
GROUND	ground jack

Part B

POWER SUPPLY BOARD			
Connector:	**Pin:**	**Name:**	**Description:**
J1	1–2	—	to K4, dump relay
J2	1–2	—	to transfer relay
J3 TO CPU AND R-WAVE BOARD	1	CPUSHK	microcontroller shock signal
	2	DUMP	energy dump signal
	3	HIGHCHG	overvoltage signal
	4	CHARGE	high voltage charge signal
	5	CAPVOLTS	storage capacitor voltage sense
	6	$\overline{\text{FULLCHG}}$	battery charging status signal
	7	ZEROPEAK	peak current zero signal
	8	PWRDWN	CPU power down signal
	9	PEAK	peak current signal
	10	BATTSTAT	analog battery signal
	11	$\overline{\text{ACON}}$	ac power on signal
	12–14	+5V	+5-V supply
	15–17	GND	ground
	18	+8V	+8-V supply
	19	XFEROK	transfer OK signal
	20	GND	ground
	21	–8V	–8-V supply
	22	REDSHK	redundant paddle shock signal
	23	1V OUT	analog 1-V output signal
	24	SHKDOG	redundant watchdog signal

Part C

POWER SUPPLY BOARD (continued)			
Connector:	**Pin:**	**Name:**	**Description:**
J4 TO CONTROL BOARD	1	PWR-ON	rotary switch power on
	2	PWR-OFF	rotary switch power off
	3	ACPWR	ac power present LED
	4	VS	unregulated +24 VDC
	5–6	+5V	+5-V supply
	7–8	GND	ground
	9–11	+12V	+12-V supply
	12–14	GND	ground
J5 TO BATTERY	1–4	—	to internal battery

CPU AND R-WAVE BOARD			
Connector:	**Pin:**	**Name:**	**Description:**
J1 FROM PADDLE CONNECTOR	1	—	apex ECG input
	2	—	analog ground
	3	—	sternum ECG input
JP1 FROM PATIENT INPUT	1	RA	right arm ECG input
	2	LA	left arm ECG input
	3	LL	left leg ECG input
	4	C	chest ECG input
	5	RL	right leg ECG input
	6	—	analog ground
JP2 FROM PADDLE CONNECTOR	1	CHARGE	paddle charge signal
	2	DSCHGEA	paddle discharge, apex
	3	DSCHGEB	paddle discharge, sternum
	4	+8V	+8-V supply
JP3 FROM PADDLE CONNECTOR	1	PADY	paddle type detection signal
	2	PADX	paddle type detection signal
	3	—	from +5-V supply
J3 FROM POWER SUPPLY BOARD	1	CPUSHK	microcontroller shock signal
	2	DUMP	energy dump signal
	3	HIGHCHG	overvoltage signal
	4	CHARGE	high voltage charge signal
	5	CAPVOLTS	storage capacitor voltage sense
	6	$\overline{\text{FULLCHG}}$	battery charging status signal
	7	ZEROPEAK	peak current zero signal
	8	PWRDWN	CPU power down signal
	9	PEAK	peak current signal

CPU AND R-WAVE BOARD (continued)			
Connector:	**Pin:**	**Name:**	**Description:**
J3 (continued)	10	BATTSTAT	analog battery signal
	11	$\overline{\text{ACON}}$	ac power on signal
	12–14	+5V	+5-V supply
	15–17	GND	ground
	18	+8V	+8-V supply
	19–20	XFEROK	transfer OK signal
	21	GND	ground
	22	–8V	–8-V supply
	23	REDSHK	redundant paddle shock signal
	24	1V OUT	analog 1-V output signal
J5 TO CONTROL BOARD	1	MTRENA	dc motor enable signal
	2	GND	ground
	3	N.C.	unused
	4	AS	microcontroller address strobe
	5	N.C.	unused
	6	AD0	data bus, bit 0
	7	MEM0	membrane switch, row 3
	8	AD1	data bus, bit 1
	9	MEM1	membrane switch, row 2
	10	AD2	data bus, bit 2
	11	MEM2	membrane switch, row 1
	12	AD3	data bus, bit 3
	13	MEM3	membrane switch, row 0
	14	AD4	data bus, bit 4
	15	MEM4	membrane switch, column 3
	16	AD5	data bus, bit 5
	17	MEM5	membrane switch, column 2
	18	AD6	data bus, bit 6
	19	MEM6	membrane switch, column 1
	20	AD7	data bus, bit 7
	21	MEM7	membrane switch, column 2
	22	A0	address bus, bit 0
	23	SYNC	signal for sync LED
	24	A1	address bus, bit 1
	25	E	microcontroller E clock
	26	A2	address bus, bit 2
	27	ROT4	rotary switch 4
	28	A3	address bus, bit 3
	29	ROT3	rotary switch 3
	30	A4	address bus, bit 4
	31	ROT2	rotary switch 2
	32	A5	address bus, bit 5
	33	ROT1	rotary switch 1

CPU AND R-WAVE BOARD (continued)			
Connector:	**Pin:**	**Name:**	**Description:**
J5 (continued)	34	A6	address bus, bit 6
	35	R/W	microcontroller read/write signal
	36	A7	address bus, bit 7
	37	RECIRQ	thermal recorder interrupt signal
	38	A8	address bus, bit 8
	39	RECCS	thermal recorder chip select
	40	A9	address bus, bit 9
	41	DISPIRQ	display interrupt signal
	42	A10	address bus, bit 10
	43	DISPCS	display chip select
	44	DISPRST	display reset signal

Part D

CONTROL BOARD			
Connector:	**Pin:**	**Name:**	**Description:**
JP1 TO CPU AND R-WAVE BOARD	1	MTRENA	dc motor enable signal
	2	GND	ground
	3	N.C.	unused
	4	AS	microcontroller address strobe
	5	N.C.	unused
	6	AD0	data bus, bit 0
	7	MEM0	membrane switch, row 3
	8	AD1	data bus, bit 1
	9	MEM1	membrane switch, row 2
	10	AD2	data bus, bit 2
	11	MEM2	membrane switch, row 1
	12	AD3	data bus, bit 3
	13	MEM3	membrane switch, row 0
	14	AD4	data bus, bit 4
	15	MEM4	membrane switch, column 3
	16	AD5	data bus, bit 5
	17	MEM5	membrane switch, column 2
	18	AD6	data bus, bit 6
	19	MEM6	membrane switch, column 1
	20	AD7	data bus, bit 7
	21	MEM7	membrane switch, column 2
	22	A0	address bus, bit 0
	23	SYNC	signal for sync LED
	24	A1	address bus, bit 1
	25	E	microcontroller E clock
	26	A2	address bus, bit 2
	27	ROT4	rotary switch 4

CONTROL BOARD (continued)			
Connector:	**Pin:**	**Name:**	**Description:**
JP1 (continued)	28	A3	address bus, bit 3
	29	ROT3	rotary switch 3
	30	A4	address bus, bit 4
	31	ROT2	rotary switch 2
	32	A5	address bus, bit 5
	33	ROT1	rotary switch 1
	34	A6	address bus, bit 6
	35	R/W	microcontroller read/write signal
	36	A7	address bus, bit 7
	37	RECIRQ	thermal recorder interrupt signal
	38	A8	address bus, bit 8
	39	RECCS	thermal recorder chip select
	40	A9	address bus, bit 9
	41	DISPIRQ	display interrupt signal
	42	A10	address bus, bit 10
	43	DISPCS	display chip select
	44	DISPRST	display reset signal
JP2 FROM POWER SUPPLY BOARD	1	PWR-ON	rotary switch power on
	2	PWR-OFF	rotary switch power off
	3	ACPWR	ac power present LED
	4	+5VS	VS supply
	5–6	+5V	+5-V supply
	7–8	GND	digital ground
	9	+12V	+12-V supply
	10–11	+12 VPRINT	+12-V printhead supply
	12–14	GND	+12-V return
JP3 TO MEMBRANE SWITCH	1	ACON	signal to AC on LED
	2	SYNC LED	signal to sync LED
	3–6	COL0–3	membrane switch columns 0–3
	7–10	ROW0–3	membrane switch rows 0–3
	11–12	GND	ground
JP4 TO MOTOR	1	—	from U6 to DC motor
	2	—	isolated ground to DC motor
JP5 TO PRINTHEAD	1	STROBE2	printhead strobe
	2	STROBE1	printhead strobe
	3	GND	ground
	4	CLOCK	printhead clock
	5	GND	ground
	6	LATCH	printhead latch
	7	+5V	+5-V supply
	8	DATA IN	printhead data

CONTROL BOARD (continued)			
Connector:	**Pin:**	**Name:**	**Description:**
JP5 (continued)	9	STROBE3	printhead strobe
	10–12	N.C.	unused
	13	GND	+12-V return
	14	+12 VPRINT	+12-V printhead supply
	15	GND	+12-V return
	16	+12 VPRINT	+12-V printhead supply
	17	GND	+12-V return
	18	+12 VPRINT	+12-V printhead supply
	19	GND	+12-V return
	20	+12 VPRINT	+12-V printhead supply
JP6 TO ROTARY SWITCH	1	ROT4	rotary switch, bit 4
	2	ROT1	rotary switch, bit 1
	3	ROT3	rotary switch, bit 3
	4	ROT2	rotary switch, bit 2
	5	VS	rotary switch common
JP8 TO DISPLAY	1–2	+12V	+12-V supply
	3–4	+5V	+5-V supply
	5	GND	ground
	6	GND	+12-V return
	7	GND	ground
	8	GND	+12-V return
	9	VERT	LCD vertical signal
	10	GND	+12-V return
	11	HORZ	LCD horizontal signal
	12	GND	+12-V return
	13	DOTCLK	LCD clock signal
	14	GND	+12-V return
	15	VDATA	LCD data signal
	16	GND	+12-V return

Section

4 *Removal & replacement procedures*

About this section

This section tells you how to remove and replace the defibrillator's major subassemblies. To find an assembly, refer to "Parts list & exploded views" on pg. 31.

Removal & replacement

Before you take apart the defibrillator, be aware of:

- **High voltage.** Be *very* careful when working inside the defibrillator. You will encounter dangerously high voltages at the storage capacitor and display. Also, watch out for high voltage near the fuse, power inlet, and power transformer. Always unplug the defibrillator, disconnect the battery pack, and discharge the storage capacitor before taking it apart. You can internally dump the capacitor charge at any time by rotating the energy select switch on the front panel.
- **Static electricity.** The CMOS (complimentary metal-oxide semiconductor) chips on the defibrillator's circuit boards are extremely sensitive to static electricity. Also, the printhead and display are sensitive to static. To minimize the risk of damage, use a grounding strap and work on an antistatic surface.

When you remove an assembly, pay attention to the wire and connector positions (refer to Figs. 10–11 on pgs. 39–40). This will make it easier to put back together!

Battery pack

1. Disconnect the AC power cord.
2. Loosen the screw on the back of the defibrillator which secures the battery cover. Remove battery cover.
3. Carefully unplug connector and remove old battery pack.
4. Position new battery pack in the compartment so the connector lead wires are next to the mating receptacle.

5. Plug the battery pack connector into mating receptacle. Dress the wires so they do not bind or pinch and make sure connector is securely plugged-in.

6. Replace battery compartment cover and tighten screw. Reconnect the AC power cord to a working outlet.

7. After installing the battery, turn the energy select switch to 1 ECG. Verify that the message "BATTERY CHARGING" or "BATTERY CHARGED" appears at the top of the screen. If it does not, connect the defibrillator to an AC outlet and let the battery charge for at least 8 hours before using again (see "Testing the battery" on pg. 6 and "Charging the battery" on pg. 42).

Enclosure

1. Carefully lay the defibrillator on its front panel.

2. Remove four (4) screws from back enclosure and carefully place the defibrillator on its back.

3. Gently separate and open both enclosure halves at the base.

4. Replace in reverse order.

Important! When you put the enclosure back together, make sure it does not pinch any internal wires.

Control board

1. Open enclosure as previously described.

2. Remove connectors and four (4) screws.

3. Carefully remove board.

4. Replace in reverse order.

Printer assembly

Caution! The printhead is very sensitive to static electricity. Handle with care.

1. Open enclosure as previously described.

2. Remove connectors and two (2) screws securing fiberglass bracket.

3. Remove recording paper and leave paper compartment door open.

4. Slide printer assembly out.

5. Replace in reverse order. *Readjust the printhead strobe* as described on page 8.

Display assembly

Caution! The display is fragile and very sensitive to static electricity. Handle with care.

1. Remove Control board as previously described.

2. Gently unsnap the display assembly from mounting latches.

3. Replace in reverse order.

CPU and R-Wave board

1. Open enclosure as previously described.

2. Remove connectors and two (2) screws securing the board.

3. Remove board.

4. Replace in reverse order.

Lithium battery

Important! If you remove this battery when the defibrillator is turned off, all memory is lost! To avoid this, carefully follow the procedure below.

1. Open enclosure as previously described.

2. Turn the energy select switch to **1 ECG**.

3. Locate and remove lithium battery.

   Caution! Watch out for high voltage inside the defibrillator! Also, make sure the positive and negative battery terminals are properly aligned.

4. Replace in reverse order.

Power Supply board

1. Remove the battery pack and open enclosure as previously described.
2. Note positions and remove all connectors from board. Carefully remove wires from capacitor, terminal block, and inductor.
3. Remove seven (7) screws securing the board and two (2) screws securing power inlet assembly.
4. Carefully slide board back towards the base and out of slots. Then, lift the board up and out from enclosure.
5. Replace in reverse order. *Make sure all wires are properly routed (especially the wire through current sensor HD1). See Fig. 11, pg. 40.*

Fuses

There are four (4) fuses on the Power Supply board. You must remove the CPU and R-Wave board to access them. Always use fuses of the same type and rating as the originals.

High voltage storage capacitor

1. Remove Power Supply board as previously described.
2. Remove two (2) screws from metal bracket and remove capacitor.

   Note: To prevent accidental charging or discharging during handling, install a jumper wire across the terminals of the storage capacitor. Only do this after the power is removed and the capacitor is discharged. Don't forget to remove the jumper before you reassemble the defibrillator.

3. Replace in reverse order.

Inductor assembly

1. Remove Power Supply board as previously described.
2. Remove connectors and one (1) screw at terminal block.
3. Remove inductor.
4. Replace in reverse order.

Keypad

1. Open enclosure as previously described.
2. Disconnect flat cable at JP3 on Control board and peel off old keypad.
3. Replace in reverse order.

Parts list & exploded views

To locate the major subassemblies, refer to Figs. 5–9 on pages 34–38 and this parts list:

PARTS LIST		
Item #	**Part #**	**Description**
1	890793	hinge pin receptacle
2	890794	hinge pin
3	850630	spring
4	890738	paper compartment cover
5	890787	bearing
6	862289	roller
7	890819 890815 890816 890817 890818	front enclosure (domestic) front enclosure (English) front enclosure (German) front enclosure (French) front enclosure (Spanish)
8	890768	foot
9	890811 890812 890813 890814	CPU and R-Wave board (domestic) CPU and R-Wave board (German) CPU and R-Wave board (French) CPU and R-Wave board (Spanish)
10	890798 890810	Power Supply board (domestic) Power Supply board (foreign)
11	890820 890821	rear enclosure (domestic) rear enclosure (foreign)
12	702008	screw
13	890785	paddle well outside bumper

PARTS LIST (continued)		
Item #	**Part #**	**Description**
14	890786	paddle well inside bumper
15	890700	female housing
16	890822	bullet
17	850690	compression spring
18	890699	male housing
19	702009	screw
20	700519	screw
21	890801	ribbon cable assembly (printer / Control)
22	890790	Control board
23	825181	44-pin cable assembly (CPU and R-Wave / Control)
24	825183	14-pin cable assembly (Power Supply / Control)
25	825184	16-pin cable assembly (display / Control)
26	827985	rotary switch and cable assembly
27	890803	bracket
28	890804	display assembly
29	890788	lens for display
30	890776	fiberglass bracket
31	862332	printer assembly
32	890803	patient cable connector assembly
33	845919	bushing
34	819560	50-Ω resistor
35	890775	shield
36	890770	spring
37	———	paper holder assembly
	890771	spring
	890777	plastic insert (uses 700519 screw)

PARTS LIST (continued)		
Item #	**Part #**	**Description**
38	844889	rotary switch knob
39	850662	lithium battery
40	825182	24-pin cable assembly (Power Supply / CPU and R-Wave)
41	890744	paddle connector bracket
42	890802	paddle connector cable assembly
43	811656	filter
44	890743	ac input cable assembly
45	890783	bracket
46	813444	storage capacitor (uses 890800 foam pads)
47	842920	nut
48	830073	terminal block
49	834547	inductor (uses 890800 foam pad)
50	890773	bracket
51	890769	foot
52	890767	handle (uses 702008 screws)
53	890779	battery compartment cover (uses 702007 screw)
54	850711	battery assembly
other	067006 067007 067008 067009 067112 007940 047262 007082 086194 825184 890780	external paddle set (English) external paddle set (German) external paddle set (French) external paddle set (Spanish) 5-lead ECG patient cable thermal recording paper power cord (domestic) power cord (foreign) *Medic 5* Operator's Manual cable assembly (display / CPU and R-Wave) keypad (domestic)

Figure 5
Exploded view: paper compartment and enclosures

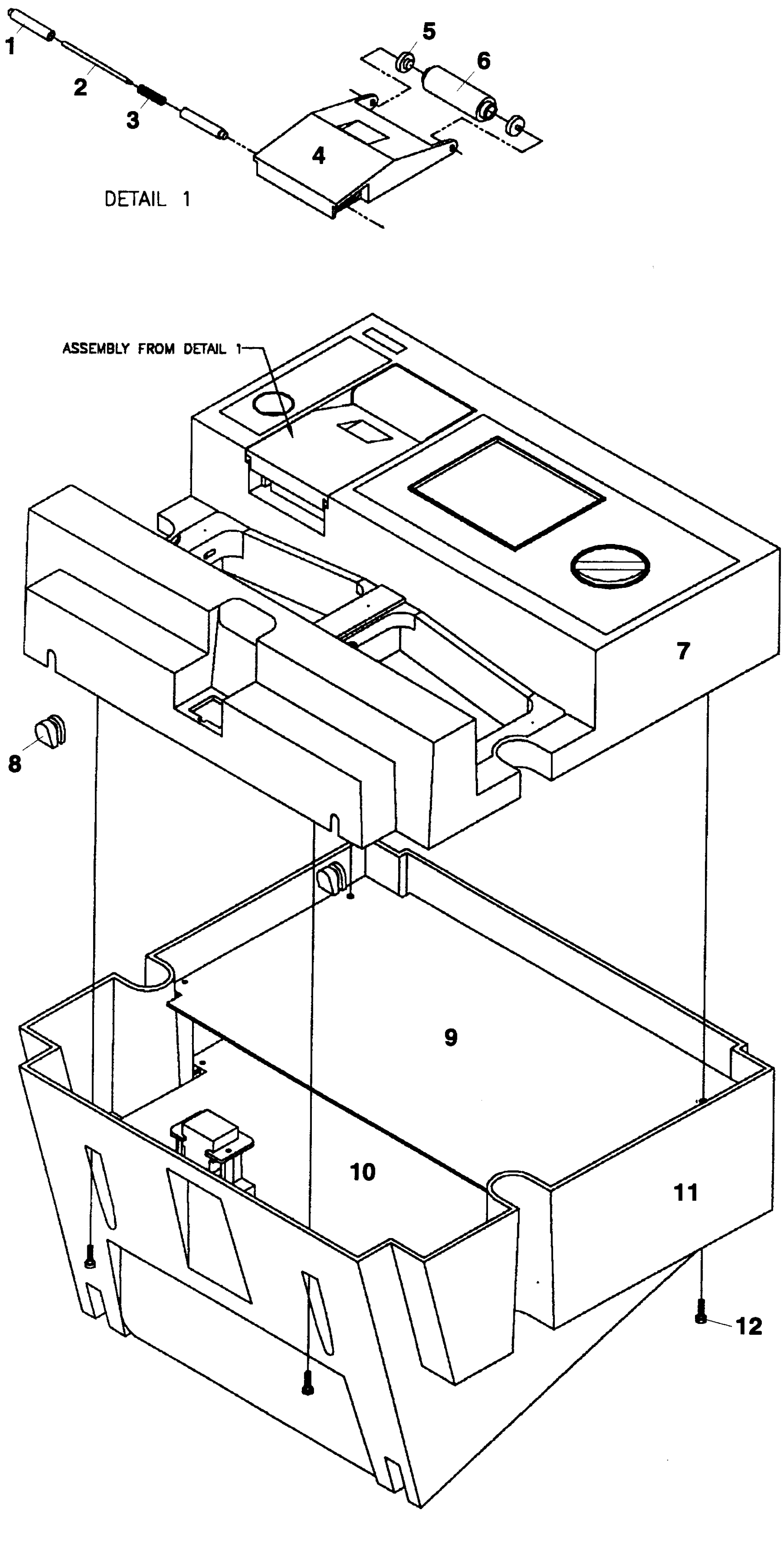


Figure 6
Exploded view:
paddle well details

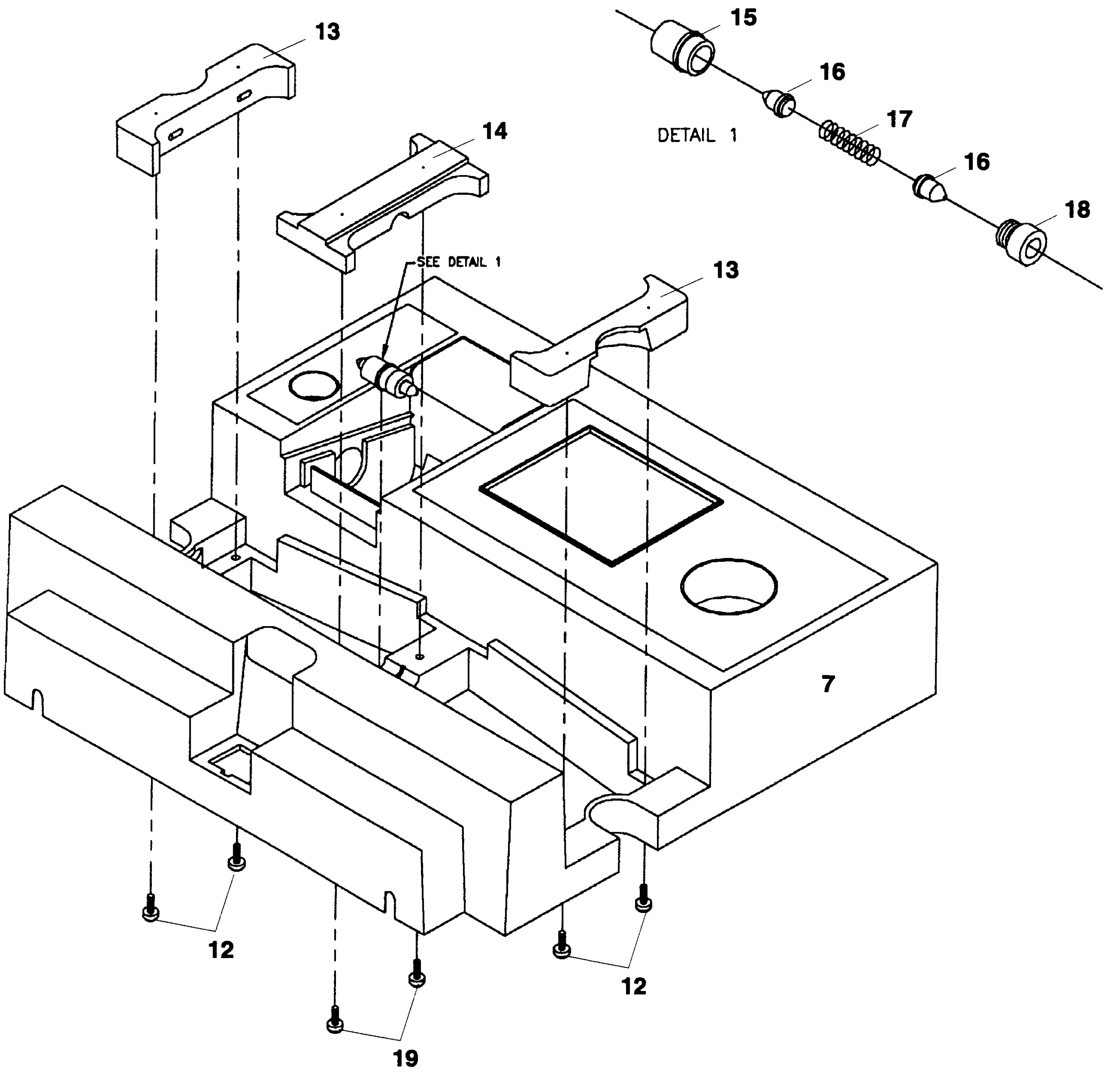


Figure 7
Exploded view: front enclosure contents

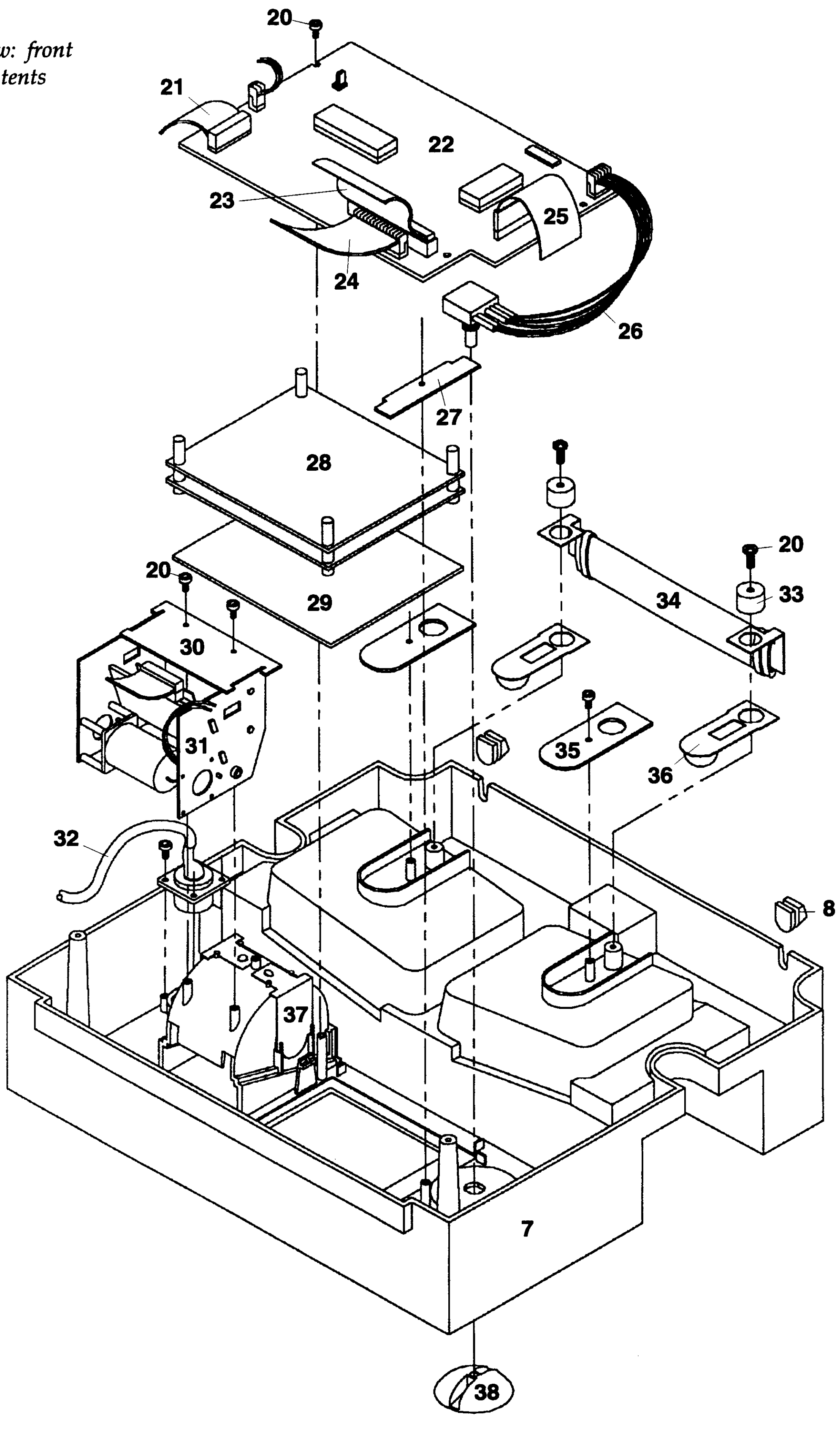


Figure 8

Exploded view: rear enclosure contents

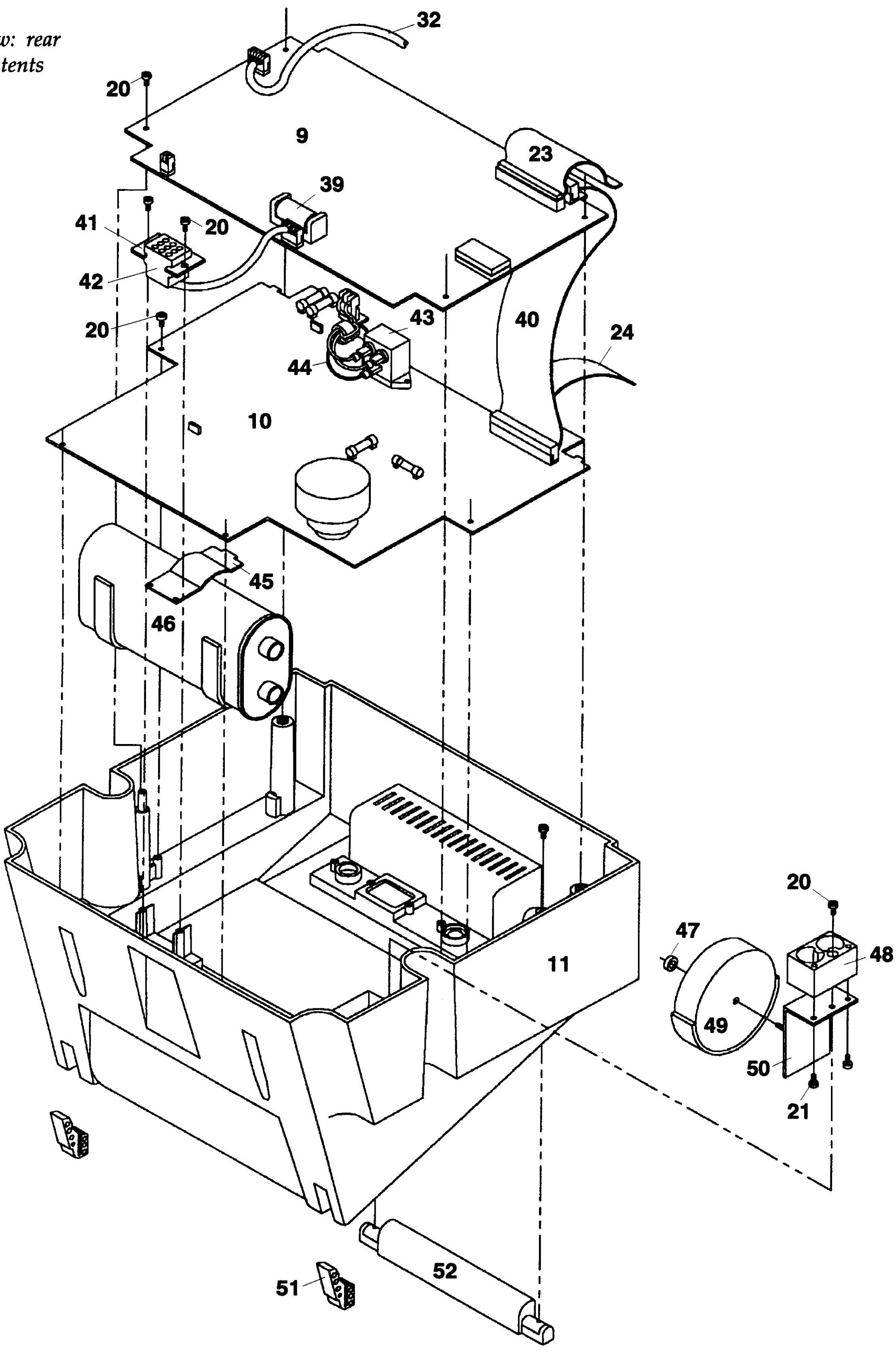


Figure 9
Exploded view: battery compartment

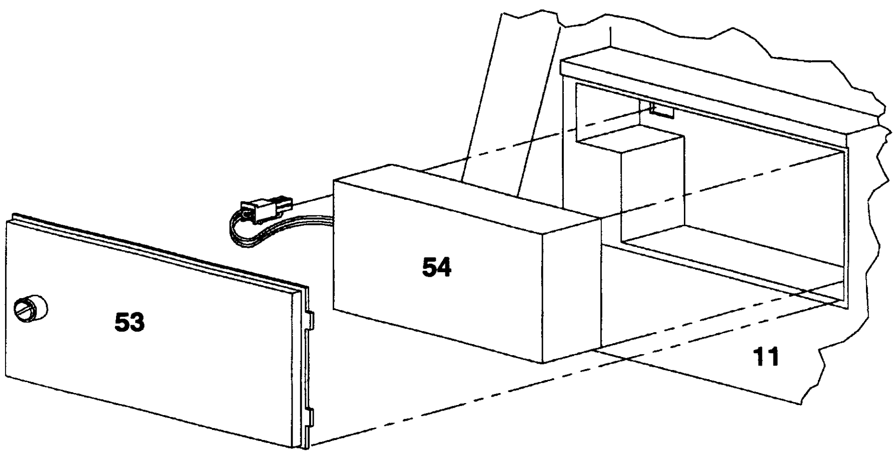


Figure 10
Front enclosure wire routings

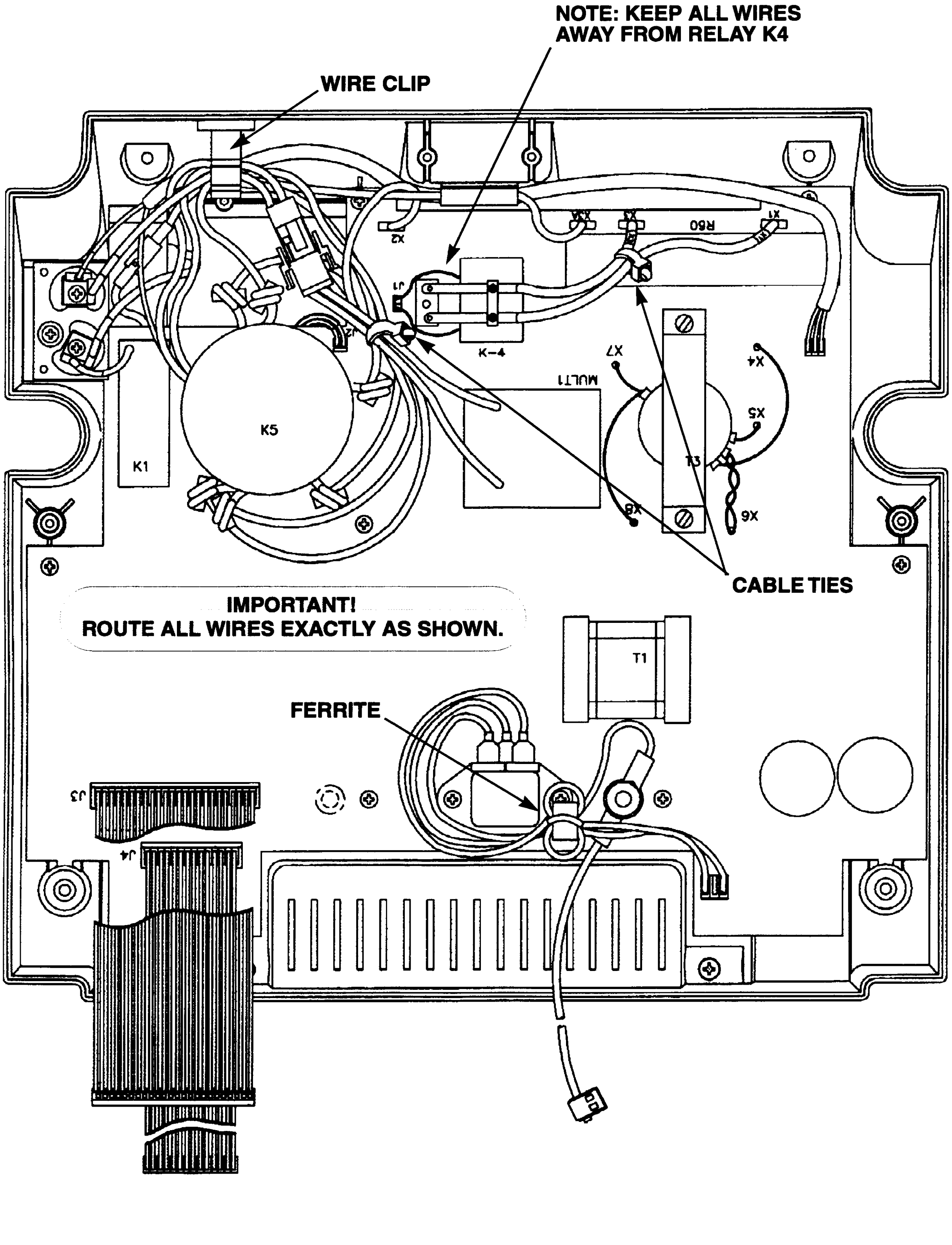
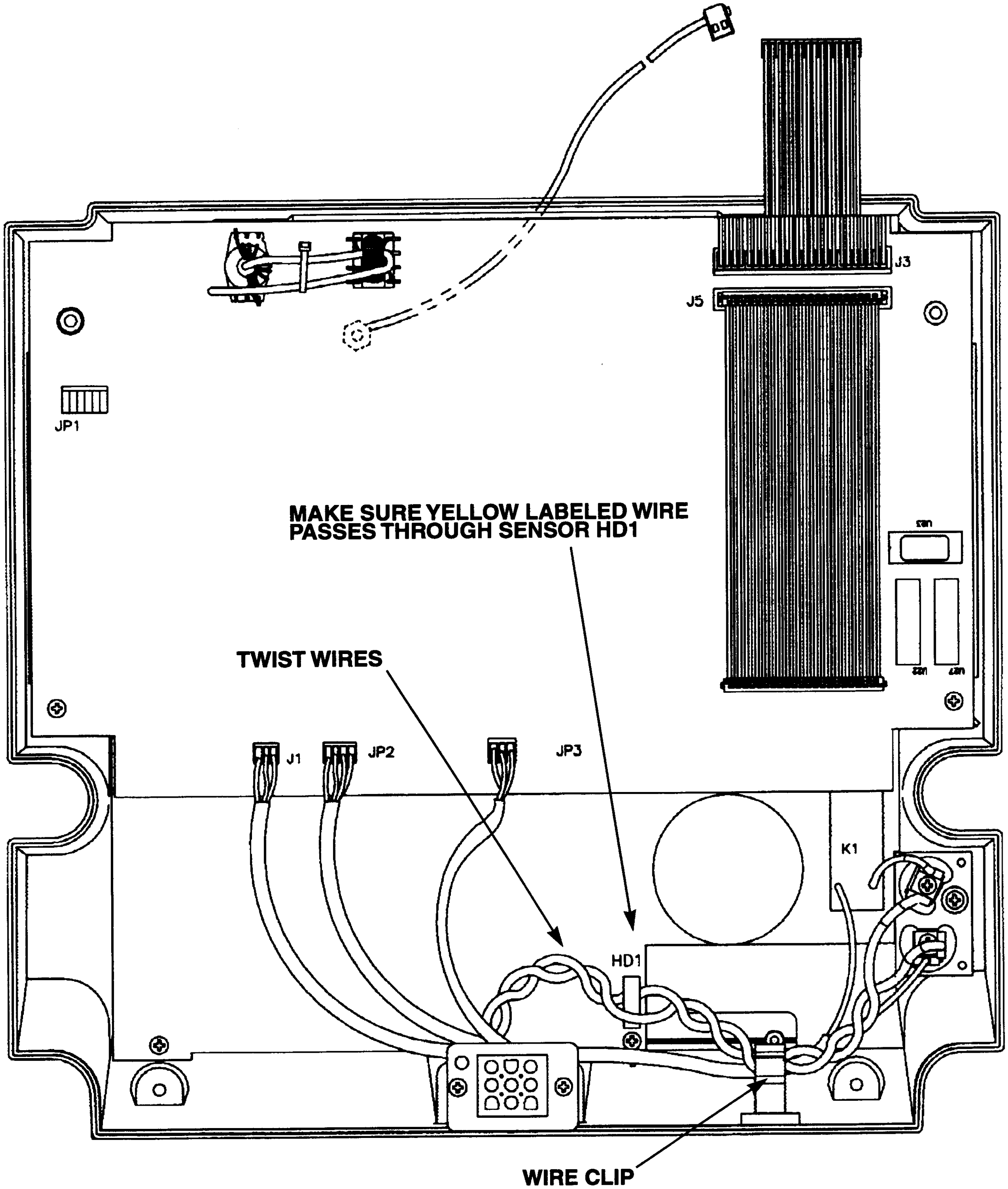


Figure 11
Rear enclosure wire routings



Section

5 Maintenance

Preventive maintenance

The purpose of preventive maintenance is to reduce or eliminate future problems as much as possible. Keeping the defibrillator in good operating condition ensures that it will perform safely and dependably.

At least once a year, you should:

- ✔ Visually inspect the defibrillator
- ✔ Clean the defibrillator
- ✔ Check the power cord
- ✔ Check the patient cable
- ✔ Inspect the printhead
- ✔ Check the internal battery
- ✔ Check the leakage currents and impedance

Additional recommendations and maintenance routines are described in your *Operator's Manual*. If a repair is required, only qualified technicians should do the work. Refer to "Service" on pg. 5.

Visual inspection

Check for anything out of the ordinary. Are there any cracks or missing parts? Are the cords and connectors damaged or weak? Does the defibrillator seem to operate properly? Is there a buildup of electrode gel on the paddles? If everything looks fine, but you still suspect a problem, check inside the defibrillator for loose connections, burn damage, or contamination from liquids.

Cleaning

The need for cleaning depends on the environment and how often the defibrillator is used. Use a damp cloth to clean the housing. Avoid abrasive cleaners or polishes. Wipe dry with a soft, clean cloth. It is especially important to clean the paddles and electrode surfaces. A buildup of gel can create a hazardous conductive pathway between the paddle electrode and the operator during defibrillation!

Caution! Always turn the defibrillator off and disconnect the power cord before cleaning. Do not pour liquids (such as alcohol or other cleaners) on the unit. This will cause severe electrical damage!

Power cord

Check the power cord and appliance inlet for any visible signs of deterioration, loose connections, or burn damage.

Patient cable

Check the patient cable and input connector for any visible signs of damage or loose connections. Disconnect the patient cable from the unit and inspect it for short circuits, broken wires, or poor contacts by measuring the resistance for individual electrode leads.

Maintaining the printhead

Keep the thermal array printhead free of dirt and other foreign materials.

Warning! The printhead is very sensitive to static electricity. Use an anti-static work surface.

Individual dots or groups of dots which do not print (particularly at the baseline) are an indication that the printhead is dirty. Use a small amount of rubbing alcohol and a lint-free swab to remove residue. Avoid abrasives or cleaners which may damage the printhead.

Charging the battery

The *Medic 5* has a rechargeable, internal battery. This battery is automatically recharged whenever the defibrillator is plugged into an AC source. Normally, the battery provides enough power for at least 50 consecutive 360-J discharges or about 2.5 hours of continuous monitoring. At least once every 3 months, check the battery performance as outlined in "Testing the battery" on pg. 6.

Note: The operating times are approximate. Actual time varies depending upon how much printing is done on battery power. If the defibrillator is stored for a long period of time, it should be recharged once every 6 months to prevent a reduction in the battery's life. Under normal circumstances, the battery's life expectancy is approximately 2 years.

Measuring chassis leakage current

Use a high quality meter or safety analyzer capable of testing to AAMI specifications. An inappropriate meter can produce erroneous leakage readings. Do the leakage tests at a nonconductive work station.

Be careful! The meter must be suitably insulated and capable of withstanding the power line voltage.

To check the chassis leakage current:

1. Turn the *Medic 5 Defibrillator* energy select switch to 1 ECG.
2. Connect a leakage meter between the rear panel chassis ground jack and power line ground. Ensure that leakage current is less than 100 μA.
3. Open ground line and ensure leakage current is less than 100 μA.
4. Reverse line polarity and ensure that leakage current is less than 100 μA with ground closed.
5. With reversed polarity, open ground line and ensure leakage is less than 100 μA.

Measuring paddle leakage current

Use a high quality meter or safety analyzer capable of testing to AAMI specifications. An inappropriate meter can produce erroneous leakage readings. Do the leakage tests at a nonconductive work station.

Be careful! The meter must be suitably insulated and capable of withstanding the power line voltage.

1. Connect a leakage meter between the paddle electrodes and measure current.
2. Make sure that there is less than1 μA leakage.

Checking the ground impedance

To check the ground impedance:

1. Disconnect the power cord from wall receptacle.
2. Connect an ohmmeter (capable of measuring milli-ohms) between chassis ground on the *Medic 5 Defibrillator* rear panel and power cord ground terminal.
3. Ensure that the ground impedance is less than 0.1 Ω.

Section

6 Theory of operation

Introduction

The *Medic 5* integrates a defibrillator, monitor, and recorder into a single, portable system controlled by three main circuit boards: the Power Supply board, the CPU and R-Wave board, and the Control board. This section describes each of the boards. See Fig. 12 on page 46 for an overview of the system.

Power Supply board

The Power Supply board circuitry generates all of the system power supplies and controls battery charging. It also generates and controls the high voltages required for defibrillation.

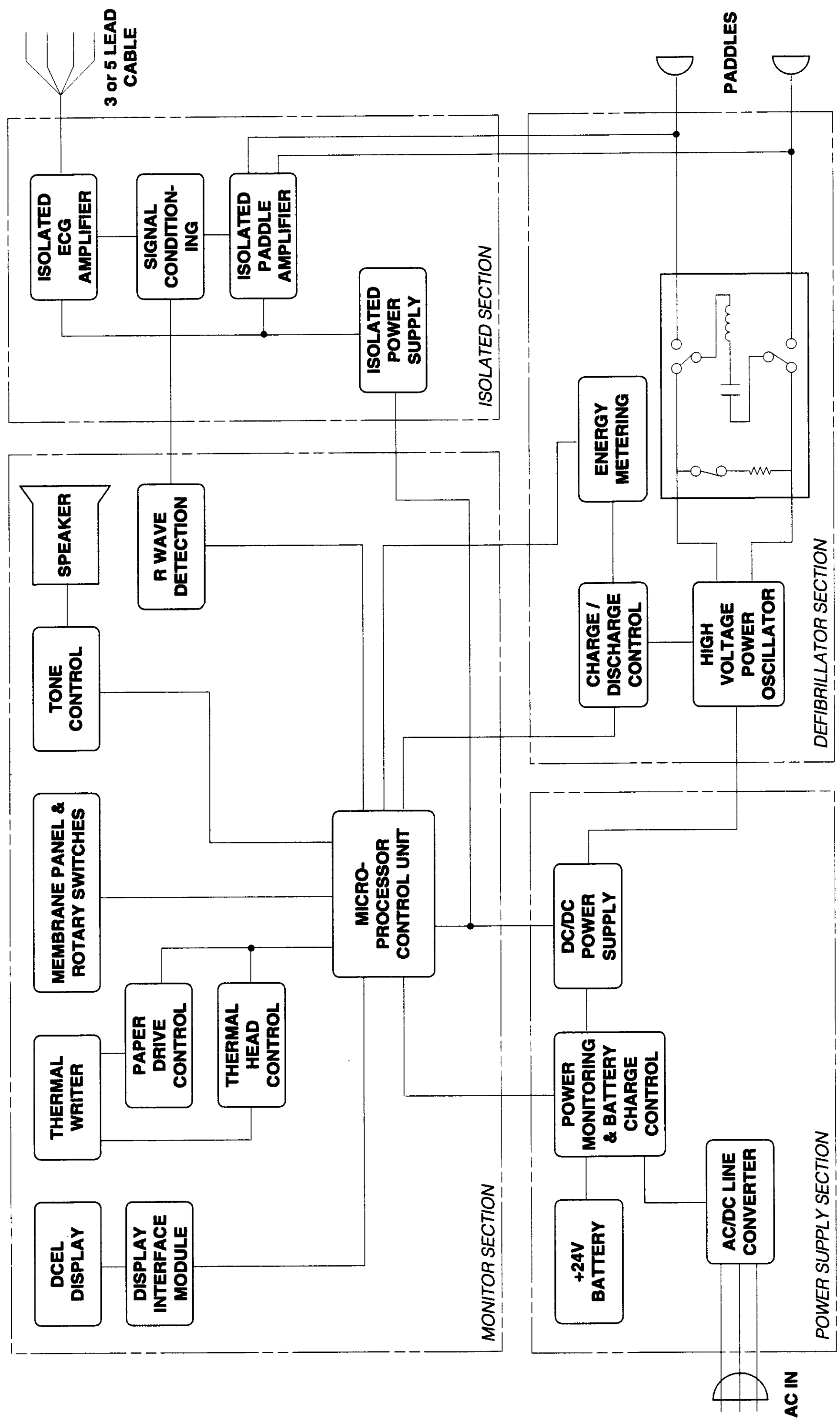
Line converter

The power line supply is connected via two board-mounted fuses, F1 and F2. For 220-VAC operation, BR1 provides full-wave rectification. It charges input filter capacitors C1 and C2 to a nominal 320 VDC. The 110-VAC input is accommodated by linking the neutral conductor to the midpoint of C1 and C2. In this case, BR1 acts as two half-wave rectifiers, charging C1 on positive half-cycles and C2 on negative half-cycles. The result is a total of 320 V DC across C1 and C2, as before. RV1 and RV2 are thermistors which limit inrush current to C1 and C2 when the power is switched on.

At power-on, Q1 turns on via R3 and C3. D1 clamps the base of Q1 at 11 V. The cathode of D2 is at approximately 10 V, providing a temporary supply for IC1. After about 200 ms, C3 charges enough to turn off Q1.

IC1 controls the switching of power MOSFETs Q4 and Q5, which drive the primary winding of T1, an isolating transformer. The feedback winding at T1, pins 3 and 5, provides a continuous supply for IC1. Its output is rectified by D9–D12 and smoothed by L8 and C21, providing an approximate 20-VDC input to IC3, a voltage regulator. D2 becomes reverse-biased by the regulated 13-V output from IC3, which takes over the supply from Q1. D3 protects IC1 if a fault occurs in IC3. If the 13-V supply is not established before Q1 turns off, the system will not start.

Figure 12
Detailed system block diagram



T2 and C15 drive the gates of Q4 and Q5 in opposite phase from IC1, pins 11 and 14. The isolated drive from T2 prevents excessive heat buildup by ensuring that Q4 is completely off when Q5 is on and vice versa. The switching frequency is set at 35 kHz by R15, C13. R16 keeps Q4 and Q5 off for approximately 2 µs to prevent any possibility of shorting the 320-V line to circuit ground. C12 performs a soft-start delay of about 300 ms to gradually establish the normal duty cycle of Q4 and Q5. C20 and R68 form a snubber circuit to reduce transients.

The main secondary winding at T1, pins 13, 15, and 16, is full-wave rectified by D6. L1, C22, and C23 filter the secondary to produce a smoothed 24 VDC. IC4 senses a fraction of this voltage via R27–29 and compares it with a 12-V reference generated by D8 and R30. Output from IC4 drives opto-isolator OP1 via R34. If the external load causes the 24-V output to vary, the light emitted from the photodiode of OP1 fluctuates, causing a corresponding change in the voltage developed across R6. IC1 monitors this voltage at pin 1. The voltage at IC1, pin 2, is held at a constant 2.5 V. Feedback at pin 9 sets the DC gain at unity. Thus, IC1 compensates for any change by controlling the length of time the switching transistors are turned on. In this manner, the output voltage is regulated via an optical link.

The center-tapped secondary winding at T1, pins 9, 10, and 12, is rectified by D13 and filtered by L7 and C25. The resulting 11-VDC output is added to the regulated 24-V supply to provide a nominal 33 V, which charges the defibrillator's internal lead-acid battery.

A current limiting circuit shuts down the drive signals to Q4 and Q5 in the event of a short or current overload. The peak voltage across R22 is applied to the inverting input of a comparator, U2, at pin 3. D5 and C17 rectify and smooth this voltage. The non-inverting input at U2, pin 2, is a constant 13-V reference derived from IC3 via R18–19. The output from IC2, pin 7, is normally high, keeping Q2 turned on via R13. If an overload occurs, the comparator switches low and turns off Q2. This causes IC1 to shut down and temporarily remove the drive to Q4 and Q5.

Secondary regulators

The 12-V regulator is based around IC14. It operates as a buck regulator, switching at 100 kHz. R80 and C52 provide frequency compensation. A fraction of the output voltage, set by R82–83, is fed back to pin 1. An internal error amplifier compares this voltage with a stable reference. If the output voltage is low, the internal switch is turned ON, and current flows through the inductor and into the output capacitor. When the output voltage exceeds the nominal value, the switch is turned off. The stored energy in the inductor reverses its polarity, takes the path through the diode, and sends current into the load while the voltage is maintained by the capacitor. C66 reduces output spikes by slowing down D30.

The 5-V regulator is based around IC15. It operates as a buck regulator, switching at 50 kHz. The output voltage is fed back to pin 4. The internal operation is the same as described previously for the 12-V regulator. L4 and C56 serve to further reduce output ripple.

The +8-V supply is a buck regulator using IC12. Switching frequency is set by C58 at 30 kHz. R86 and R88 provide feedback to the error amplifier. R87 sets the output current limit at 500 mA.

The –8-V supply uses IC13. Q18 allows it to operate in the buck inverting mode. R89 and R94 configure the error amplifier in the opposite polarity from the +8-V supply. C63 sets the operating frequency at 70 kHz. C61 and R90 provide frequency compensation for the error amplifier. R91 sets the output current limit at 500 mA. R92–93 provide the base drive for Q18.

Power selection

Relay K2 selects battery power or rectified ac. When AC is applied to the relay, its coil is energized through R118 and D19. If the AC supply falls below 18 V, the relay coil is de-energized and battery power is selected.

On/Standby selection

Q19 performs the on / standby selection. When standby is selected, the rotary switch holds the reset on flip-flop IC5-A high at pin 4. If the switch is moved to any other position, pin 4 goes low. This momentarily sets pin 6 high and forces pin 1 high, driving Q16 to turn on Q19. When the switch is moved back to standby, IC5-A goes high at pin 4 and forces pin 1 low, turning off Q16 and Q19. If the software detects a low battery condition, it lowers the input to Q7. This clocks IC5-A at pin 3 and forces pin 1 low to shut off the power.

Battery charger

The battery charging circuit is based around IC7, which operates in a dual-float mode and regulates the charging current to the battery by controlling Q22. R107 limits the charging current to 500 mA during bulk charging. R100 limits the initial charging current to prevent high current charging if a battery cell is shorted. When the battery voltage reaches 28.3 V, a threshold set by R101–103, the charger goes to overcharge mode until it reaches 29.9 V. At this point, the battery is completely charged and IC7 reverts to the float-charge mode, maintaining the battery at a constant 27.6 V.

High voltage converter & discharge control

The heart of the power oscillator circuit is T3, a high voltage step-up transformer. Transistors Q10–Q11 drive the center-tapped primary of T3 in push-pull mode under the control of IC9, a dual-output pulse-width regulator. R51–52, D21, and D22 protect the gates of Q10 and Q11 from spurious oscillations and switching spikes. D24 and D25 protect each transistor from high voltage spikes caused by leakage inductance from the primary winding. C40 and R54 form a snubber circuit to further reduce switching transients.

Power for IC9 is derived from the main 24-V line by means of a simple 15-V linear regulator, IC8. The switching frequency is set at approximately 35 kHz by R49 and C37. R50 provides about a 2-µs dead time during which Q10 and Q11 are turned off. C36 implements a soft-start function to gradually increase the oscillator duty cycle and limit the initial primary current in-rush after charging begins. Charging current to the energy storage capacitor is monitored through a 150-Ω resistor and the internal error amplifier of IC9. R47, C32, and R45 configure the amplifier as an integrator with the non-inverting terminal held at 5 V via R48. The amplifier output controls the duty cycle of the driver waveforms to the gates of Q10–Q11 and maintains a constant voltage across the 150-Ω resistor. Therefore, the storage capacitor is charged with a constant current of approximately 33 mA.

A charge is initiated when the microcontroller sets the CHARGE line high, turning on Q8 and bringing the shutdown pin on IC9 low via R42 (assuming Q9 is off, see later discussion). A low on the shutdown pin enables the drive to the switching transistors and the capacitor begins to charge. The voltage on the storage capacitor is continuously monitored by the microcontroller via the CAPVOLTS line, which senses a fraction of the actual voltage through R72–73 and a 40-MΩ tap resistor within the multiplier. When the value corresponding to the energy selection is reached, the microcontroller sets the CHARGE line low again, and the oscillator is disabled. The multiplier doubles the peak-to-peak voltage on the output of T3. In addition to the 150-Ω current-sense resistor and 40-MΩ tap resistor, another 40-MΩ tap resistor allows for independent monitoring of the charging voltage in the event of a failure in the microcontroller's A/D circuitry.

The dump relay, K4, internally disarms the energy storage capacitor when necessary. Under normal circumstances, the relay is held closed to connect the 3.9-kΩ, 50-W power resistor, R60, across the terminals of the storage capacitor. Whenever a charge is requested, the microcontroller first sets the DUMP signal high, then the CHARGE signal high. Q12 turns on via R61 and energizes the dump relay coil, disconnecting R60 from the storage capacitor terminals. (Note that Q13 normally is held on by the overcharge comparator, IC10.) If a software or other fault associated with the DUMP or CHARGE signals causes IC9 to charge when the dump relay is closed, a hardware interlock between Q12 and the shutdown pin of IC9 is activated. Normally, Q9 is held on, keeping the shutdown high via D20 and R44. This additional drive from Q9 is sufficient to override an incorrect CHARGE signal which attempts to pull shutdown low via Q8. When the relay energizes normally, Q9 is turned off and the shutdown operates properly.

The same hardware interlock can be used by the overcharge comparator, IC10. A fraction of the storage capacitor charging voltage as determined by R66 and R67 is compared with a fixed 5-V reference derived from IC9. The output of the comparator is normally high, keeping T13 turned on via R62. If the storage capacitor continues to charge beyond the voltage corresponding to the 360-J selection, the output of IC10 switches to 0 V. Q13 switches off, de-energizing the dump relay and disarming the storage capacitor. In addition, shutdown is forced high via Q9 and charging is disabled. D26 becomes forward biased and reduces the reference level on pin 2 of the comparator. This hysteresis action ensures that IC10 does not switch back as the capacitor voltage decays. The overcharge condition is signalled to the microcontroller via R58 and R59 on the OVERCHGE line. A level change on OVERCHGE causes the microcontroller to set the DUMP signal low, which ensures that K4 stays closed after IC10 reverts to its normally high state.

Simultaneously pressing the APEX and STERNUM paddle DISCHARGE buttons causes the microcontroller to set the SHOCK line high. SHOCK switches on Q14 via C41, R70, and R71 for about 90 ms. The SHOCK line is gated with a signal from IC11, which performs a watchdog function. If IC11 is not tickled every 300 ms, the energy transfer is disabled. If IC11 is functioning, Q25 is energized as a redundant drive transistor for the transfer relay, RL2. Q24 and associated components provide fault detection for Q14 and Q25. When Q14 and Q25 are on, RL2 is energized and the stored capacitor energy is transferred to the patient via the paddle electrodes.

Current sensor HD1 produces a voltage proportional to the discharge current at IC21-D, pin 12. The signal is amplified, filtered, and presented at IC21-C, pin 10. A timing circuit, comprised of IC11-A, Q23, and C77, allows the microcontroller to read and process the signal at IC21-A, pin 1. Any offset due to variations in the current sensor is subtracted from the final result by reading IC21-C, pin 8, prior to the discharge.

CPU and R-Wave board

The CPU and R-Wave board contains the main logic for the system. It acquires and amplifies the ECG signal, detects R-waves, and communicates with the peripheral components to operate the defibrillator.

Isolated power supply

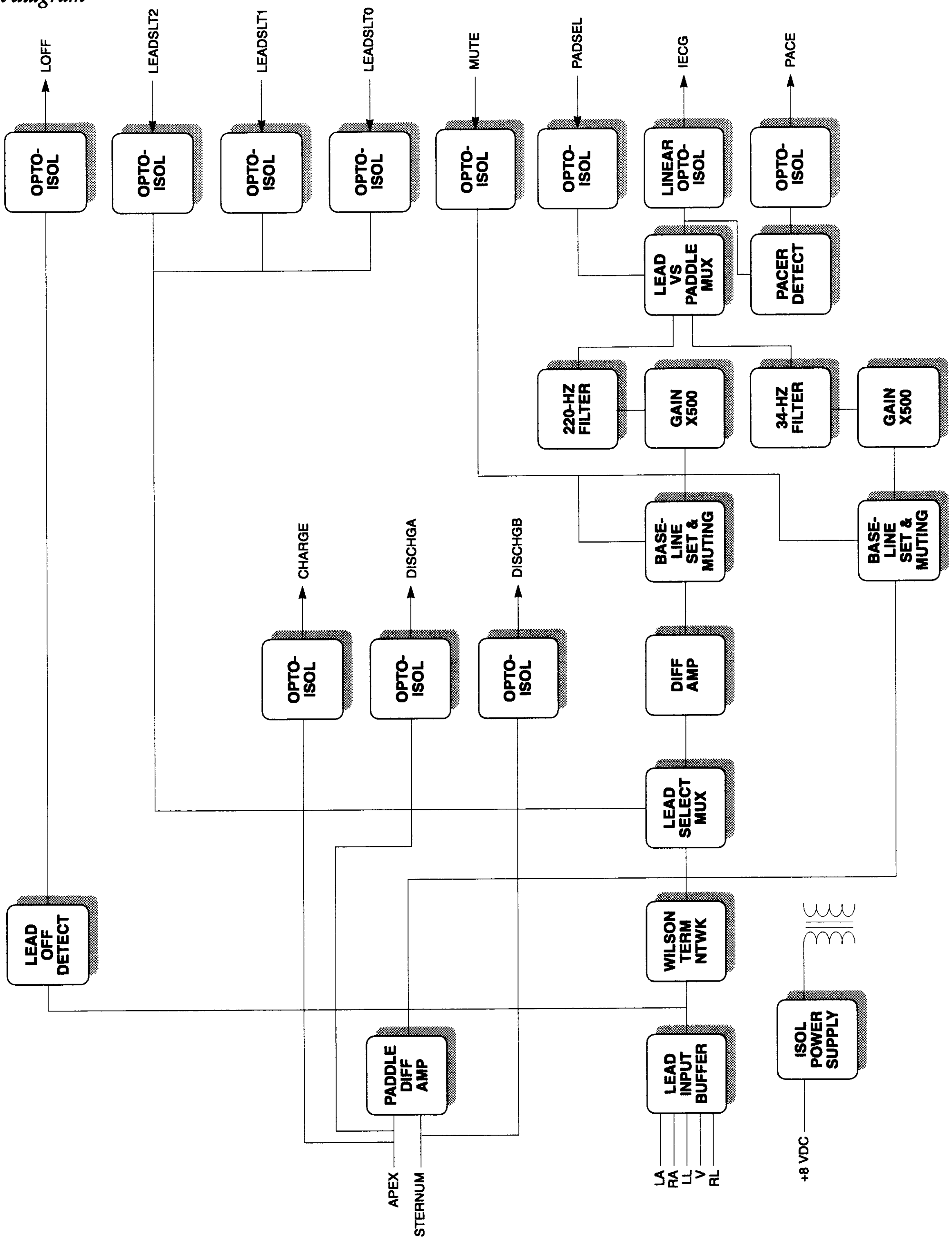
Power for the isolated leads amplifier is derived from the +8-VDC power supply via a double-toroid assembly linked across the isolation gap by a single turn of high voltage cable. At power-up, Q3 turns on via R213 and the 8-V supply appears across the bottom winding. The current rises linearly in Q3, inducing a constant voltage in both the middle and top windings and causing the collector of Q4 to rise to 16 V. Also, 8 V is induced in the bottom winding. This keeps Q3 switched on. As the ferrite core begins to saturate, the induced voltage decreases to reduce the base drive to Q3. Also, collector current in Q3 decreases; and the polarity of the induced voltages is reversed. This switches Q3 off and Q4 on. In this way, the circuit oscillates at a frequency determined by the saturation flux of the ferrite core.

The switching waveform also is induced in the secondary core. It is rectified and smoothed by D23, D24, C6 and C12 to provide the ±8-V isolated supplies for the amplifier.

Isolated lead amplifier

A block diagram for the isolated front end is shown is Fig. 12, pg. 46. Current limiting resistors R4 and R66–69 protect the RA, LA, LL, RL, and C electrode inputs against defibrillator voltages. Diodes D1–8 and D91–92

Figure 13
Isolated front end block diagram



further reduce the breakdown voltage and limit the maximum input voltage. Buffer amplifiers U1 provide a high input impedance for the electrode connections and help reduce the effect of high electrode contact impedance on the amplifier.

U19-A sums, amplifies, and inverts the outputs from the RA, LA, and LL amplifiers. The combined output from U19-A drives the RL patient connection. R51 limits the direct current which can flow to the patient under fault conditions to approximately ±1 μA.

R1–3 provide small negative bias currents to the inputs of the RA, LA, and LL buffer amplifiers. If any of the patient electrodes become detached, U19-B signals the lead off condition to the microcontroller via opto-isolator U5. C11 filters noise to prevent false triggering of the lead off signal. The chest electrode (C) is not included in the lead off detection circuit.

The outputs of the RA, LA, and LL amplifiers are connected to a standard Wilson network consisting of 10-kΩ resistors. This network derives the average of each electrode signal pair, together with the average of all three signals. These four new signal combinations, plus the original three, are applied to the inputs of two analog multiplexers, U3 and U4. The multiplexers select which patient signals are presented to the inputs of the differential amplifier system, under control of the three lead select signals at the outputs of U6–8.

LEAD SELECT CODE			LEAD	AMPLIFIER INPUTS	
C	B	A		+U9-B, pin 5	–U9-C, pin 10
0	0	0	TEST	GND	GND
0	0	1	I	RA	LA
0	1	0	II	RA	LL
0	1	1	III	LA	LL
1	0	0	AVR	(LA+LL)/2	RA
1	0	1	AVL	(RA+LL)/2	LA
1	1	0	AVF	(RA+LA)/2	LL
1	1	1	V	(RA+LA+LL)/3	C

U9-B, U9-C, and U9-D form a differential amplifier with a total gain of 573. The output at U9-D, pin 14, is integrated by U9-A, R11, and C15. Any DC offset voltage at U9-D, pin 14, causes the integrator output to increase in the opposite polarity. The integrator output feeds back via R83 and causes the DC offset to decay to zero. The feedback action is equivalent to a high pass filter with a break frequency of approximately 0.05 Hz.

A fast recovery system, consisting of R13–14, D16–17, R44, and C16, ensures rapid ECG signal recovery after defibrillator transients. The dynamic range of the amplifier system is ±5 mV. 5-mV input signals appear at U9-D, pin 14, with an amplitude of 2.86 V. R14 and R44 reduce the amplitude to 694 mV, which forward biases either D16 or D17, depending on signal polarity. R11 is shunted by R13–14 with a much lower resistance (approx. 85 kΩ). This allows a proportionately faster recovery of the signal back towards the display baseline. The low frequency breakpoint reverts to 0.05 Hz when the input signal is reduced to the normal operating range. C16 ensures that the fast recovery system is not triggered by pacemaker pulses.

In addition to the fast recovery system, U18, U57-A, and Q1 provide faster baseline stabilization during lead switching and cal pulse generation. The output of U18 is a positive pulse which causes U57-A, pin 1, to swing positive and turn on Q1. This shunts R11 with the a much lower value (R12). The integrator time constant is decreased and any DC offset is quickly nulled.

The signal at U9-D, pin 14, is low-pass filtered by U57-B with a 3-dB frequency of 224 Hz. D28 and D30 limit the signal to ±4 V. Then, it is multiplexed by U11 to U15, which drives opto-coupler U14. The output from U14 is amplified by U54-B and associated components. Potentiometer R224 is adjusted to eliminate any offset due to variations in the gain of U14.

The ECG signal is multiplexed to the pace-pulse detector circuitry starting with U16-A, a bandpass filter. The upper and lower 3-dB break frequencies are 4.8 kHz and 1.6 kHz, respectively. This attenuates the ECG signal, while enhancing any incoming pace-pulse spikes. U16-D provides further enhancement by amplifying the input signals according to their rise times. R47 minimizes ringing. U16-C, D19, D22, and R23–25 produce a positive pulse output, regardless of the output from U16-D. Comparator U16-B switches when the voltage at pin 5 exceeds the reference set by R26 and R49. U12 transmits the level change with each pace-pulse detection.

Isolated paddle amplifier

A block diagram for the isolated front end is shown is Fig. 12, pg. 46. Operation of the paddle amplifier is similar to the lead amplifier, except for lead selection and muting. Other differences include: 0.5-Hz integrator frequency response, 34-Hz low-pass filter.

Gain & filter selection

A block diagram is shown in Fig. 12, pg. 46. U38, an analog multiplexer, selects bandwidth filtering and 50-Hz or 60-Hz notch filtering. The output from U38, pin 15, also is passed to the gain select circuitry, comprised of U43, U37-B, and associated components. Four gains are available at the output of U37-B, depending on the status of gain select lines GS0 and GS1:

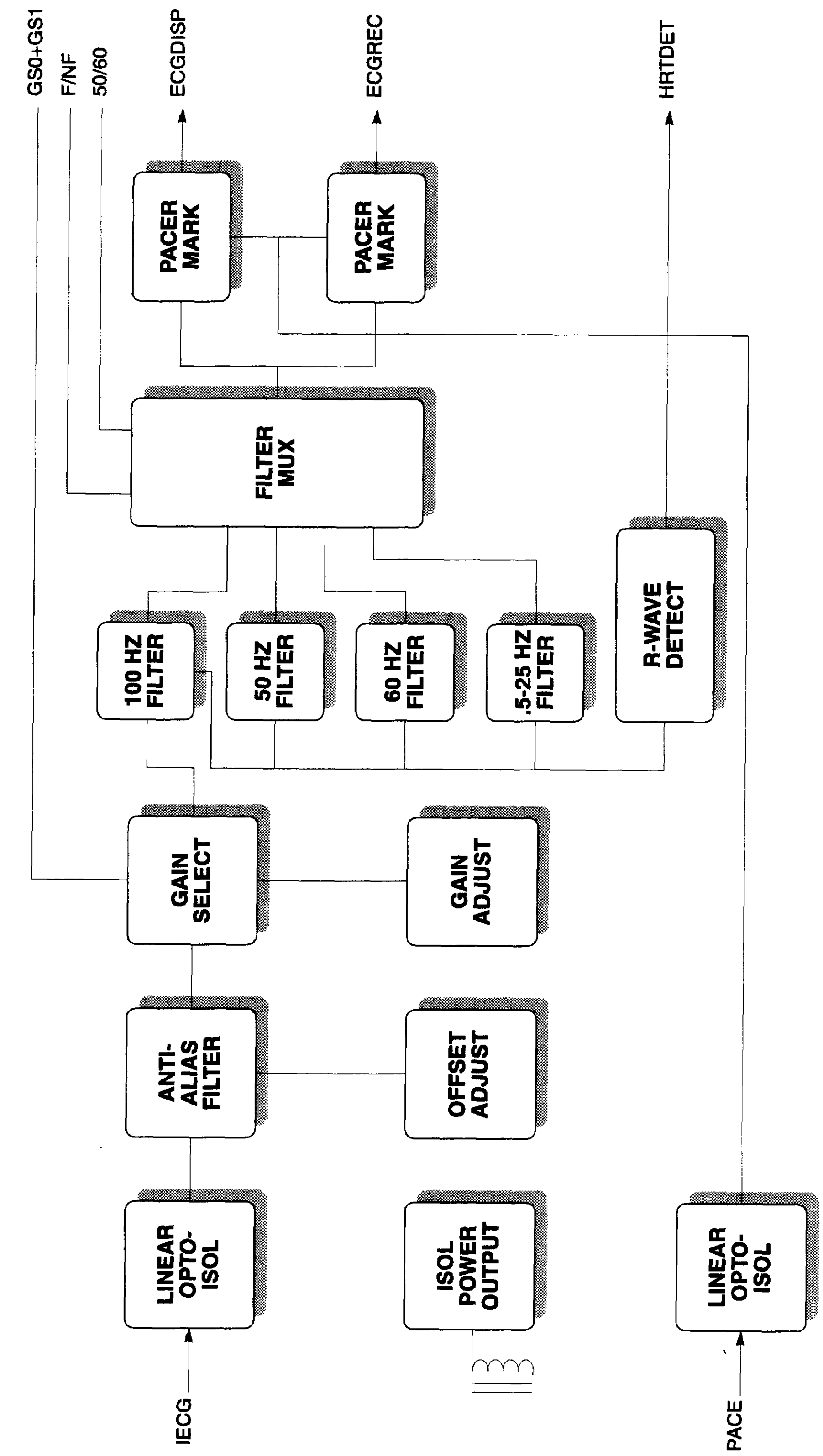
GS1	GS0	OUTPUT GAIN, V/mV
0	0	0.25
0	1	0.5
1	0	1.0
1	1	2.0

Potentiometer R127 controls the gain. The output from U37-B, pin 7, is low-pass filtered at 100 Hz by U37-C, C92, C112, and R208–209. A further band-pass stage, comprised of U37-D and U37-A, limits the signal bandwidth from 0.5–25 Hz. If required, this extra filtering can be selected through U38.

At this point, the ECG signal is sent to both the thermal recorder and front panel display. For the recorder, U42-D sums the signal with a 2.5-V reference (generated by U42-C, R176 and R177) and a 2.5-V, 15-ms pulse (generated by U41-A). U41-A is triggered by the pace-pulse detection circuitry. The output of U42-D is the analog input signal which is digitized for the thermal recorder.

For the front panel display, the ECG signal is low-pass filtered at 40 Hz by U42-B, C110, C122, and R194–195. U42-A sums the output, along with a 2.5-V reference and the 15-ms pace pulses from U41-A. Under control by the gain select keys, the ECG signal is amplified for display at 2.5, 5, 10, or 20 mm/mV.

Figure 14
Non-isolated R-wave block diagram



Heart rate detector

The ECG signal at U37-B, pin 7, passes to the heart rate detector circuitry beginning with U39-A, which together with R156, R129, and C99, limits the slew rate to a maximum of 110 V/s. This prevents pace pulses from triggering the heart rate detector.

U39-C and associated components form a bandpass filter with a center frequency of 8.8 Hz. This emphasizes the QRS complex and attenuates the lower frequency P- and T-waves. U39-B, C102, C113, and R132–133 provide additional low-pass filtering to attenuate short-duration QRS complexes.

U40-A, U40-D, R203–207, R218, and D75–76 form a precision full-wave rectifier. A –0.5-V offset is added at the output of the rectifier via R214. This ensures that pace pulses or other fast noise spikes do not cause false triggering.

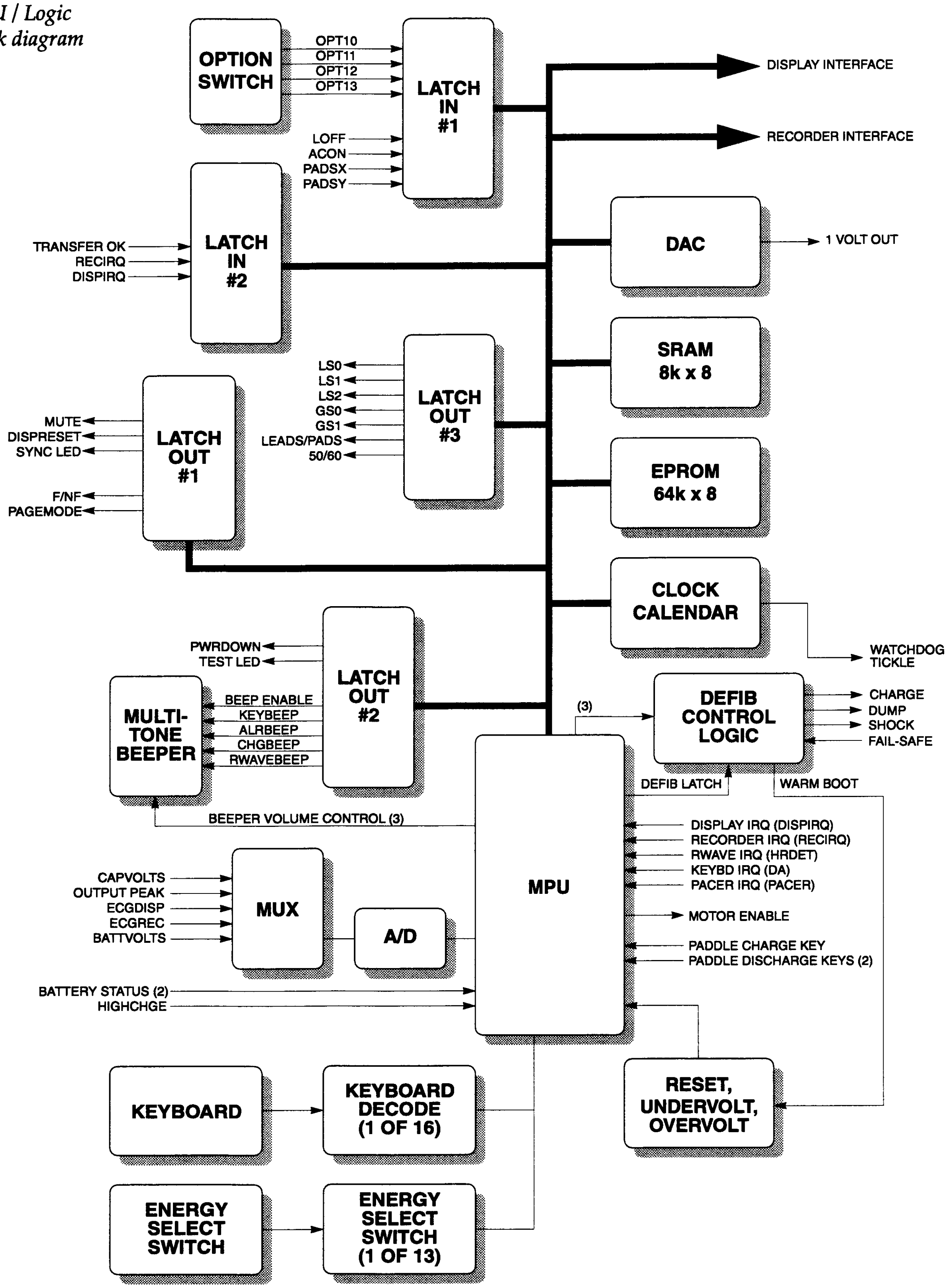
The peak detector circuit is comprised of U40-C, U40-B, D66, R215, R217, R134, R158, C103, and C118. As the incoming signals rise above the voltage on C103, D66 becomes forward-biased, causing C103 to charge via R217. As the input signal falls again, the peak is held on C103 when D66 is reverse-biased. Since the voltage peak at pin 6 is greater than the input fed to pin 5 via R158, U40-B saturates negatively. As C103 starts to discharge through R134 and R215, the voltage at U40-B, pin 6, falls until the comparator switches and saturates positively. Again, D66 is forward-biased and C103 charges to the peak. In this way, every peak exceeding the dynamic threshold voltage at U40-B, pin 6, causes a positive output pulse at U40-B, pin 7.

The output pulse triggers U41-B. R221 and C158 set the monostable lockout period at 165 ms. This ensures that only one pulse from each detected QRS complex can trigger the heart rate count.

Microcontroller & interface

A block diagram is shown in Fig. 12, pg. 46. The microcontroller is a Motorola 68HCP11AO, running at 2.1 MHz. It operates in the expanded, multiplexed mode. The eight least significant address lines are multiplexed with the data bus under control of the address strobe pin. The status of the defibrillator is monitored and controlled by a series of I/O ports, some of which are internal to the microcontroller. The external ports appear to the microcontroller as memory locations which it can read or write. Address decoding circuitry sorts out all accesses to the external I/O ports; and a watchdog circuit continually monitors the operation of the microcontroller.

Figure 15
CPU / Logic block diagram



The function of each port is summarized in the following tables. Also, Port E may be configured independently as an analog input to the internal A/D converter.

PORT A

Mode:	Bit:	Function:
input	0	R-wave detection signal
input	1	keyboard data available signal
output	2	pacer pulse detection
output	3	defib. control latch clock
output	4	writer enable control
output	5	digital volume clock
output	6	digital volume chip select
output	7	digital volume direction control

PORT D

Mode:	Bit:	Function:
output	0	shock monostable trigger pulse
output	1	dump relay engage
output	2	charge enable
input	3	paddle charge button
input	4	paddle discharge button A
input	5	paddle discharge button B

PORT E

Mode:	Bit:	Function:
input	0	storage capacitor voltage
input	1	capacitor overcharge detect
input	2	ECG signal to display
input	3	ECG signal to recorder
input	4	battery charging status signal
input	5	battery analog voltage
input	6	peak output current
input	7	peak zero current

PORT OUT1

Mode:	Bit:	Function:
output	1	ECG mute signal
output	2	not used
output	3	display reset signal
output	4	sync LED enable
output	5–6	not used
output	7	bandpass filter enable
output	8	page mode

PORT OUT2

Mode:	Bit:	Function:
output	1–3	ECG lead selection: I = 110, II = 101, III = 110, aVR = 011, aVL = 010, aVF = 001, V = 000, test = 111
output	4–5	ECG gain selection: 0.25x = 0, 0.5x = 01, 1x = 10, 2x = 11
output	6	leads/paddle amplifier selection
output	7	notch filter enable/disable
output	8	50/60 Hz notch selection

PORT OUT3

Mode:	Bit:	Function:
output	1	power-down control signal
output	2	enable keypress tone
output	3	enable alarm tone
output	4	enable charge tone
output	5	enable R-wave tone
output	6	enable beeper circuit
output	7	not used
output	8	test LED

PORT IN1

Mode:	Bit:	Function:
input	1–2	language select: English = 00, Spanish = 01, German = 10, and French = 11
input	3	not used
input	4	display self test
input	5	leads-off indicator
input	6	line voltage present
input	7–8	paddle type select: none = 00, internal = 01, external = 10, disposable = 11

PORT IN2

Mode:	Bit:	Function:
input	1	transfer OK
input	2	IRQ source recorder
input	3	IRQ source display
input	4–8	not used

System monitoring & reset

At power-on, U28 resets the microcontroller, the output ports, and the latches for about 50 ms. When the microcontroller, U21, receives the reset signal, it checks eleven internal memory locations. If it finds random values in these locations, the microcontroller initializes the values, verifies the system RAM, and performs a status check on the three paddle control switches. If a fault is detected in any of the paddle switches, all defibrillator controls are disabled. However, the monitor is not disabled.

The software operation is monitored continuously by the microcontroller's internal watchdog. The watchdog timer is accessed regularly by the processor and remains inactive when the software is running properly.

However, if a software fault occurs, the watchdog is not accessed as usual, and a reset is generated.

When the defibrillator discharges, a reset occurs. The microcontroller checks its memory locations and determines that the values are not random. Therefore, it resumes with the same machine status as prior to the defibrillation.

Overvoltage protection is provided by U60, which compares +5 V with a 5.6-V reference set by D89 and R244. A reset is generated if +5-V line rises above 5.6 V DC.

Address multiplexing & decoding

The microcontroller has a common bus for the data and lower eight address lines. An 8-bit latch, U22, interfaces the microcontroller (U21), EPROM (U23), and RAM (U24). The address strobe line, AS, controls the latch to maintain the correct timing between data transfer and address selection. U32 and U31 decode the addresses for the memories, interface ports, keyboard controller, and recorder. U31 decodes the two most significant address lines, placing the 64k EPROM at 8000–FFFF in two switched banks and the 8k static RAM at 2000–3FFF. U32 decodes 4000–7FFF into seven 2k blocks to select the I/O peripherals. U68 decodes 7800–7FFF into a 2k block to select the display. Zener diodes D32–55 protect the bus from transients.

Defibrillator controls

The defibrillator controls (CHARGE and DISCHARGE) are located on the paddles and connect to the board via the low voltage paddle wires at JP2. Normally, each line is held low by R189–191. The associated capacitors and zener diodes provide protection against noise which the high voltage paddle cables may induce. Pressing a paddle button switches the corresponding line to 5 V and alerts the microcontroller via the appropriate port. Also, the two DISCHARGE switches are gated to U35-D. If both DISCHARGE switches are not pressed, the output from this gate disables the transfer relay. The same signal controls the redundant transistor which drives the transfer relay.

The microcontroller interfaces to the power oscillator circuitry via output Port D and U34. Pressing the CHARGE button on the apex paddle initiates a charge sequence. In response, the processor sets the DUMP line high (PD1), energizing the dump relay, K2, and disconnecting the dump resistor from the terminals of the storage capacitor. Then, it sets the CHARGE line high (PD2) to enable the high voltage charging circuitry. Note that CHARGE is gated with DUMP. This provides a hardware interlock which inhibits charging unless the DUMP line is already high. C56, R46, D58, and C57, R100, D61 provide transient protection for the DUMP and CHARGE lines, respectively. During charging, the microcontroller continuously monitors the voltage on the storage capacitor via the CAPVOLTS line. This signal is filtered and buffered by C55, R148, and U28 before being read by the microcontroller's internal A/D converter at Port E, bit 0. D56 clamps the output of U28 and D77 generates a 5-V reference for the internal A/D converter from the 8-V line via R185. A charging voltage value corresponding to the each energy selection is held in memory. When the appropriate matching value is sensed on the CAPVOLTS line, the defibrillator charges and the CHARGE line is set low to disable the high voltage converter.

The charge beeper tone pulses on and off when the defibrillator is charging. Upon completion, the tone becomes continuous, the READY indication appears on the display, and a timer in U21 is enabled. If the defibrillator is not discharged after 25 seconds, the charge beeper tone rapidly pulses on and off to alert the operator that the charge will automatically dump in 5 seconds. If there is no discharge after 5 more seconds, the dump relay is de-energized and the defibrillator is disarmed.

To fire the defibrillator, both paddle DISCHARGE buttons must be pressed simultaneously. While the defibrillator is charging, both buttons are disabled until the READY status is reached. The processor reads the status of the DISCHARGE switches on Port E, bits 4 and 5. When both buttons are pressed simultaneously, the processor generates an output trigger pulse on PD0. The pulse is clocked through U34 and triggers U44-A via U35-B, which provides additional hardware interlocking to prevent U44-A from triggering if the FSAFE line is low. The width of the output pulse from U44-A is 100 ms, set by R102 and C152. This pulse is gated at U35-C to provide the SHOCK signal (if CHARGE is low). R188, C59, and D60 protect against transients. The rising edge of the SHOCK signal operates the transfer relay. The microcontroller is reset during the discharge to protect it from noise generated by the transfer relay.

Synchronized cardioversion

Synchronized cardioversion is selected by pressing the SYNC button on the defibrillator's front panel. An LED near the button illuminates when the sync mode is on. In this mode, the energy discharge is synchronized with the R-wave pulse. The microcontroller is notified of R-wave pulses via Port

A, bit 0. A discharge is enabled only if both paddle DISCHARGE buttons are held closed. The defibrillator automatically reverts to non-synchronized mode, after each synchronized discharge. The synchronized mode can be cancelled at any time by pressing the SYNC button a second time.

Keypad & energy control interface

The keypad encoder, U25, in conjunction with an 8-bit latch, U48, implement all the logic necessary to encode the membrane keypad matrix and the energy selection switch. The matrix keypad interfaces to U25 via J5 and is menu driven. Successively pressing the MENU key allows the user to select and change leads, gains, alarm settings, filters, and recorder parameters. The current menu level is held as a byte in RAM; and U25 provides a 4-bit output code corresponding to each distinct keypress. C117 sets the keypad scan rate at 300 Hz; and C51 sets a debounce period of 20 ms.

Data is latched when the debounce circuitry times-out and the DA output at U26, pin 12, goes high. This is signalled to the microcontroller through Port A, bit 1, and the keypad latch, U25, is read. The output from U25 is an 8-bit code. Bits 0–3 provide keypad information. Bits 4–7 indicate the selected energy. The front panel energy select control is a binary-coded rotary switch, providing a 4-bit code which corresponds to the selected energy. J5 interfaces to U25.

When the CHARGE button is activated, the defibrillator charges to the level indicated by the energy select switch. If the energy level is changed during or after the charging period, the microcontroller will either "top-up" the energy on the storage capacitor or activate the dump relay to reduce the stored energy down to the new level. Any time the energy select switch is turned to the STANDBY or ECG position, the defibrillator is completely disarmed.

Real time clock

A real time clock, U27, provides the time and date. It has a battery-backed supply, allowing it to operate when the defibrillator is off. The time and date may be set at any time by using the keypad. Each time the defibrillator is turned on, a self-check verifies that the 32-kHz oscillator waveform is present. If the check fails, the keypad menu automatically goes to the clock setup mode and the operator is alerted. The clock's INTR function "tickles" the transfer relay watchdog circuit. During a warm reset, the system defaults are stored in the clock's internal RAM.

Display & recorder interface

Data transfer between the microcontroller, front panel display, and thermal array recorder is interrupt driven via the processor's IRQ line. The microcontroller identifies the interrupt and services the appropriate device. The display appears as a single memory location to the microcontroller; and the recorder appears as a 2k RAM. The address decoding circuitry enables the appropriate select lines of U32 to control each device.

Analog 1-V output

U52, a digital to analog converter, generates a 1-V analog ECG output. U50 and associated components apply a 40-Hz low-pass filter to the output.

Control board

The Control board circuitry controls the thermal array printhead, the DC paper drive motor, and the liquid crystal display.

Printhead control

U1 is an ASIC (application specific integrated circuit) which handles printhead loading and control. It interfaces to the system via the address and data bus. U1 has several distinct sets of control and data registers. The text handling portion is connected to U2, an external 8k static RAM, and U3, an external EPROM. U2 holds one page of text information, while U3 contains the bit patterns for the text font. Another part of U1 handles the waveform data.

DC motor control

U6 and associated components regulate the DC motor speed. The motor enable signal is generated from the microcontroller. Potentiometer R15 provides for the speed adjustment.

LCD control

U24 and associated circuitry handle the display of waveforms, text, and graphics. First, U26–U29 and U21 latch the data, address, and control lines. Then, U24 reads the lines for processing.

U24, in conjunction with its EPROM, U10, and temporary storage RAMs, U8–U9, processes the data for display on the LCD. U24 also generates control signals for the display and two video RAMs, U17–18. The video

RAMs contain text and graphic information to allow overlay functions between the graphic planes controlled by U19.

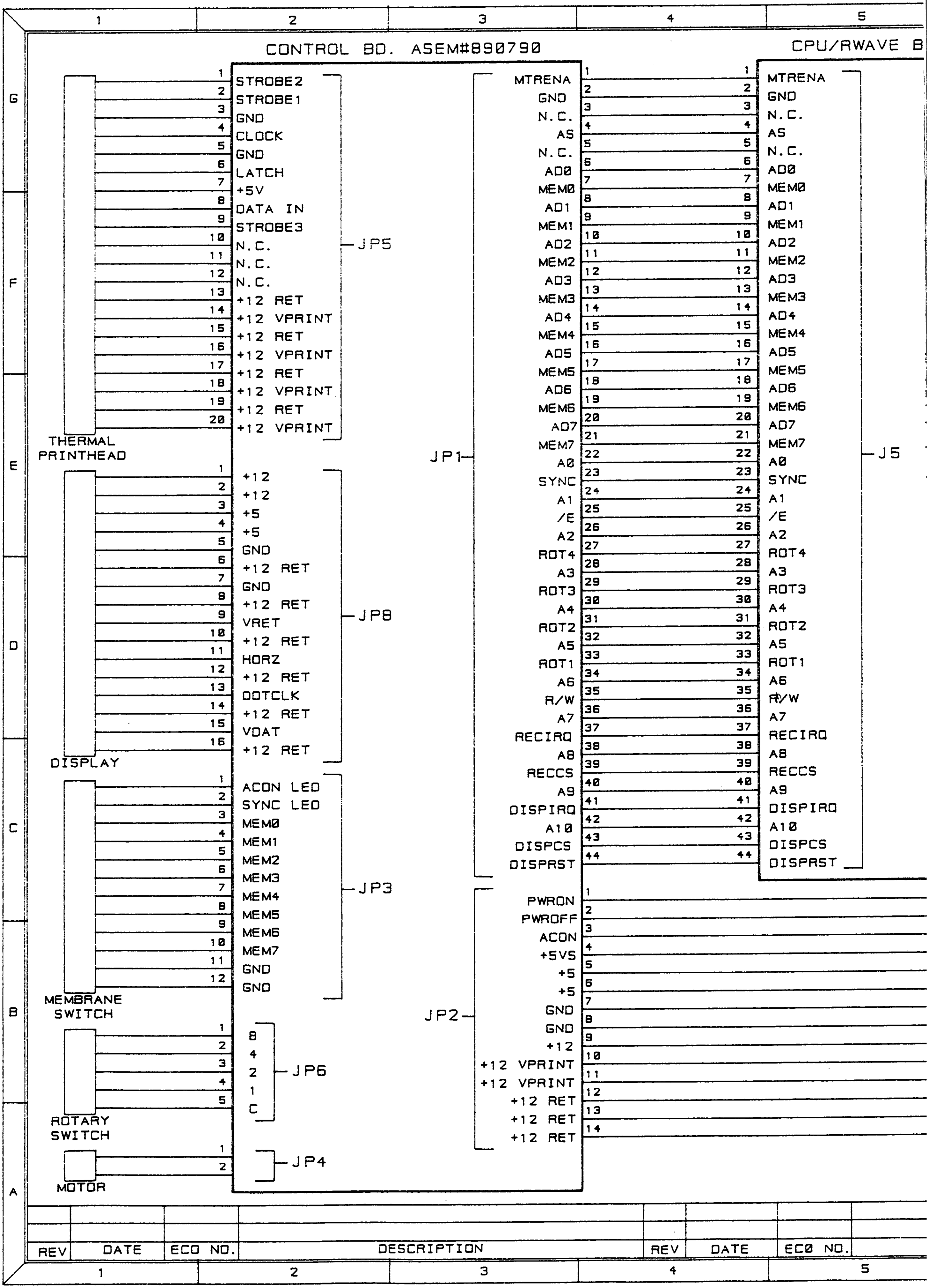
Section

7 Schematics

Schematics

The schematics appear on the following pages.

Schematic	Sheet
Wiring diagram	1
Power Supply board	2, 3, 4
CPU and R-Wave board	5, 6, 7, 8
Control board	9, 10, 11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STROBE1
GND
CLOCK
GND
LATCH
+5V
DATA IN
STROBE3
N.C.
N.C.
N.C.
+12 RET
+12 VPRINT
+12 RET
+12 VPRINT
+12 RET
+12 VPRINT
+12 RET
+12 VPRINT
THERMAL PRINTHEAD
JP8
+12
+12
+5
+5
GND
+12 RET
GND
+12 RET
VRET
+12 RET
HORZ
+12 RET
DOTCLK
+12 RET
VDAT
+12 RET
DISPLAY
JP3
ACON LED
SYNC LED
MEM0
MEM1
MEM2
MEM3
MEM4
MEM5
MEM6
MEM7
GND
GND
MEMBRANE SWITCH
JP6
8
4
2
1
C
ROTARY SWITCH
JP4
MOTOR
JP1
J5
MTRENA
GND
N.C.
AS
N.C.
AD0
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AD1
MEM1
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MEM2
AD3
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AD4
MEM4
AD5
MEM5
AD6
MEM6
AD7
MEM7
A0
SYNC
A1
/E
A2
ROT4
A3
ROT3
A4
ROT2
A5
ROT1
A6
R/W
A7
RECIRQ
A8
RECCS
A9
DISPIRQ
A10
DISPCS
DISPRST
JP2
PWRON
PWROFF
ACON
+5VS
+5
+5
GND
GND
+12
+12 VPRINT
+12 VPRINT
+12 RET
+12 RET
+12 RET
REV
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4
5
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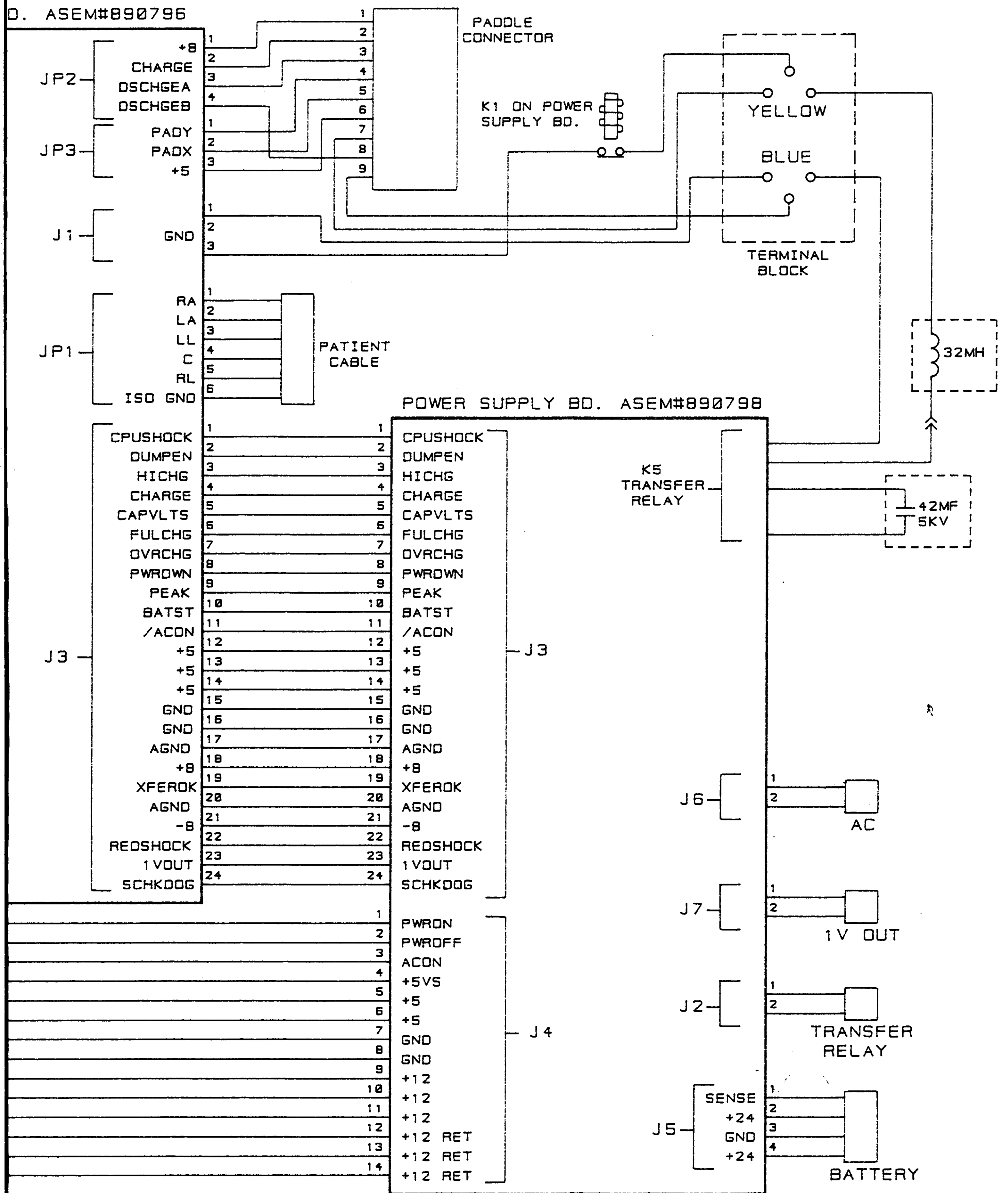
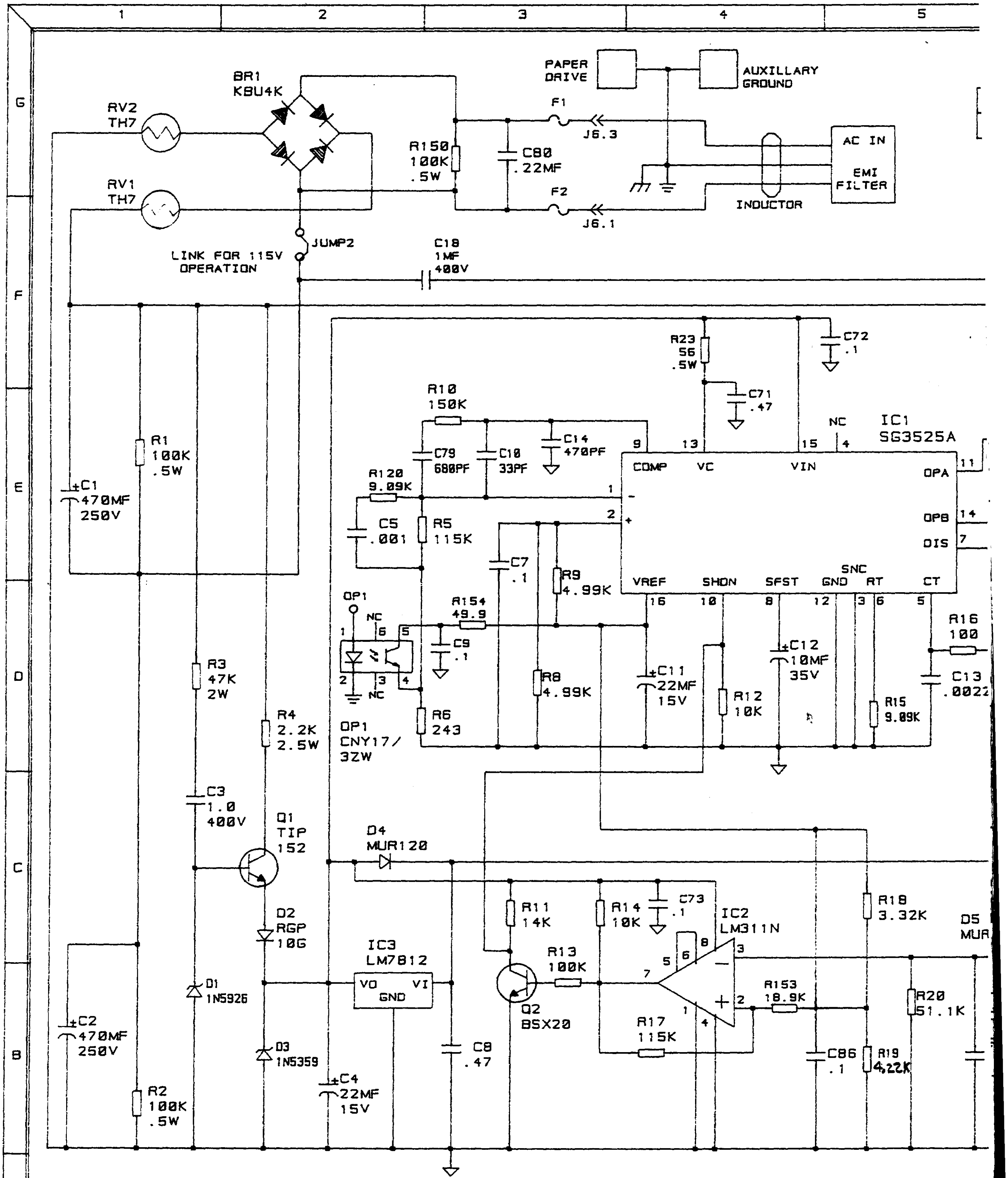


DRAWN RAW 11-1-93	BURDICK, INC.	MILTON, WI
CHKED RAW 11-23-93	TITLE: MEDIC5	UNIT: MEDIC5
APPED 11-23-93	WIRING DIAGRAM	
DWG NO. 590017		SHT 1 OF 11

DESCRIPTION



NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTANCE VALUES ARE IN OHMS
2. ALL FIXED RESISTORS >10 OHMS & <1 MEG ARE 1%---ALL OTHERS ARE 5%
3. CAPACITANCE VALUES ARE IN MICROFARADS

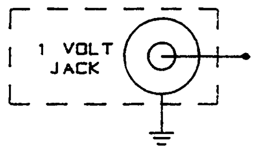
REV	DATE	ECO NO.	DESCRIPTION	REV	DATE	ECO NO.
1	6-8-94	14279 RW	CONNECTED C86 TO R9 AND R18, R19 WAS 619 OHMS			

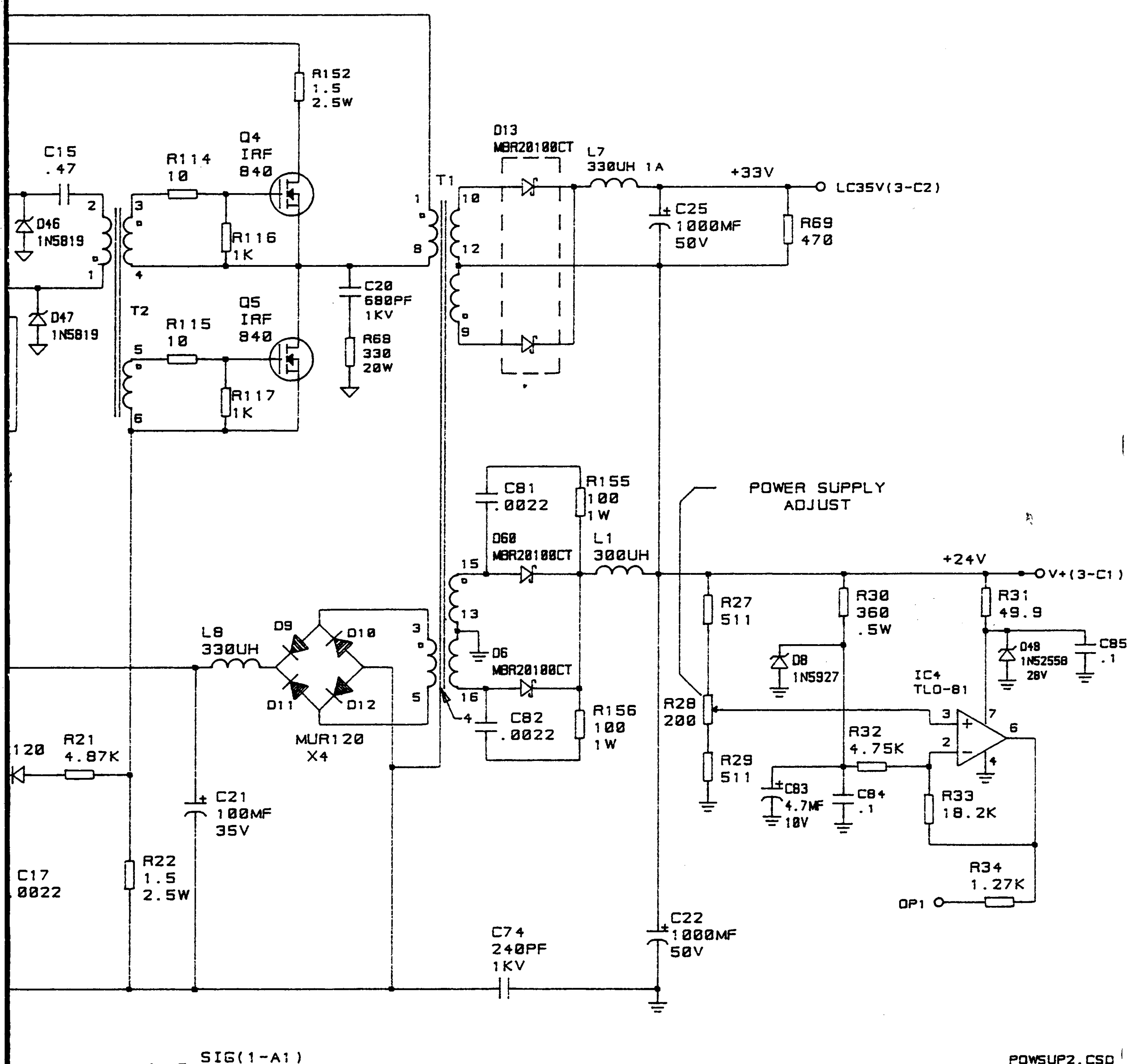
1	2	3	4	5

	6	7	8	9	10

	F1	F2	
10V	2A 5mm X 20mm	2A 5mm X 20mm	SLO-BLO TYPE
230V	T1A 5mm X 20mm	T1A 5mm X 20mm	TIME DELAY TYPE

FUSE CHART





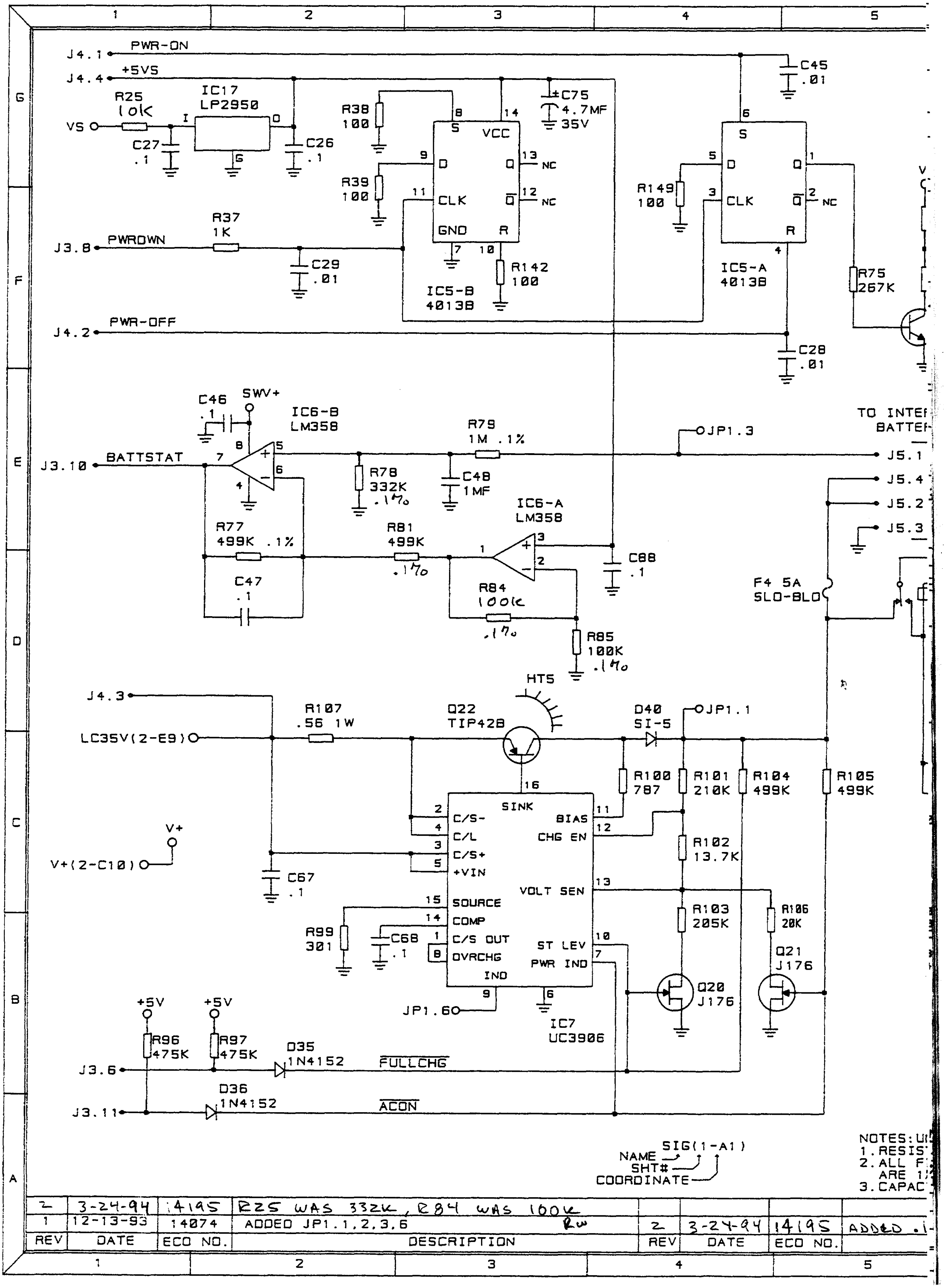
NAME SIG(1-A1)
SHT#
COORDINATE

POWSUP2.CSD

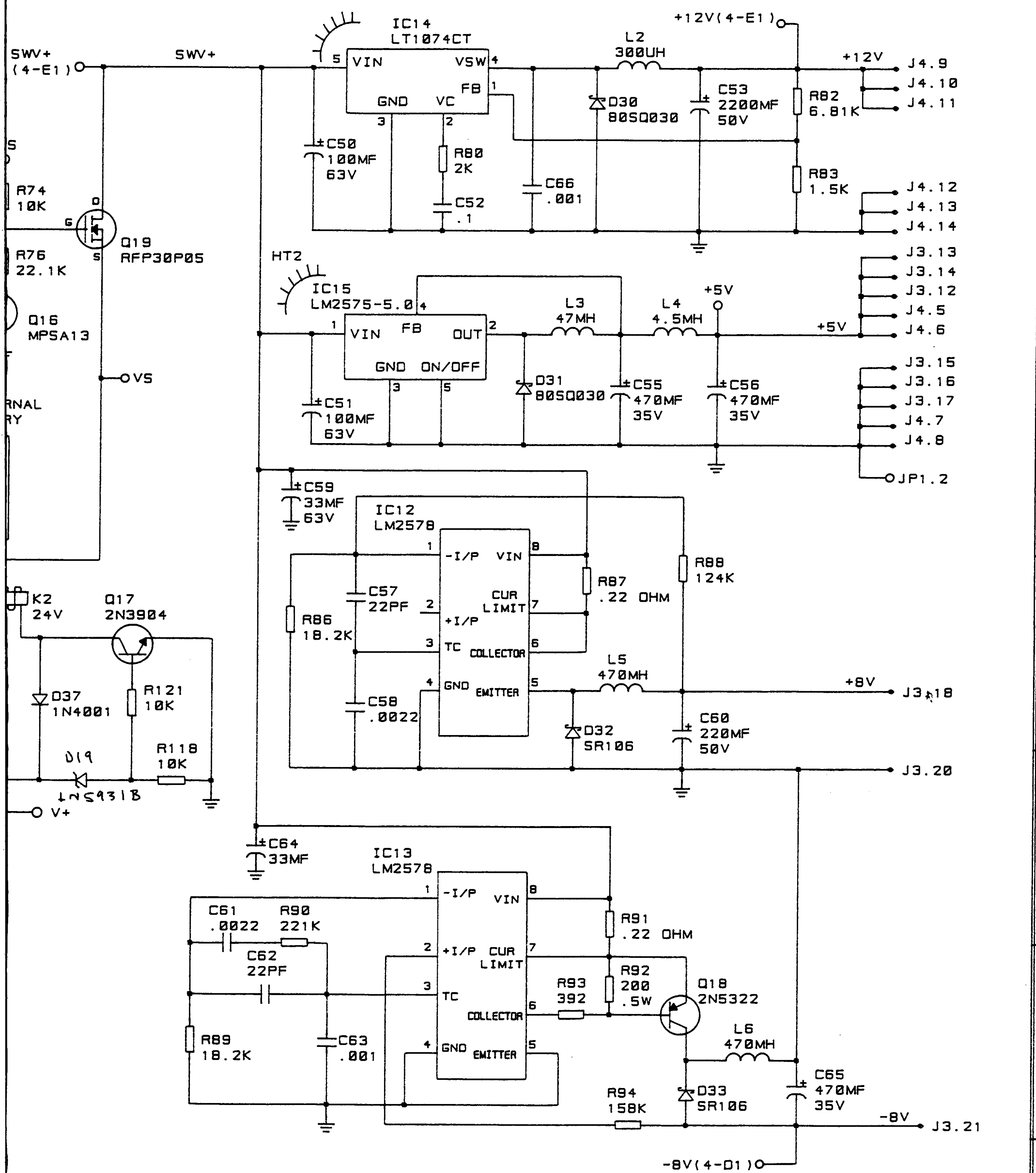
DRAWN RAW 11-1-93	BURDICK, INC.		MILTON, WI
CHKED RAW 11-23-93	TITLE: POWER SUPPLY (LINE CONVERTER CKT)	UNIT: MEDIC5	
APPED SAP 11-23-93			
DWG NO. 590017		SHT 2 OF 11	

DESCRIPTION

	6	7	8	9	10



PWR-ON
J4.1
J4.4
+5VS
IC17
LP2950
R25
10K
VS
C27
.1
C26
.1
R38
100
R39
100
C75
4.7MF
35V
S
VCC
D
Q
CLK
GND
R
NC
R37
1K
J3.8
PWRDWN
C29
.01
R142
100
IC5-B
4013B
C45
.01
R149
100
IC5-A
4013B
R75
267K
PWR-OFF
J4.2
C28
.01
C46
.1
SWV+
IC6-B
LM358
R79
1M .1%
JP1.3
TO INTER
BATTER
J5.1
J3.10
BATTSTAT
R78
332K
.1%
C48
1MF
J5.4
J5.2
J5.3
IC6-A
LM358
R77
499K .1%
R81
499K
.1%
C88
.1
C47
.1
R84
100K
.1%
F4 5A
SLO-BLO
R85
100K
.1%
HT5
J4.3
R107
.56 1W
Q22
TIP42B
D40
SI-5
JP1.1
LC35V(2-E9)
R100
787
R101
210K
R104
499K
R105
499K
SINK
C/S-
BIAS
C/L
CHG EN
C/S+
+VIN
V+
V+(2-C10)
C67
.1
R102
13.7K
VOLT SEN
SOURCE
COMP
C/S OUT
OVRCHG
IND
ST LEV
PWR IND
R99
301
C68
.1
R103
205K
R106
20K
Q21
J176
Q20
J176
JP1.6
IC7
UC3906
+5V
R96
475K
R97
475K
D35
1N4152
J3.6
FULLCHG
D36
1N4152
J3.11
ACON
NAME
SHT#
COORDINATE
SIG(1-A1)
NOTES:U
1. RESIS
2. ALL F
ARE 1
3. CAPAC
2 | 3-24-94 | 14195 | R25 WAS 332K, R84 WAS 100K
1 | 12-13-93 | 14074 | ADDED JP1.1,2,3,6
RW
REV | DATE | ECO NO. | DESCRIPTION
2 | 3-24-94 | 14195 | ADDED .1
REV | DATE | ECO NO.



UNLESS OTHERWISE SPECIFIED
RESISTANCE VALUES ARE IN OHMS
FIXED RESISTORS >10 OHMS & <1 MEG
1%---ALL OTHERS ARE 5%
CAPACITANCE VALUES ARE IN MICROFARADS

POWSUP3.CSD

DRAWN	RAW 11-1-93
CHKED	RAW 11-23-93
APPED	SCP 11-23-93
DWG NO.	590017

BURDICK, INC. MILTON, WI

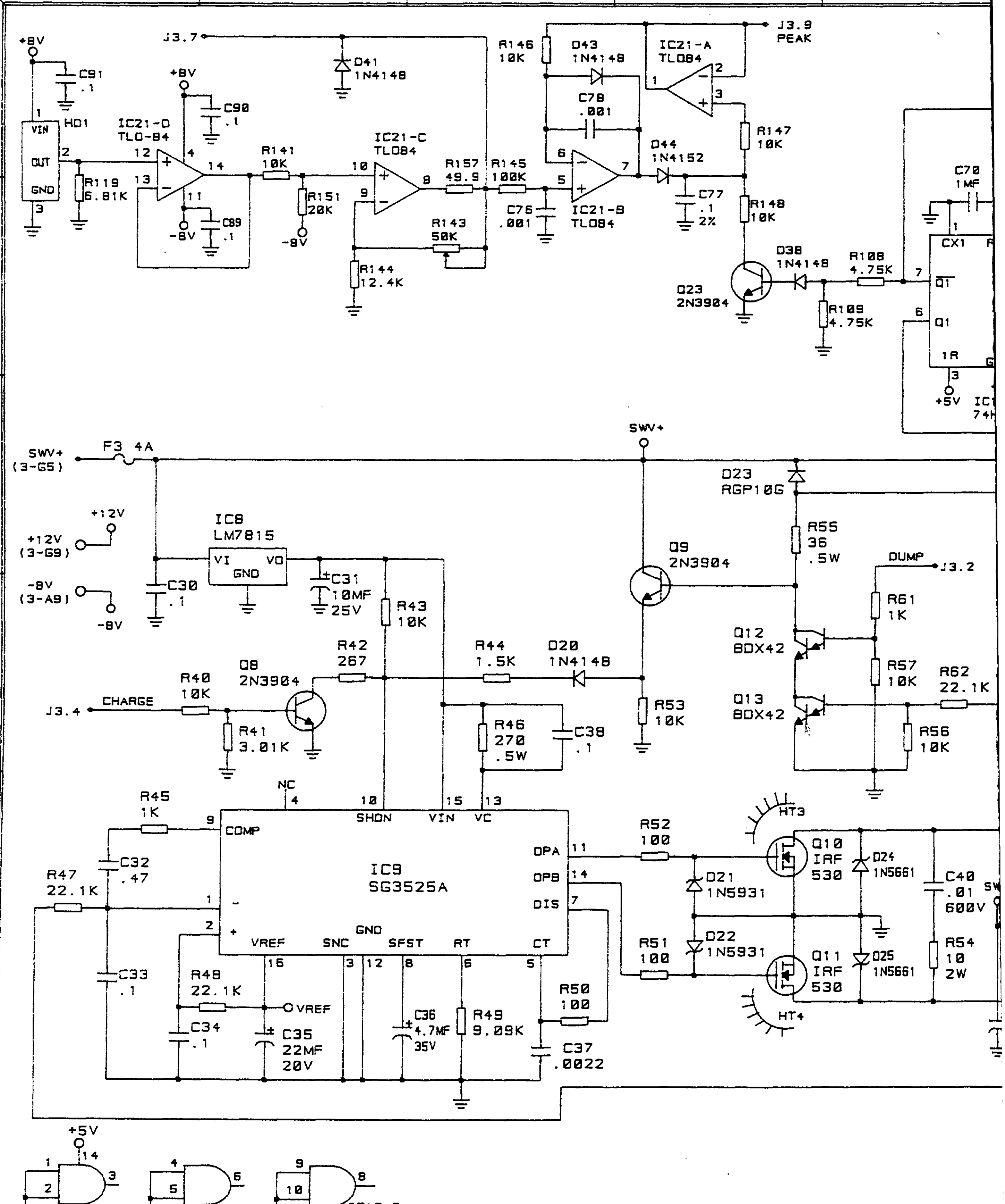
TITLE: POWER SUPPLY

UNIT: MEDICS

SHT 3 OF 11

1% TO R78, 81, 84, 85

DESCRIPTION

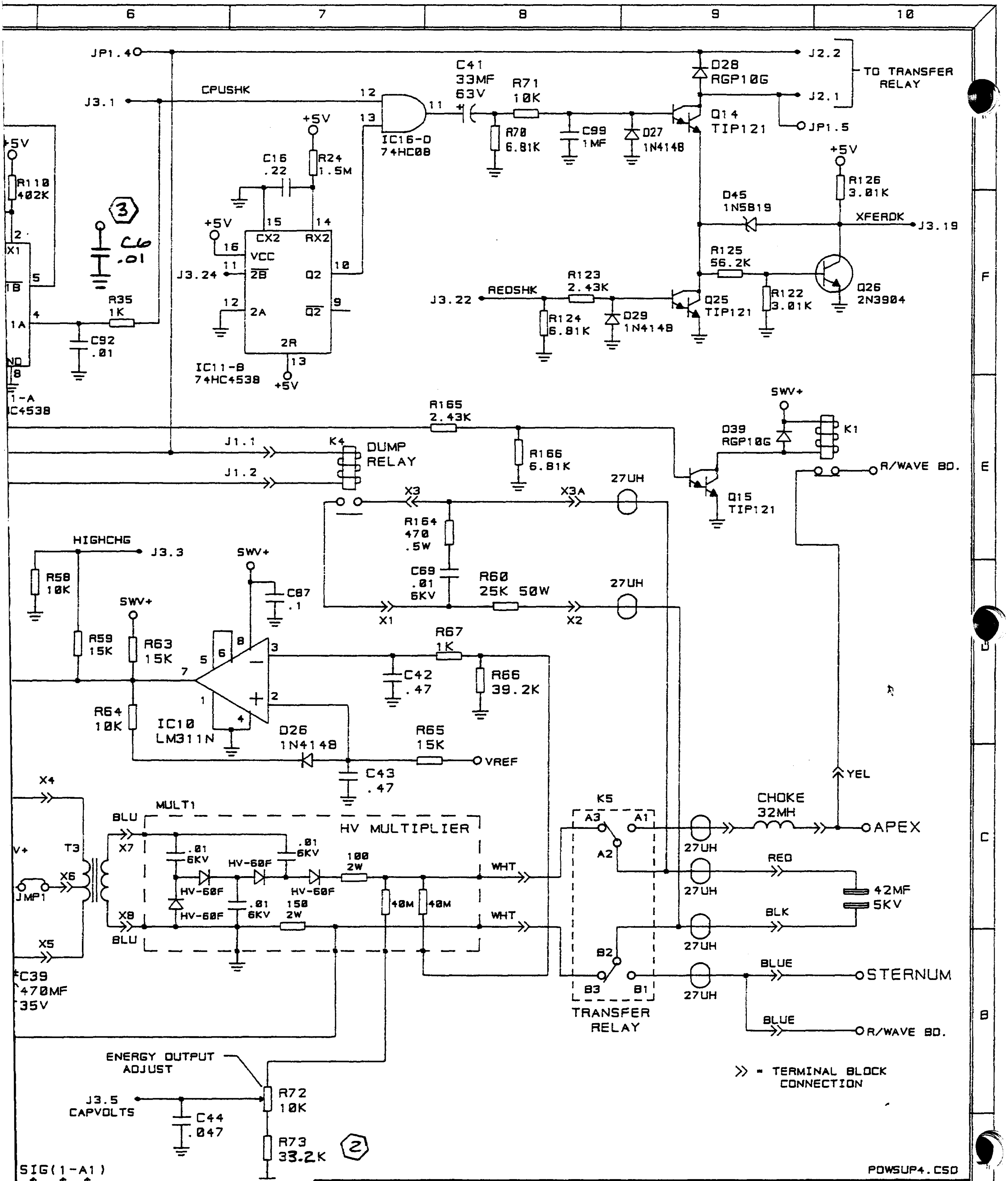


NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTANCE VALUES ARE IN OHMS
2. ALL FIXED RESISTORS >10 OHMS & <1 MEG ARE 1%---ALL OTHERS ARE 5%
3. CAPACITANCE VALUES ARE IN MICROFARADS

NAME...
SHT...
COORDIN...

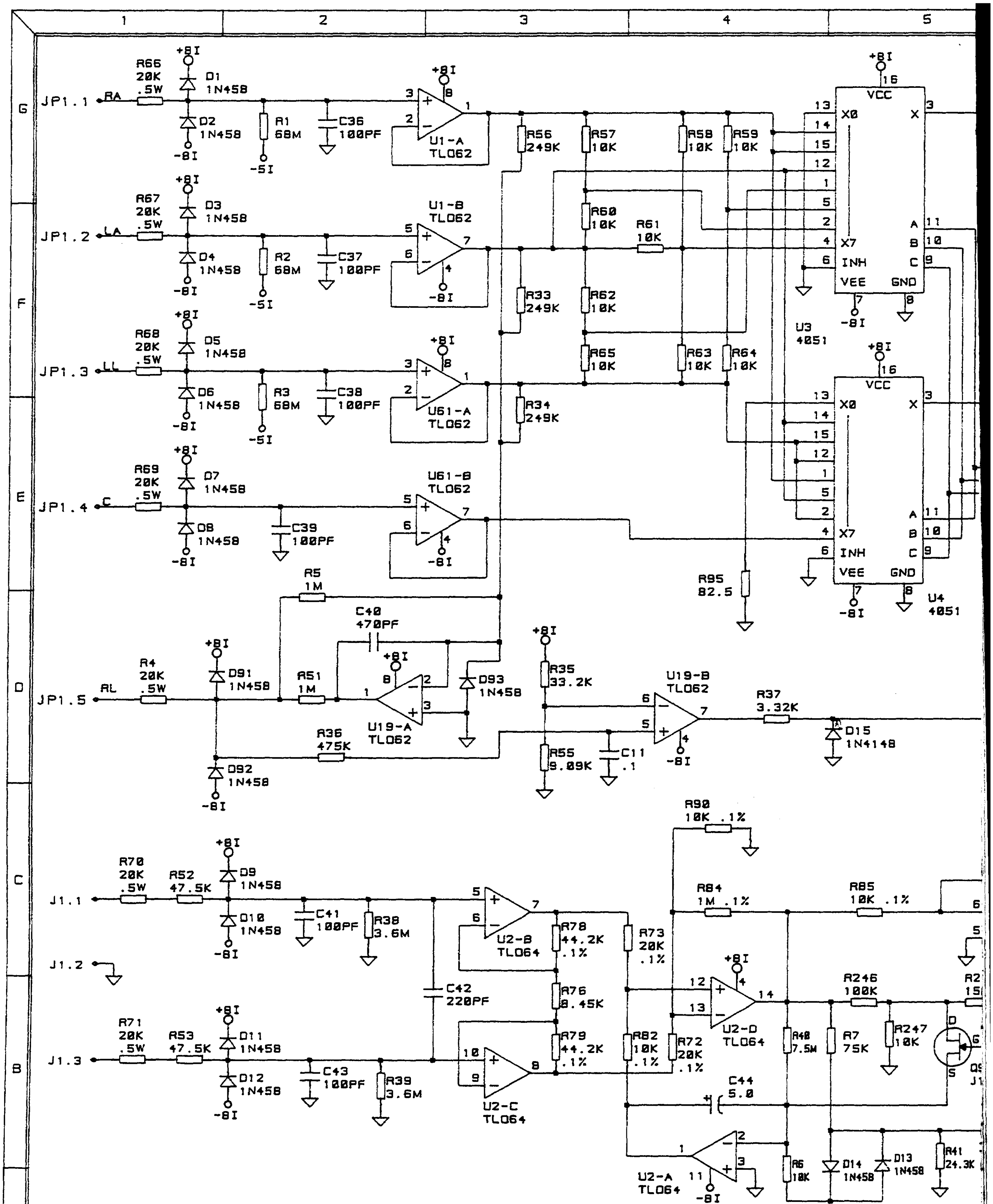
REV	DATE	ECO NO.	DESCRIPTION	REV	DATE	ECO NO.	
2	1-11-94	14101	R73 was 30.1K				
1	12-13-93	14058/14074	ADDED R35, C92, AND JP1.4.5	3	1-12-94	14105	ADDED C...

1 2 3 4 5



DRAWN RAW 11-1-93	BURDICK, INC.		MILTON, WI
CHKED RAW 11-23-93	TITLE: POWER SUPPLY (POW OSC & DISCHARGE CKT)		UNIT: MEDIC5
APPED SCP 11-23-93			
DWG NO. 590017			SHT 4 OF 11

DESCRIPTION

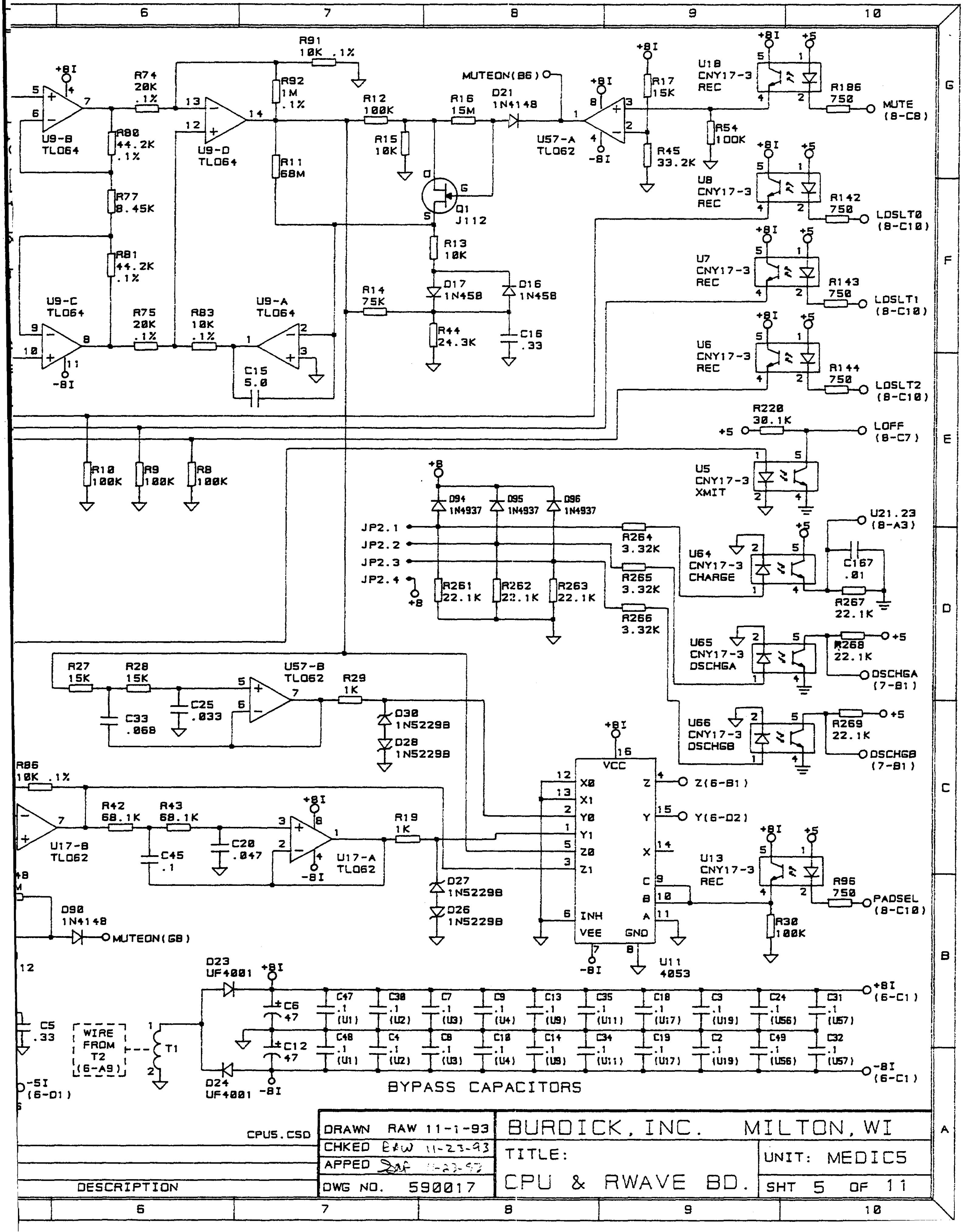


NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTANCE VALUES ARE IN OHMS
2. ALL FIXED RESISTORS >10 OHMS & <1 MEG
ARE 1%---ALL OTHERS ARE 5%
3. CAPACITANCE VALUES ARE IN MICROFARADS

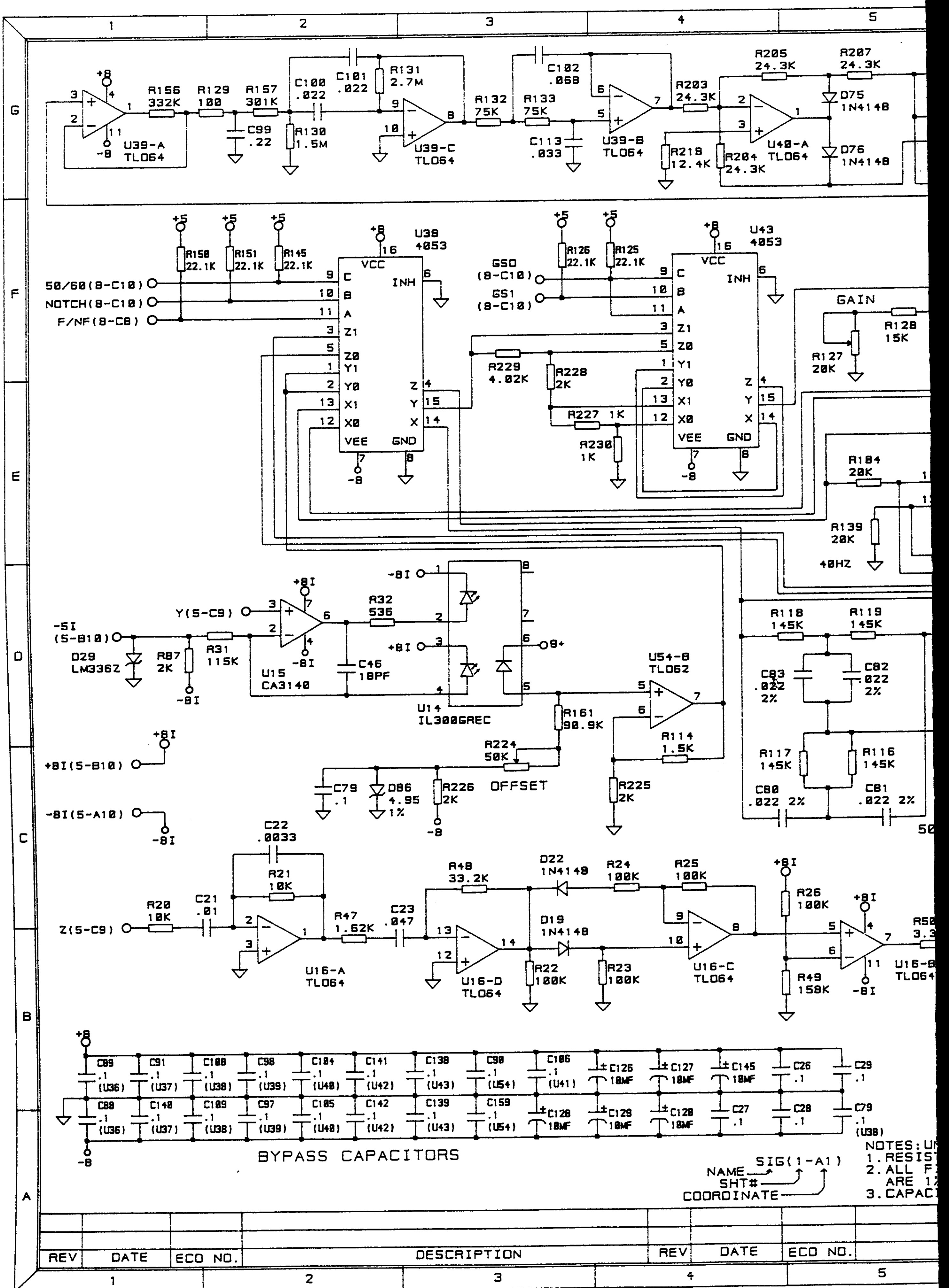
NAME SIG(1-A1)
SHT#
COORDINATE

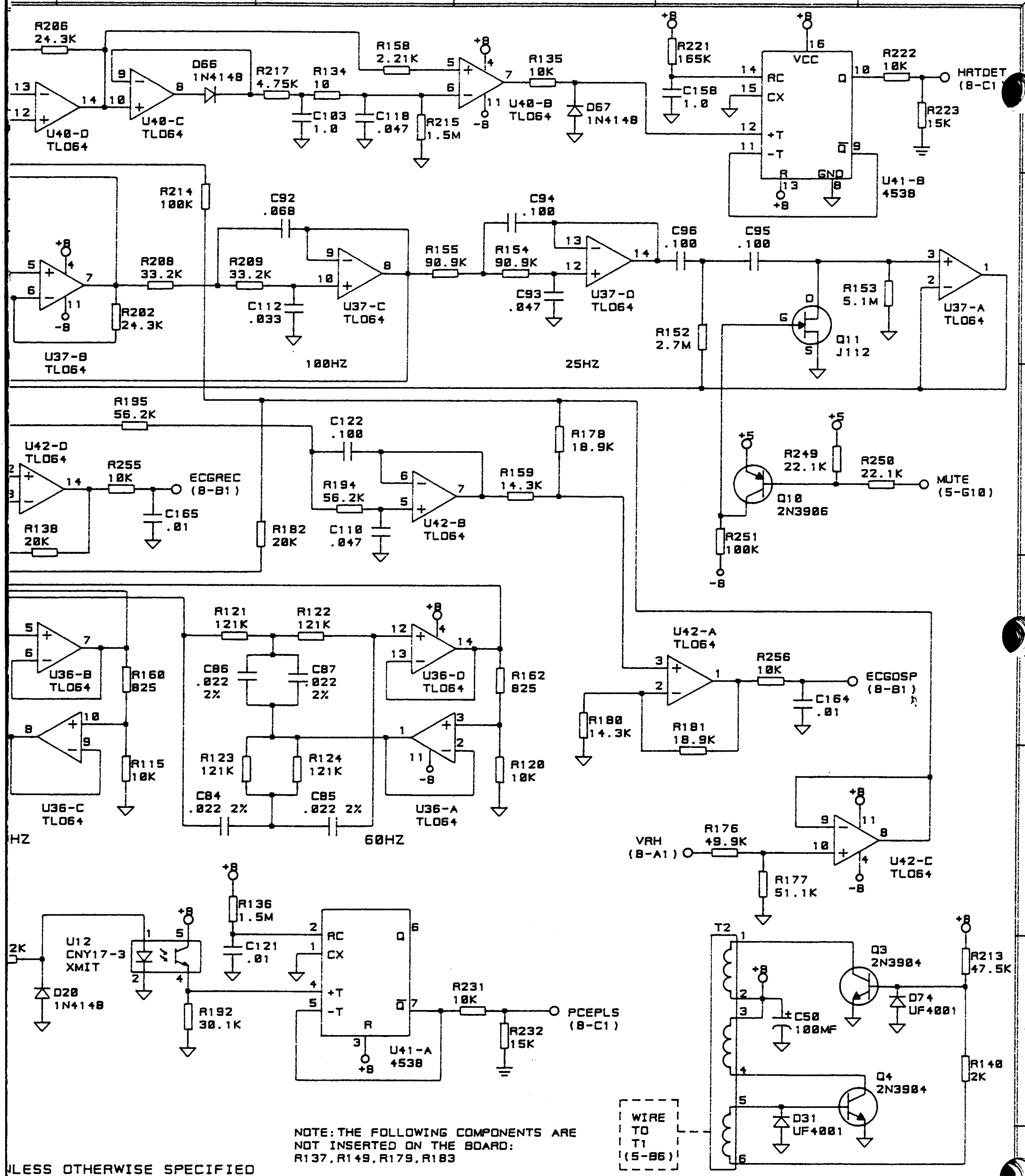
REV	DATE	ECO NO.	DESCRIPTION	REV	DATE	ECO NO.

1 2 3 4 5



6
7
8
9
10
G
F
E
D
C
B
A
R91 10K .1%
R74 20K .1%
R92 1M .1%
R80 44.2K .1%
R77 8.45K
R81 44.2K .1%
R11 68M
R12 100K
R15 10K
R16 15M
D21 1N4148
MUTEON(B6)
U9-B TL064
U9-D TL064
U9-C TL064
U9-A TL064
U57-A TL062
Q1 J112
R13 10K
D17 1N458
D16 1N458
R14 75K
R44 24.3K
C16 .33
R75 20K .1%
R83 10K .1%
C15 5.0
R17 15K
R45 33.2K
R54 100K
U18 CNY17-3 REC
R186 750
MUTE (8-C8)
U8 CNY17-3 REC
R142 750
LOSLT0 (8-C10)
U7 CNY17-3 REC
R143 750
LOSLT1 (8-C10)
U6 CNY17-3 REC
R144 750
LOSLT2 (8-C10)
R220 30.1K
LOFF (8-C7)
U5 CNY17-3 XMIT
R10 100K
R9 100K
R8 100K
D94 1N4937
D95 1N4937
D96 1N4937
JP2.1
JP2.2
JP2.3
JP2.4
R261 22.1K
R262 22.1K
R263 22.1K
R264 3.32K
R265 3.32K
R266 3.32K
U21.23 (8-A3)
U64 CNY17-3 CHARGE
C167 .01
R267 22.1K
U65 CNY17-3 DSCHGA
R268 22.1K
DSCHGA (7-B1)
U66 CNY17-3 DSCHGB
R269 22.1K
DSCHGB (7-B1)
R27 15K
R28 15K
U57-B TL062
R29 1K
C33 .068
C25 .033
D30 1N5229B
D28 1N5229B
R86 10K .1%
R42 68.1K
R43 68.1K
U17-B TL062
U17-A TL062
C45 .1
C20 .047
R19 1K
D27 1N5229B
D26 1N5229B
D90 1N4148
MUTEON(G8)
VCC
X0
X1
Y0
Y1
Z0
Z1
INH
VEE
GND
Z(6-B1)
Y(6-D2)
U11 4053
U13 CNY17-3 REC
R96 750
PADSEL (8-C10)
R30 100K
D23 UF4001
D24 UF4001
C6 47
C12 47
C5 .33
WIRE FROM T2 (6-A9)
T1
-5I (6-D1)
+8I (6-C1)
-8I (6-C1)
C47 .1 (U1)
C38 .1 (U2)
C7 .1 (U3)
C9 .1 (U4)
C13 .1 (U9)
C35 .1 (U11)
C18 .1 (U17)
C3 .1 (U19)
C24 .1 (U56)
C31 .1 (U57)
C48 .1 (U1)
C4 .1 (U2)
C8 .1 (U3)
C10 .1 (U4)
C14 .1 (U9)
C34 .1 (U11)
C19 .1 (U17)
C2 .1 (U19)
C49 .1 (U56)
C32 .1 (U57)
BYPASS CAPACITORS
CPU5.CSD
DESCRIPTION
DRAWN RAW 11-1-93
CHKED EAW 11-23-93
APPED 11-23-93
DWG NO. 590017
BURDICK, INC. MILTON, WI
TITLE:
CPU & RWAVE BD.
UNIT: MEDIC5
SHT 5 OF 11


U39-A TL064
U39-C TL064
U39-B TL064
U40-A TL064
U38 4053
U43 4053
GAIN
40HZ
U15 CA3140
U14 IL300GREC
U54-B TL062
OFFSET
U16-A TL064
U16-D TL064
U16-C TL064
BYPASS CAPACITORS
NAME SHT# COORDINATE SIG(1-A1)
NOTES:
1.RESIST
2.ALL
ARE 1
3.CAPAC
REV DATE ECO NO. DESCRIPTION REV DATE ECO NO.



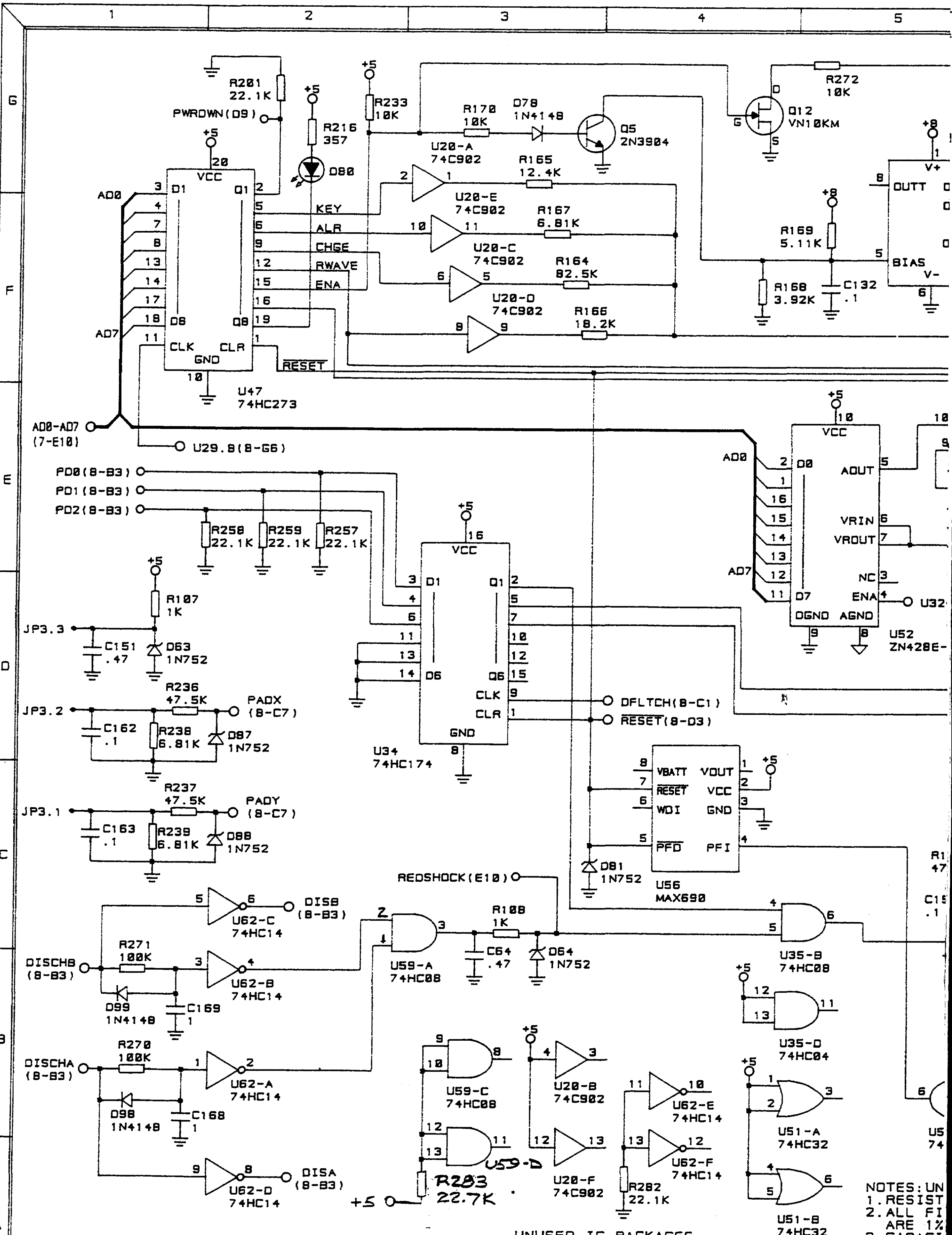
NOTE: THE FOLLOWING COMPONENTS ARE NOT INSERTED ON THE BOARD: R137, R149, R179, R183

…LESS OTHERWISE SPECIFIED
…TANCE VALUES ARE IN OHMS
…XED RESISTORS >10 OHMS & <1 MEG
…---ALL OTHERS ARE 5%
…TANCE VALUES ARE IN MICROFARADS

CPU6.CS…

DRAWN RAW 11-1-93	BURDICK, INC. MILTON, WI	
CHKED RAW 11-23-93	TITLE:	UNIT: MEDIC5
APPED [illegible] 11-23-93		
DWG NO. 590017	CPU & RWAVE BD.	SHT 6 OF 11

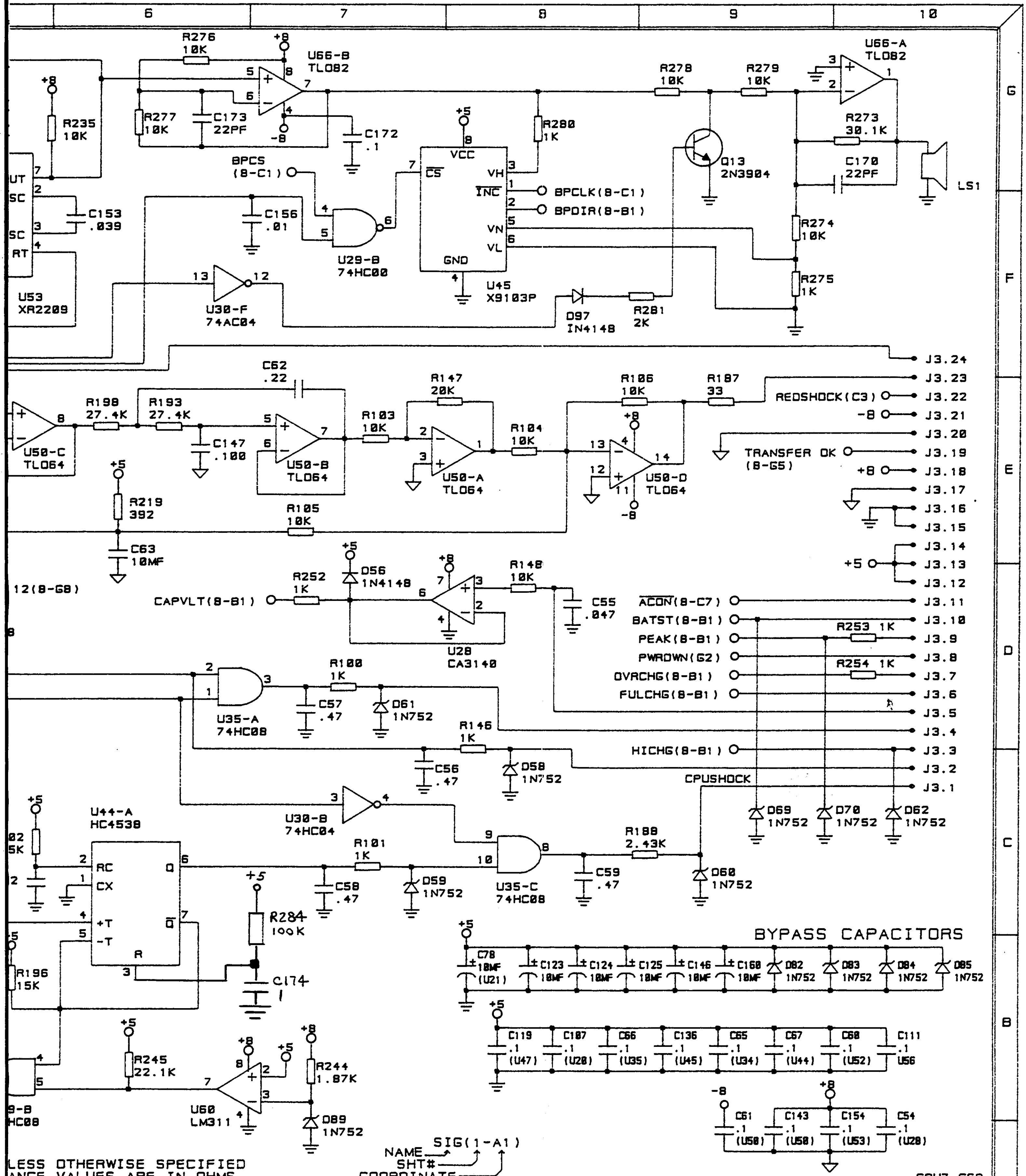
DESCRIPTION



1	6-8-94	14279 ew.	DELETED GROUND SIGN + ADDED +5 AT R283, REVERSED 1+2 AT U59-A
REV	DATE	ECO NO.	DESCRIPTION

2	7-15-94	14303/RGH	ADDED C
REV	DATE	ECO NO.	

1 2 3 4 5



LESS OTHERWISE SPECIFIED
ANCE VALUES ARE IN OHMS
XED RESISTORS >10 OHMS & <1 MEG
---ALL OTHERS ARE 5%
TANCE VALUES ARE IN MICROFARADS

AP.(C174) AND RES.(R284)

DESCRIPTION

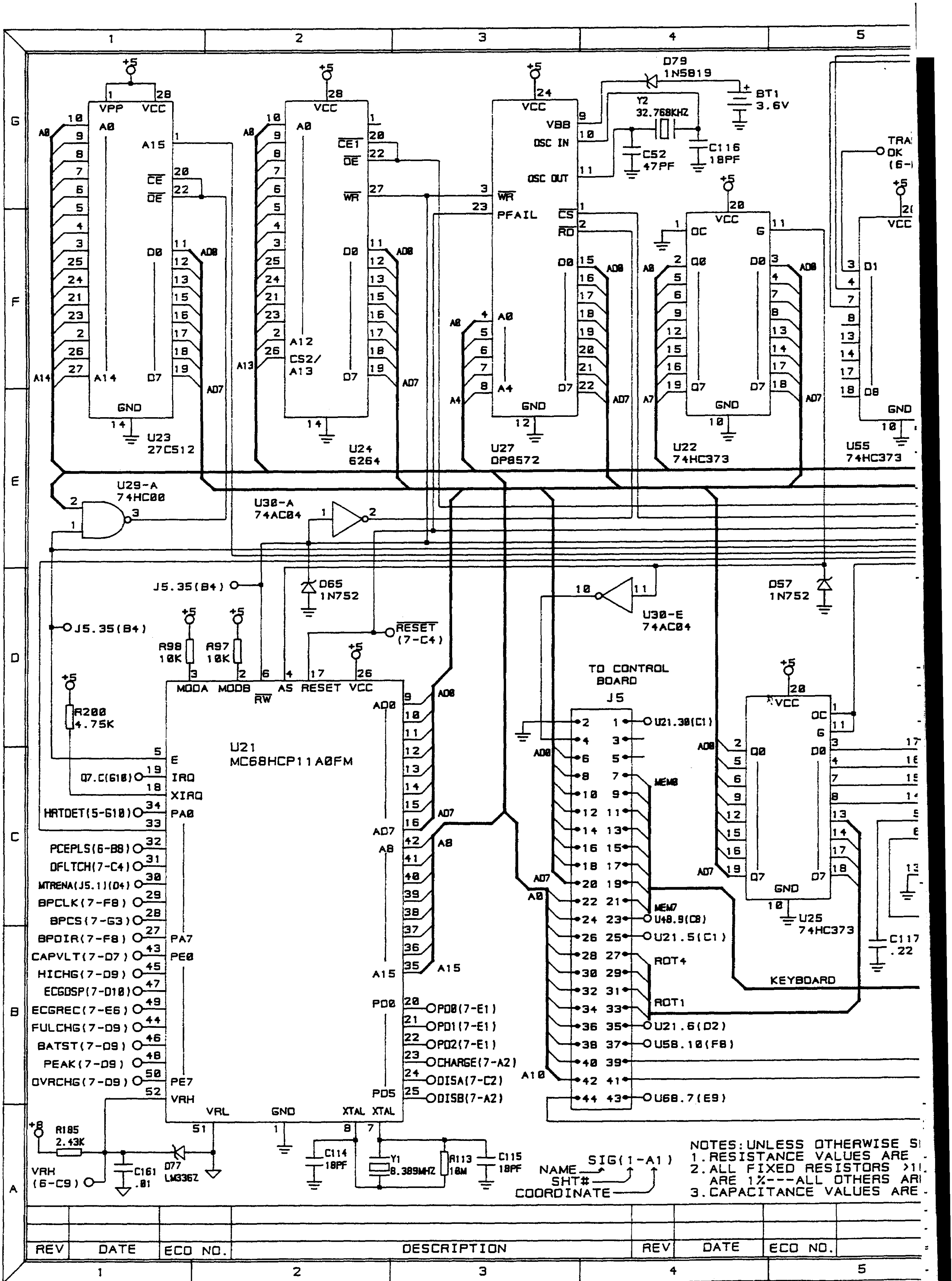
DRAWN	RAW 11-1-93
CHKED	RAW 11-23-93
APPED	[illegible] 11-23-93
DWG NO.	590017

BURDICK, INC. MILTON, WI

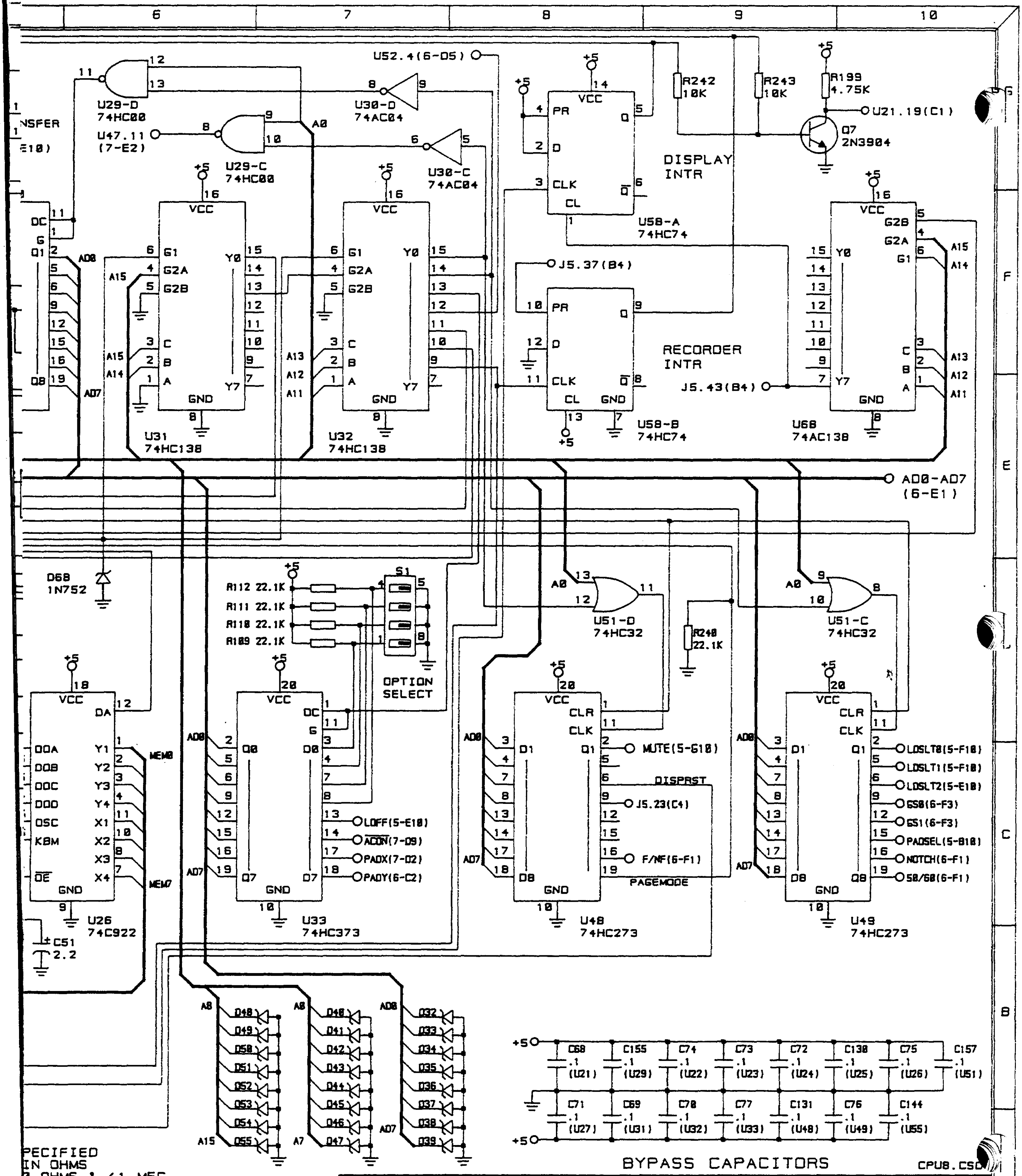
TITLE: PRE-AMP/CPU BD.

UNIT: MEDIC5

SHT 7 OF 11



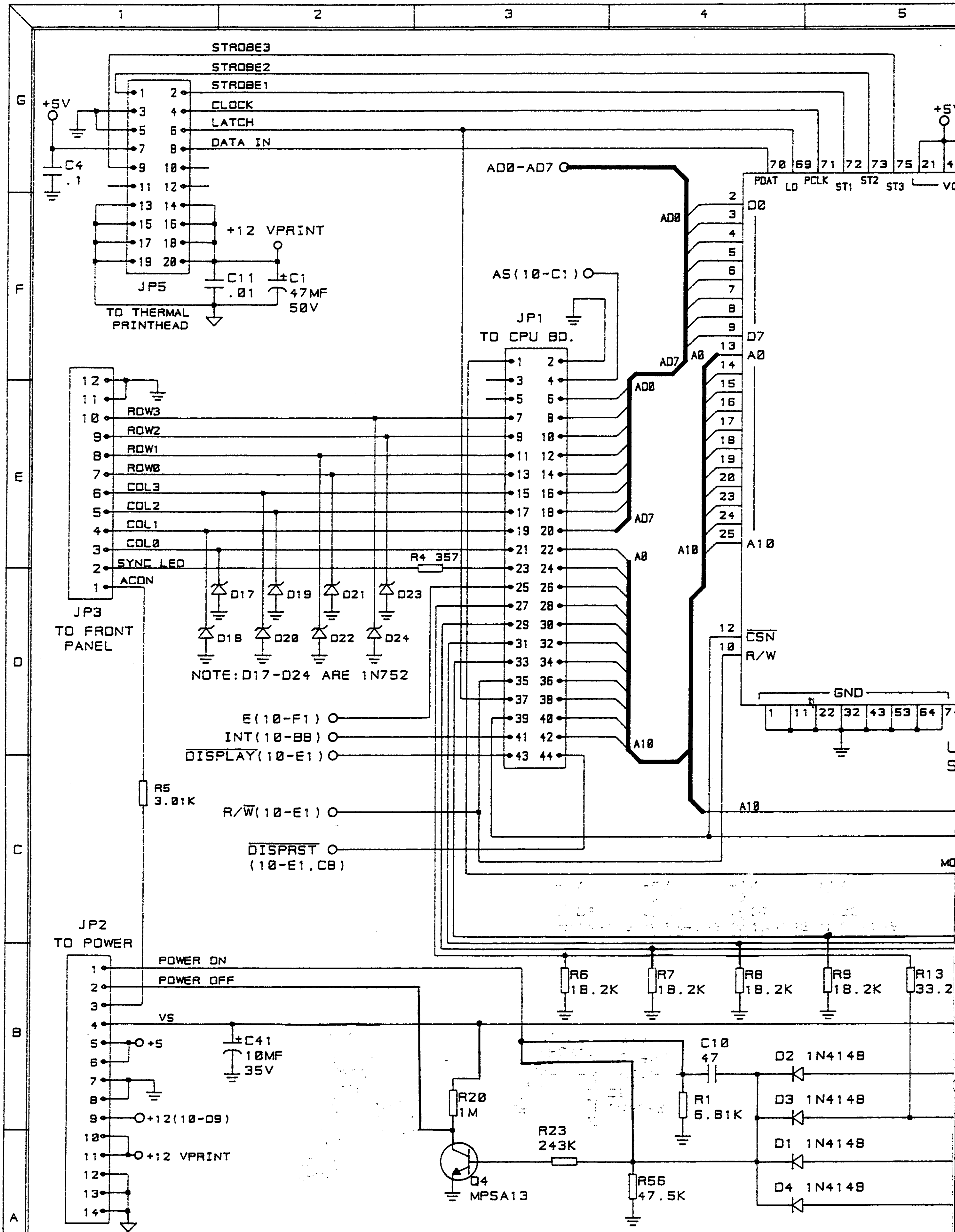
U23
27C512
U24
6264
U27
DP8572
U22
74HC373
U55
74HC373
U29-A
74HC00
U30-A
74AC04
U30-E
74AC04
D79
1N5819
BT1
3.6V
Y2
32.768KHZ
C52
47PF
C116
18PF
D65
1N752
D57
1N752
J5.35(B4)
RESET
(7-C4)
R98
10K
R97
10K
R200
4.75K
U21
MC68HCP11A0FM
TO CONTROL
BOARD
J5
U21.30(C1)
MEM0
MEM7
U48.9(C8)
U21.5(C1)
ROT4
ROT1
U21.6(D2)
U58.10(F8)
U68.7(E9)
KEYBOARD
U25
74HC373
C117
.22
Q7.C(G10)
HRTDET(5-G10)
PCEPLS(6-B8)
DFLTCH(7-C4)
MTRENA(J5.1)(D4)
BPCLK(7-F8)
BPCS(7-G3)
BPDIR(7-F8)
CAPVLT(7-D7)
HICHG(7-D9)
ECGDSP(7-D10)
ECGREC(7-E6)
FULCHG(7-D9)
BATST(7-D9)
PEAK(7-D9)
OVRCHG(7-D9)
PD0(7-E1)
PD1(7-E1)
PD2(7-E1)
CHARGE(7-A2)
DISA(7-C2)
DISB(7-A2)
R185
2.43K
VRH
(6-C9)
C161
.01
D77
LM336Z
C114
18PF
Y1
8.389MHZ
R113
10M
C115
18PF
NAME
SHT#
COORDINATE
SIG(1-A1)
NOTES: UNLESS OTHERWISE S
1. RESISTANCE VALUES ARE
2. ALL FIXED RESISTORS >1
ARE 1%---ALL OTHERS AR
3. CAPACITANCE VALUES ARE
REV
DATE
ECO NO.
DESCRIPTION



PECIFIED
IN OHMS
0 OHMS & <1 MEG
E 5%
IN MICROFARADS

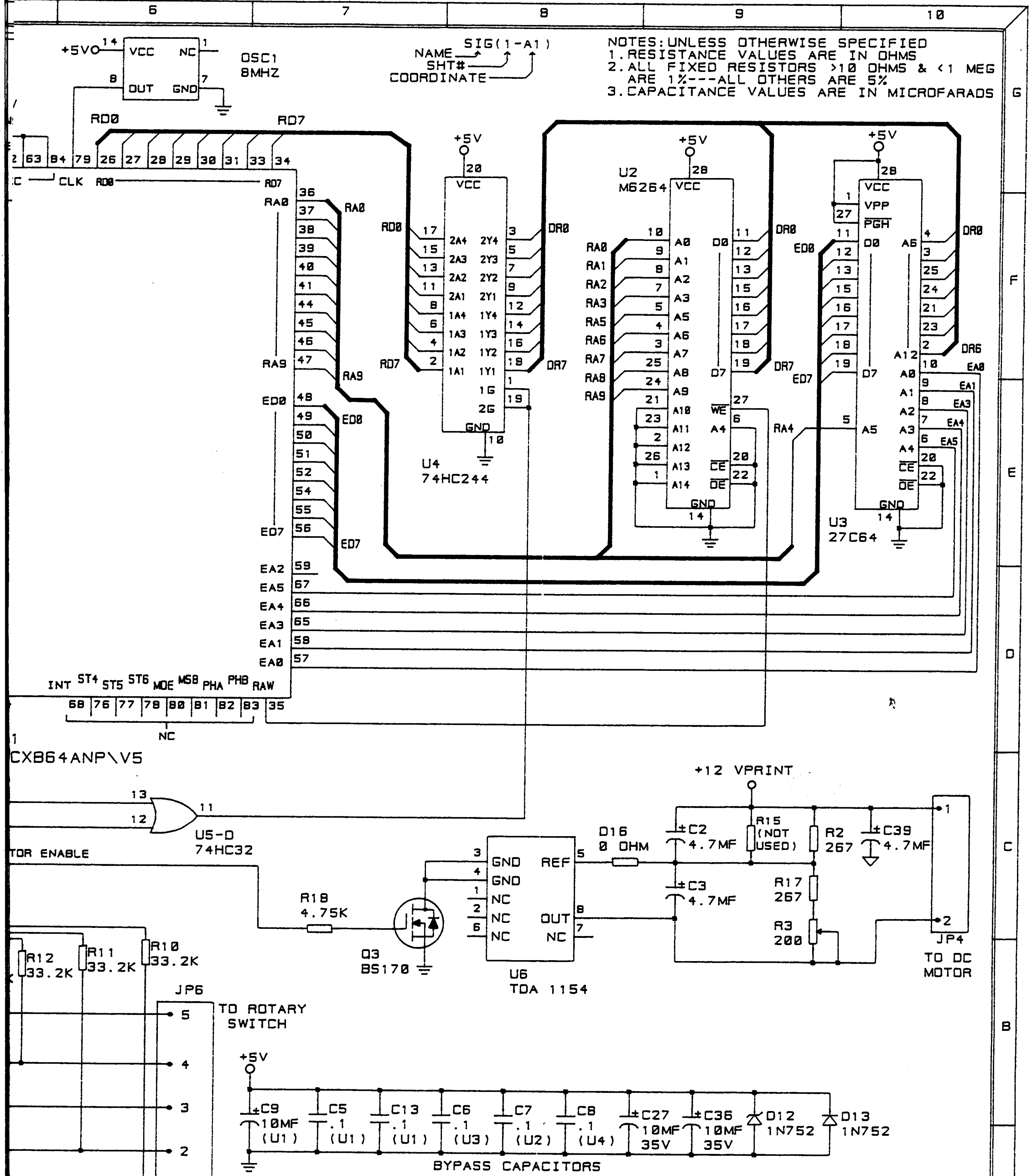
DESCRIPTION

DRAWN RAW 11-1-93	BURDICK, INC. MILTON, WI		
CHKED RAW 11-23-93	TITLE:	UNIT: MEDIC5	
APPED SAP 11-23-93			
DWG NO. 590017	PRE-AMP/CPU BD.	SHT 8	OF 11



REV	DATE	ECO NO.	DESCRIPTION	REV	DATE	ECO NO.
1	7-20-94	14313 RW.	REMOVED D5-D9, R16, R21, R22, Q1, Q5, REMOVE +50V FROM R20 & TIE TO VS LINE			

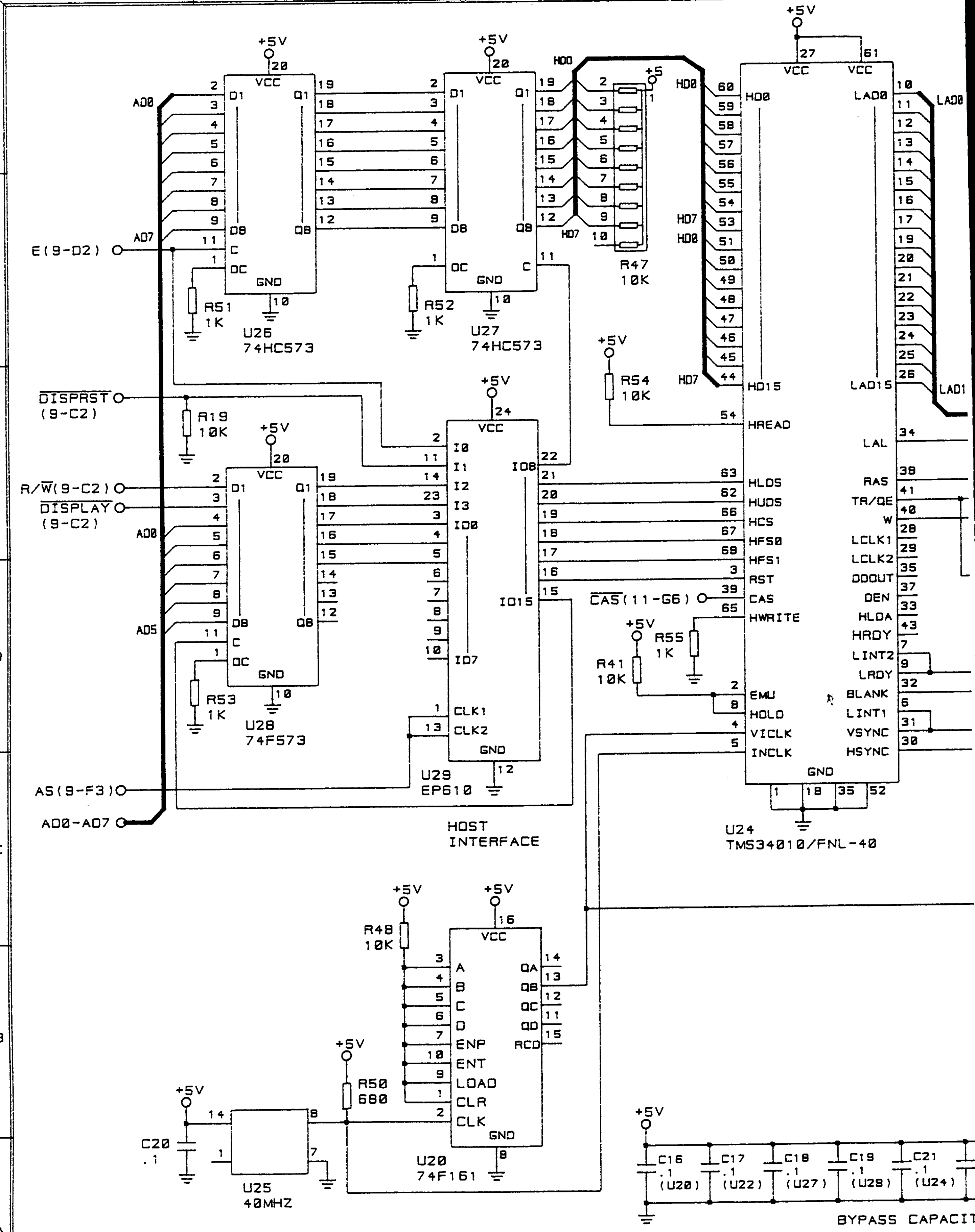
1 2 3 4 5



CONTRL9.CSD

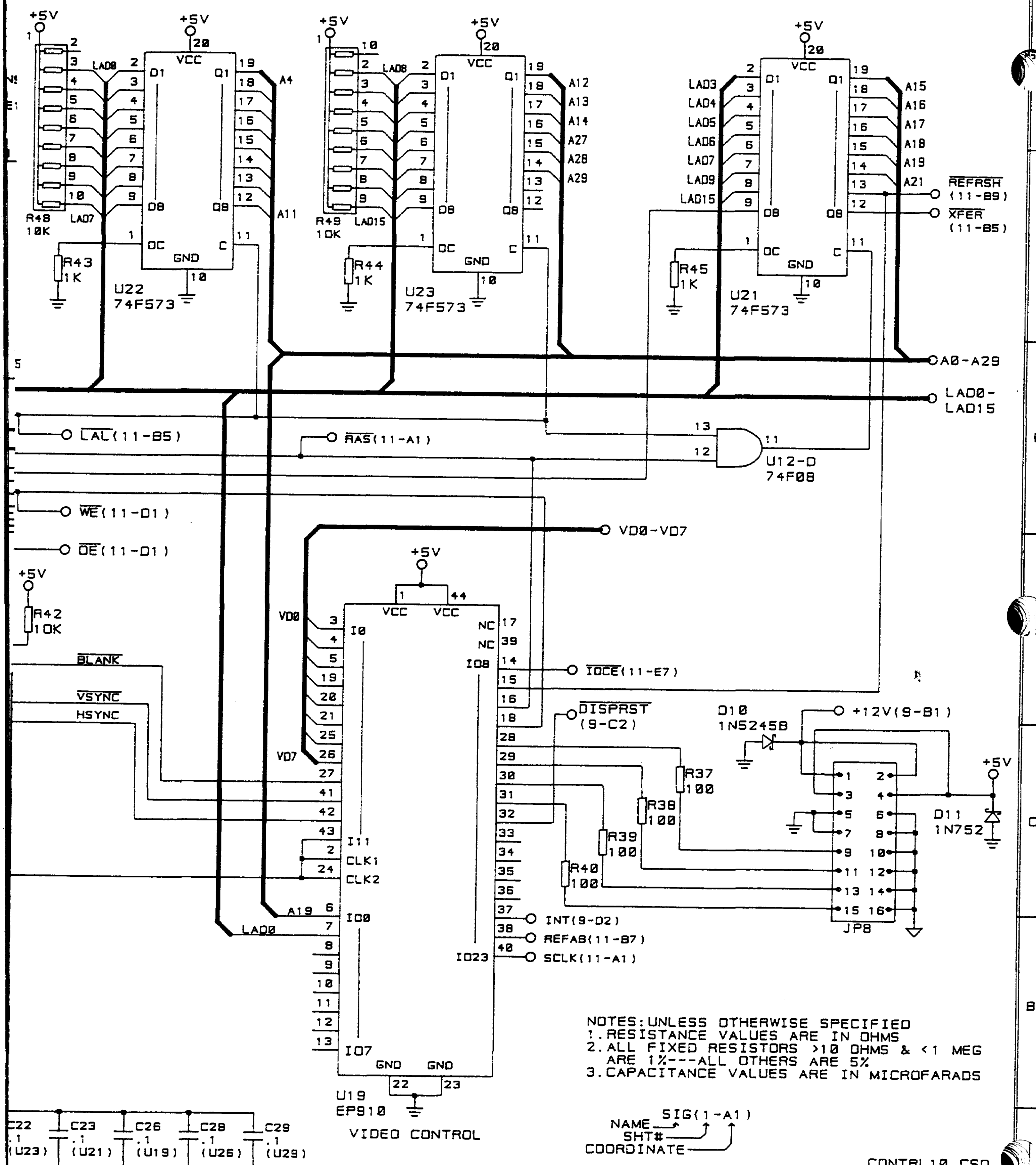
DRAWN RAW 11-1-93	BURDICK, INC. MILTON, WI
CHKED RAW 11-23-93	TITLE: CONTROL BD.
APPED [illegible] 11-23-93	UNIT: MEDICS
DWG NO. 590017	SHT 9 OF 11

DESCRIPTION



REV	DATE	ECO NO.	DESCRIPTION	REV	DATE	ECO NO.	

1 2 3 4 5

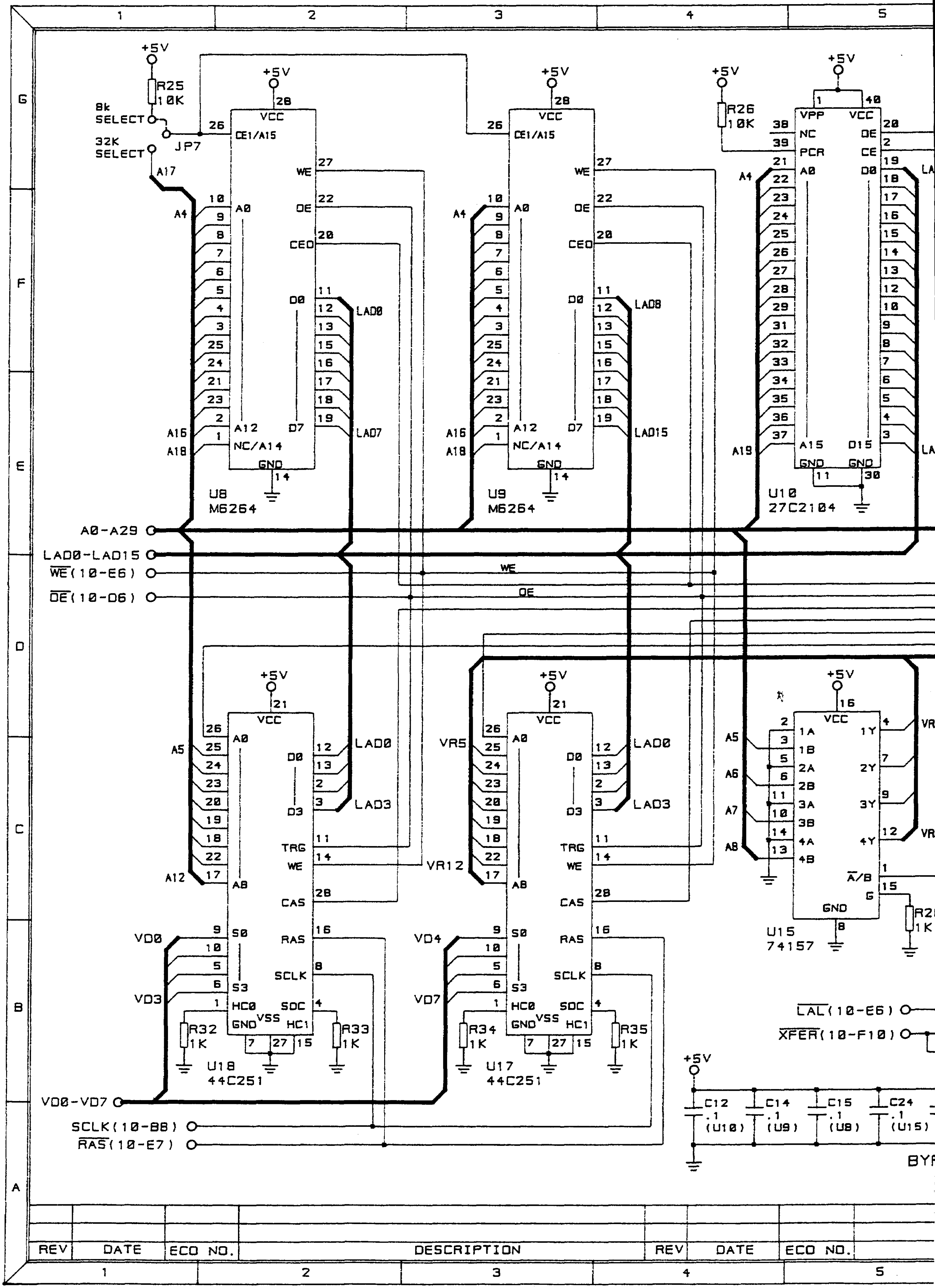


NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTANCE VALUES ARE IN OHMS
2. ALL FIXED RESISTORS >10 OHMS & <1 MEG ARE 1%---ALL OTHERS ARE 5%
3. CAPACITANCE VALUES ARE IN MICROFARADS

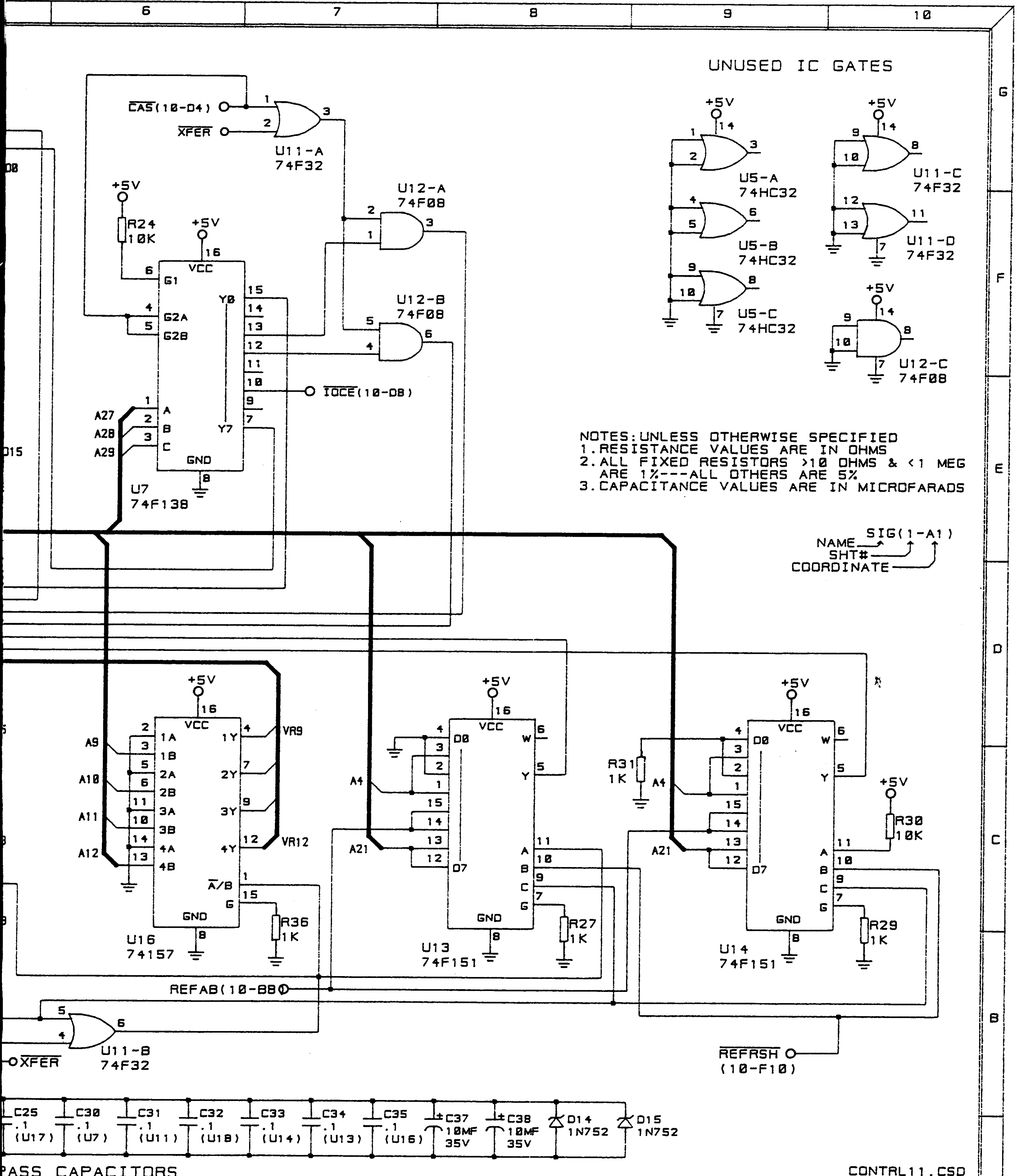
CONTRL10.CSD

DRAWN RAW 11-1-93	BURDICK, INC.		MILTON, WI
CHKED RAW 11-23-93	TITLE:		UNIT: MEDIC5
APPED [illegible] 11-23-93			
DWG NO. 590017	CONTROL BD.		SHT 10 OF 11

DESCRIPTION



+5V
R25
10K
8k SELECT
32K SELECT
JP7
A17
U8
M6264
U9
M6264
U10
27C2104
R26
10K
VCC
CE1/A15
WE
OE
CEO
A0
A12
NC/A14
D0
D7
GND
VPP
NC
PCR
CE
A15
D15
A4
A16
A18
A19
LAD0
LAD7
LAD8
LAD15
A0-A29
LAD0-LAD15
WE(10-E6)
OE(10-D6)
WE
OE
U18
44C251
U17
44C251
TRG
CAS
RAS
SCLK
SDC
S0
S3
HC0
HC1
VSS
D3
A8
A5
A12
VR5
VR12
LAD3
VD0
VD3
VD4
VD7
R32
1K
R33
1K
R34
1K
R35
1K
VD0-VD7
SCLK(10-B8)
RAS(10-E7)
U15
74157
1A
1B
2A
2B
3A
3B
4A
4B
1Y
2Y
3Y
4Y
A/B
G
A6
A7
LAL(10-E6)
XFER(10-F10)
C12
C14
C15
C24
.1
(U10)
(U9)
(U8)
(U15)
REV
DATE
ECO NO.
DESCRIPTION



CONTRL11.CSD

DRAWN RAW 11-1-93	BURDICK, INC.	MILTON, WI
CHKED RAW 11-23-93	TITLE:	UNIT: MEDIC5
APPED SAP 11-23-93	CONTROL BD.	
DWG NO. 590017		SHT 11 OF 11

DESCRIPTION

Service: (800) 333-7770 • Orders: (800) 777-1777

Burdick, Inc. 15 Plumb Street Milton, WI 53563 U.S.A. (608) 868-6000