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WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

400-SERIES
Medical Monitors

SYSTEM CALIBRATION
SERVICE

INSTRUCTION MANUAL

Tektronix, Inc.
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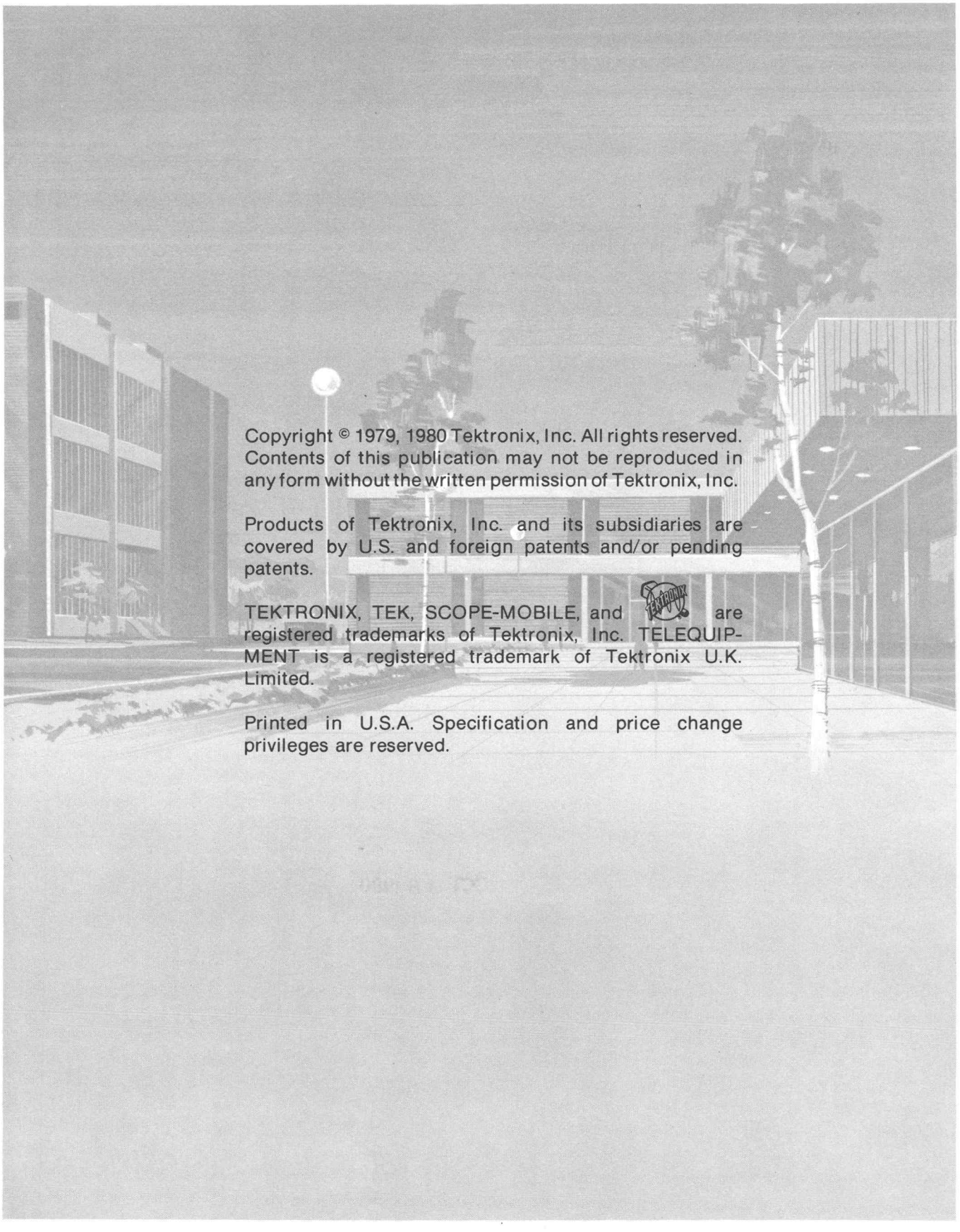

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GENERAL INFORMATION

THE MONITOR SYSTEM

A 413 or 414 Monitor is considered to be a system when mated to a Tektronix 400 Recorder, having the alpha-numeric printing feature, and/or to a 401 Digital Readout Module.

The following is a list of Monitor/Recorder/Digital Readout Module combinations that make full use of digital-readout capabilities.

Monitor	Recorder	Digital Readout Module
413	400 Option 4	401 Standard
414	400 Option 2	401 Option 1
414 Option 21	400 Option 3	401 Option 2

PURPOSE OF SYSTEM CALIBRATION

Each individual digital display in the monitor system is produced by a different digitizing circuit (DVM) monitoring a common analog bus P2400 in the monitor (see Fig. 1-1). Digital-display accuracy depends directly on accuracy of analog signals at P2400.

The individual units in the monitor system each have a different combination of buffering, multiplexing, and polarity switching. (See block diagrams of analog-to-digital conversion circuits at the back of this manual.) Because of this, errors can accumulate to cause individual digital displays to read different values for a given parameter, even though monitoring the same analog voltage. Excessive deviation can be confusing to the operator.

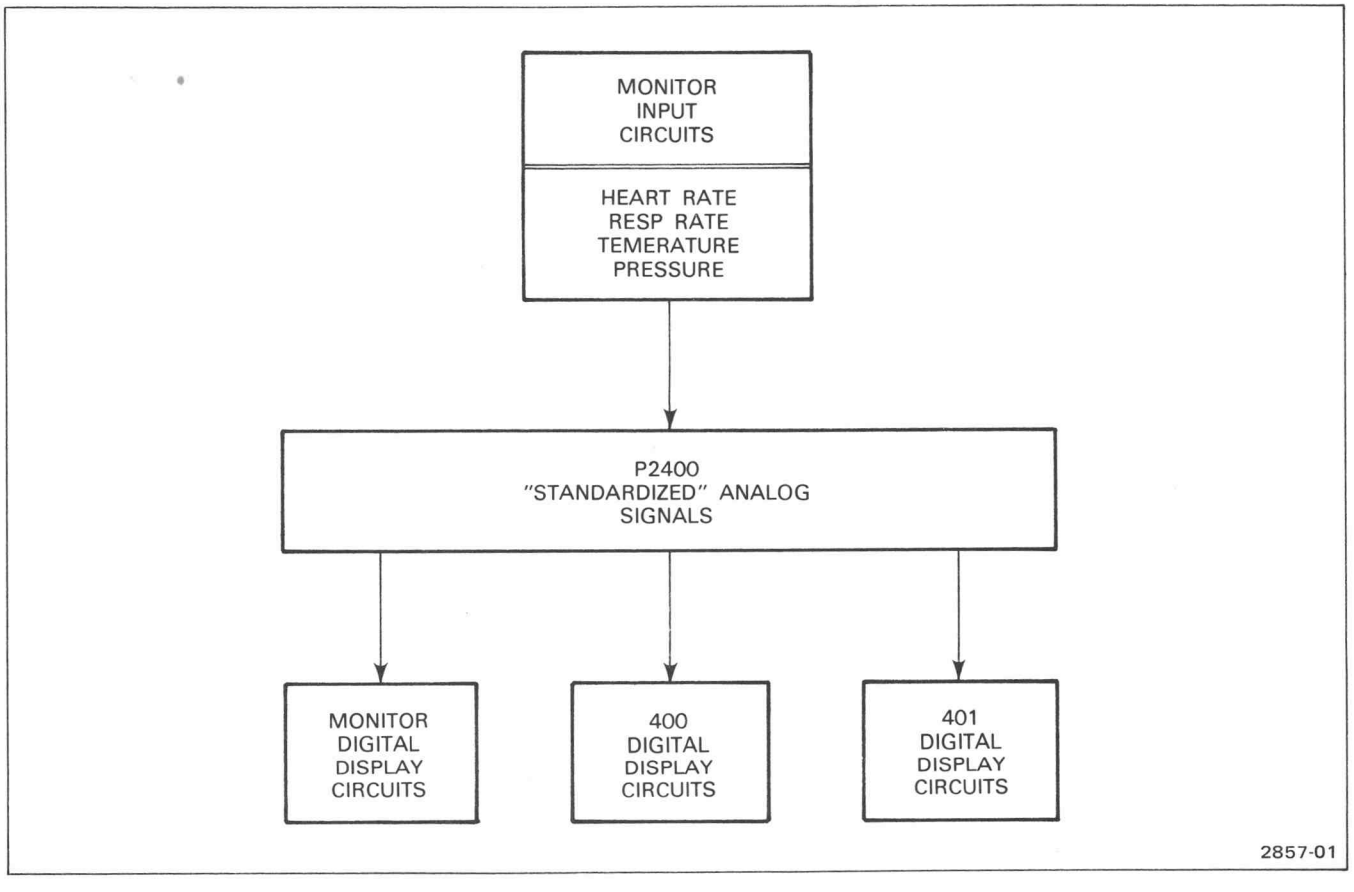

Figure 1-1. Digital-parameter signal flow diagram.

The intent of this document is to allow all instruments in the monitor system to be calibrated in such a way as to minimize the discrepencies between individual digital displays. First, analog voltages at P2400 are adjusted as closely as possible to represent 10 mV per unit of digital display. (For example, 500 mV equals 50.0 degrees F.) Next, all DVM's are adjusted to obtain the digital display values. Then, the 400 and/or 401 digital displays are checked for deviation from the monitor and each other.

Check ECG leakage after all other procedures are completed.

NOTE

DO NOT readjust analog voltages at P2400 to make the digital displays read correctly. P2400 must be the most accurate point in the system to produce the best digital-display correspondence.

Individual DVM's should be adjusted to the "standardized" analog voltages at P2400.

When checking digital display correspondence, only the 400 and/or 401 DVM adjustments may be touched up in certain cases, not the monitor DVM adjustments. No other method will provide consistent results.

DIGITAL DISPLAY SPECIFICATIONS

The electrical specifications in Table 1-1 apply to a monitor system when the following conditions are met: (1) The 401 Digital Readout Module or 400 Recorder must have been mated to an appropriate Tektronix monitor (refer to 400 and 401 Service Manuals), (2) The system must have been adjusted in an ambient temperature between +20 and +30 ° C (+68 and +86 ° F), (3) The system must be operating in an ambient temperature between +15 and +35 ° C.

TABLE 1-1

Digital-Display Electrical Characteristics

Characteristics	Performance Requirements	Information
DIGITAL DISPLAY		
PRESSURE		
Accuracy (413/414)	2% of reading or 3 mmHg whichever is greater, excluding transducer error and zero balance.	
Deviation of 400 or 401 Digital Displays	5 mmHg or less.	Typically 3mmHg or less.
HEART RATE		
Accuracy (413/414)	2% of reading or 3 bpm whichever is greater.	
Deviation of 400 or 401 Digital Displays	5 bpm or less.	Typically 3 bpm or less.
RESPIRATION RATE		
Accuracy (413)	2% of reading or 3 breaths/min whichever is greater.	
Deviation of 400 or 401 Digital Displays	5 breaths/min or less.	Typically 3 breaths/min or less.
TEMPERATURE		
Accuracy (with Yellow Springs Instrument Co. probe models 701 or 702)		
TA or TB	±0.3° or 0.5 ° F over a range of +5 to +45° C or +41 to +113° F.	
TA - TB	±0.6° C or ±1.0° F over a range of +5° C to +45° C or +41 to +113° F.	
Deviation of 400 or 401 Digital Display	0.5° (C or F) or less.	Typically 0.3° (C or F) or less.

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TEST EQUIPMENT REQUIRED

Table 1-2 lists the test equipment and accessories required to completely recalibrate the monitor system and check digital display correspondence.

The specifications given for the test equipment are the minimum necessary for accurate calibration. All test equipment should be correctly calibrated and operating within manufacturer's specifications. This is particularly important for the Test DVM.

SPECIAL TEST ACCESSORIES

The special test accessories required for adjustment can be readily constructed using common electronic components. Be sure to use components with at least the accuracy specified.

TABLE 1-2

Test Equipment

Description	Minimum Specifications	Usage	Examples of Applicable Test Equipment
1. Function Generator	Output, 0.5 Hz to 10 Hz Square wave; Amplitude, 1 to 3 V (offset 0 to +1 V).	414/413-Horiz Width, ECG Gain and Rate Cal Adjustments. Pacer signal rejection and ECG output checks. 400—Chart speed, and Pen amplifier gain, Damping and spike adjustments. 401—Heart Rate and Respiration DVM checks and adjustments.	TEKTRONIX FG501 Function Generator.[1]
2. Test Oscilloscope	Bandwidth, dc to at least 500 kHz; Minimum Vertical Deflection factor, 1 mV/div; Sweep rates, 10 μs/div to 200 ms/div.	414/413—Clock, ECG Gain and Input Offset Null adjustments, QRS Width and Rate Alarms. Respiration Null and Balance.	Any TEKTRONIX Oscilloscope.
3. Universal Counter	Measures periods and pulse length; Range is 800 μs; Frequency Range 1 Hz to 4 Hz; Accuracy within 1%.	413/414/401—Frequency Generator frequency verification. 400—Chart Speed, 1165 Hz Oscillator, Run Clock, Alphanumeric dot intensity adjustments.	TEKTRONIX DC503 Universal Counter.[1]
4. Digital Voltmeter (test DVM)	Accuracy, within 0.1% ±2 counts.	413/414—+5 volt, DVM, Temperature, Rate and pressure adjustments. Pressure/pulse output checks. 400—-11.9 V reference supply, Pen amplifier gain, Damping and Spike; DVM Sign Polarity, Full Scale Gain, and Zero Offset adjustments. 401—+5 volt adjustment.	TEKTRONIX DM501 Digital Multimeter.[1]

[1]Requires TM500 Power Module.

TABLE 1-2 (CONT.)

Test Equipment

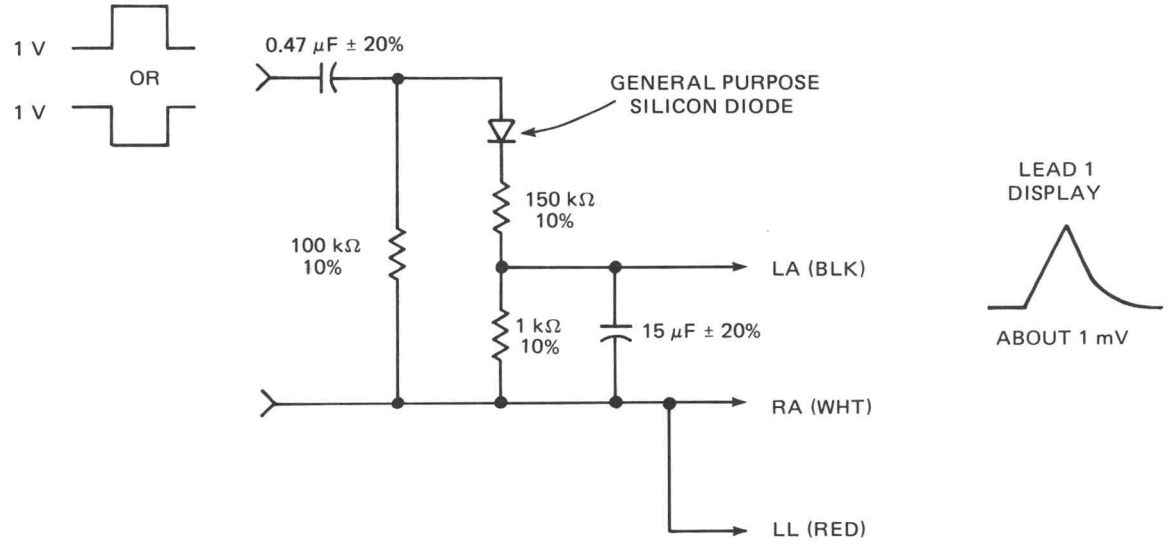
Description	Minimum Specifications	Usage	Examples of Applicable Test Equipment
5. Manometer[2]	Range 0 to 250 mmHg; Accuracy, within 1%.	413/414/401—Pressure adjustments and checks.	
6. Pressure Transducer[2]	Standardized to 50 μV/V/cmHg.	413/414/401—Pressure adjustments and checks.	
7. Pulse Sensor		413/414—Pulse checks.	TEKTRONIX pulse sensors: 015-0236-01 (finger) 015-0237-01 (radial)
8. Low-Pass Filter and Attenuator	Figure 1-2A.	413/414—Horiz Width, ECG Gain, and Rate Cal Adjustments. ECG output checks. 401—Heart Rate and Respiration Rate DVM adjustments.	
9. ECG Shorting Connector	Figure 1-2B.	413/414—Input Offset Null and Dc Level adjustments.	
10. Stereo Phone Plug	Figure 1-2C.	413/414—Dc Level and ECG Gain adjustments. Pressure/Pulse Output checks. Respiration checks and adjustments.	
11. Precision Attenuator	Figure 1-3A.	413/414—ECG Gain check.	
12. Pacer Input Circuit Adapter	Figure 1-3B	Pacer signal rejection checks.	
13. CMRR Test Fixture	Figure 1-3C.	CMRR checks.	
14. Substitution Plugs	Figure 1-4.	Temperature checks and adjustments.	
15. Respiration Test Fixture	Figure 1-5.	413—Respiration adjustments.	
16. Patient Cable		413—Respiration adjustments. 413/4414—ECG LEAD CHECK signal checks.	Use only TEKTRONIX Part 012-0739-00 for 413 respiration adjustments. Any TEKTRONIX Patient cable for ECG LEAD CHECKS.
17. Calibration Aid		400—To connect external signals.	TEKTRONIX Part 067-0851-00
18. Servicing Extender Set		413—To make Main board adjustments.	TEKTRONIX Part 020-0291-00
19. 10 Megohm Resistor		413/414/401—Respiration rate checks and adjustments.	
20. Safety Analyzer		ECG Leakage Checks.	Neurodyne-Dempsey Safety Analyzer, Model 431.

[2]Use two for 414 Option 21.

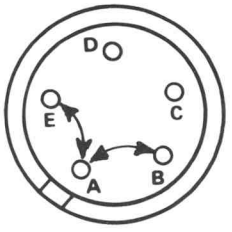
[3]Neurodyne-Dempsey Inc., P. O. Box 1925, Carson City Nevada 89701.

A. LOW-PASS FILTER AND ATTENUATOR

THE VALUES WERE SELECTED TO DETERIORATE PULSE RISETIME, PERMITTING THE QRS DETECTOR AND TRIGGER TO FUNCTION AND TO PROVIDE A SINGLE POSITIVE PULSE DISPLAY FOR EACH SQUARE WAVE.



B. ECG SHORTING CONNECTOR



MS3102A-14S-5P
BACK OF PLUG

C. STEREO PHONE PLUG

A STEREO PHONE PLUG WITH ITS COVER REMOVED MAKES A CONVENIENT TEST POINT FOR OBTAINING OUTPUT SIGNAL.

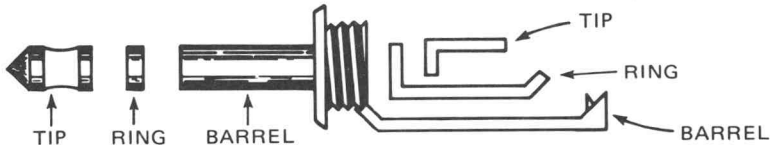


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Figure 1-2. Wiring details for low-pass filter and attenuator, ECG shorting connector, and stereo phone plug test fixture.

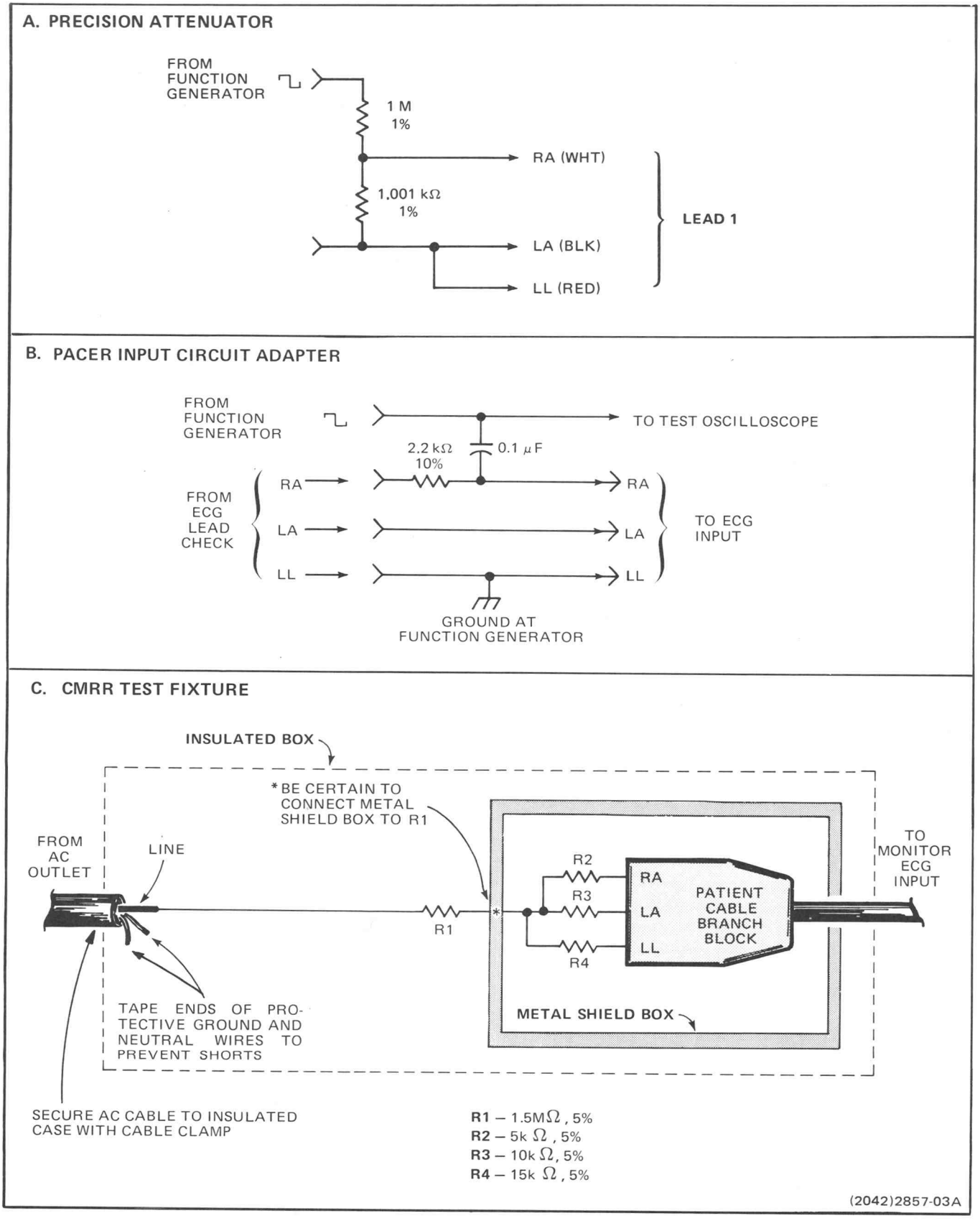

Figure 1-3. Wiring details for the precision attenuator pacer input circuit adapter, and CMRR test fixture.

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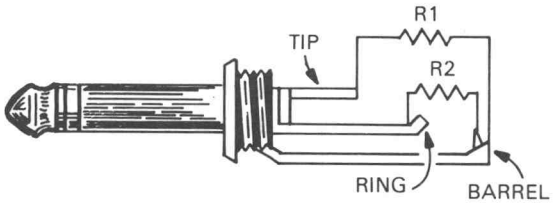

NOTES:

1. RESISTORS USED FOR THESE PLUGS SHOULD HAVE VALUES WITHIN 0.1% AND HAVE LOW TEMPERATURE COEFFICIENTS.
2. ANY SERIES OR PARALLEL COMBINATION OF QUALITY RESISTORS CAN BE USED TO PRODUCE VALUES OF R1 AND R2.
3. 98.6°F/37°C IS NOT NEEDED FOR ADJUSTMENT PROCEDURE; IT IS GIVEN FOR REFERENCE ONLY.
4. 23°F/−5°C RANGE CHECKED IN 400 RECORDER ONLY.

°F	°C	R1(Ω)	TEKTRONIX Part Number	R2(Ω)	TEKTRONIX Part Number
23	−5	25.40 K	321-1690-07	122.1 K	321-1692-07
41	5	15.24 K	321-1688-07	74.44 K	321-1691-07
77	25	6000	321-1696-07	30.00 K	321-0685-07
113	45	2620	321-1694-07	13.28 K	321-1687-07
98.6	37	3610	NONE	18.21 K	NONE

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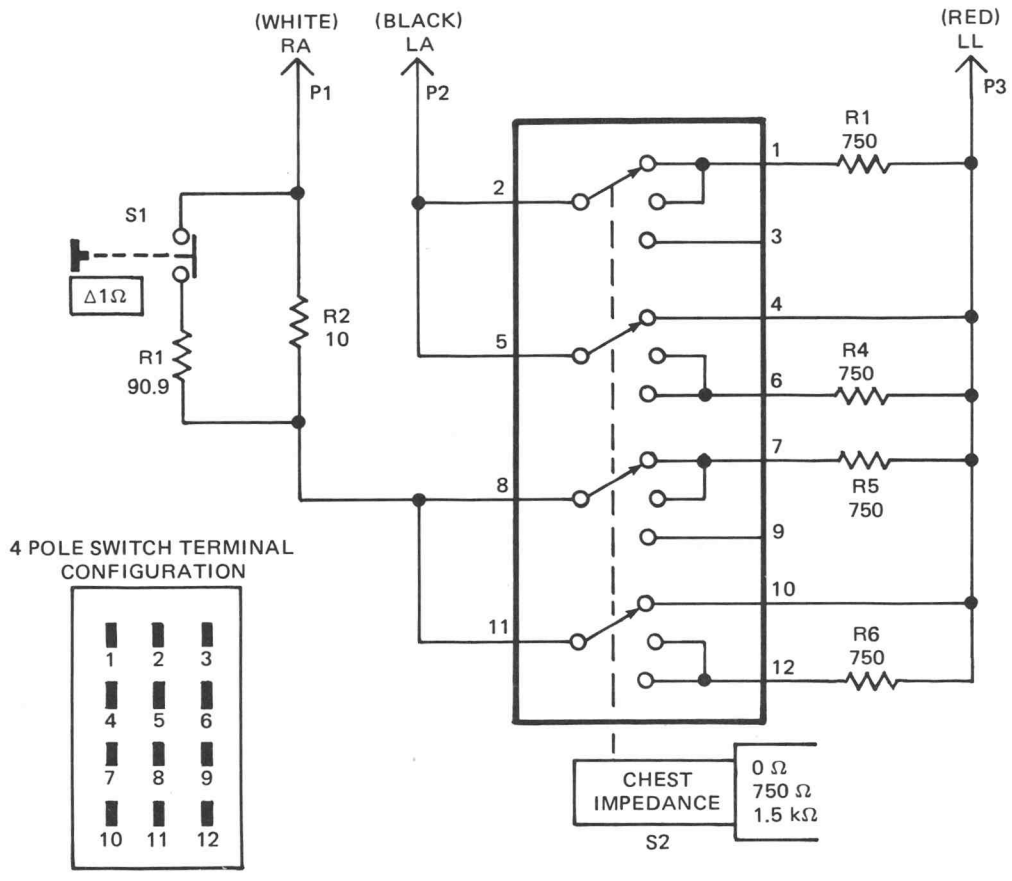
Figure 1-4. Temperature sensor Simulation Plugs.



		SUGGESTED TEKTRONIX PART NO.
P1, P2, P3	FEED THRU TERMINAL (FOR ELECTRODE WIRE SNAP CONNECTORS)	(3) 131-1371-00
	BUSHING, INSULATOR (ATTACHING PARTS FOR TERMINALS)	(3) 358-0176-00
R2	RESISTOR MF 10 Ω, 1%, 1/4 W	321-0001-00
R1	RESISTOR 90.9 Ω, 1%, 1/4 W	321-0093-00
R3, R4, R5, R6	RESISTOR MF 750 Ω, 1%, 1/4 W	(4) 321-0181-00
S1	SWITCH, SP, MOMENTARY NORMALLY CLOSED	260-1285-00
S2	SWITCH, 4 POLE	260-1447-00

(2277)2857-05

Figure 1-5. Respiration test fixture.

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USING PROCEDURES

A complete calibration procedure is provided for each unit in the system, plus a digital-display correspondence check procedure and an ECG Leakage Check Procedure.

Calibrate each unit in the monitor system, in order, using the System Calibration Procedures. Then check digital-display correspondence using the Digital-Display Correspondence Check Procedure.

If the units in the monitor system have recently been calibrated according to the System Calibration Procedures, you can use the Correspondence Check Procedure to check for excessive digital-display deviation. Minor adjustments to 400 and/or 401 DVM's can be made in some cases to minimize digital display deviation.

DISASSEMBLY FOR CALIBRATION

CAUTION

Static discharge can damage components. See Recommended Handling Rules on page 1-10.

1. Turn monitor power off and unplug ac power cord.

2. Remove cabinet covers.

   a. Remove four cover-mounting screws from each side of the instrument.

   b. Pull bottom cover straight away from instrument.

   c. Lift left side of top cover to permit right side to clear ECG LEAD CHECK terminals.

3. Remove 401 Digital Readout Module (when present).

   a. Rotate slotted fastener, at rear of 401 chassis, 90 degrees counterclockwise to release rear of 401 from monitor.

   b. Lift rear of 401 and slide it backwards to free it from monitor.

   c. Remove battery plugs P4040, P4050, P4060, and P4010. See Figure 1-6.

NOTE

Monitor will not operate on battery with P4040 and P4050 disconnected.

   d. Disconnect green-yellow protective-ground wire from 401 chassis. Remove nut holding solder lug to chassis. Do not unsolder green-yellow wire from solder lug.

   e. Set 401 aside and calibrate monitor first.

4. Remove 400 Recorder (when present).

   a. Separate recorder and monitor by removing screws from monitor side of adapter plates. Remove adapter plates.

   b. Lift monitor off recorder.

   c. Disconnect interconnecting plug from recorder.

   d. Disconnect recorder battery plug from side of monitor battery pack.

   e. Set 400 recorder module aside and calibrate monitor first.

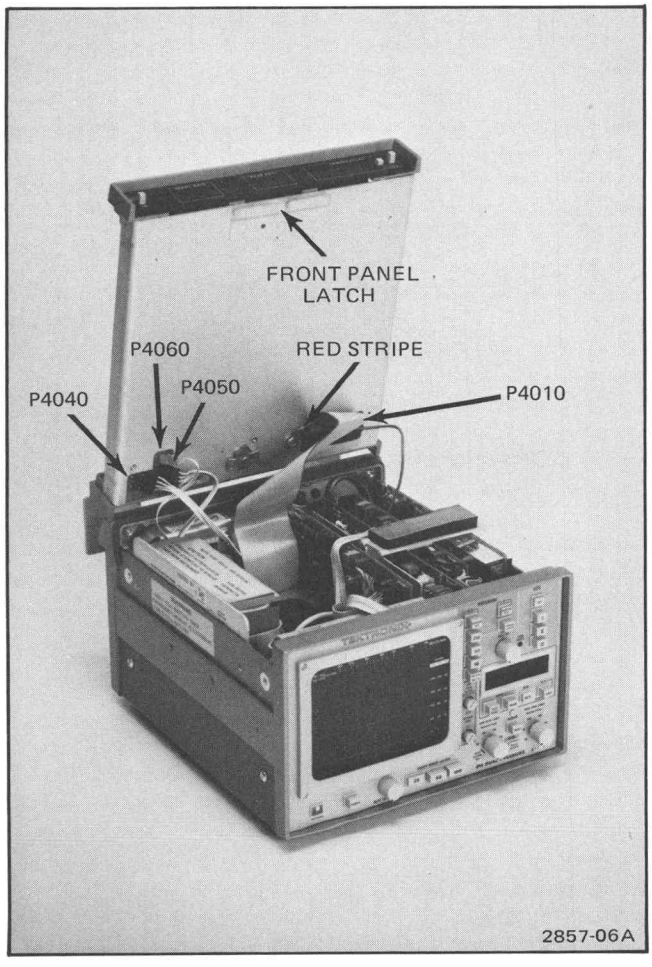

Figure 1-6. Digital Readout Module removal and replacement.

CAUTION
STATIC ELECTRICITY DISCHARGE
CAN DAMAGE COMPONENTS

FACT: BOTH **MOS** AND **BIPOLAR** INTEGRATED CIRCUITS CAN BE DAMAGED BY DISCHARGE OF STATIC ELECTRICITY.

FACT: BOTH **DIGITAL** AND **LINEAR** I.C.'S CAN BE DAMAGED.

FACT: I.C.'S CAN BE DAMAGED WHEN THEY ARE **IN THE CIRCUIT** AS WELL AS WHEN THEY ARE NOT.

FACT: DAMAGE MAY **NOT** BE **APPARENT FOR SEVERAL MONTHS.**

RECOMMENDED HANDLING RULES

STORING AND TRANSPORTING

Don't *remove semiconductors or boards containing semiconductors from original antistatic container until needed.*

Don't *place semiconductors or boards containing semiconductors on or in plastic containers, styrofoam or other nonconductive material. Use material specifically treated for antistatic qualities.*

INSTALLING

Do *discharge static charge from your body. Connect yourself to ground through 100 kΩ while handling circuits or semiconductors.*

Do *use grounded soldering iron and test equipment.*

Do *turn the instrument power off before removing or inserting semiconductors.*

Do *use a grounded conductive bench top when working on boards or instruments containing semiconductors. If not available, use uncoated cardboard as a substitute.*

Don't *slide semiconductors or boards containing semiconductors across any surface.*

Don't *touch semiconductor leads unless necessary.*

413 CALIBRATION PROCEDURE

PRELIMINARY PROCEDURE

1. Check operation of all modes and correct any defects before attempting to adjust the monitor.

2. To gain access to Mainboard adjustments, remove Conditioner board and add extender board and cables (from Servicing Extender Set, Tektronix Part 020-0291-00) to P1100, P1145, P1402, and P1462.

Remove Conditioner board as follows:

a. Unplug 3 cables from board (at P1145, P1402, P1462).

b. If monitor had 400 or 401 installed, remove interconnecting cable from conditioner board.

c. If 401 was attached, unsolder white-orange wire from R1447 as shown in Figure 2-1.

d. Remove 2 screws and threaded hex post holding Conditioner board to Main board.

e. Unplug pins (P1101) from 60-pin interface connector (P1100). Use a small screwdriver and pry between side rail and edge of board. Pry a little at a time along the length of connector until the pins are released from the plug.

3. Set monitor controls as follows:

ON ..... In (on)
DISPLAY OFF (Resp) ..... In (off)
DISPLAY OFF (Press/Pulse) ..... In (off)
OFF (ECG) ..... In (off)
LOW RATE LIMIT .....RATE ALARM OFF (ccw)
SWEEP SPEED mm/SEC 100 ..... In
BEAT LOUDNESS ..... Midrange

DO NOT PRESET INTERNAL CONTROLS

4. Set the remaining controls as desired.

5. Connect the monitor to the correct ac-line source.

6. Allow monitor to warm up for about 20 minutes before making adjustments.

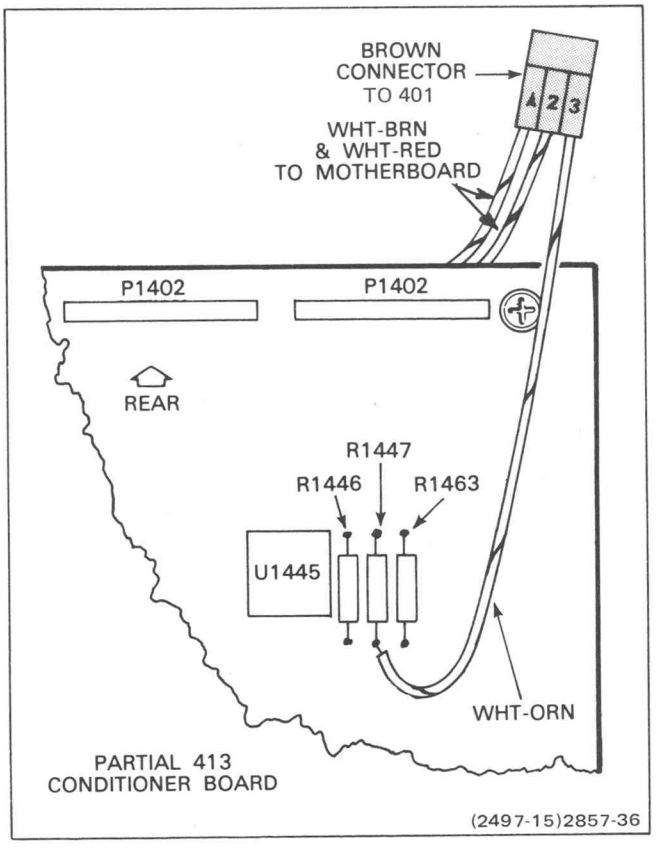

Figure 2-1. Location of white-orange wire between 413 and 401.

A. POWER SUPPLY AND CRT DISPLAY

Equipment Required

1. Digital voltmeter (test DVM)
2. Function generator
3. Low-pass filter (Fig. 1-2A)
4. Test oscilloscope

For adjustments and test points, see 413 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

A1. +5 VOLTS

a. Connect test DVM leads to Main board between ground (ground lug inside of rear panel) and +5 V (TP1994 Main board).

b. **CHECK**–Supply voltage should be +5 V, within 25 mV.

NOTE

Do not readjust +5 V supply if it is within 25 mV unless a complete recalibration is intended.

c. **ADJUST**–+5 V (R1990, Main board) for +5 V at TP1994.

d. Remove test DVM leads.

A2. CLOCK

a. Connect counter input to TP1623 on Main board. Display 2 kHz square wave.

b. **CHECK**–Frequency of square-wave signal at TP1623 is 2 kHz.

c. **ADJUST**—Clock (R1610) so that square-wave frequency is 2 kHz.

A3. TRACE ROTATION

a. **CHECK**–Trace should be parallel with graticule lines.

WARNING

To avoid electric shock, be careful when making yoke adjustments. There is + and -35 V at the yoke, +175 V in the crt socket, and +3400 V on the crt anode.

b. Loosen yoke clamp (Fig. 2-2).

c. **ROTATE**—Yoke for non-tilted trace. Keep yoke forward as far as possible.

d. Tighten yoke clamp.

e. Recheck trace to ensure yoke was not moved when yoke clamp was tightened.

NOTE

Due to effects of earth's magnetic field, monitor should be placed in normal operating position when performing steps A4 and A5. Monitor will have to be supported above bench to make adjustments.

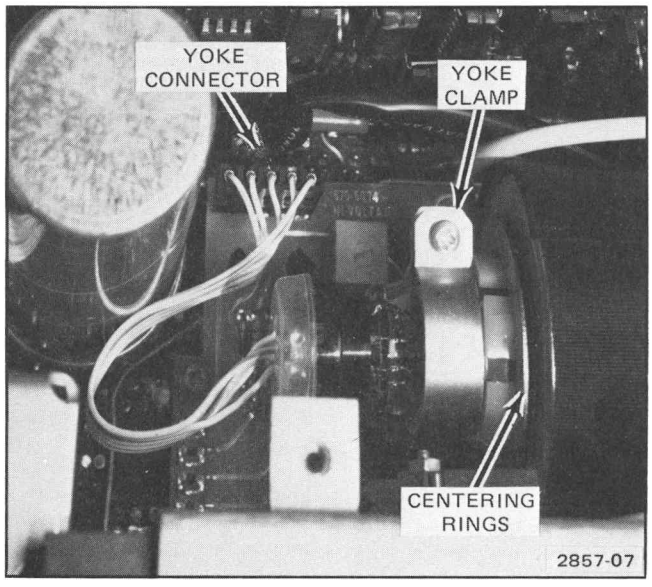

Figure 2-2. Yoke clamp, yoke connector (P1690), and centering rings.

A4. SPOT CENTERING AND FOCUS

a. Set ON button out (off) and disconnect yoke plug, P1690 (Fig 2-2). Set ON button in (on).

b. **CHECK**–Spot should be centered on the graticule, within (approximately) 2 mm. Graticule center is at intersection of 75 mmHg line and straight edge centered diagonally across graticule.

c. **ADJUST**–Centering Rings for centered spot. Refer to Fig. 2-2.

d. **CHECK**–Spot should be finely focused.

e. **ADJUST**–Focus (R2140, High-Voltage board) for smallest possible round spot.

f. Set ON button out (off) and reconnect yoke plug. Be sure to match arrow on Main board. Set ON button in (on).

A5. HORIZONTAL WIDTH AND POSITION

a. Set:

ECG I ..... In
ECG SIZE ..... CW
SWEEP SPEED mm/SEC 100 ..... In

b. Connect function generator square wave through low-pass filter (Fig. 1-2A) to ECG INPUT connector. Set generator to display approximately 4 cm at 4 Hz (verify with counter). Monitor should produce beat tone and triggered display. Adjust BEAT LOUDNESS control as desired.

NOTE

The position of the trace at approximately 38 to 40 bpm is relatively unaffected by the Horiz Width control. For this reason it works best to adjust the fourth pulse to the 40 bpm mark with the Horiz Position, then to adjust the second pulse to the 120 bpm mark. One repetition of the above is usually enough to get both pulses right on.

View perpendicularly to graticule at each pulse to eliminate parallax.

c. **ADJUST**–Horizontal Position (R1835) until rising edge of fourth pulse coincides with 40 bpm graticule mark. See Figure 2-3.

d. **ADJUST**–Horizontal Width (R1845) until rising edge of second pulse coincides with 120 bpm graticule mark. See Fig. 2-3.

e. **INTERACTION**-Repeat parts c an d.

f. **CHECK**–Rising edge of third pulse coincides with 60 bpm graticule mark.

g. Set 413 SWEEP SPEED mm/SEC 50 button in.

h. Set function generator frequency (about 2 Hz) so that rising edges of second and fourth pulses coincide respectively with 120 and 40 bpm graticule marks.

i. **CHECK**–Rising edge of third pulse coincides with 60 bpm graticule mark, within 2 mm.

j. **CHECK**–Function generator frequency (verified with universal counter) is 2.00 Hz, within 0.06 Hz.

k. Set 413 SWEEP SPEED mm/SEC 25 in.

l. Set function generator frequency to 2.5 Hz (verify with counter). Set output for about 1 cm display.

m. **CHECK**–9 to 11 pulses are displayed.

n. Set function generator frequency to 1.25 Hz (verify with counter).

o. Set 413 SWEEP SPEED mm/SEC 12.5 in. Set output for about 1 cm display.

p. **CHECK**–9 to 11 pulses are displayed.

q. Turn off function generator.

r. **CHECK**–Trace starts at left end of graticule line, within 2 mm.

s. Disconnect function generator and low-pass filter.

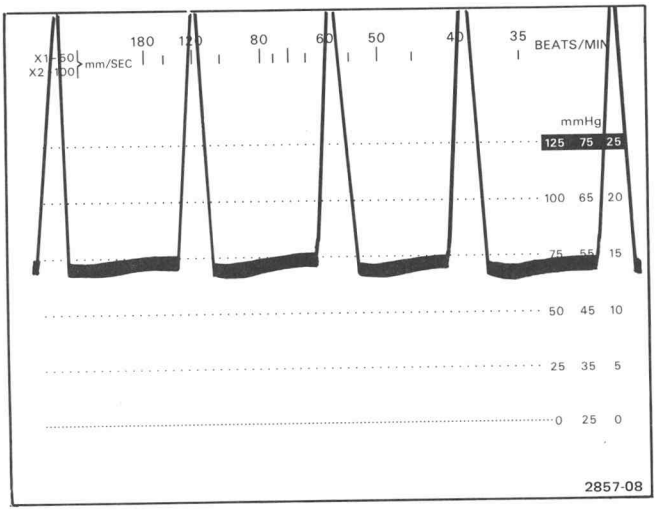

Figure 2-3. Adjusting Horizontal Width and Position.

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B. ECG

Equipment Required:

1. Patient cable (Tektronix Part 012-0739-00)
2. ECG Shorting Connector (Fig. 1-2B)
3. Test oscilloscope
4. Function generator
5. Stereo phone plug (Fig. 1-2C)
6. CMRR test fixture (Fig. 1-3C)
7. Precision attenuator (Fig. 1-3A)
8. Pacer input circuit adapter (Fig. 1-3B)

For adjustments and test points, see 413 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

B1. INPUT OFFSET NULL

a. Set:

DISPLAY OFF (Resp) ..... In (off)
DISPLAY OFF (Press/Pulse) ..... In (off)
ECG I ..... In

b. Connect ECG shorting connector (See Fig. 1-2B) to ECG INPUT connector.

c. **CHECK**—Voltage level at TP183 (ECG board) should be 0.0 V, within 200 mV. Use test oscilloscope.

d. **ADJUST**—Input Offset Null (R180, ECG board) for 0.0 V.

B2. DC LEVEL

a. Insert stereo phone plug (Fig. 1-2C) into ECG/RATE OUTPUT connector.

b. **CHECK**—ECG/RATE OUTPUT (TIP) should be 0.0 V, within 25 mV. Use test oscilloscope.

c. **ADJUST**—DC Level (R200, ECG board) for 0.0 V.

d. **CHECK**—Trace is vertically centered at 75 mmHg line, within 3 mm.

e. Remove ECG shorting plug

B3. ECG OUTPUT GAIN

a. Connect function generator to test oscilloscope and through precision attenuator (See Fig. 1-3A) to ECG INPUT connector (via patient cable). Apply 1.0 V, 10 Hz sine wave. Note reference amplitude on test oscilloscope, then connect test oscilloscope to ECG OUTPUT (TIP).

b. **CHECK**—ECG/RATE OUTPUT (TIP) should be equal to reference amplitude, noted in part a.

c. **ADJUST**—Gain (R195, ECG board) for output equal to reference amplitude.

d. Disconnect test oscilloscope, function generator, stereo phone Plug, and precision attenuator.

B4. ECG LEAD CHECK SIGNAL

a. Connect ECG LEAD CHECK signal to ECG INPUT connector through patient cable. Leads connect front to back as follows: LL (red) LA (black), RA (white).

b. **CHECK**—Positive-going pulses should be approximately 100 bpm (not critical).

c. Set ECG SIZE to index mark (20 mm/mV).

d. **CHECK**—Approximate pulse amplitude for each of the three ECG lead configurations is as follows: I, 2 cm; II, 3 cm; III, 1 cm.

e. **CHECK**—QRS indicator lights with each beat.

B5. LEAD FAULT OPERATION

a. **CHECK**—LEAD FAULT lamp lights when any ECG lead is removed from an ECG LEAD CHECK terminal.

b. Reconnect lead to ECG LEAD CHECK terminal.

B6. QRS TIMING

a. Connect test oscilloscope channel 1 input to TP360 (ECG board) and channel 2 input to TP371. Set oscilloscope vertical mode to chop and sweep speed to 10 ms/div X10. Trigger on channel 1, positive slope.

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b. **CHECK**—Interval to first positive-going edge at TP360 is 5 ms, ±1 ms (see Fig. 2-4).

B7. QRS WIDTH

a. Set test oscilloscope vertical mode to channel 2 and sweep speed to 50 ms/div X1. Trigger oscilloscope on channel 2, + slope.

b. **CHECK**—Pulse duration at TP371 (ECG board) is 150 ms, ±25 ms (see Fig. 2-5).

c. Disconnect test oscilloscope.

B8. PACER SIGNAL REJECTION

a. Connect pacer input circuit adapter and function generator as shown in Fig. 1-3B.

b. Set function generator output for approximately 500 mV, 1 Hz square wave.

c. Set monitor ECG I button in.

d. **CHECK**—QRS detector (triggers beat tone) should respond only to ECG LEAD CHECK signal and not to simulated pacer signal. When pacer signal coincides with leading edge of ECG LEAD CHECK signal, QRS selection should occur at trailing edge.

e. Disconnect function generator and pacer input circuit adapter.

B9. ECG CMRR CHECK

a. Connect CMRR test fixture (Fig. 1-3C) to ECG INPUT connector. Then connect test circuit to ac-power line.

b. Set ECG SIZE control to midrange mark (20 mm/mV).

c. Set ECG I button in.

d. **CHECK**—Monitor display amplitude should be less than 1.3 cm p-p for nominal 115 V lines (or less than 2.6 cm, p-p for nominal 230 V lines, if the lines are unbalanced).

e. Set ECG III in.

f. Repeat part d.

g. Set ECG II in.

h. **CHECK**—Monitor display amplitude should be less than 1.9 cm p-p for nominal 115 V lines (or less than 3.8 cm, p-p for nominal 230 V lines, if the lines are unbalanced).

i. Disconnect CMRR test fixture.

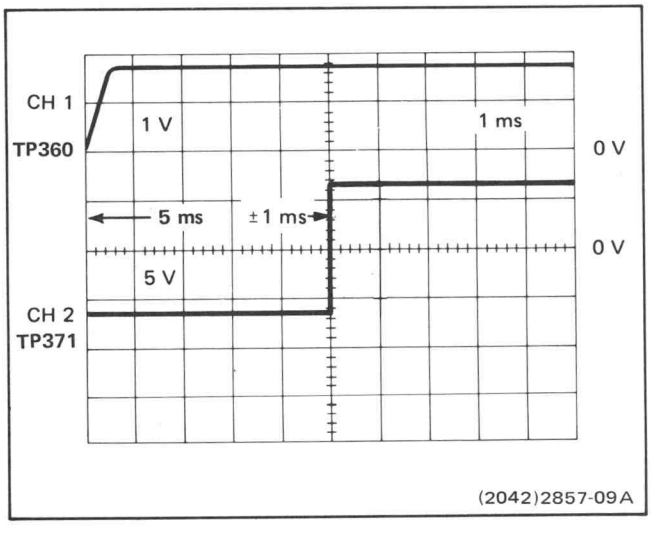

Figure 2-4. QRS Timing.

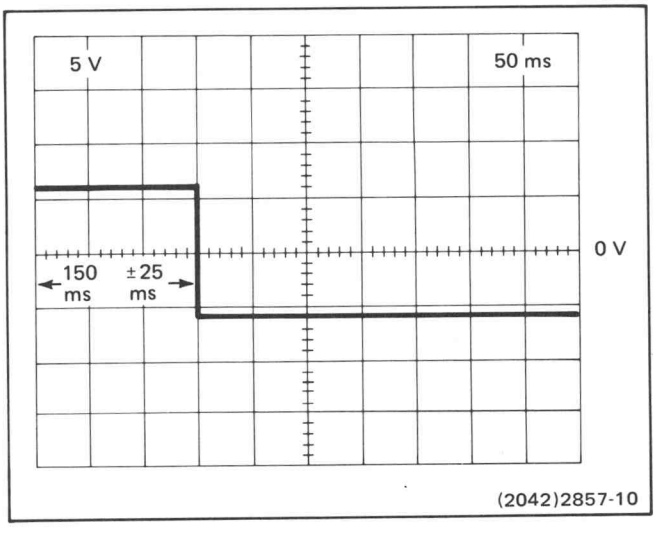

Figure 2-5. QRS Width.

C. RESPIRATION

Equipment Required:

1. Patient Cable (Tektronix Part 012-0739-00)
2. Respiration test fixture (Fig. 1-5)
3. Stereo phone plug (Fig. 1-2C)
4. Test oscilloscope

For adjustments and test points, see 413 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

C1. NULL

a. Set:

ECG OFF ..... In (off)
DISPLAY OFF (Resp) ..... Out (on)
DISPLAY OFF (Press) ..... In (off)
RESPIRATION SIZE ..... Midpoint (dot on panel)

b. Connect Respiration test fixture to ECG/RESPIRATION INPUT via patient cable as shown in Fig. 1-5.

c. Set Chest Impedance switch on respiration test fixture to 750 Ω (center) position.

d. **CHECK**—Voltage level at TP441 (Respiration board) should be 0.0 V within 200 mV. Use test oscilloscope.

e. **ADJUST**—Null (R425, Respiration board) for 0.0 V at TP441.

C2. BALANCE

a. Insert stereo phone plug (Fig. 1-2C) into PRESS/PULSE RESPIRATION OUTPUT connector on rear panel.

b. **CHECK**—RING contact should be 0.0 V, ±25 mV. Use test oscilloscope.

c. **ADJUST**—Balance (R455, Respiration board) for 0.0 V on RING contact.

d. **CHECK**—Trace is vertically centered at 75 mmHg line, ±3 mm (±0.3 div).

C3. GAIN

a. Alternately press and release △ 1 Ω pushbutton on respiration test fixture at about 1 second intervals.

b. **CHECK**—Crt beam is deflected 2 cm, ±2 mm each time the △ 1 Ω pushbutton is pressed or released.

c. **ADJUST**—Gain (R540, Respiration board) so that crt beam is deflected 2 cm each time △ 1 Ω pushbutton is pressed or released.

d. **CHECK**—INSPIRATION indicator lights with each positive rise of respiration waveform.

C4. CHEST IMPEDANCE RANGE CHECK

a. Set switch on respiration test fixture to 0 Ω position.

b. **CHECK**—LEAD FAULT LED is on while respiration display is momentarily off screen and goes off as respiration display returns to screen.

c. Set switch on respiration test fixture to 1.5 kΩ position.

d. **CHECK**—LEAD FAULT LED is on while respiration display is momentarily off screen and goes off as respiration display returns to screen.

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D. DIGITAL DISPLAY

Equipment Required:

1. Digital voltmeter (test DVM)
2. Temperature sensor substitution plug, 113° F/45° C (Fig 1-4)
3. Pressure transducer

For adjustments and test points, see 413 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

D1. DVM ZERO AND DVM CAL

a. Set:

ECG OFF ..... In (off)
PRESSURE 0-125 ..... In
DISPLAY OFF (Resp) ..... In (off)
DISPLAY OFF (Press) ..... In (off)
MEAN ..... In
° C/° F ..... ° F
(rear panel)
ON ..... Out (off)

b. Connect pressure transducer to PRESSURE TRANSDUCER INPUT connector on rear panel.

c. Connect test DVM between TP1241 (ground 1) and TP1221 (Conditioner board).

d. Set ON button in (on).

e. Push and rotate pressure ZERO control for a test DVM reading of 0.0000 within 2 mV (-0.0020 to +0.0020 V).

f. Release ZERO control and wait for test DVM reading to stabilize.

g. **ADJUST**—DVM Zero (R920, DVM board) so that 413 digital display reads about 2; then rotate R920 counterclockwise until reading just starts to alternate between +0 and −0; then continue to rotate R920 about 1/8th of a turn more.

h. Set TEMPERATURE A pushbutton in. Display should blank.

i. Insert a 113°F temperature sensor substitution plug[1] (Fig. 1-4) into TEMPERATURE SENSOR A INPUT jack on rear panel.

j. Move test DVM +lead from TP1221 to P2400-9.

NOTE

Part k adjusts the monitor DVM to accurately display whatever voltage may appear on the analog bus. If the temperature converter is incorrectly adjusted, this voltage may differ significantly from the nominal 1.1300 volts. This is unimportant at this time. The temperature converter will be adjusted to produce the correct bus voltage later in this procedure.

k. **ADJUST**—DVM Cal (R910, DVM board) so that 413 digital display reads same number as test DVM (i.e., if test DVM reads I.I288, set DVM Cal so that 413 digital display reads 112.9).

l. Set MEAN button in.

m. **INTERACTION**—Occurs between DVM Zero and DVM Cal adjustments. Repeat steps g through l as necessary.

n. Push and rotate pressure ZERO control CW for a digital display reading of +10; then CCW slowly toward -10, checking for smooth digital change through zero and that no digits are missed. If necessary go back and readjust DVM Zero and DVM Cal adjustments.

o. Remove pressure transducer, temperature sensor substitution plug and test DVM.

[1] **The 113° F temperature sensor substitution plug is used to produce an arbitrary high number on the digital display, which is just below the over-range point, for use in setting the DVM Cal adjustment (actual temperature readout will be adjusted in later step). If 0.1% resistors are not available to make the 113° F substitution plug, use the closest 1% values (e.g. 2.61 K for R1 and 13.1 K for R2). Other value combinations can also be used. The important consideration is to produce a reading on the test DVM between 1.00 V and 1.20 V.**

E. TEMPERATURE

Equipment Required:

1. Digital voltmeter (test DVM)

2. Temperature sensor substitution plugs (Fig. 1-4)

For adjustments and test points, see 413 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

NOTE

To ensure specified temperature readout accuracy, the temperature readout adjustments should be set at a Tektronix Medical Products Service Center. If this is not feasible, use the following method to make these adjustments. The accuracy of these adjustments depends directly on the quality and accuracy of the resistors used in the temperature sensor substitution Plugs.

E1. TEMP SPAN

a. Set:

TEMPERATURE A ..... In
°C/°F ..... °F
ON ..... Out (off)

b. Connect test DVM between TP1241 (ground #1) and TP1439 (+1.76 V) on Conditioner board.

c. Set ON button in (on).

d. **CHECK**—test DVM reads 1.759 V, ±1 count.

e. **ADJUST**—Span (R1435, Conditioner board) so that test DVM reads 1.759 V.

f. Remove test DVM.

E2. °F CAL AND °C CAL

NOTE

°F Cal and °C Cal adjustments located on Conditioner board.

a. Insert 77°F temperature sensor substitution plug (Fig. 1-4) into TEMPERATURE SENSOR INPUT A jack on rear panel. Connect test DVM between P2400-9 and TP1241 (ground 1), located on Conditioner board.

b. Using Table 2-1, check test DVM and 413 digital display readings of simulated temperature values for channel A. Adjust °F Cal (R1425) and °C Cal (R1427) as necessary to obtain correct reading on test DVM.

NOTE

Do not compromise bus voltage to produce exact desired readout. This will cause difficulty in adjusting 400 and 401 DVMs.

c. Set TEMPERATURE B pushbutton in.

d. Remove temperature sensor substitution plug from TEMPERATURE SENSOR INPUT A and insert 77° F plug into TEMPERATURE SENSOR INPUT B. Move + lead of test DVM to P2400-16.

e. Using Table 2-1, check test DVM and 413 digital display readings of simulated temperature values for channel B. Adjust °F Cal (R1485) and °C Cal (R1487) as necessary to obtain correct reading on test DVM.

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TABLE 2-1
Temperature Readout Checks and Adjustments

°F/°C Switch	Temperature Sensor Substitution Plug (Fig. 5-4)	Test DVM Readings at P2400-9 (TEMP A) P2400-16 (TEMP B)	413 Digital Display Reading (Checks Only)	Adjustments
°F	77°F/25°C	0.7700 ± 0.0020 V[1]	77.0 ±0.5°	°F Cal Temp A (R1425) Temp B (R1485)
°C	77°F/25°C	0.25000 ± 0.0010[1]	25.0 ± 0.3°	°C Cal Temp A (R1427) Temp B (R1487)
°C	41°F/5°C	[2]	5.0 ± 0.3°	Check Only
°F	41°F/5°C	[2]	41.0 ± 0.5°	Check Only
°F	113°F/45°C	[2]	113.0 ± 0.5°	Check Only
°C	113°F/45°C	[2]	45.0 ± 0.3°	Check Only

[1] If you cannot obtain the accuracy indicated, it will be necessary to readjust the Span, °C Cal and °F Cal adjustments and slightly compromise the settings.

[2] Test DVM reading for these temperature values are equivalent to 10 mV/degree.

E3. △ T ZERO

a. Insert 77 °F temperature sensor substitution plug (Fig. 1-4) into TEMPERATURE SENSOR INPUT A jack on rear panel and a 113 °F plug into INPUT B.

b. Record TEMPERATURE A digital readout and TEMPERATURE B digital readout, then calculate A minus B.

c. Set both TEMPERATURE A and B pushbuttons in at the same time.

d. **CHECK**—Digital display of A minus B is the same as the calculated value, ±1 count.

e. **ADJUST**—△ T Zero (R1445, Conditioner board) so that digital display reads same as calculated A minus B value.

f. Remove test DVM and temperature sensor substitution plugs.

F. PRESSURE/PULSE

Equipment Required:

1. Manometer
2. Pressure transducer
3. Digital voltmeter (test DVM)
4. Stereo phone plug (Fig. 1-2C)
5. Pulse sensor

For adjustments and test points, see 413 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

F1. GAGE FACTOR

a. Set:

PRESS 0-125 ..... In
DISPLAY OFF (Press) ..... In (off)
MEAN ..... In

b. Connect manometer to pressure transducer and pressure transducer to PRESSURE TRANSDUCER INPUT connector on rear panel. Connect test DVM between P2400-27 and TP1241 (ground 1), located on Conditioner board.

c. Press in ZERO control and adjust for test DVM reading of 0.0000, within 0.0200 V. Record exact reading for use in later steps.

d. Apply 125 mmHg pressure as indicated by manometer. Make sure pressure remains at 125 mmHg and is not slowly diminishing.

e. **ADJUST**—Gage Factor (R865, Pressure/pulse board) for test DVM reading of 1.2500 ±0.0100 V plus reading noted in step c. Record exact reading.

f. Release manometer pressure.

g. **CHECK**—Test DVM reading equals reading noted in step e minus 1.2500 , ±0.0200 V.

h. **INTERACTION**—Can occur between Pressure ZERO and Gage Factor adjustments. Repeat steps c through g as necessary until difference between pressure reading at 0 mmHg and 125 mmHg is 1.2500, ±0.0100 V.

i. Apply 125 mmHg pressure as indicated by manometer.

j. **CHECK**—413 digital display reads 125, ±3 mmHg.

k. Apply 75 mmHg pressure as indicated by manometer.

l. **CHECK**—Digital display reads 25, ±3 mmHg.

m. Apply 25 mmHg pressure as indicated by manometer.

n. **CHECK**—Digital display reads 25, ±3 mmHg.

o. Set SYST/DIAST pushbutton in.

p. Apply 125 mmHg pressure as indicated by manometer.

q. **CHECK**—Digital display reads 125, ±3 mmHg.

r. Release manometer pressure.

s. Remove test DVM.

F2. TRACE ZERO AND VERTICAL SENSITIVITY

a. Set DISPLAY OFF (Press) out (off).

b. Press in ZERO control and adjust for digital display reading of ±0. Release ZERO control.

c. **CHECK**—Trace should coincide with ZERO graticule line, ±1 mm.

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d. **ADJUST**—Trace ZERO (R690, Pressure/pulse board) to make trace coincide with ZERO graticule line.

e. Apply 250 mmHg pressure as indicated by manometer.

f. **CHECK**–Trace should coincide with 250 mmHg graticule line, ±1 mm (0.1 div).

g. **ADJUST**—Vertical Sensitivity (R1685, Main board) to correct one half crt display error.

h. **INTERACTION**—Occurs between Vertical Sensitivity and Trace Zero adjustments. Repeat steps b through g as necessary.

F3. PRESSURE/PULSE OUTPUT

a. Release manometer pressure.

b. Insert stereo phone plug (Fig. 1-2C) into PRESSURE/PULSE OUTPUT jack and connect test DVM between TIP and barrel (chassis ground).

c. Press in ZERO control and adjust for digital display reading of ±0. Release ZERO control.

d. **CHECK**—Test DVM reads 0, ±5 mV.

e. Apply 250 mmHg pressure as indicated by 413 digital display.

f. **CHECK**—Test DVM reads 2.50 V, ±50 mV.

g. Remove test DVM and stereo phone plug.

F4. PRESSURE ALARM

a. Set ALARM LOUDNESS (rear panel) to midrange.

b. Simulate a pulsatile pressure display by pressing and releasing the 100 mm CHECK button approximately once every second. Set PULSE ALARM in (on). Continue to press and release 100 mm CHECK button for more than 30 seconds and check that alarm is not triggered.

c. Stop pressing 100 mm CHECK button.

d. **CHECK**—Alarm is triggered within about 30 seconds.

e. Set PULSE ALARM button out (off).

f. Disconnect manometer and pressure transducer.

F5. PULSE DISPLAY

a. Set PULSE button in.

b. Connect Pulse sensor to PULSE SENSOR INPUT on rear panel and monitor your pulse.

c. **CHECK**—Monitor displays pulse. Digital display is blanked.

F6. PULSE ALARM

a. Set PULSE ALARM button in (on).

b. **CHECK**—Alarm is not triggered after waiting more than 30 seconds.

c. Disconnect Pulse sensor.

d. **CHECK**—Alarm is triggered within 3-15 seconds.

e. Push in and release ALARM RESET button.

f. **CHECK**–Audible alarm ends and ALARM light remains on. Check that audible alarm recurs within 1 minute.

g. Set PULSE ALARM button out.

h. **CHECK**–Alarm light and audio alarm go off.

G. RATE

Equipment Required:

1. Function generator
2. Low-pass filter (Fig. 1-2C)
3. Test DVM
4. Test oscilloscope
5. Universal counter
6. 10 MΩ resistor

For adjustments and test points, see 413 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

G1. HEART RATE

a. Set

ECG I ..... In
LOW RATE LIMIT ..... RATE ALARM OFF
HEART RATE/MIN ..... In
DISPLAY OFF (Press) ..... In (off)

b. Connect function generator square wave through low-pass filter (Fig. 1-2C) to ECG INPUT connector and display about 4 cm at 3 Hz (180 bpm). Verify function generator frequency with universal counter. Connect test DVM between P2400-11 and TP1241 (ground 1), located on Conditioner board.

c. **ADJUST**—Heart Rate (R1315, Conditioner board) so that test DVM reads 1.8000, ±0.0100 V.

d. **CHECK**—413 digital display reads 180, ±3.

e. Set function generator to 1 Hz (verify with universal counter). Wait 15 seconds.

f. **CHECK**—Digital display reads 60, ±3.

g. Set function generator to 4 Hz (verify with universal counter). Wait for 15 seconds.

h. **CHECK**—Digital display reads 240, ±5.

i. Turn off function generator. Wait 15 seconds.

j. **CHECK**—Digital display reads 0 to 3.

k. Turn on function generator.

G2. RATE OUTPUT

a. Insert stereo phone plug into ECG/RATE OUTPUT jack on rear panel.

b. Connect test oscilloscope to RATE OUTPUT (RING).

c. **CHECK**–An approximate 68 ms wide pulse occurs for each ECG pulse. Pulse amplitude is at least 5.5 V.

d. Disconnect test oscilloscope and stereo phone plug.

G3. RESPIRATION RATE

a. Connect a 10 MΩ resistor between TP371 on the ECG board and TP441 on the Respiration board.

b. Set function generator frequency so that the test DVM reads 0.7500 to 0.8000 V (test DVM should still be connected to P2400-11). Record exact readings on test DVM and on 413 digital display.

c. Set:

DISPLAY OFF (resp) ..... Out (on)
RESPIRATION SIZE ..... Midpoint (dot on panel)
RESP RATE/MIN ..... In

d. **CHECK**—INSPIRATION light goes on with each positive-going excursion of the displayed pulse.

e. Connect test DVM between P2400-33 and TP1241 (ground 1), located on Conditioner board.

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NOTE

It can take up to one minute after signal is applied and the respiration channel is turned on for an accurate reading to be displayed on the test DVM.

f. **ADJUST**—Respiration Rate (R1345, Conditioner board) so that test DVM reads same as value for heart rate recorded in an earlier step, within 0.0100 V. Note that response to control is very slow.

g. **CHECK**—413 digital display reads the same as the heart rate recorded in an earlier step, within 2 beats/minute.

h. Disconnect 10 MΩ resistor and set DISPLAY OFF (Resp) in.

G4. HEART RATE ALARM LIMITS

a. Set:

ALARM LOUDNESS (rear panel) ..... Midrange
LOW RATE LIMIT 116
(press for digital display)
HIGH RATE LIMIT 124
(press for digital display)
HEART RATE/MIN ..... In

b. Set function generator frequency to read 120, ±1 bpm on digital display.

c. Press LOW RATE LIMIT control in and set to read 124 on digital display.

d. **CHECK**-Alarm tone sounds and ALARM light turns on within 30 seconds.

e. Press in RESET button.

f. Set LOW RATE LIMIT to read 116 on digital display.

g. Press HIGH RATE LIMIT control in and set to read 116 on digital display.

h. **CHECK**—Alarm tone sounds and alarm light turns on within 30 seconds.

i. Set LOW RATE LIMIT control to RATE ALARM OFF.

j. Set HIGH RATE LIMIT control to 150 (printed on front panel). Press control in and check that digital display reads 150, ±15 bpm. Repeat check at 90 and 240 for digital display readings within 5 bpm. Loosen set screw and readjust knob on shaft to make panel settings and digital dsplay within 15 bpm of each other at 150 and within 5 bpm at 90 and 240.

k. Set HIGH RATE LIMIT fully clockwise.

l. Set LOW RATE LIMIT control to 90 (printed on front panel). Reset alarm as necessary. Press control in and check that digital display reads 90, ±15. Repeat check at 30 and 150 for digital dislay reading within 5 bpm. Loosen set screw and readjust knob on shaft to make front-panel settings and digital display within 15 bpm of each of other at 90 and with 5 bpm at 30 and 150.

m. Disconnect function generator and low-pass filter.

n. Install Conditioner board as follows:

1. Set insulating sheet in place over Main board components.

2. Align Conditioner board interface pins with sockets on Main board.

3. Press along length of connector a little at a time until all pins are seated firmly into their sockets.

4. Connect 3 cables to Conditioner board; P1145, violet, 6-conductor plug; P1402, blue, 10 conductor plug; P1462, green, 10-conductor plug. If 401 was attached, solder white-orange wire to R1447 as shown in Figure 2-1.

413 OPTION 20 CALIBRATION PROCEDURE

PERFORM 413 CALIBRATION PROCEDURE MAKING CHANGES AS FOLLOWS:

D. DIGITAL DISPLAY

Change Equipment Required list as follows:

Delete—Pressure Transducer

Add—5°C Temperature Sensor

D1. DVM ZERO AND DVM CAL

Replace parts a through o with the following:

a. Set:

ECG OFF ..... In (off)
DISPLAY OFF (Resp) ..... In (off)
°C/°F (rear panel) ..... °C
TEMPERATURE A ..... In

b. Insert a 5°C temperature sensor substitution plug into TEMPERATURE SENSOR INPUT A jack on rear panel.

c. Connect test DVM between P2400-9 (Conditioner board) and TP 1241 (ground 1).

d. Adjust the Temp A °C Cal (R1427) for a reading between +0.0020 V and -0.0020 V on test DVM.

e. **ADJUST**--DVM Zero (R920, DVM board) so that 413 digital display reads about 2; then rotate R920 counter clockwise until reading just starts to alternate between + and -0; then continue to rotate R920 about 1/8th turn more.

f. Set °C/°F switch (rear panel) to °F.

g. Remove 5°C temperature sensor substitution plug and insert a 113°C temperature sensor substitution plug (Fig. 1-4). The 113°F temperature value produces and arbitrarily high number on the digital display for setting the DVM Cal adjustment. Actual temperature ratdout is adjusted in Part E, Temperature.

h. **ADJUST**—DVM Cal (R920, DVM board) so that 413 digital display reads same number as test DVM (i.e., if test DVM reads 1.1288, set DVM Cal so that 413 digital display reads 112.9).

i. **INTERACTION**-Occurs between DVM Zero and DVM Cal adjustments. Repeat steps a through h as necessary.

F. PRESSURE/PULSE

Delete all but Pulse Sensor from Equipment Required list.

Delete steps F1 through F4.

413 OPTION 22 CALIBRATION PROCEDURE

Perform the 413 Calibration Procedure making changes as follows:

B. ECG

B2. DC LEVEL

References to center of screen at 75 mmHg is changed to 150 mmHg line.

B6 QRS TIMING

c. **CHECK**—Interval to first positive-going edge at TP360 is 6 ms, ±1 ms.

C. RESPIRATION

C2. BALANCE

Reference to center of screen at 75 mmHg line are changed to 150 mmHg line.

F. PRESSURE/PULSE

F1. GAGE FACTOR

Replace with the following:

a. Set:

PRESS 0-250 ..... In
DISPLAY OFF (Resp) ..... In (off)
PULSE ALARM ..... OUT (off)
MEAN ..... In

b. Connect manometer to pressure transducer and pressure transducer to PRESSURE TRANSDUCER INPUT connector on rear panel. Connect test DVM between P2400-27 and TP1241 (ground 1), located on Conditioner board.

c. Press in ZERO control and adjust for test DVM reading of 0.0000, ±0.0200 V.

d. Apply 250 mmHg pressure as indicated by manometer. Make sure pressure remains at 250 mmHg and is not slowly diminishing.

e. **ADJUST**—Gage Factor (R865, Pressure/Pulse board) for test DVM reading of 2.5000,±0.0100 V plus reading noted in step c.

f. Release manometer pressure.

g. **CHECK**—Test DVM reading noted in step e minus 2.5000.

h. **INTERACTION**—Occurs between Pressure and Gage Factor adjustments. Repeat steps c through g as necessary until difference between 0 mmHg and 250 mmHg is 2.5000 V ±0.0100 V.

i. Apply 250 mmHg as indicated by manometer.

j. **CHECK**—413 digital display reads 250, ±3 mmHg.

k. Apply 150 mmHg pressure as indicated by manometer.

l. **CHECK**—Digital display read 150, ±3 mmHg.

m. Apply 50 mmHg pressure as indicated by manometer.

n. **CHECK**—Digital display reads 50, ±3 mmHg.

o. Set SYST/DIAST pushbutton in.

p. Apply 250 mmHg pressure as indicated by manometer.

q. **CHECK**—Digital display reads 250, ±3 mmHg.

r. Release manometer pressure.

s. Remove test DVM.

F2. TRACE ZERO AND VERTICAL SENSITIVITY

Change the following steps:

e. Apply 250 mmHg pressure as indicated by manometer.

f. **CHECK**—Trace should coincide with 250 mmHg graticule line, ±1 mm (0.1 div).

F3. PRESSURE/PULSE OUTPUT

Change the following steps:

e. Apply 250 mmHg pressure as indicated by 413 digital display.

f. **CHECK**—Test DVM reads 2.50 V, ±50 mV.

414 CALIBRATION PROCEDURE

PRELIMINARY PROCEDURE

1. Check operation of all modes and correct any defects before making adjustments to the monitor.

2. Set monitor controls as follows:

POWER ..... In (on)
DISPLAY OFF ..... In (off)
OFF (ECG) ..... In (off)
LOW RATE LIMIT ..... RATE ALARM OFF (ccw)
PULSE ALARM ..... Out (off)
SWEEP SPEED mm/SEC 100 ..... In
BEAT LOUDNESS ..... Midrange
DO NOT PRESET INTERNAL CONTROLS

3. Set the remaining controls as desired.

4. Connect the monitor to the correct ac-line source.

5. Allow monitor to warmup for about 20 minutes before making adjustments.

A. POWER SUPPLY AND CRT DISPLAY

Equipment Required:

1. Digital voltmeter (test DVM)
2. Function generator
3. Low-pass filter (Fig. 1-2A)

For adjustments and test points, see 414 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

A1. -12 VOLTS

a. Connect test DVM leads to Main board between ground (ground lug inside of rear panel) and -12 V (TP-12 V Main board).

b. **CHECK**—Supply voltage should be -12.0 V, within 25 mV.

NOTE

Do not readjust -12 V supply if it is within 25 mV unless a complete recalibration is intended.

c. **ADJUST**—12 V (R737, Main board) for 12 V at TP-12 V.

d. Remove test DVM leads.

A2. TRACE ROTATION

a. **CHECK**—Trace should be parallel with graticule lines.

WARNING

To avoid electric shock, be careful when making yoke adjustments. There is + and -35 V at the yoke, +175 V in the crt socket and +3400 V on the crt anode.

b. Loosen yoke clamp (Fig. 4-1).

c. ROTATE—Yoke for non-tilted trace. Keep yoke forward as far as possible.

d. Tighten yoke clamp.

e. Recheck trace to ensure yoke was not moved when yoke clamp was tightened.

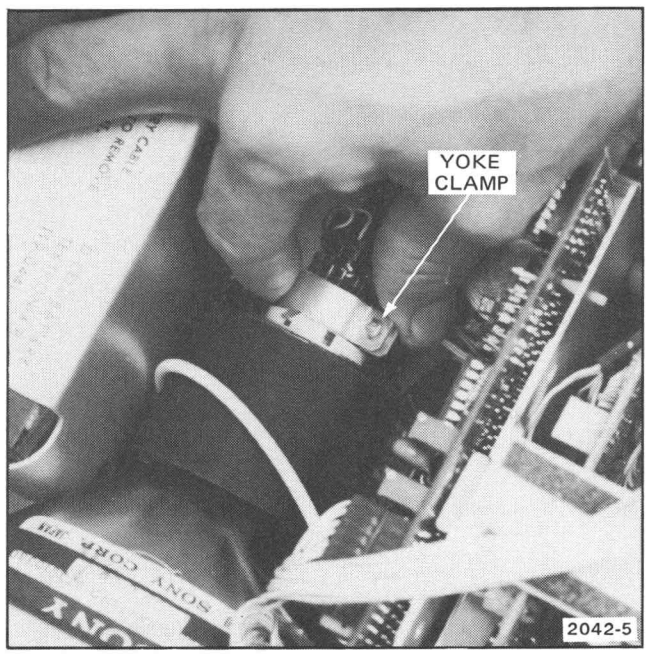

Figure 4-1. Deflection yoke adjustment.

NOTE

Due to effects of earth's magnetic field, monitor should be positioned upright when performing steps A3, and A4. Monitor will have to be supported above bench to make adjustments.

A3. SPOT CENTERING AND FOCUS

a. Set POWER button out (off) and disconnect yoke plug, P641. Set POWER button in (on).

b. **CHECK**—Spot should be centered on the graticule, within (approximately) 2 mm. Graticule center is at intersection of 150 mmHg line and straight edge centered diagonally across graticule.

c. **ADJUST**—Centering Rings for centered spot. Refer to Fig. 4-2.

d. **CHECK**—Spot should be finely focused.

e. **ADJUST**—Focus (R841, High-Voltage board) for smallest possible round spot.

f. Set POWER button out (off) and reconnect yoke plug. Be sure to match arrow on Main board. Set POWER button in (on).

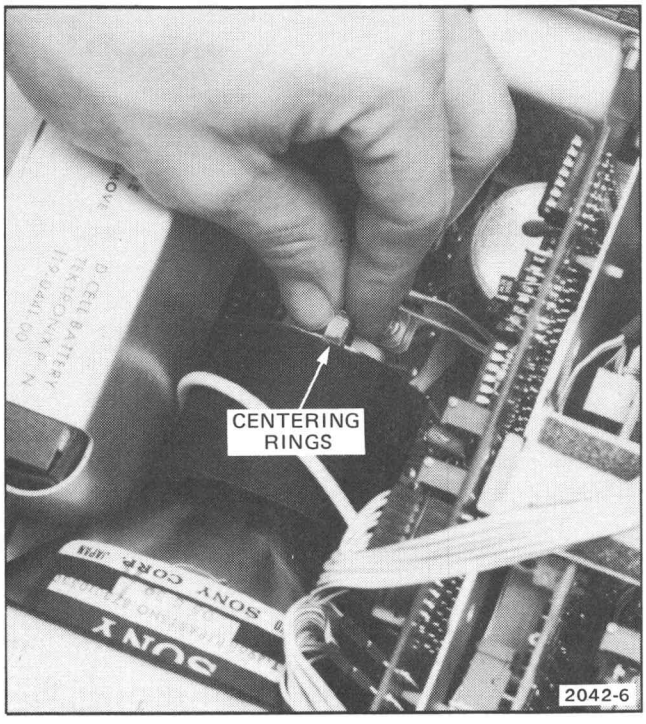

Figure 4-2. Yoke connector, P641, and spot centering rings.

A4. HORIZONTAL WIDTH AND POSITION

a. Set:

ECG I ..... In
ECG SIZE ..... CW
SWEEP SPEED mm/SEC 100 ..... In

b. Connect function generator square wave through low-pass filter (Fig. 4-2A) to ECG INPUT connector. Set generator to display approximately 4 cm at 4 Hz (verify with universal counter). Monitor should produce beat tone and triggered display. Adjust BEAT LOUDNESS control as desired.

NOTE

The position of the trace at approximately 38 to 40 bpm is relatively unaffected by the Horiz Width control. For this reason it works best to adjust the fourth pulse to the 40 bpm mark with the Horiz Position, then to adjust the second pulse to the 120 bpm mark with the Horiz Width. One repetition of the above is usually enough to get both pulses right on.

View perpendicularly to graticule at each pulse to eliminate parallax.

c. **ADJUST**–Horizontal Position (R671) until rising edge of fourth pulse coincides with 40 bpm graticule mark. See Figure 4-3.

d. **ADJUST**—Horizontal Width (R667) until rising edge of second pulse coincides with 120 bpm graticule mark. See Figure 4-3.

e. **INTERACTION**—Repeat parts c and d.

f. **CHECK**—Rising edge of third pulse coincides with 60 bpm graticule mark.

g. Set 414 SWEEP SPEED mm/SEC 50 button in.

h. Set function generator frequency (about 2 Hz) so that rising edges of second and fourth pulses coincide respectively with 120 and 40 bpm graticule marks.

i. **CHECK**—Function generator frequency (verified with universal counter) is 2.00 Hz, within 0.06 Hz.

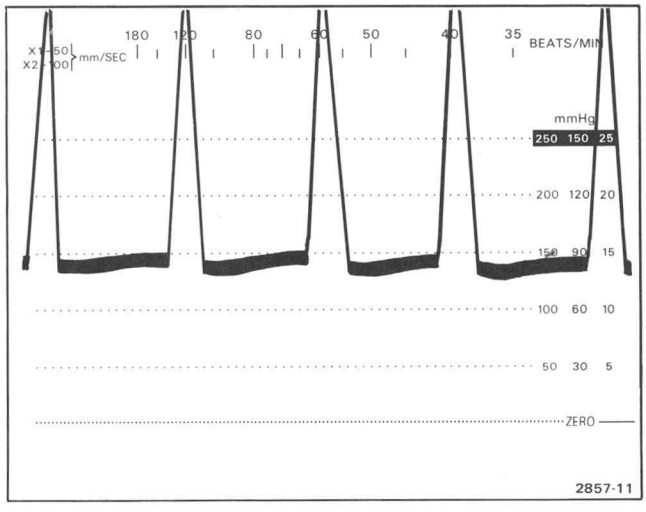

Figure 4-3. Adjusting Horizontal Width and Position.

j. **CHECK**—Rising edge of third pulse coincides with 60 bpm graticule mark, within 2 mm.

k. Set function generator frequency to 2.5 Hz (verify with universal counter). Set output for about 1 cm display.

l. **CHECK**—9 to 11 pulses are displayed.

m. Turn off function generator.

n. **CHECK**–Trace starts at left end of graticule line, within 4 mm.

o. Disconnect function generator and low-pass filter.

B. ECG

Equipment Required:

1. Patient cable
2. ECG Shorting Connector (Fig. 1-2B)
3. Test oscilloscope
4. Function generator
5. Stereo phone plug (Fig. 1-2C)
6. Precision attenuator (Fig. 1-3A)

For adjustments and test points, see 414 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

B1. INPUT OFFSET NULL

a. Set:

DISPLAY OFF (Press/Pulse .....In (off)
ECG I..... In

b. Connect ECG shorting connector (See Fig. 1-2B) to ECG INPUT connector.

c. **CHECK**—Voltage level at TP178 (ECG board) should be 0.0 V, within 200 mV. Use test oscilloscope.

d. **ADJUST**—Input Offset Null (R170, ECG board) for 0.0 V.

B2. DC LEVEL

a. Insert stereo phone plug (Fig. 1-2C) into ECG OUTPUT connector.

b. **CHECK**—ECG OUTPUT (TIP × 1000) should be 0.0 V, within 25 mV. Use test oscilloscope.

c. **ADJUST**—DC Level (R185, ECG board) for 0.0 V.

d. **CHECK**—Trace is vertically centered at 150 mmHg line, within 3 mm.

e. Remove ECG shorting plug.

B3. ECG OUTPUT GAIN

a. Connect function generator to test oscilloscope and through precision attenuator (See Fig. 1-3A) to ECG INPUT connector (via patient cable). Apply 1.0 V, 10 Hz sine wave. Note reference amplitude on test oscilloscope, then connect test oscilloscope to ECG OUTPUT (TIP × 1000).

b. **CHECK**—ECG OUTPUT (TIP x 1000) should be equal to reference amplitude ÷ 1000 attenuator and x 1000 monitor gain = 1).

c. **ADJUST**—Gain (R184, ECG board) for output equal to reference amplitude.

d. Move test oscilloscope to ECG OUTPUT (RING × 1).

e. **CHECK**—ECG OUTPUT (RING × 1) for 1.0 mV p-p, $\pm$ 5%.

f. OPTION 4 ONLY

1. Turn off function generator.
2. Set ECG lead selector to STD.
3. **CHECK**—Trace is deflected 2 cm each time 1 mV CAL button is pressed momentarily.
4. **ADJUST**—1 mV Cal (R119, ECG board) for 2 cm deflection of trace each time 1 mV CAL button is pressed.
5. Set ECG lead selector to I.

g. Disconnect test oscilloscope, function generator, stereo phone Plug, and precision attenuator.

B4. ECG LEAD CHECK SIGNAL

a. Connect ECG LEAD CHECK signal to ECG INPUT connector through patient cable. Leads connect front to back as follows: LL (red) LA (black), RA (white); Opt 4 also includes RL (green) and C (brown).

b. **CHECK**—Positive-going pulses should be approximately 100 bpm (not critical).

c. Set ECG SIZE to index mark (20 mm/mV).

d. **CHECK**—Approximate pulse amplitude for each of the three ECG lead configurations is as follows: I, 2 cm; II, 3 cm; III, 1 cm. (OPTION 4—aVR, -2.5 cm; aVL, 0.5 cm; aVF, 2 cm; V, 3 cm.)

B5. LEAD FAULT OPERATION

a. **CHECK**–LEAD FAULT lamp lights when either LA or RA ECG lead is removed from its ECG LEAD CHECK terminal.

b. Reconnect lead to ECG LEAD CHECK terminal.

B6. QRS TIMING

a. Connect test oscilloscope channel 1 input to TP382 (ECG board) and channel 2 input to TP388. Set oscilloscope vertical mode to chop and sweep speed to 10 ms/div X10. Trigger on channel 1, positive slope.

b. **CHECK**–Interval to first positive-going edge at TP382 is 6 ms, ±1 ms (see Fig. 4-4).

B7. QRS WIDTH

a. Set test oscilloscope vertical mode to channel 2 and sweep speed to 50 ms/div X1. Trigger oscilloscope on composite or normal, + slope.

b. **CHECK**–Pulse duration at TP388 (ECG board) is 150 ms, ±25 ms (see Fig. 4-5).

c. Disconnect test oscilloscope.

B8. PACER SIGNAL REJECTION

a. Connect pacer input circuit adapter and function generator as shown in Fig. 1-3B.

b. Set function generator output for approximately 500 mV, 1 Hz square wave.

c. Set monitor ECG I button in.

d. **CHECK**–QRS detector (triggers beat tone) should respond only to ECG LEAD CHECK signal and not to simulated pacer signal. When pacer signal coincides with leading edge of ECG LEAD CHECK signal, QRS selection should occur at trailing edge.

e. Disconnect function generator and pacer input circuit adapter.

B9. ECG CMRR CHECK

a. Connect CMRR test fixture (Fig. 1-3C) to ECG INPUT connector. Then connect test circuit to ac-power line.

b. Set ECG SIZE control to midrange mark (20 mm/mV).

c. Set ECG I button in.

d. **CHECK**–Monitor display amplitude should be less than 1.3 cm p-p for nominal 115 V lines (or less than 2.6 cm, p-p for nominal 230 V lines, if the lines are unbalanced).

e. Set ECG III in.

f. Repeat part d.

g. Set ECG II in.

h. **CHECK**–Monitor display amplitude should be less than 1.9 cm p-p for nominal 115 V lines (or less than 3.8 cm, p-p for nominal 230 V lines, if the lines are unbalanced).

i. Disconnect CMRR test fixture.

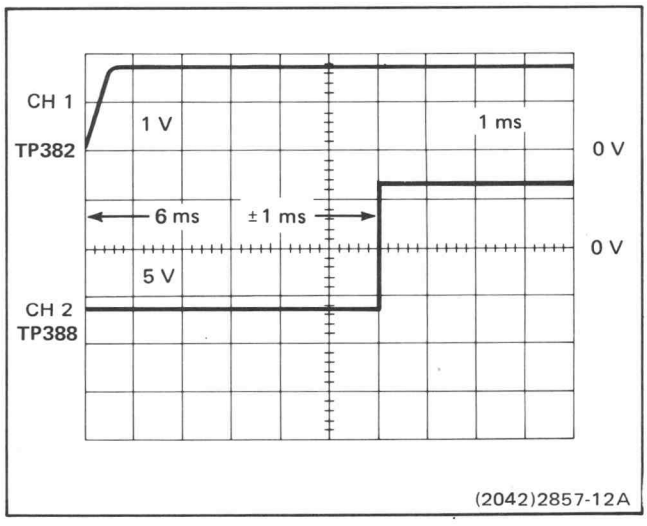

Figure 4-4. QRS timing.

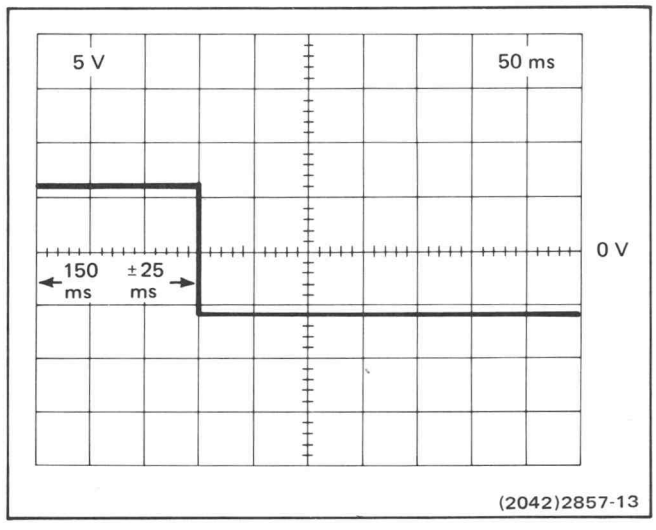

Figure 4-5. QRS width.

C. DIGITAL DISPLAY

Equipment Required:

1. Digital voltmeter (test DVM)
2. Temperature sensor substitution plug, 113° F/45° C (Fig. 1-4)
3. Pressure transducer

For adjustments and test points, see 414 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

C1. DVM ZERO AND DVM CAL

a. Set:

ECG OFF ..... In (off)
PRESSURE 150 ..... In
DISPLAY OFF ..... In (off)
MEAN ..... In
°C/°F (rear panel) ..... °F
POWER ..... Out (off)

b. Connect pressure transducer to PRESSURE TRANSDUCER INPUT connector on rear panel.

c. Connect test DVM between TP GND 1 and TP1012 (Readout Conditioner board).

d. Set POWER button in (on).

e. Push and rotate pressure ZERO control for a test DVM reading of 0.0000 within 2 mV (−0.0020 to +0.0020 V).

f. Release ZERO control and wait for test DVM reading to stabilize.

g. **ADJUST**—DVM Zero (R2334, DVM board) so that 414 digital display reads about 2; then rotate R920 counterclockwise until reading just starts to alternate between +0 and −0; then continue to rotate R2334 about 1/8 turn more.

h. Set TEMP button in. Display should blank.

i. Insert a 113° F temperature sensor substitution plug[1] (Fig. 1-4) into TEMPERATURE SENSOR INPUT jack on rear panel.

j. Move test DVM +lead from TP1012 to P2400-9.

NOTE

Part k adjusts the monitor DVM to accurately display whatever voltage may appear on the analog bus. If the temperature converter is incorrectly adjusted, this voltage may differ significantly from the nominal 1.1300 volts. This is unimportant at this time. The temperature converter will be adjusted to produce the correct bus voltage later in this procedure.

k. **ADJUST**—DVM Cal (R2332, DVM board) so that 414 digital display reads same number as test DVM (i.e., if test DVM reads 1.1288, set DVM Cal so that 414 digital display reads 112.8).

l. Set MEAN button in.

m. **INTERACTION**-Occurs between DVM Zero and DVM Cal adjustments. Repeat steps g through n as necessary.

n. Push and rotate pressure ZERO control CW for a digital display reading of +10; then CCW slowly toward −10, checking for smooth digital change through zero and that no digits are missed. If necessary go back and readjust DVM ZERO and DVM Cal adjustments.

o. Remove temperature sensor substitution plug and test DVM.

[1]**The 113° F temperature sensor substitution plug is used to produce an arbitrary high number on the digital display, which is just below the overrange point, for use in setting the DVM Cal adjustment (actual temperature readout will be adjusted in later step). If 0.1% resistors are not available to make the 113° F substitution plug, use the closest 1% values (e.g., 2.61 K for R1 and 13.1 K for R2). Other value combinations can also be used. The important consideration is to produce a reading on the test DVM between 1.00 V and 1.20 V.**

D. TEMPERATURE

Equipment Required:

1. Digital voltmeter (test DVM)

2. Temperature sensor substitution plugs (Fig. 1-4)

For adjustments and test points, see 414 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

NOTE

To ensure specified temperature readout accuracy, the temperature readout adjustments should be set at a Tektronix Medical Products Service Center. If this is not feasible, use the following method to make these adjustments. However, keep in mind The accuracy of these adjustments depends directly on the accuracy of the resistors used in the temperature sensor substitution Plugs.

D1. TEMP SPAN

a. Set:

TEMP ..... In
°C/°F ..... °F
POWER ..... Out (off)

b. Connect test DVM between TP GND 1 and TP +1.76 V on Readout Conditioner board. c. Set POWER button in (on).

d. **CHECK**—test DVM reads 1.759 V, ±0.001 V.

e. **ADJUST**—Temp Span (R1410, Readout Conditioner board) so that test DVM reads 1.759 V.

f. Remove test DVM.

D2. °F CAL AND °C CAL

a. Insert 77° F temperature sensor substitution plug (Fig. 1-4) into TEMPERATURE SENSOR INPUT jack on rear panel. Connect test DVM between P2400-9 (Manifold board) and TP GND 1 (Readout Conditioner board).

b. Using Table 4-1, check test DVM and 414 digital display readings of simulated temperature values. Adjust °F Cal (R1424) and °C Cal (R1420) as necessary to obtain correct reading on test DVM.

c. Remove test DVM and temperature sensor substitution plug.

TABLE 4-1

Temperature Readout Checks and Adjustments

°F/°C Switch	Temperature Sensor Substitution Plug (Fig. 1-4)	Test DVM Readings at P2400-9	414 Digital Display Reading (Checks Only)	Adjustments
°F	77°F/25°C	0.7700 ± 0.0020 V[1]	77.0 ± 0.5°	°F Cal (R1424)
°C	77°F/25°C	0.25000 ± 0.0010[1]	25.0 ± 0.3°	°C Cal (R1420)
°C	41°F/5°C	[2]	5.0 ± 0.3°	Check Only
°F	41°F/5°C	[2]	41.0 ± 0.5°	Check Only
°F	113°F/45°C	[2]	113.0 ± 0.5°	Check Only
°C	113°F/45°C	[2]	45.0 ± 0.3°	Check Only

[1] If you cannot obtain the accuracy indicated, it will be necessary to readjust the Temp Span, °C Cal and °F Cal adjustments and slightly compromise the settings.

[2] Test DVM reading for these temperature values are equivalent to 10 mV/degree.

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E. PRESSURE/PULSE

Equipment Required:

1. Manometer
2. Pressure transducer
3. Digital voltmeter (test DVM)
4. Stereo phone plug (Fig. 1-2C)
5. Pulse sensor

For adjustments and test points, see 414 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

E1. GAGE FACTOR

a. Set:

PRESS 250 ..... In
DISPLAY OFF ..... In (off)
MEAN ..... In
GAGE FACTOR (Rear panel)
(Option 2 only) ..... Preset (CW)

b. Connect manometer to pressure transducer and pressure transducer to PRESSURE TRANSDUCER INPUT connector on rear panel. Connect test DVM between P2400-27 (Manifold board) and TP GND 1 (Readout Conditioner board).

c. Press in ZERO control and adjust for test DVM reading of 0.0000, within 0.0200 V. Record exact reading for use in later steps.

d. Apply 250 mmHg pressure as indicated by manometer. Make sure pressure remains at 250 mmHg and is not slowly diminishing.

e. **ADJUST**—Gage Factor (R456, Pressure/pulse board; OPT 2—R457, inside rear panel) for test DVM reading of 2.5000 ±0.0300 V plus reading noted in step c. Record exact reading.

f. Release manometer pressure.

g. **CHECK**—Test DVM reading equals reading noted in step e minus 2.5000, ±0.0200 V.

h. **INTERACTION**—Can occur between Pressure ZERO and Gage Factor adjustments. Repeat steps c through g as necessary until difference between pressure reading at 0 mmHg and 250 mmHg is 2.5000, ±0.0300 V.

E2. MEAN PRESSURE DISPLAY

a. Apply 250 mmHg pressure as indicated by manometer.

b. **CHECK**—414 digital display reads 250, ±5 mmHg.

c. Apply 150 mmHg pressure as indicated by manometer.

d. **CHECK**—414 Digital display reads 150, ±3 mmHg.

e. Apply 25 mmHg pressure as indicated by manometer.

f. **CHECK**–414 Digital display reads 25, ±3 mmHg.

E3. SYSTOLIC/DIASTOLIC PRESSURE

a. Set:

SYST/DIAST ..... In
PRESSURE 250 ..... In

b. Move test DVM + lead to P2400-26.

c. Apply 250 mmHg pressure as indicated by manometer.

d. Check—Test DVM reads 2.5000, ±0.0300 V.

e. **CHECK**—414 Digital display reads 250, ±5 mmHg.

f. Move test DVM + lead to P2400-10. Make sure manometer still reads 250 mmHg.

g. **CHECK**—Test DVM reads 2.5000, ±0.0300 V.

h. Release manometer pressure.

i. Remove test DVM.

E4. PRESSURE POSITION AND VERTICAL SENSITIVITY

a. Set DISPLAY OFF out (on).

b. Press in ZERO control and adjust for digital display reading of ±0. Release ZERO control.

c. **CHECK**—Trace should coincide with ZERO graticule line, ±1 mm.

d. **ADJUST**—Pressure Position (R495, Pressure/pulse board) to make trace coincide with ZERO graticule line.

e. Apply 250 mmHg pressure as indicated by digital display.

f. **CHECK**—Trace should coincide with 250 mmHg graticule line, ±1 mm (0.1 div.).

g. **ADJUST**—Vertical Sensitivity (R647, Main board) to correct one half crt display error.

h. Release manometer pressure.

i. **INTERACTION**—Occurs between Vertical Sensitivity and Pressure Position adjustments. Repeat steps b through h as necessary.

E5. PRESSURE/PULSE OUTPUT

a. Release manometer pressure.

b. Insert stereo phone plug (Fig. 1-2C) into PRESSURE/PULSE OUTPUT jack and connect test DVM between TIP and barrel (chassis ground).

c. Press in ZERO control and adjust for digital display reading of ±0. Release ZERO control.

d. **CHECK**–test DVM reads 0 V, ±0.0050 V.

e. Apply 250 mmHg pressure as indicated by 414 digital display.

f. **CHECK**—test DVM reads 2.5 V, ±0.0500.

g. Remove test DVM and stereo phone plug.

h. Release manometer pressure.

E6. PRESSURE ALARM

a. Set ALARM LOUDNESS (rear panel) to midrange.

b. Simulate a pulsatile pressure display by pressing and releasing the 100 mm CHECK button approximately once every second. Set PULSE ALARM in (on). Continue to press and release 100 mm CHECK button for more than 30 seconds and check that alarm is not triggered.

c. Stop pressing 100 mm CHECK button.

d. **CHECK**—Alarm is triggered within about 30 seconds.

e. Set PULSE ALARM button out (off).

f. Disconnect manometer and pressure transducer.

E7. PULSE DISPLAY

a. Set PULSE button in.

b. Connect Pulse sensor to PULSE SENSOR INPUT on rear panel and monitor your pulse.

c. **CHECK**—Monitor displays pulse. Digital display is blanked.

E8. PULSE ALARM

a. Set PULSE ALARM button in (on).

b. **CHECK**—Alarm is not triggered after waiting more than 30 seconds.

c. Disconnect Pulse sensor.

d. **CHECK**—Alarm is triggered within 3-15 seconds.

e. Momentarily push ALARM RESET.

f. **CHECK**–Audible alarm ends and ALARM light goes out. Alarms recur within 3-15 seconds.

g. Set PULSE ALARM button out.

h. **CHECK**–Alarm light is off.

F. RATE

Equipment Required:

1. Function generator
2. Low-pass filter (Fig. 1-2A)
3. Test DVM
4. Test oscilloscope
5. Universal counter

For adjustments and test points, see 414 ADJUSTMENT AND TEST POINT LOCATIONS pullout page.

F1. RATE CAL

a. Set:

ECG I ..... In
LOW RATE LIMIT ..... RATE ALARM OFF
RATE ..... In
DISPLAY OFF ..... In (off)

b. Connect function generator square wave through low-pass filter (Fig. 1-2A) to ECG INPUT connector and display about 4 cm at 3 Hz (180 bpm). Verify function generator frequency with universal counter. Connect test DVM between P2400-11 (Manifold board) and TP GND 1 (Readout Conditioner board).

c. **ADJUST**—Heart Rate (R1215, Readout Conditioner board) so that test DVM reads 1.8000, ±0.0100 V.

d. **CHECK**—414 digital display reads 180, ±3.

e. Set function generator to 1 Hz (verify with universal counter). Wait 15 seconds.

f. **CHECK**—Digital display reads 60, ±3.

g. Set function generator to 4 Hz (verify with universal counter). Wait for 15 seconds.

h. **CHECK**—Digital display reads 240, ±5.

i. Turn off function generator. Wait 15 seconds.

j. **CHECK**—Digital display reads 0 to 3.

F2. RATE ALARM LIMITS

a. Turn on function generator and set frequency to read 120, ±1 bpm (2 Hz) on digital display.

b. Set:

ALARM LOUDNESS (rear panel) ..... Midrange
LOW RATE LIMIT (press for digital display) 116
HIGH RATE LIMIT (press for digital display) 124

c. Press LOW RATE LIMIT control in and set to read 124 on digital display.

d. **CHECK**–Alarm tone sounds and ALARM light turns on within 30 seconds.

e. Set LOW RATE LIMIT to read 116 on digital display.

f. Press in RESET button.

g. **CHECK**—Audio alarm and light go out.

h. Press HIGH RATE LIMIT control in and set to read 116 on digital display.

i. **CHECK**–Alarm tone sounds and alarm light turns on within 30 seconds.

j. Set LOW RATE LIMIT control to RATE ALARM OFF.

k. **CHECK**–Audio alarm and light go out.

l. Set HIGH RATE LIMIT control to 150 (printed on front panel). Press control in and check that digital display reads 150, ±15 bpm. Repeat check at 90 and 240 for digital display readings within 5 bpm. Loosen set screw and readjust knob on shaft to make panel settings and digital dsplay within 15 bpm of each other at 150 and within 5 bpm at 90 and 240.

m. Set HIGH RATE LIMIT fully clockwise.

n. Set LOW RATE LIMIT control to 90 (printed on front panel). Reset alarm as necessary. Press control in and check that digital display reads 90, ±15. Repeat check at 30 and 150 for digital dislay reading within 5 bpm. Loosen set screw and readjust knob on shaft to make front-panel settings and digital display within 15 bpm of each of other at 90 and with 5 bpm at 30 and 150.

o. Disconnect function generator and low-pass filter.

414 OPTION 20 CALIBRATION PROCEDURE

PERFORM 414 CALIBRATION PROCEDURE MAKING CHANGES AS FOLLOWS:

B. ECG

Delete item 5, "Stereo phone plug (Fig. 1-2C)" from the Equipment Required list.

B2. DC LEVEL

Replace parts a through e with the following:

a. **CHECK**—Trace is vertically centered within 3 mm.

b. **ADJUST**—Dc Level (R185) for vertically centered trace.

c. Remove ECG shorting plug.

B3. ECG OUTPUT GAIN

Delete.

C. DIGITAL DISPLAY

Delete "Pressure transducer" from Equipment Required list.

C1. DVM ZERO AND DVM CAL

Replace parts a through p with the following:

a. Set:

ECG OFF ..... In (off)
DISPLAY OFF (Press) ..... In (off)
TEMP ..... In

b. Insert a 5°C temperature sensor substitution plug into TEMPERATURE SENSOR INPUT jack on rear panel.

c. Connect test DVM between TP GND 1 and TP1012 (Readout Conditioner board).

d. **ADJUST**—°C Cal (R1420) for a reading between 0.0020 V and −0.0020 V on test DVM.

e. **ADJUST**—DVM Zero (R2334) so that 414 digital display reads about 2; then rotate R2334 CCW until reading just starts to alternate between + and −0; then continue to rotate R920 about 1/8th turn more.

f. Remove 5°C temperature sensor substitution plug and insert a 45°C temperature sensor substitution plug (Fig. 1-4).

g. Move test DVM +lead from TP1012 to P2400-9 (Manifold board).

h. **ADJUST**–DVM Cal (R2332, DVM board) so that 414 digital display reads same number as test DVM (i.e., if test DVM reads 0.4488, set DVM Cal so that 414 digital display reads 44.8).

i. Remove 45°C temperature sensor substitution plug and insert the 5°C temperature sensor substitution plug.

j. **INTERACTION**-Occurs between DVM Zero and DVM Cal adjustments. Repeat steps d through i as necessary.

k. Readjust °C Cal (R1420 for display of 5.0 and remove temperature sensor substitution plug and test DVM.

D. TEMPERATURE

D1. TEMP SPAN

a. Delete "°C/°F ..... °F"

D2. °C CAL

a. Change "77°F" to "25°C" (use Table 5-1 instead of Table 4-1).

E. PRESSURE/PULSE

Delete "1. Manometer", "2. Pressure Transducer", and "4. Stereo phone plug (Fig. 1-2C)" from Equipment Required List.

E1. through E4

Delete

TABLE 5-1

Temperature Readout Checks and Adjustments

Temperature Sensor Substitution Plug (Fig. 1-4)	Test DVM Readings at P2400-9	414 Option 20 Digital Display Readings (Checks Only)	Adjustments
25°C	0.2500 ± 0.0010 V[1]	25.0 ± 0.3°C	°C Cal (R1420)
5°C	[2]	5.0 ± 0.3°C	Check Only
45°C	[2]	45.0 ± 0.3°C	Check Only

[1] If you cannot obtain the accuracy indicated, it will be necessary to readjust the Temp Span and the °C Cal adjustments and slightly compromise the settings.

[2] Test DVM reading for these temperature values are equivalent to 10 mV/degree.

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414 OPTION 21 CALIBRATION PROCEDURE

PERFORM 414 CALIBRATION PROCEDURE REPLACING SUBSECTION: E. PRESSURE/PULSE WITH THE FOLLOWING:

E. PRESSURE

Equipment Required:

1. Manometer
2. Pressure Transducer
3. Digital Voltmeter
4. Stereo Phone Plug (Fig. 1-2C)

For adjustments, see Figure 6-1.

For test points, see 414 ADJUSTMENT AND TEST POINT LOCATIONS pull out page.

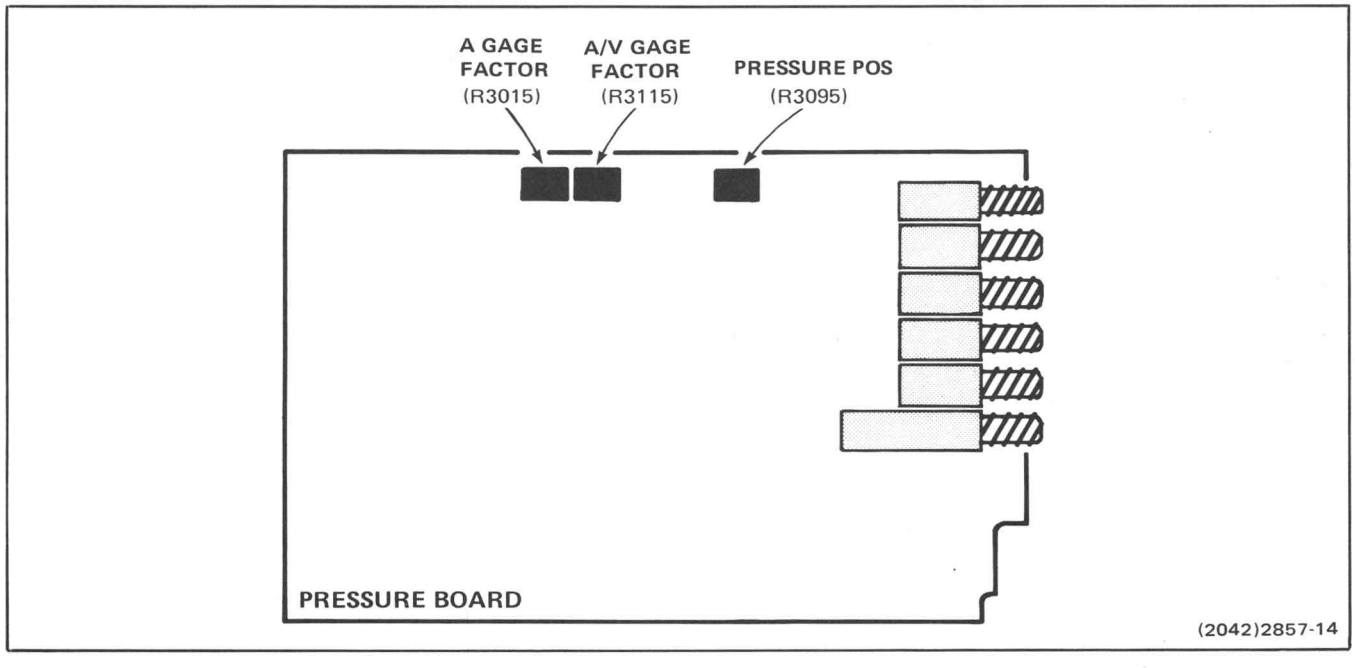

Figure 6-1. 414 Option 21 Pressure-Board adjustment locations.

E1. A GAGE FACTOR

a. Set:

DISPLAY OFF (both) ..... In (off)
MEAN ..... In
OUT A, IN A/V ..... OUT A
A GAGE FACTOR
(Opt 2 with Opt 21 only) ..... Preset (CW)

b. Connect manometer to pressure transducer and pressure transducer to ARTERIAL TRANSDUCER INPUT connector on rear panel. Connect test DVM between P2400-20 (Manifold board) and TP GND 1 (Readout Conditioner board).

c. Press in A ZERO control and adjust for test DVM reading of 0.0000, ±0.0200 V. Record exact reading for use in later steps.

d. Apply 250 mmHg pressure as indicated by manometer. Make sure pressure remains at 250 mmHg and is not slowly diminishing.

e. **ADJUST**–A Gage Factor (R3015, Pressure/pulse board; OPT 2—inside rear panel) for test DVM reading of 2.5000 ±0.0200 V plus reading noted in step c. Record exact reading.

f. Release manometer pressure.

g. **CHECK**—Test DVM reading equals reading noted in step e minus 2.5000, ±0.0200 V.

h. **INTERACTION**—Can occur between Pressure ZERO and Gage Factor adjustments. Repeat steps c through g as necessary until difference between pressure reading at 0 mmHg and 250 mmHg is 2.5000, ±0.0200 V.

E2. A/V GAGE FACTOR

a. Set:

A/V PRESSURE 250 ..... In
OUT A, IN A/V ..... IN A/V
MEAN ..... In
A/V GAGE FACTOR
(Opt 2 with Opt 21 only) ..... PRESET (CW)

b. Connect manometer to pressure transducer and pressure transducer to ARTERIAL/VENOUS TRANSDUCER INPUT connector on rear panel. Connect test DVM between P2400-3 (Manifold board) and TP GND 1 (Readout Conditioner board).

c. Press in A/V ZERO control and adjust for test DVM reading of 0.0000, ±0.0200 V. Record exact reading for use in later steps.

d. Apply 250 mmHg pressure as indicated by manometer. Make sure pressure remains at 250 mmHg and is not slowly diminishing.

e. **ADJUST**—A/V Gage Factor (R3115, Pressure/pulse board; OPT 2—inside rear panel) for test DVM reading of 2.5000 ±0.0200 V plus reading noted in step c. Record exact reading.

f. Release manometer pressure.

g. **CHECK**—Test DVM reading equals reading noted in step e minus 2.5000, ±0.0200 V.

h. **INTERACTION**—Can occur between Pressure A/V ZERO and A/V Gage Factor adjustments. Repeat steps c through g as necessary until difference between pressure reading at 0 mmHg and 250 mmHg is 2.5000, ±0.0200 V.

E3. MEAN PRESSURE DISPLAY

a. Apply 250 mmHg pressure as indicated by manometer.

b. **CHECK**—414 digital display reads 250, ±5 mmHg.

c. Apply 150 mmHg pressure as indicated by manometer.

d. **CHECK**—Digital display reads 150, ±3 mmHg.

e. Apply 25 mmHg pressure as indicated by manometer.

f. **CHECK**—Digital display reads 25, ±3 mmHg.

E4. SYSTOLIC/DIASTOLIC PRESSURE DISPLAY

a. Set:

SYST/DIAST ..... In
A/V PRESSURE 250 ..... In
A/V DISPLAY OFF ..... Out (on)

b. Move test DVM + lead to P2400-26.

c. Apply 250 mmHg pressure as indicated by manometer.

d. Check—Test DVM reads 2.5000, ±0.0200 V.

e. **CHECK**—Digital display reads 250, ±5 mmHg.

f. Move test DVM + lead to P2400-10. Make sure manometer still reads 250 mmHg.

g. **CHECK**—Test DVM reads 2.5000, ±0.0300 V.

h. Release manometer pressure.

i. Remove test DVM.

E5. CHECK DUAL-PRESSURE DISPLAY

a. Set:

DISPLAY OFF (both) ..... Out (display on)
SWEEP SPEED mm/SEC 100 ..... In
A/V PRESSURE 250 ..... In

b. Apply about 100 mmHg pressure as indicated by manometer connected to the A/V channel.

c. **CHECK**—Two traces appear on crt screen indicating dual-Pressure display is present.

d. Release manometer pressure.

E6. PRESSURE POSITION AND VERTICAL SENSITIVITY

a. Set A DISPLAY OFF out (on).

b. Press in A/V ZERO control and adjust for digital display reading of ±0. Release ZERO control.

c. **CHECK**—Trace should coincide with ZERO graticule line, ±1 mm (0.1 div).

d. **ADJUST**—Pressure Position (R3095, Pressure/pulse board) to make trace coincide with ZERO graticule line.

e. Apply 250 mmHg pressure as indicated by digital display.

f. **CHECK**—Trace should coincide with 250 mmHg graticule line, ±1 mm (0.1 div.).

g. **ADJUST**—Vertical Sensitivity (R647, Main board) to correct one half crt display error.

h. **INTERACTION**—Occurs between Vertical Sensitivity and Pressure Position adjustments. Repeat steps b through g as necessary.

E7. PRESSURE OUTPUT

a. Release manometer pressure.

b. Insert stereo phone plug (Fig. 1-2C) into PRESSURE OUTPUT jack and connect test DVM between TIP and barrel (chassis ground).

c. Set A/V PRESSURE 250 pushbutton in.

d. Press in A/V ZERO control and adjust for digital display reading of ±0. Release ZERO control.

e. **CHECK**—test DVM reads 0, ±0.0050 V.

f. Apply 250 mmHg pressure as indicated by 414 digital display.

g. **CHECK**—test DVM reads 2.5 V, ±0.0500 V.

h. Move manometer and pressure transducer to ARTERIAL PRESSURE INPUT connector.

i. Connect test DVM between ring and barrel contacts of phone plug.

j. Press in A ZERO control and adjust for digital display reading of ±0. Release ZERO control.

k. **CHECK**—Test DVM reads 0 V, ±0.0050 V.

l. Set OUT A IN A/V out (A) and apply 250 mmHg pressure to channel A as indicated by the 414 digital display.

m. **CHECK**—Test DVM reads 2.5 V, ±0.0500 V.

n. Remove DVM and stereo phone plug.

E8. PRESSURE ALARM AND TRIGGER SOURCE

a. Set:

ALARM LOUDNESS (rear panel) ..... Midrange
OUT A, IN A/V ..... Out (A)

b. Connect a pressure transducer and manometer to each channel.

c. Simulate a pulsatile pressure display by applying and releasing manometer pressure to channel A about once every second. Apply sufficient pressure each time to produce a 2-3 cm display. Set PULSE ALARM in (on). Continue applying and releasing pressure for at least 30 seconds and check that alarm is not triggered. Also check that the sweep is triggered, rather than free-running.

d. Set OUT A, IN A/V pushbutton in (A/V). While continuing to apply and release pressure to channel A.

e. **CHECK**—Alarm is triggered within about 30 seconds. This checks that the trigger source is no longer from channel A.

f. Set PULSE ALARM pushbutton out (off).

g. Disconnect manometer and pressure transducer from channel A.

h. Simulate a pulsatile-pressure display by applying and releasing manometer pressure to channel A/V about once every second. Apply sufficient pressure each time to produce a 2-3 cm display. Set PULSE ALARM in (on). Continue applying and releasing pressure for at least 30 seconds and check that alarm is not triggered.

i. Stop applying and releasing pressure to channel A/V.

j. **CHECK**—Alarm is triggered within about 30 seconds.

k. Set PULSE ALARM pushbutton out (off).

l. Disconnect manometer and pressure transducer from channel A/V.

400 CALIBRATION PROCEDURE

PRELIMINARY PROCEDURE

1. Check operation of all modes and correct any defects before attempting to adjust the recorder. The Functional Check, given in the 400 Service Manual, can be used if necessary.

2. Turn monitor power off and disconnect from ac power line.

3. Connect 400 Recorder battery plug to side of battery pack.

4. Connect interconnecting plug onto recorder. Note proper location of red stripe.

NOTE

If the recorder being calibrated is connected to a 413 Monitor, Calibration Aid 067-0851-00 must be connected between the monitor and the interconnecting cable from the recorder. This Calibration Aid allows external signals to be connected to the recorder during calibration. (The 413 Monitor does not use the Manifold board required by the 414 Monitor.)

5. Connect monitor to ac power line and press ON button. You should begin calibration procedure with fully charged batteries.

NOTE

If a 401 Digital Readout Module had been previously removed, the battery is no longer connected to the battery-charge circuitry and could result in the battery being discharged before the 400 Recorder is completely calibrated.

6. Set:

SPEED ..... In (50)
AUTOMATIC SAMPLE
MODES ..... Both pushbuttons out

ADJUSTMENT PROCEDURE

Refer to TEST POINT AND ADJUSTMENT LOCATIONS pullout page.

1. -11.9 VOLT REFERENCE SUPPLY

a. Connect test DVM leads between -11.9 test point and ground (power supply shield).

b. Press SAMPLE/MARK pushbutton to start recorder.

NOTE

Press the SAMPLE/MARK pushbutton as necessary to keep recorder running.

c. **CHECK**—Test DVM reads -11.9 V ±35 mV.

d. **ADJUST**—R2095 (-11.9 V) for -11.9 V.

2. 50 mm/SEC CHART SPEED

a. Apply a 3.0 volt peak-to-peak 1 Hz square-wave signal from the Function Generator as follows. See Figure 7-1 for locations of signal inputs.

(1) 414 Monitor:
Unplug the green connector (P2415) from the Manifold board in the monitor. Connect the function generator output to A/V Wave input (P2415-1), and the function generator common to Wave Common input (P2415-3). Press the recorder A/V pushbutton.

(2) 413 Monitor:
Unplug the A/V Wave jumper connector from the 400 Recorder Calibration Aid. Connect the function generator output to A/V Wave (to Recorder) input and the function generator common to Wave Common input. Press the recorder A/V PULSE or A/V pushbutton.

Press SAMPLE/MARK pushbutton to start recorder.

c. **CHECK**—One complete square wave period occurs every 10 major divisions (5 cm) within 0.5 minor division.

d. **ADJUST**—R2014 (50 mm) for one complete square wave per 10 major divisions.

3. 25 mm/SEC CHART SPEED

a. Set SPEED pushbutton out (25).

b. Press SAMPLE/MARK pushbutton to start recorder.

c. **CHECK**—One complete square wave occurs every 5 major divisions (2.5 cm) within 0.5 minor division.

d. **ADJUST**—R2012 (25 mm) for one complete square wave per 5 major divisions.

4. PEN AMPLIFIER GAIN

a. Press SAMPLE/MARK button to start recorder.

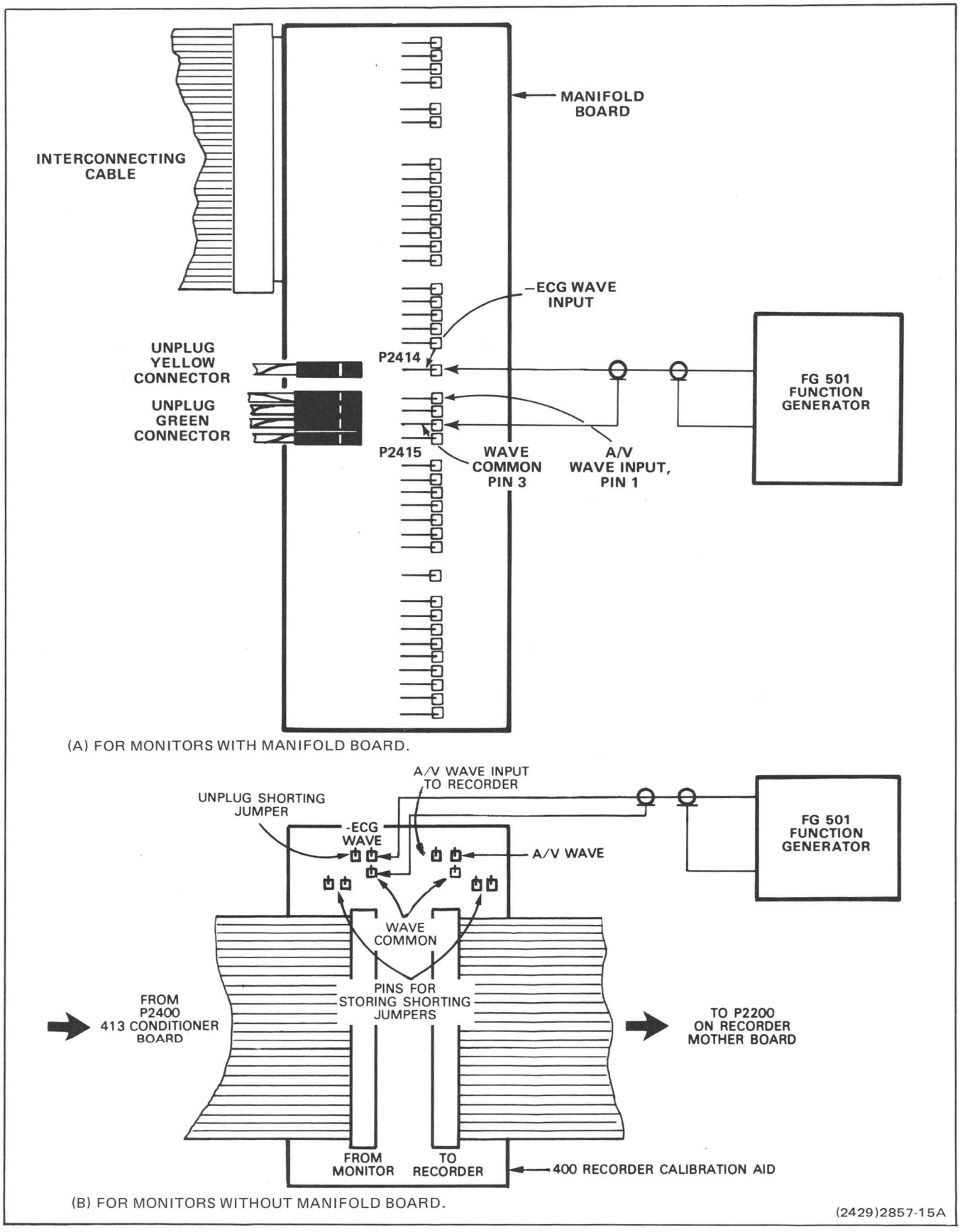

Figure 7-1. Connecting square wave to -ECG wave input.

b. Center written square wave on grid with function generator offset control.

c. **CHECK**—Peak-to-peak amplitude of written square wave is 6 major divisions (3 cm) within 1.5 minor divisions. Ignore overshoot or undershoot.

d. **ADJUST**—R375 (Gain) for an amplitude of 6 major divisions.

5. PRESSURE ZERO POSITION

a. Set monitor pressure range to 250 (0-125 for 413).

b. Short together A/V Wave (P2415-1) to Wave Common (P2415-3) on Manifold board or on Calibration Aid. (See Fig. 7-1.)

c. Press SAMPLE/MARK pushbutton.

c. **CHECK**—Zero reference line is written 1 major division up from bottom grid line, within 0.5 minor division.

e. **ADJUST**—R352 (Pressure Zero Postion) so that zero reference line is written 1 major division up from bottom grid line.

f. Remove short.

g. Recheck Step 4 Pen Amplifier Gain. Interaction occurs between steps 4 and 5.

6. PEN AMPLIFIER DAMPING AND SPIKE

a. Reduce input signal to about 1 volt peak-to-peak.

b. Press SAMPLE/MARK pushbutton.

c. Center written square wave on grid with function generator offset control.

d. **CHECK**—Written square wave has flat top.

e. **ADJUST**—R380 (Damping) for flat-top square wave.

f. **CHECK**—Written waveform has no svershoot or undershoot.

g. **ADJUST**—R365 (Spike) for no overshoot or undershoot on waveform.

h. **INTERACTION**—Occurs between Damping and Spike adjustments. Repeat Steps d through g as necessary.

i. Disconnect test equipment. Reconnect yellow and green connectors to P2414 and P2415 on Manifold board. (If using Calibration Aid, replace shorting jumpers.)

7. 1165 HZ OSCILLATOR

a. Connect universal counter input to TP134 and ground lead to the recorder-module frame.

b. **CHECK**—Waveform period is 858 μs, within 30 μs.

c. **ADJUST**—R134 (1165 Hz Oscillator) for a period of 858 μs.

8. RUN CLOCK

a. Connect universal counter to TP178.

b. **CHECK**–Waveform period is 437.5 ms (500 ms for OPT 4). within 30 ms.

c. **ADJUST**–R176 for a period of 437.5 ms (500 ms for OPT 4).

9. 25 mm/SEC DOT INTENSITY

a. Connect a test oscilloscope to TP1830 on Print Drive board.

b. Set SPEED pushbutton out (25 mm/sec).

c. Press SAMPLE/MARK pushbutton.

d. **CHECK**—Positive-going pulse duration is 8 ms, within 0.2 ms.

e. **ADJUST**—R1810 (25 mm Intensity) fully counterclockwise then clockwise for a positive-going pulse of 8 ms.

CAUTION

Do not increase the dot-on time greater than 8 ms. Exceeding this value increases the print head temperature resulting in a substantial reduction in print head life.

10. 50 mm/SEC DOT INTENSITY

a. Press SPEED pushbutton in (50 mm/sec).

b. Press SAMPLE/MARK pushbutton.

c. **CHECK**—Positive-going pulse duration is 7.6 ms +0.1, -0.2 ms.

d. **ADJUST**—R1815 (50 mm Intensity) fully counterclockwise then clockwise for a positive-going pulse of 7.6 ms duration.

e. Set SPEED pushbutton out (25).

11. DVM SIGN POLARITY

a. Connect test DVM input to TP845 and common to P830 pin 3 on the DVM Analog board. (Pin 3 is towards the front of the recorder.)

b. Move P830 jumper connector from pins 1 and 2 to pins 2 and 3. Note that the test DVM common lead is also connected to pin 3.

c. Press the SAMPLE/MARK pushbutton.

d. **CHECK**—For negative voltage.

e. **ADJUST**—R845 (Sign) so that the voltage at TP845 just changes from positive to negative.

f. Replace P830 jumper connector on pin 1 and 2.

12. DVM FULL SCALE GAIN

a. Connect a 113°F/45°C temperature simulation plug (Fig. 1-4) to the monitor TEMPERATURE SENSOR INPUT jack (input A on monitors with multiple temperature capability).

b. Place the monitor °C/°F switch in the °F position.

c. Connect the test DVM input to the TEMP A signal in the monitor/recorder interconnecting ribbon cable, at P2200 pin 9 or to the 400 Recorder Calibration Aid. The test DVM common remains on DVM GND at P830 pin 3 or to the 400 Recorder Calibration Aid.

d. Press SAMPLE/MARK pushbutton.

e. **CHECK**–Recorder TEMP A printout reads same value as test DVM within 0.1° F. For example, if the test DVM indicates 1131 mV, the printout must be in the range 113.0° to 113.2°.

f. **ADJUST**–R806 (Full Scale) so tape readout is within 0.1° of the test DVM readout.

13. DVM ZERO OFFSET

a. Move the P830 jumper connector to pins 2 and 3.

b. Press SAMPLE/MARK pushbutton.

c. **CHECK**—Tape TEMP A printout reads 0.0°F.

d. **ADJUST**—R815 (Zero) counterwise, until numbers other than zero appear in the TEMP A printout.

e. **ADJUST**—R815 clockwise until 0.0°F just appears in the TEMP A printout. Do not adjust R815 past the setting where 0.0 first appears.

f. **INTERACTION**—Repeat steps 12f and 13d as needed to null out interaction between the DVM Full Scale Gain and Zero Offset adjustments.

14. CHECK RECORDER RESPONSE TO A DVM NEGATIVE INPUT

a. Replace the 23°F/-5°C plug.

b. Place the monitor °C/°F switch in the °C position.

c. Move the P830 jumper connector to pins 1 and 2.

d. Press SAMPLE/MARK pushbutton.

e. **CHECK**—Tape TEMP A readout corresponds to test DVM reading within 0.2°C (based on bus voltage equivalent of 10 mV/degree). For example, if the test DVM indicates -52 mV, the printout must be in the range -5.0°C to -5.4°C.

f. Remove test DVM leads.

15. REASSEMBLE RECORDER AND MONITOR

a. Turn monitor power off, and disconnect from ac power line.

b. Remove Calibration Aid from interconnecting cable. Reconnect interconnecting plug.

c. Mount recorder to monitor. Be sure to fold inteconnecting cable correctly. See illustration on top of recorder.

401 CALIBRATION PROCEDURE

PRELIMINARY PROCEDURE

1. Install 401 Digital Readout Module as follows: (Refer to Fig. 8-1)

   a. Turn off monitor power and disconnect ac power cord.

   b. Position 401 over monitor.

   c. Fold main interconnecting cable, as shown, and connect P4010 to 401.

   d. Connect remaining interconnecting cable plugs (connect P4040 and P4050 last).

   e. Gently slide bottom front edge of 401 up to monitor front frame casting to engage the front latch.

   f. Keeping interconnecting cables clear, lower back of 401 so that it meets monitor rear frame casting.

   g. Rotate slotted fastener, at rear of 401 chassis, 90 degrees clockwise to secure 401 to monitor.

2. Set monitor controls as follows:

   DISPLAY OFF
   (Resp., 413 only) ..... In (off)
   DISPLAY OFF (Press/Pulse) ..... In (off)
   OFF (ECG) ..... In (off)
   LOW RATE LIMIT ..... RATE ALARM OFF (ccw)
   PULSE ALARM ..... Out (off)
   POWER ..... In (on)

3. Set the remaining monitor controls as desired. Connect the monitor to the correct ac-line source.

4. Set 401 Readout Module button in (on).

For adjustments and test-points, see Fig. 8-2.

ADJUSTMENT PROCEDURE

1. +5 VOLT ADJUSTMENT

a. Connect test-DVM ground (-) lead to TP4065 (GND) and positive (+) lead to TP4040 (+5).

b. **CHECK**—Test DVM reads +5 volts within 50 mV.

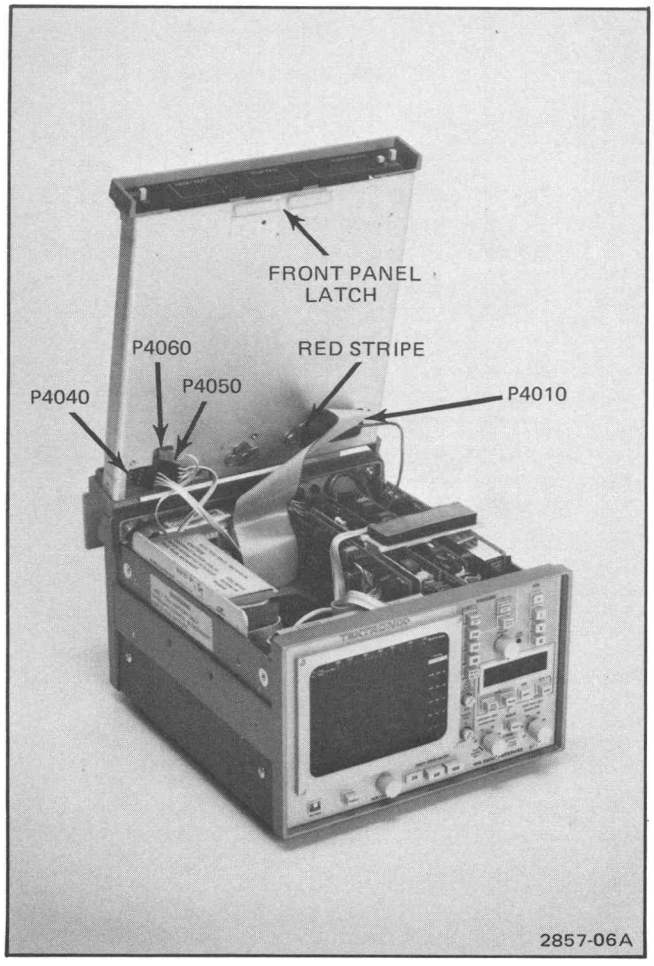

Figure 8-1. Digital Readout Module removal and replacement.

c. **ADJUST**—R4061 (+5 V Adj) so that test DVM reads +5 volts.

d. Remove test-DVM leads from test points.

2. TEMPERATURE DVM CAL

a. Set monitor controls as follows:

   TEMPERATURE A (413) ..... In
   TEMPERATURE (414 or 414 Opt 21) ..... In
   °C/°F (monitor) ..... °F

b. Set 401 TEMPERATURE A pushbutton in.

c. Insert 113°F/45°C temperature sensor substitution plug (Fig. 1-4) into TEMPERATURE SENSOR INPUT (A, 413) jack on monitor rear panel.

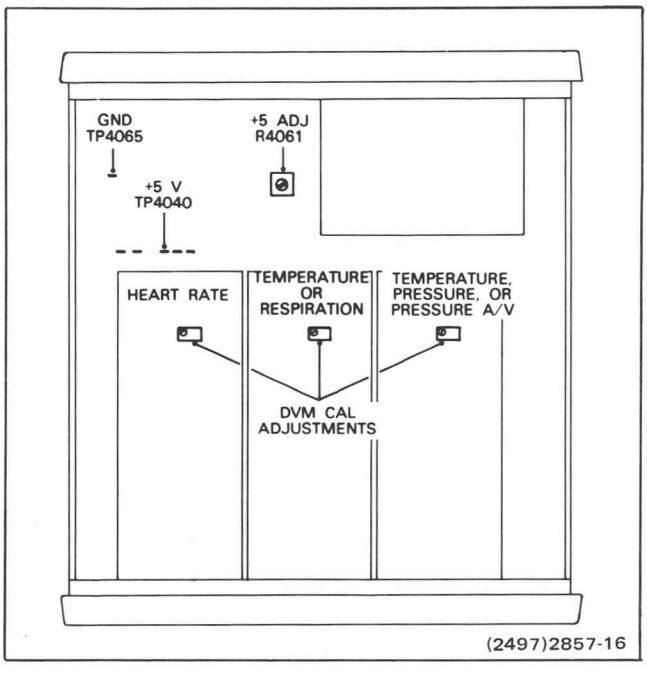

Figure 8-2. Test-point and adjustment locations.

d. **ADJUST**—Temperature DVM Cal so that 401 digital display reads 113.0 ±0.1.

e. **CHECK**—Monitor digital display reads same as 401 TEMPERATURE display within 0.5.

f. Using Table 8-1, check 401 TEMPERATURE display accuracy and deviation from monitor. Skip TEMPERATURE B when calibrating a 401 with a 414 or 414 option 21.

g. Insert 113°F/45°C temperature sensor substitution plug into TEMPERATURE SENSOR INPUT (A) and a 77°F/25°C plug into TEMPERATURE SENSOR INPUT B(413).

h. Press in 401 TEMPERATURE A pushbutton and record digital readout. Press in B pushbutton and record digital readout. Calculate A-B.

i. Set both 401 TEMPERATURE A and B pushbuttons in at the same time (A MINUS B).

j. **CHECK**—401 digital display of A minus B is same as the caculated value within 1.0°F or 0.6°C.

TABLE 8-1

Temperature Readout Checks

Temperature Input & Display Selection[1]	Temperature Sensor Simulation Plug	°C/°F Switch Setting	401 Temperature Display Reading	Recommended Maximum Allowable Deviation Between Monitor and 401 Readings
A	113°F/45°C	°C	45.0 ± 0.3	0.4
B	113°F/45°C	°C	45.0 ± 0.3	0.4
B	113°F/45°C	°F	113.0 ± 0.5	0.4
A	77°F/25°C	°F	77.0 ± 0.5	0.4
A	77°F/25°C	°C	25.0 ± 0.3	0.4
B	77°F/25°C	°C	25.0 ± 0.3	0.4
B	77°F/25°C	°F	77.0 ± 0.5	0.4
A	41°F/5°C	°F	41.0 ± 0.5	0.4
A	41°F/5°C	°C	5.0 ± 0.3	0.4
B	41°F/5°C	°C	5.0 ± 0.3	0.4
B	41°F/5°C	°F	41.0 ± 0.5	0.4

[1]Insert temperature sensor substitution plug in the TEMPERATURE SENSOR INPUT jack as indicated in second column. Set TEMPERATURE A, B pushbuttons (on monitor and 401) to corresponding positions.

When calibrating 401 with 414 or 414 Option 21 monitor, ignore TEMPERATURE INPUT B checks since there is only one temperature input.

k. Set both monitor TEMPERATURE A and B pushbuttons in at the same time (A MINUS B).

l. **CHECK**—Monitor digital display reads same as 401 TEMPERATURE A MINUS B display within 0.5°F or 0.5°C.

m. Remove temperature sensor substutition plugs.

3. HEART RATE DVM CAL

a. Set monitor ECG I and HEART RATE/MIN pushbuttons in.

b. Connect function generator square wave through low-pass filter (Fig. 1-2A) to monitor ECG INPUT connector. Display about 4 cm at 4 Hz (verify frequency with universal counter).

c. **ADJUST**—Heart Rate DVM Cal so that 401 HEART RATE display reads 240 ±1.

d. **CHECK**—Monitor digital display reads the same as 401 HEART RATE display within 5.

e. Set function generator frequency to 2 Hz (verify with counter).

f. **CHECK**—401 HEART RATE display reads 120 ±3.

g. **CHECK**—Monitor digital display reads same as 401 HEART RATE display within 5.

h. Set function generator frequency to 1 Hz (verify with counter).

i. **CHECK**—401 HEART RATE display reads 60 ±3.

j. **CHECK**—Monitor digital display reads the same as 401 HEART RATE display within 5.

IF YOU ARE CALIBRATING A 401 WITH A 414 OR 414 OPTION 21 SKIP TO STEP 5.

4. RESPIRATION RATE DVM CAL (STANDARD 401 ONLY)

a. Remove 401 Digital Readout Module from 413 Monitor as follows:

1. Place 413/401 on its side.

2. Rotate slotted fastener at rear of 401 chassis with screwdriver 90 degrees counterclockwise to release rear of 401 from monitor.

3. Lift rear of 401 away from monitor; then slide 401 backwards to free it from the monitor.

4. Leave monitor and 401 on their sides while calibrating.

b. Connect a 10 MΩ resistor between TP371 on the monitor ECG board and TP441 on the monitor Respiration board. See Figure 8-3.

c. Set function generator frequency so that 401 HEART RATE display reads 115 to 120.

d. Set monitor control as follows:

RESPIRATION SIZE ..... Midpoint (dot on panel)
RESP RATE/MIN ..... In

Allow one minute for respiration display to stabilize.

e. **ADJUST**—Respiration DVM Cal so that 401 RESPIRATION display reads same as 401 HEART RATE display within 1.

f. **CHECK**—Monitor digital display reads same as 401 RESPIRATION RATE display within 5.

g. Set function generator so that 401 HEART RATE display reads 55 to 60. Allow at least 30 seconds for RESPIRATION display reading to settle.

h. **CHECK**—401 RESPIRATION RATE display reads same as HEART RATE display within 3.

i. **CHECK**—Monitor digital display reads same as 401 RESPIRATION display within 5.

j. Remove 10 MΩ resistor.

k. Reinstall 401 on monitor as follows:

1. Gently slide bottom front edge of 401 up to monitor front frame casting to engage front latch.

2. Keeping interconnecting cables clear, lower back of 401 so that it meets monitor rear frame casting. Rotate slotted fastener, at rear of 401, with screwdriver 90 degrees clockwise to secure 401 to monitor.

IF YOU ARE CALIBRATING A 401 WITH A 413 MONITOR, THE PROCEDURE IS COMPLETE AT THIS POINT.

5. PRESSURE (A/V) DVM CAL (401 OPTIONS 1 & 2 ONLY)

a. Set:

Pressure Range (414 or 414 Opt21)..... 250
MEAN ..... in
DISPLAY OFF (Pressure, A/V) ..... in (off)
READOUT AND PULSE ALARM..... In(A/V)
(414 Opt 21)

b. Set 401 SYST and DIAST pushbuttons both in to select MEAN PRESSURE display.

c. Connect manometer to pressure transducer and pressure transducer to PRESSURE TRANSDUCER INPUT connector on monitor rear panel. Use ARTERIAL/VENOUS TRANSDUCER INPUT with 414 Option 21 monitor.

d. Press in monitor ZERO (A/V, 414 Opt 21) control and adjust for monitor digital display reading of + or −0.

NOTE

Make sure pressure, applied in following steps, remains at the indicated value and does not slowly diminish.

e. Apply 250 mmHg pressure as indicated by manometer.

f. **ADJUST**–Pressure DVM Cal so that 401 PRESSURE display reads 250 ±5.

g. **CHECK**—Monitor reads same as 401 PRESSURE display within 5.

h. Apply 150 mmHg pressure as indicated by manometer.

i. **CHECK**—401 PRESSURE display reads 150 ±3.

j. **CHECK**—Monitor digital display reads same as 401 PRESSURE display within 5.

k. Apply 50 mmHg pressure as indicated by manometer.

l. **CHECK**—401 PRESSURE display reads 50 ±3.

m. **CHECK**—Monitor digital display reads same as 401 PRESSURE display within 5.

n. Apply 25 mmHg pressure as indicated by manometer.

o. **CHECK**—401 PRESSURE display reads 25 ±3.

p. **CHECK**—Monitor digital display reads same as 401 PRESSURE display within 5.

q. Disconnect pressure transducer and manometer.

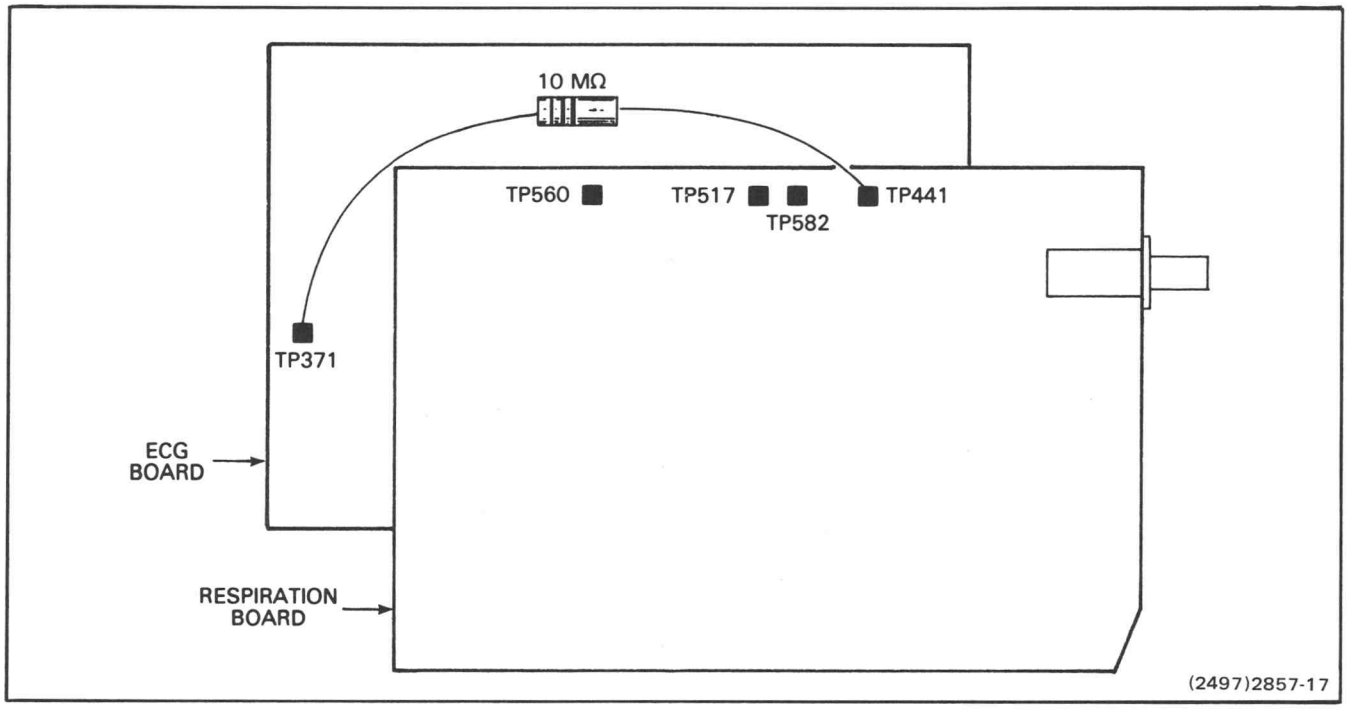

Figure 8-3. Respiration-rate test-signal connection.

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DIGITAL-DISPLAY CORRESPONDENCE CHECK PROCEDURE

INTRODUCTION

This procedure is to be used as a final check of monitor-system digital-display correspondence.

When monitor digital display does not readout parameter values within limits given in this procedure, either the signal inputs are not correct or analog signals at P2400 in the monitor are improperly calibrated. If this happens, first check that input signals are correct, then recalibrate monitor as necessary.

If, after completing the Correspondence Check, you find that the digital display deviation is only slightly greater than the recommended maximum (e.g., 0.5° instead of 0.4°), you may slightly readjust the 400 and/or 401 DVM's to reduce this deviation. NEVER readjust the monitor's DVM to reduce digital display deviation.

If in doubt about what should be done to reduce excessive deviation always go back to the monitor calibration procedure and recalibrate parameter channels where deviation has occurred.

Always repeat Digital-Display Correspondence Check after readjustment has been done.

PRELIMINARY PROCEDURE

1. Remove top and bottom covers from monitor system if not already off.

2. Set monitor controls as follows:

ON	In (power on)
DISPLAY OFF(s)	In (off)
ECG OFF	In (off)
RESP OFF (413)	In (off)
TEMPERATURE A (413)	In
TEMP (414)	In

3. Set 401 controls as follows:

READOUT MODULE ON	In (on)
TEMPERATURE A (Std. 401	In

4. Set remaining controls on all units in the system as desired. Connect the monitor to the correct ac-line source. Monitor system should have been on about 20 minutes before continuing with this procedure.

CORRESPONDENCE CHECK PROCEDURE

1. TEMPERATURE

a. Insert 113° F/45° C temperature sensor simulation plug (Fig. 1-4) into TEMPERATURE SENSOR INPUT (A, 413) jack on monitor rear panel.

NOTE

Each time a digital display is required from the 400 Recorder make a new record sample by pressing the SAMPLE/MARK button.

b. Using Table 9-1, check 400 and/or 401 TEMPERATURE display accuracy and deviation from monitor. Check both A and B channels with all simulated temperature values as given in table. Skip TEMPERATURE B when monitor is a 414 or 414 Option 21.

If there is no 401 in your monitor system, skip to step i.

c. Insert 113° F/45° C temperature sensor simulation plug into TEMPERATURE SENSOR INPUT A and a 77° F/25° C plug into TEMPERATURE SENSOR INPUT B (413).

d. Press in 401 TEMPERATURE A pushbutton and record digital readout. Press in B pushbutton and record digital readout. Calculate A-B.

e. Set both 401 TEMPERATURE A and B pushbuttons in at the same time (A MINUS B).

f. **CHECK**—401 digital display of A minus B is same as the caculated value within 1.0° F or 0.6° C.

g. Set both monitor TEMPERATURE A and B pushbuttons in at the same time (A MINUS B).

h. **CHECK**—Monitor digital display reads same as 401 TEMPERATURE A MINUS B display within 0.5°F or 0.5°C.

i. Remove temperature sensor substutition plugs.

2. HEART RATE

a. Set monitor controls:

ECG I ..... In
HEART RATE/MIN ..... In
RATE (414) ..... In

b. Connect function generator square wave through low-pass filter (Fig. 1-2A) to monitor ECG INPUT connector. Display about 4 cm at 4 Hz (verify frequency with universal counter).

TABLE 9-1

Temperature Readout Checks

Temperature Input & Display Selection[1]	Temperature Sensor Simulation Plug	°C/°F Switch	Monitor 400, and 401 Temperature Display Readings	Maximum Recommended Deviation Between Monitor, 400, and 401 Readings
A	113°F/45°C	°C	45.0 ± 0.3	0.4
B	113°F/45°C	°C	45.0 ± 0.3	0.4
B	113°F/45°C	°F	113.0 ± 0.5	0.4
A	77°F/25°C	°F	77.0 ± 0.5	0.4
A	77°F/25°C	°C	25.0 ± 0.3	0.4
B	77°F/25°C	°C	25.0 ± 0.3	0.4
B	77°F/25°C	°F	77.7 ± 0.5	0.4
A	41°F/5°C	°F	41.0 ± 0.5	0.4
A	41°F/5°C	°C	5.0 ± 0.3	0.4
B	41°F/5°C	°C	5.0 ± 0.3	0.4
B	41°F/5°C	°F	41.0 ± 0.5	0.4

[1] Insert temperature sensor substitution plug in the TEMPERATURE SENSOR INPUT jack as indicated. Set TEMPERATURE A, B, pushbutton (on monitor and 401) to corresponding positions.

When calibrating 401 with 414 or 414 Option 21 monitor, ignore TEMPERATURE INPUT B checks since there is only one temperature input.

c. Using Table 9-2, check monitor, 400 and/or 401 digital display readings and deviation between monitor, 400 and/or 401 readings.

IF YOU ARE CALIBRATING A 400 AND/OR 401 WITH A 414 OR 414 OPTION 21 SKIP TO STEP 4.

3. RESPIRATION RATE DVM CAL (400 OPT 4 AND/OR STD 401 ONLY)

a. Remove 401 Digital Readout Module from 413 Monitor as follows:

1. Place monitor system on its side.

2. Rotate slotted fastener at rear of 401 chassis with screwdriver 90 degrees counter-clockwise to release rear of 401 from monitor.

3. Lift rear of 401 away from monitor; then slide 401 backwards to free it from the monitor. DO NOT disconnect wires or cables.

4. Leave 413 Monitor system on its side for the remainder of this check.

b. Connect a 10 MΩ resistor between TP371 on the monitor ECG board and TP441 on the monitor Respiration board (see Figure 8-3).

c. Set 413 controls as follows:

RESPIRATION SIZE ..... Midpoint (dot on panel)
RESP RATE/MIN ..... in

d. Using Table 9-2, check monitor, 400 and/or 401 digital display readings and deviation between monitor, 400 and/or 401 readings at 2 Hz and 1 Hz only.

(Allow at least 60 seconds after changing frequency for RESPIRATION display reading to settle.)

e. Remove 10 MΩ resistor.

f. Reinstall 401 on monitor as follows:

1. Gently slide bottom front edge of 401 up to monitor front frame casting to engage front latch.

2. Keeping interconnecting cables clear, lower back of 401 so that it meets monitor rear frame casting. Rotate slotted fastener, at rear of 401, with screwdriver 90 degrees clockwise to secure 401 to monitor.

TABLE 9-2
Heart Rate and Respiration Readout Checks

Set Function Generator Frequency (Verify with Counter)	Check Monitor, 400 and/or 401 Digital Display Readings	Check Deviation Between Monitor, 400 and/or 401 Readings
4 Hz	240 ± 5	≤ 4
2 Hz	120 + 3	≤ 4
1 Hz	60 ± 3.	≤ 4

4. PRESSURE (A/V)

NOTE

Make sure pressure, applied in following steps, remains at the indicated value and does not slowly diminish.

a. Set monitor controls:

Pressure Range (413) 0-125
(413 Opt 22) 0-250
(414 or 414 Opt 21) 250
MEAN . . . . . In
DISPLAY OFF (Pressure, A/V) . . . . . In (off)
READOUT AND PULSE ALARM
(414 Opt 21) . . . . . In (A/V)

b. Set 401 (Opt 1 or 2 only) SYST and DIAST pushbuttons both in to select MEAN PRESSURE display.

c. Connect manometer to pressure transducer and pressure transducer to PRESSURE TRANSDUCER INPUT connector on monitor rear panel. Use ARTERIAL/VENOUS TRANSDUCER INPUT with 414 Option 21 monitor.

d. Press in monitor ZERO (A/V, 414 Opt 21) control and adjust for monitor digital display reading of + or - 0.

NOTE

Make sure pressure, applied in following steps, remains at the indicated value and does not slowly diminish.

e. Using Table 9-3, check monitor, 400 and/or 401 digital display readings and deviation between monitor, 400 and/or 401 readings. (Use appropriate pressures ranges for your particular monitor.)

f. Set monitor SYST/DIAST in and, if present, 401 SYST button in.

g. Repeat step e.

h. Set 401 DIAST button in.

i. Repeat step e.

j. Disconnect pressure transducer and manometer.

THE FOLLOWING IS FOR 414 OPT 21, WITH 400 OPT 3 AND/OR 401 OPT 2

5. PRESSURE A

a. Connect manometer to pressure transducer and pressure transducer to ARTERIAL TRANSDUCER INPUT connector.

b. Set 401 SYST and DIAST pushbuttons both in to select MEAN pressure display.

c. Set 414 Option 21 monitor controls:

READOUT AND PULSE ALARM. . . . . Out (A)
MEAN . . . . . In

d. Press in monitor ZERO A control and adjust for digital display reading of + or -0.

e. Repeat steps 4e through 4i.

f. Disconnect pressure and manometer.

NOTE

ECG leakage should be checked at this point. Refer to the ECG Leakage Check Procedure which follows.

TABLE 9-3
Pressure Readout Checks

Apply Pressure As Indicated By Manometer	Check Monitor, 400 and/or 401 Digital Display Readings	Check Deviation Between Monitor, 400 and/or 401 Readings
250 mmHg	250 ± 5	≤ 4
150 mmHg	150 ± 3	≤ 4
125 mmHg	125 ± 3	≤ 4
75 mmHg	75± 3	≤ 4
50 mmHg	50 ± 3	≤ 4
25 mmHg	25 ± 3	≤ 4

ECG LEAKAGE CHECK PROCEDURE

PURPOSE

This check determines the amount of leakage current which could be present between the patient and the ECG circuit of the monitor under either of the following abnormal conditions: (1) monitor is properly grounded and patient is at 115 V ac, 60 Hz, or (2) monitor is not grounded, case is connected to 115 V ac, 60 Hz and patient is grounded.

TEST EQUIPMENT REQUIRED

Use an instrument such as the Model 431 Safety Analyzer, manufactured by Neutrodyne-Dempsey Inc., P.O. Box 1925, Carson City, Nevada.

LEAKAGE CHECK PROCEDURE

1. Replace 400 and/or 401 onto monitor and install top and bottom covers. Leakage check is valid only with covers installed.

2. Check ECG-leakage current using procedure supplied by the the Safety Analyzer manufacturer.

Continue with the following steps only if the monitor fails the leakage check.

3. Disconnect monitor from ac power source.

4. Separate 400 and/or 401 from monitor. Do not disconnect interconnecting cables or wires.

5. **CHECK**–All plug-in circuit boards are pushed firmly into their mating receptacles.

6. **CHECK**–All cables are plugged firmly into their mating pins and that they are dressed away from ECG shield, input connector shield and pushbutton switch shafts.

7. **CHECK**–Screw and spacer securing ECG circuit board are tight.

8. **CHECK**–Plastic board retainer is installed and properly seated at top of circuit boards.

9. Repeat steps 1 and 2.

CONTENTS

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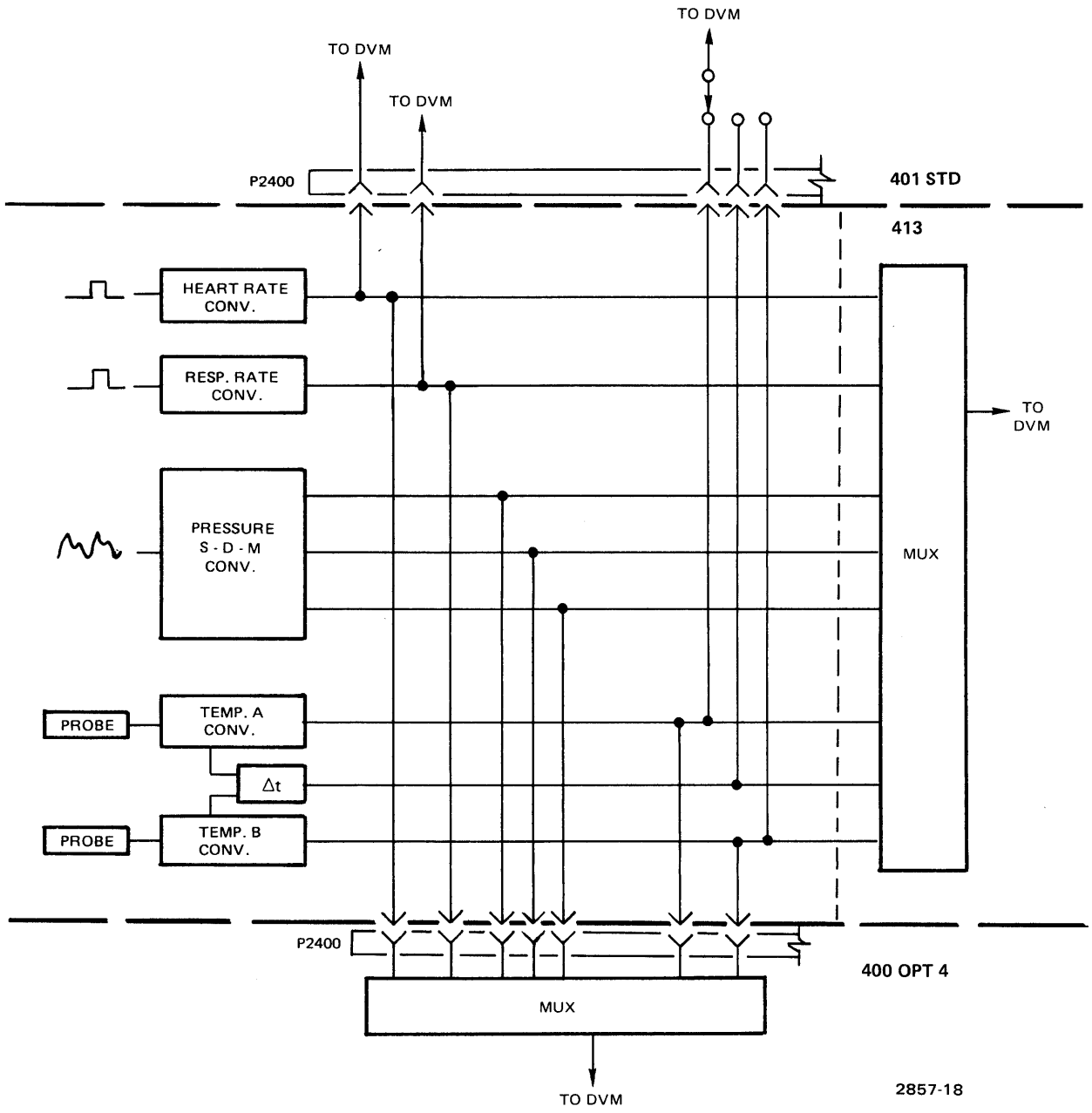
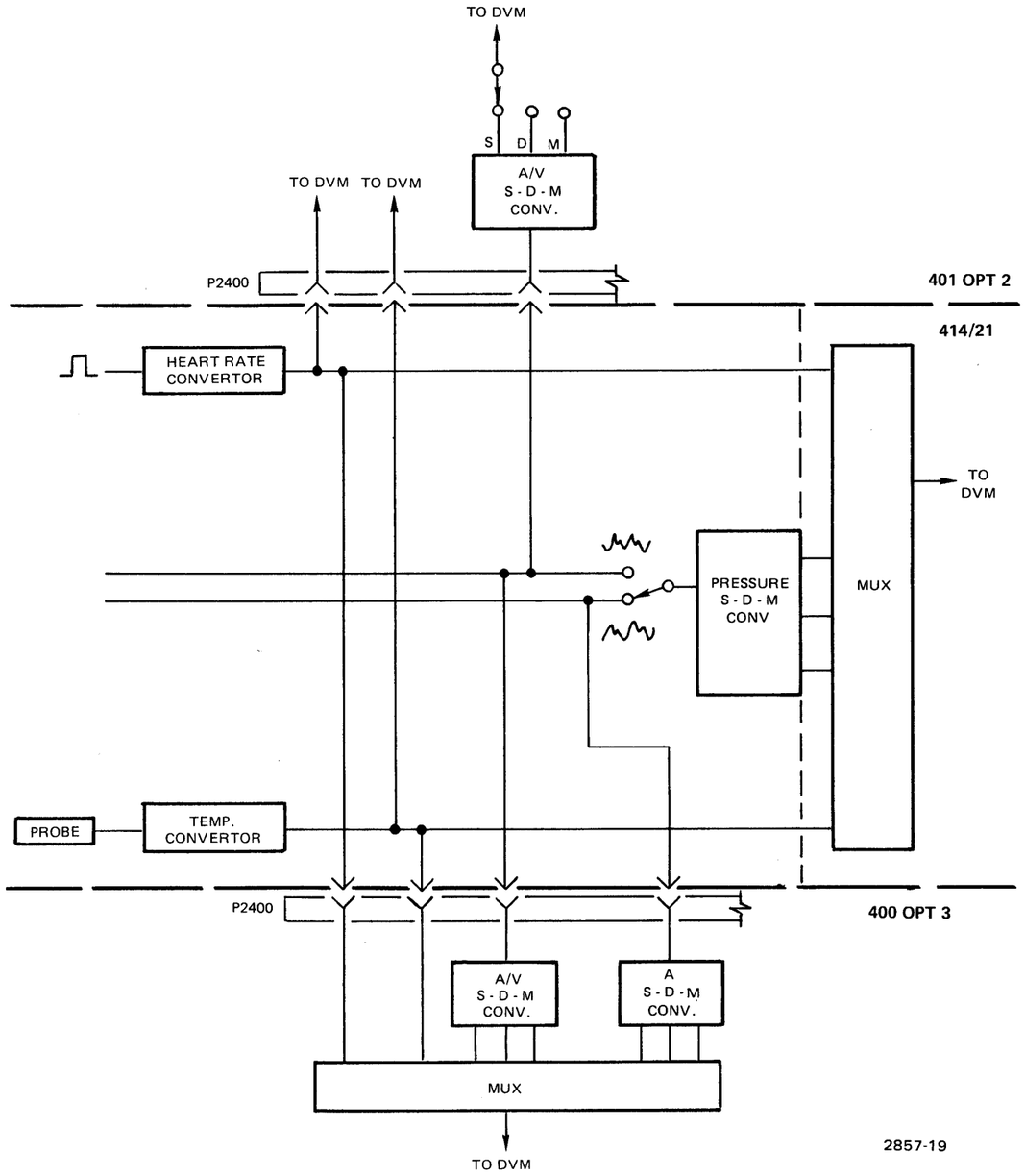
TABLE 11-1

P2400 INTERCONNECTING SIGNALS

P2400	SIGNAL NAME	DIGITAL VOLTAGE LIMITS		ANALOG VOLTAGE EQUIV
		LO	HI	
1	ALARM EXT OUT	0V	+7V	
2	ALARM RESET	0V	+7V	
3	A/V WAVE SCALED			10 mV/mmHg
4	SKIP A	-7V	+7V	
5	SKIP TEMP A	-7V	+7V	
6	HEART RATE OVERRANGE	-7V	+7V	
7	°F/$\overline{°C}$	0V	+1V	
8	A/V WAVE (PULSE WAVE)			0.5 V/cm
9	TEMP A (DVM)			10 mV/°C or °F
10	DIAST (DVM)			10 mV/mmHg
11	HEART RATE (DVM)			10 mV/bpm
12	DVM COMMON			
13	LOW BATT/$\overline{\text{MONITOR ON}}$	-7V	+7V	
14	TEMP B OVERRANGE	-7V	+7V	
15	SKIP TEMP B	-7V	+7V	
16	TEMP B (DVM)			10 mV/°C or °F
17	+7 V			
18	A WAVE SCALED			10 mV/°C or °F
19	RESP WAVE			0.5 V/cm
20	A WAVE			0.5 V/cm
21	SKIP A/V	-7V	+7V	
22	A/V OVERRANGE	-7V	+7V	
23	TEMP A OVERRANGE	-7V	+7V	
24	-ECG WAVE			0.5 V/cm
25	WAVE COMMON			
26	SYST (DVM)			10 mV/mmHg
27	MEAN (DVM)			10 mV/mmHg
28	PRESS/PULSE TRIG	-7V	+7V	
29	PRESS/$\overline{\text{PULSE}}$	-3.6V	+7V	
30	ALARM	-7V	+7V	
31	RESP RATE OVERRANGE	-7V	+7V	
32	SKIP RESP RATE	-7V	+7V	
33	RESP RATE (DVM)			10 mV/brth/min
34	RESP TRIG	-7V	+7V	

@


TO DVM
TO DVM
TO DVM
P2400
401 STD
413
HEART RATE CONV.
RESP. RATE CONV.
PRESSURE S - D - M CONV.
PROBE
TEMP. A CONV.
Δt
PROBE
TEMP. B CONV.
MUX
TO DVM
P2400
400 OPT 4
MUX
TO DVM
2857-18



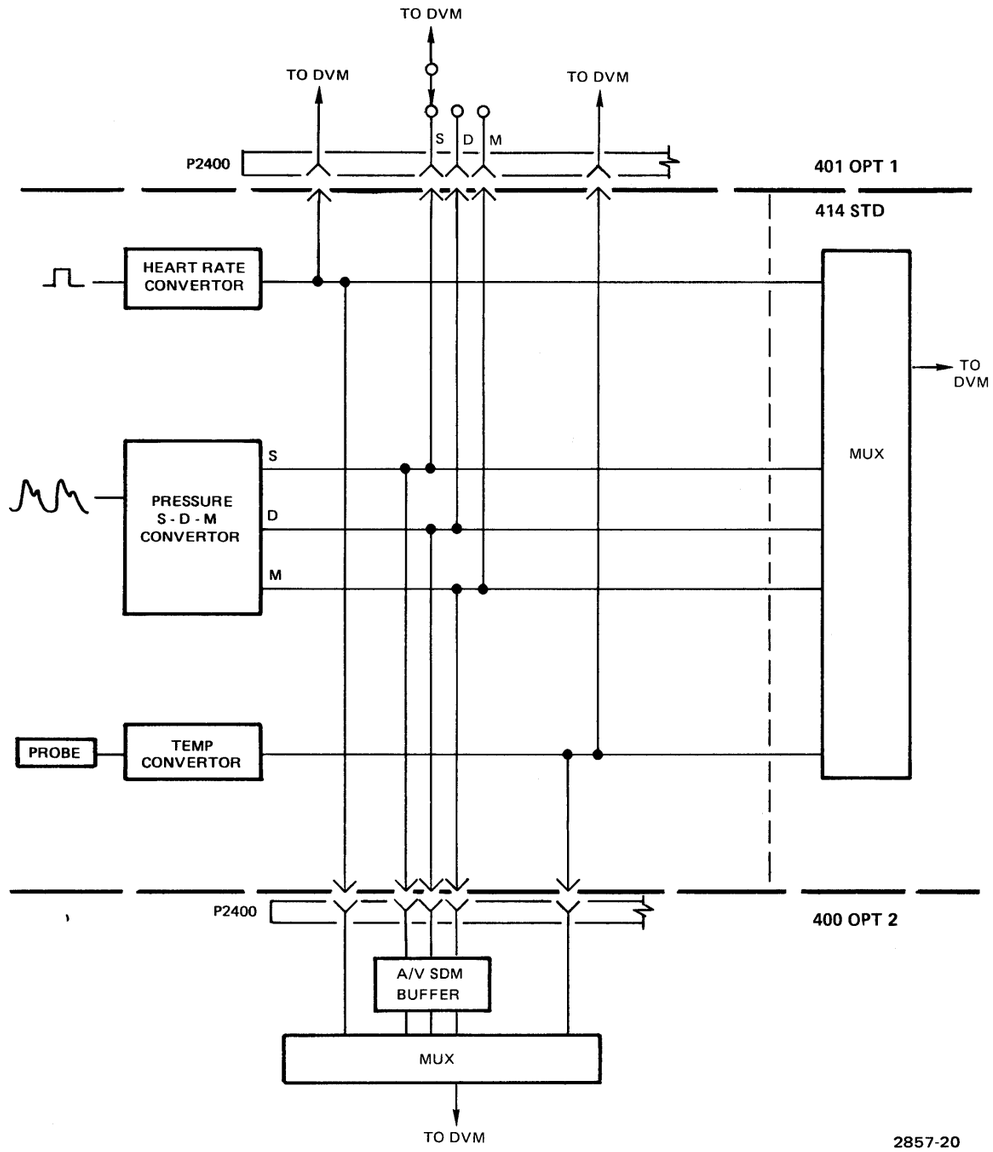
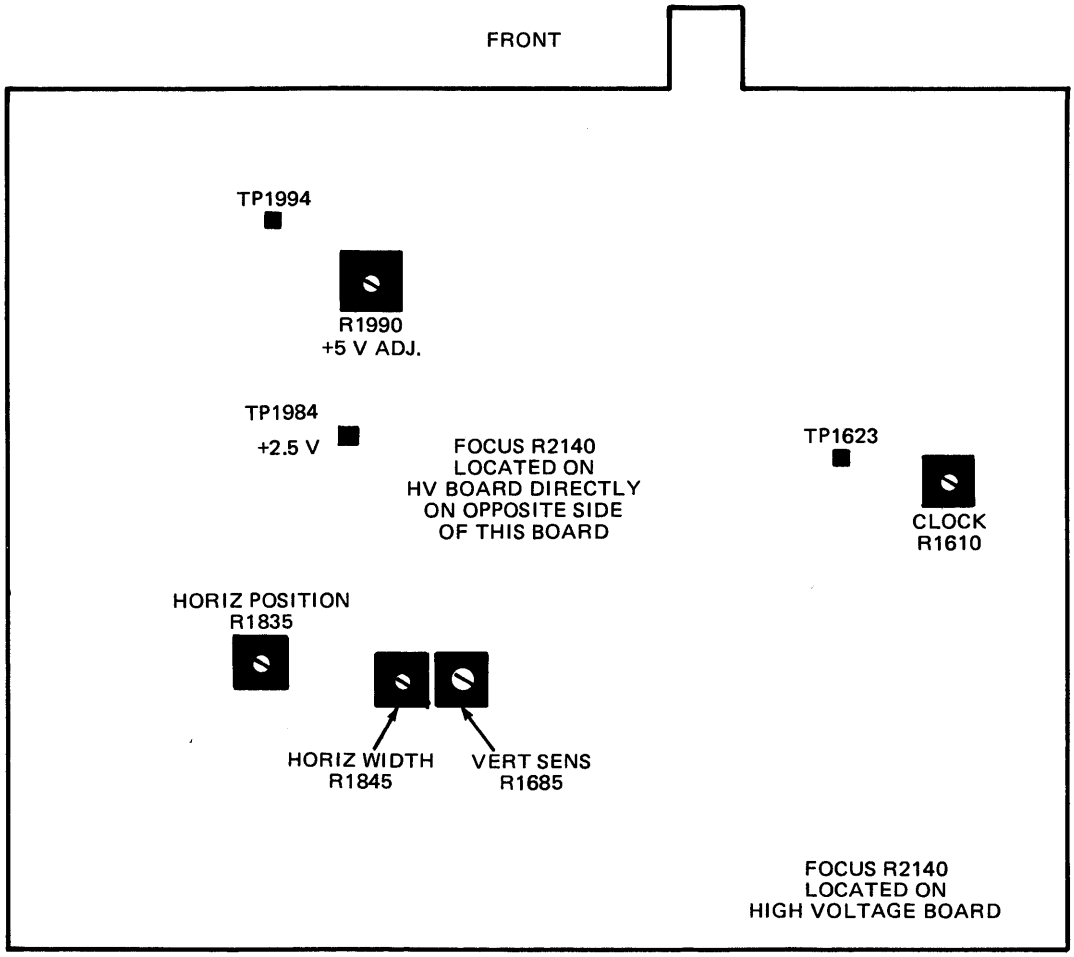
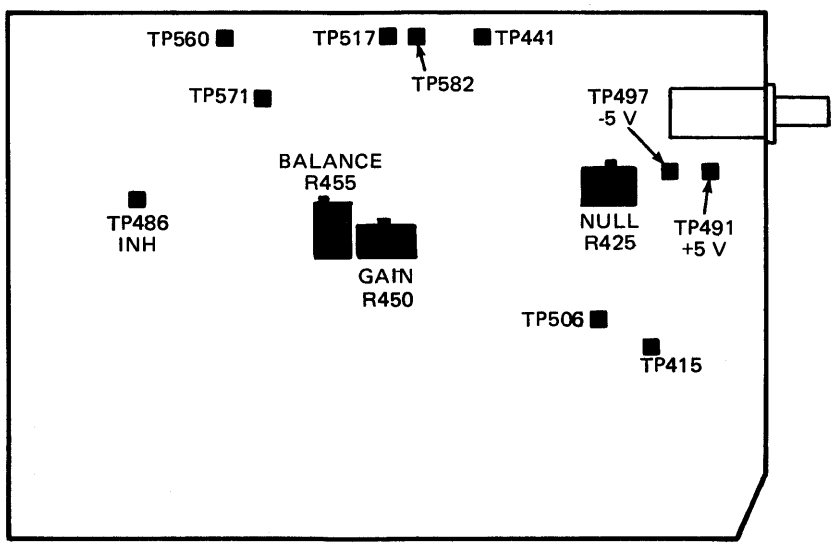


Fig. 11-1. Analog-to-digital conversion block diagrams.



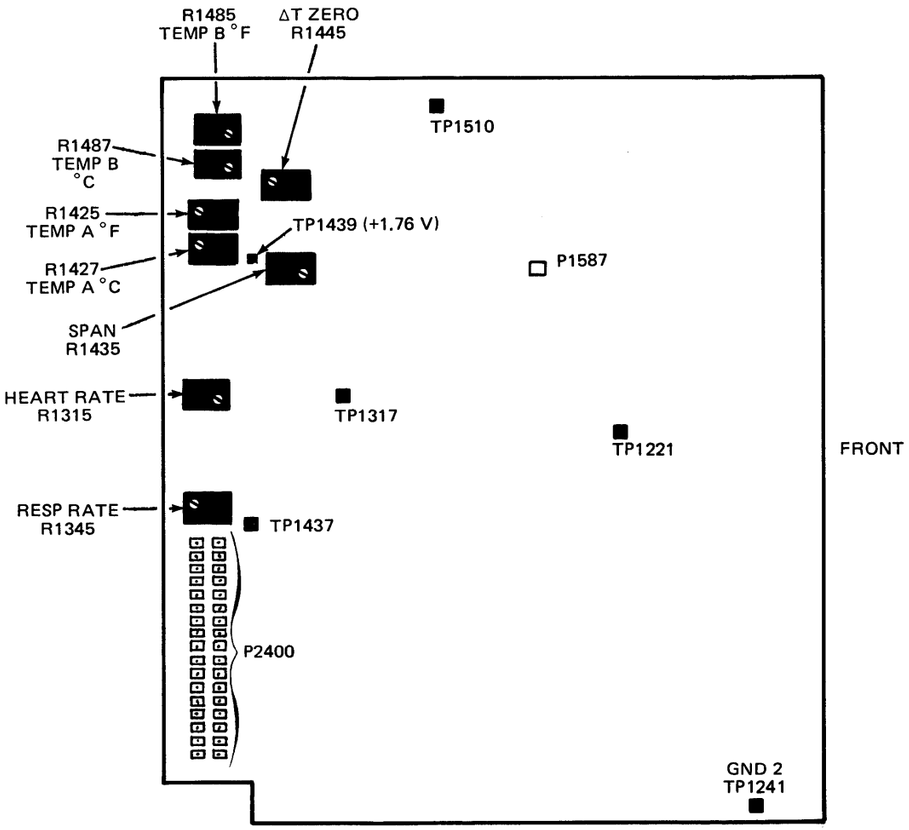
MAIN BOARD

(2277)2857-21



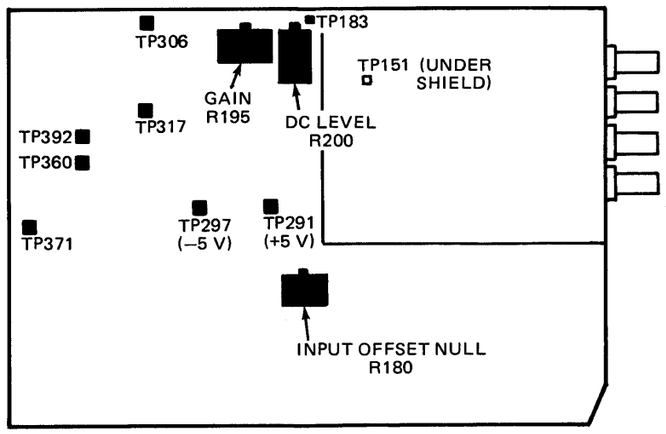
RESPIRATION BOARD

(2277)2857-22



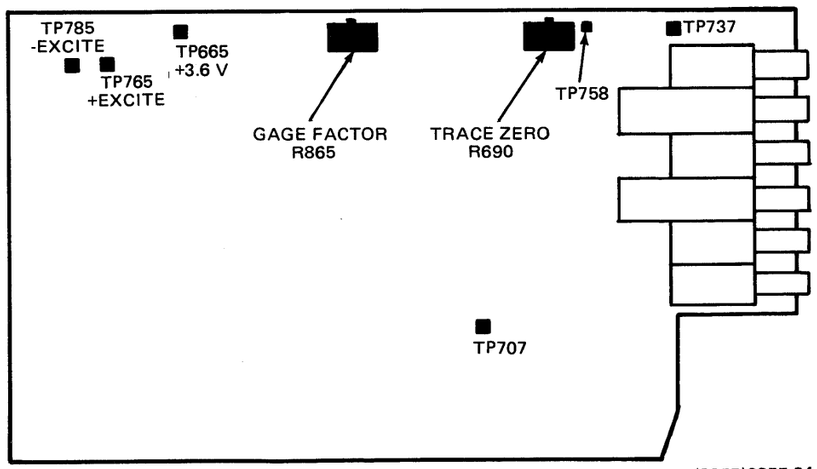
CONDITIONER BOARD

(2277)2857-23



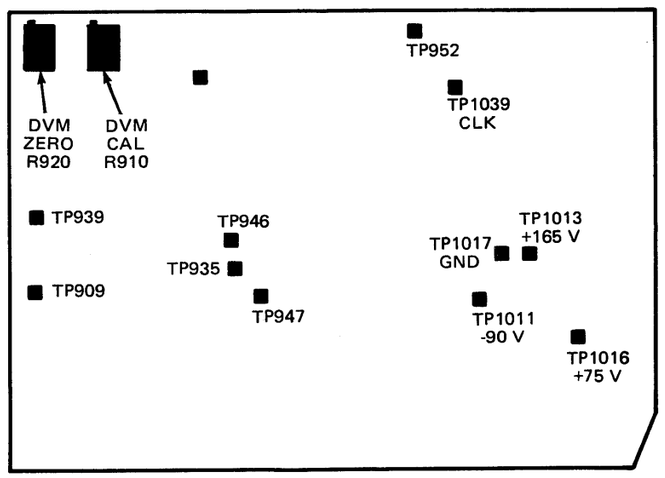
ECG BOARD

(2277)2857-25



PRESSURE/PULSE BOARD

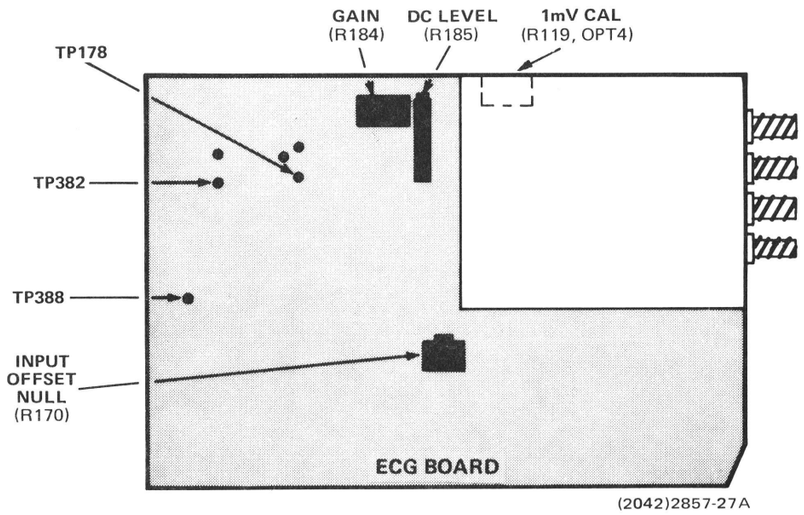
(2277)2857-24



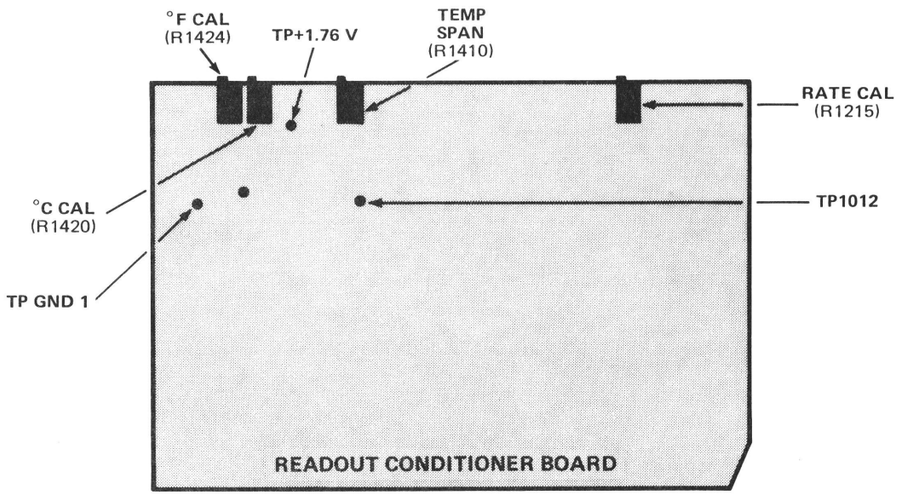
DVM BOARD

(2277)2857-26

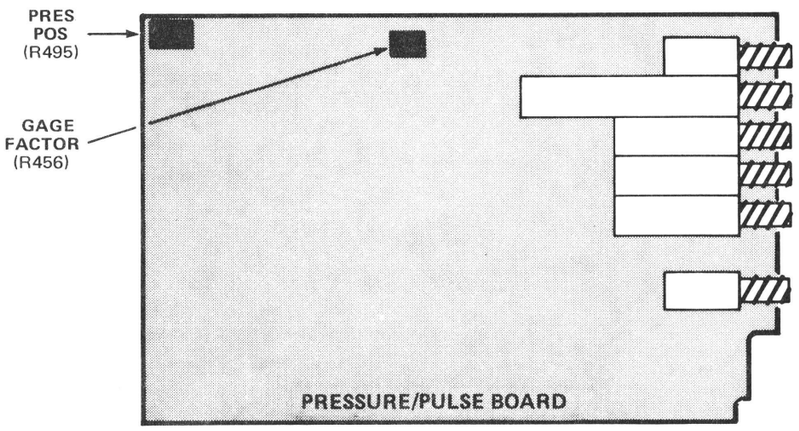
Fig. 11-2. 413 Adjustment and test-point locations.



(2042)2857-27A

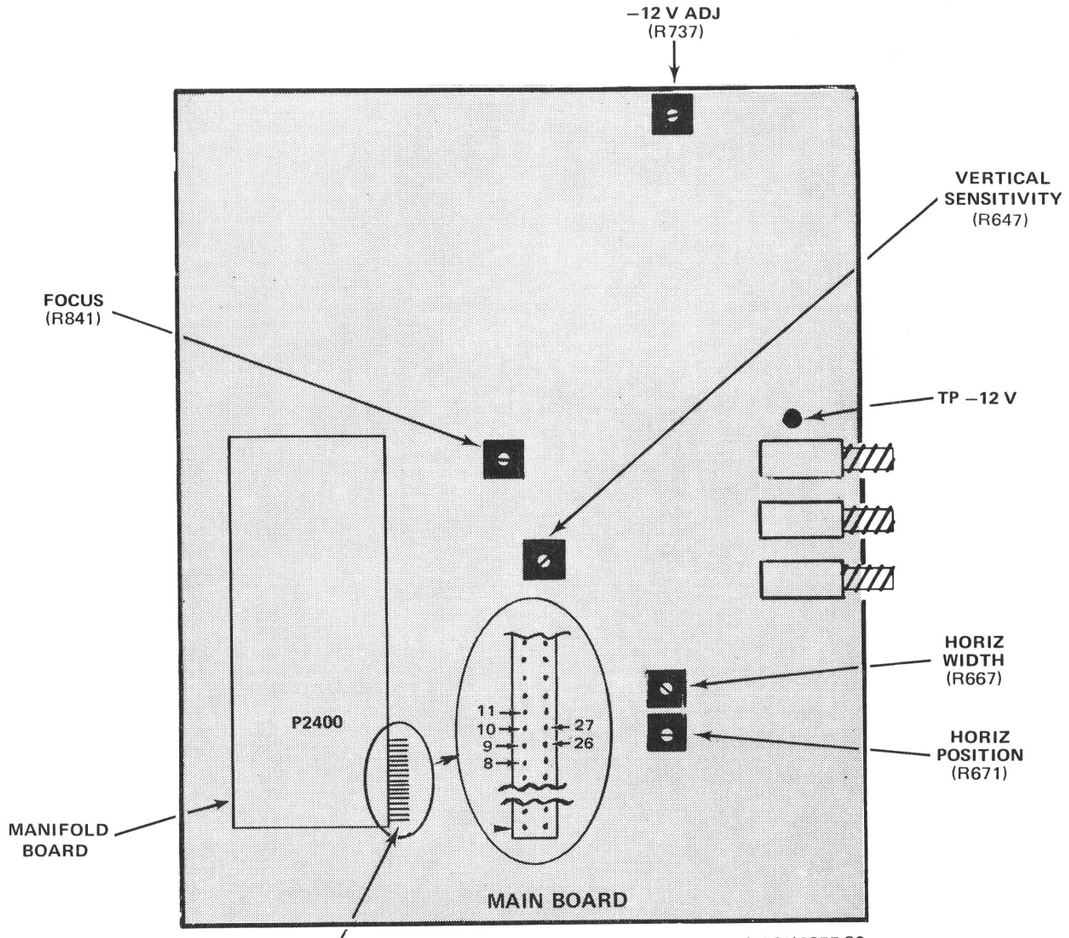


(2042)2857-28

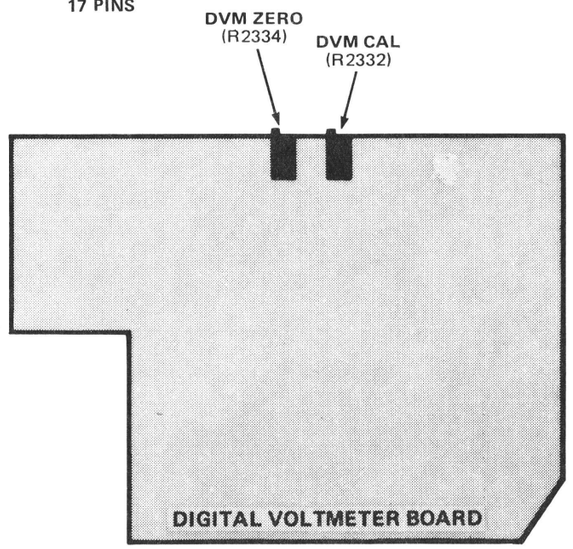


(2042)2857-29

FRONT

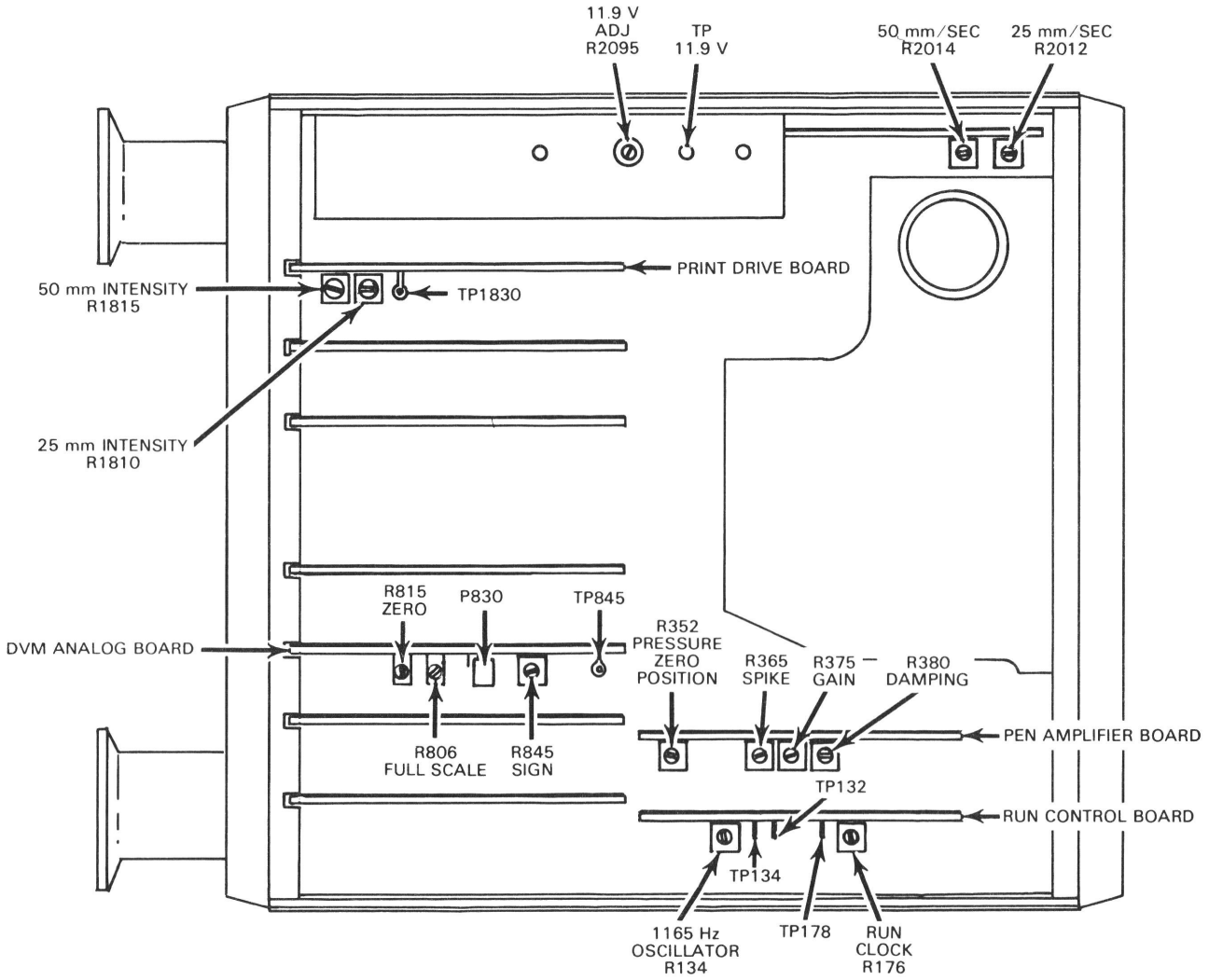


(2042)2857-30



(2042)2857-31

Fig. 11-3. 414 Adjustment and test-point locations.

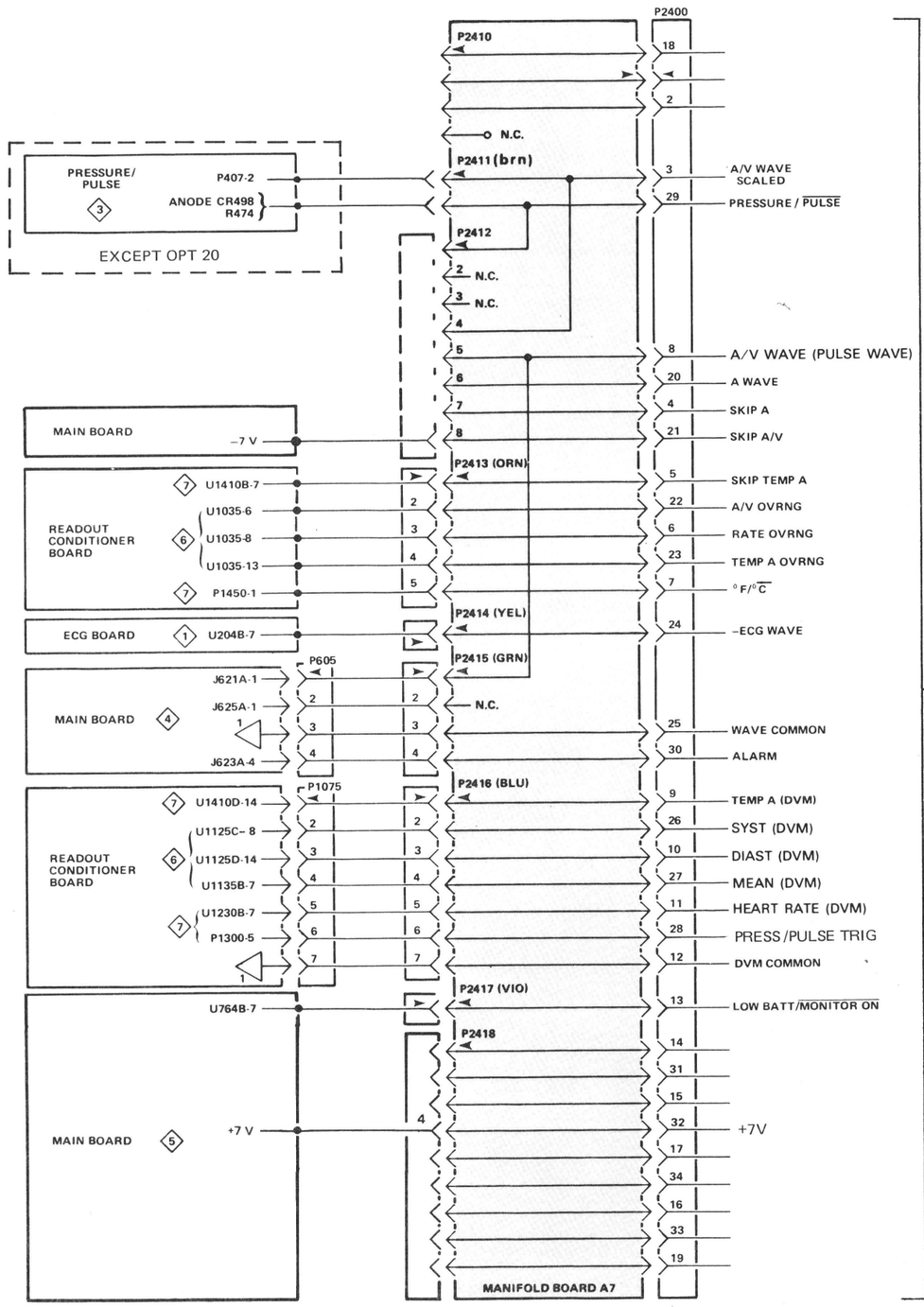


400 RECORDER BOTTOM VIEW

(2429)2857-32

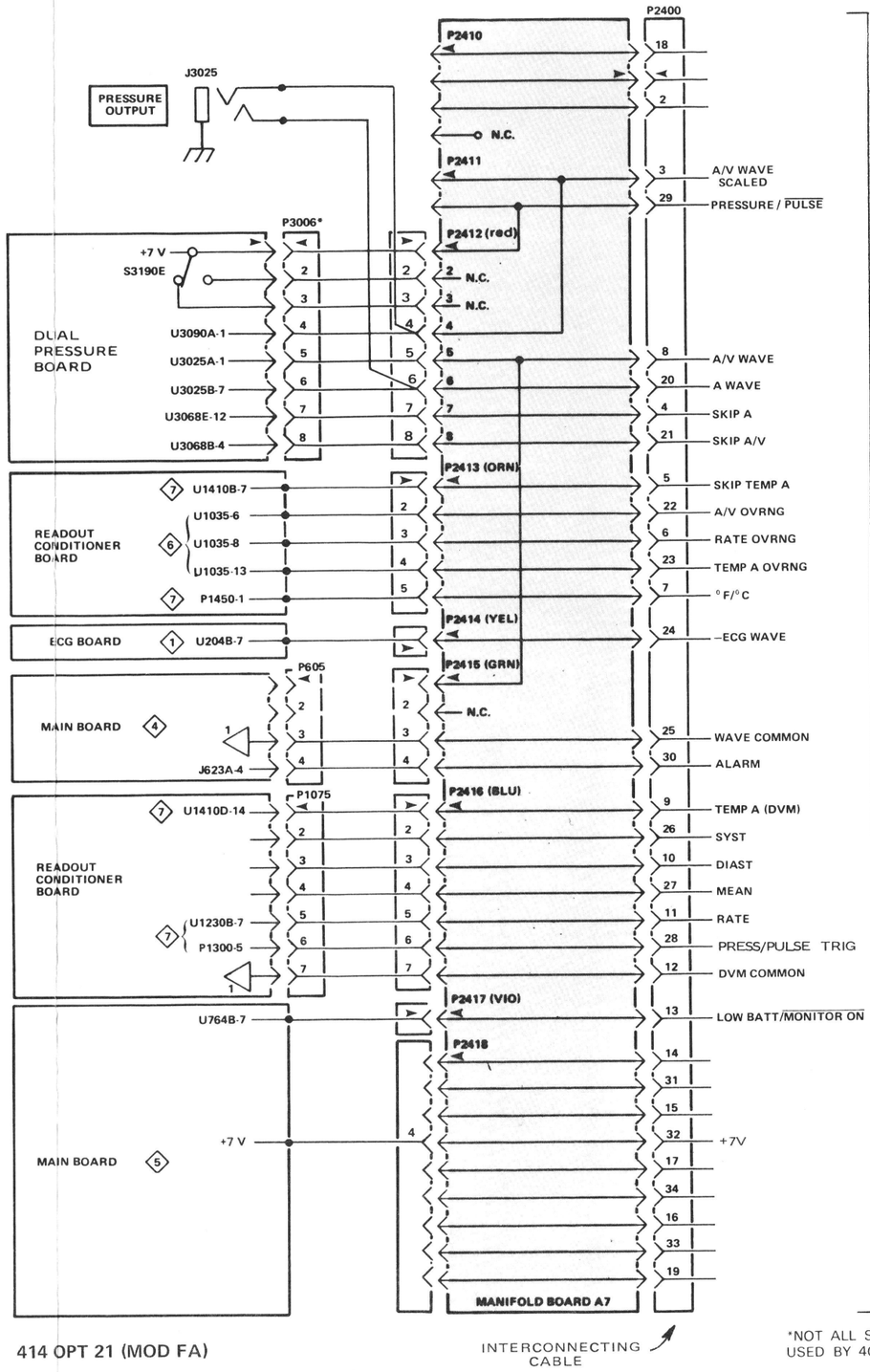
Fig. 11-4. 400 Adjustment and test-point locations.

@



414/414 OPT 20 (MOD XA)

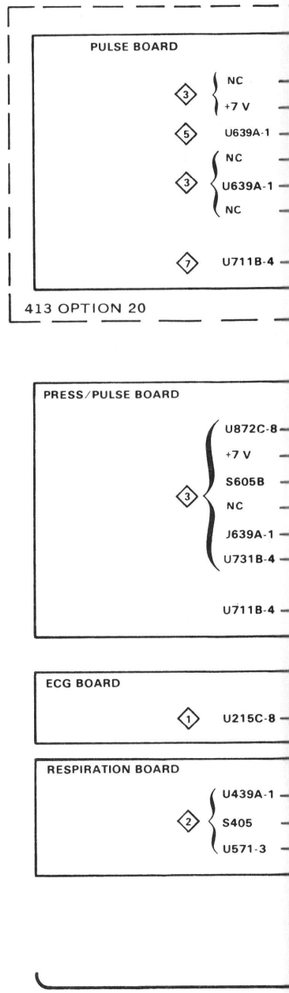
(2429)2857-33



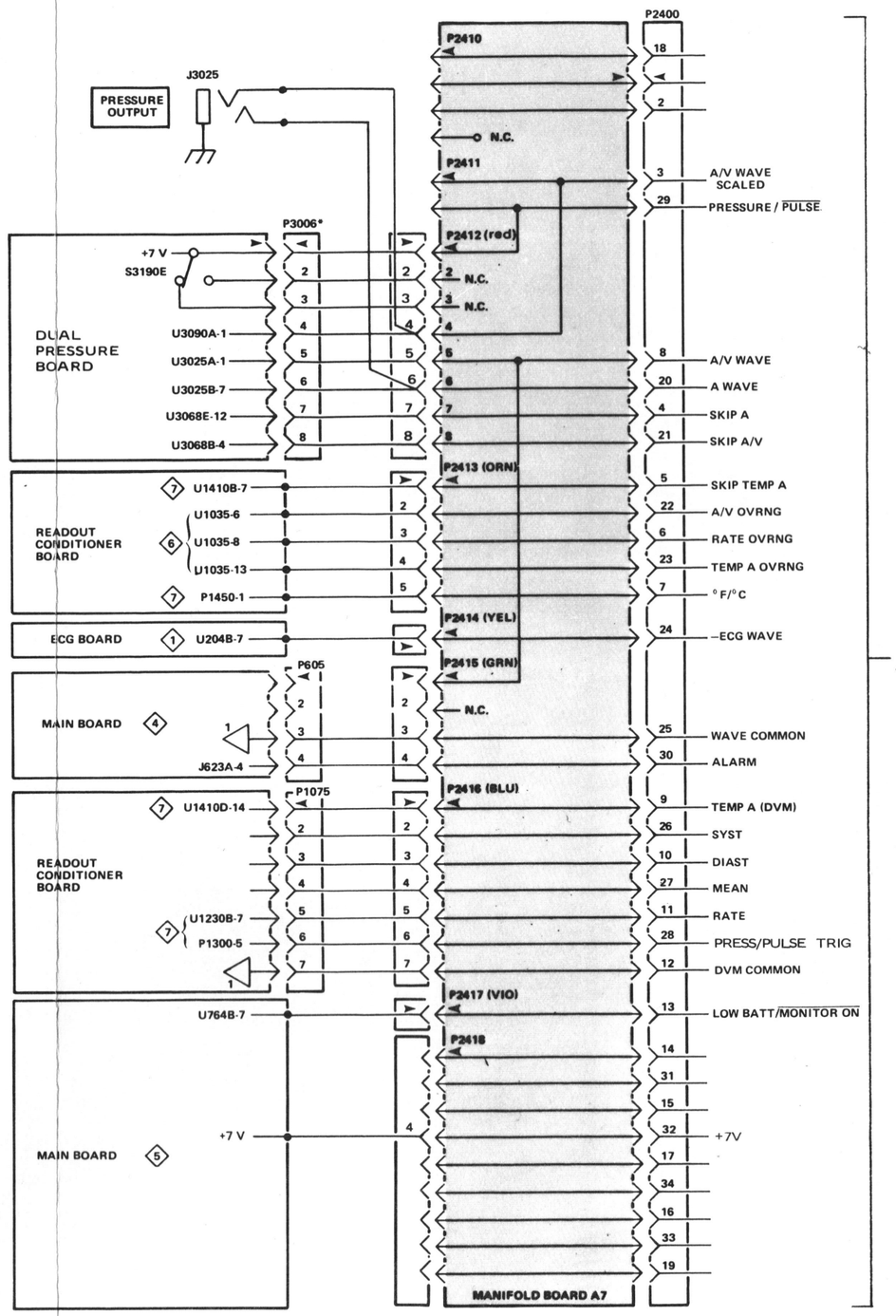
414 OPT 21 (MOD FA)

(2497)2857-34

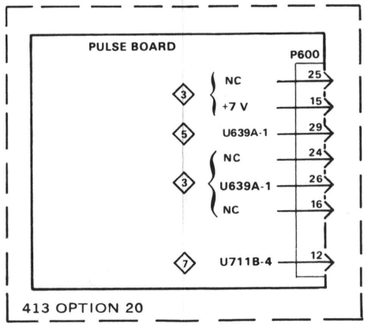
Fig. 11-5. Monitor-system signal interconnections.

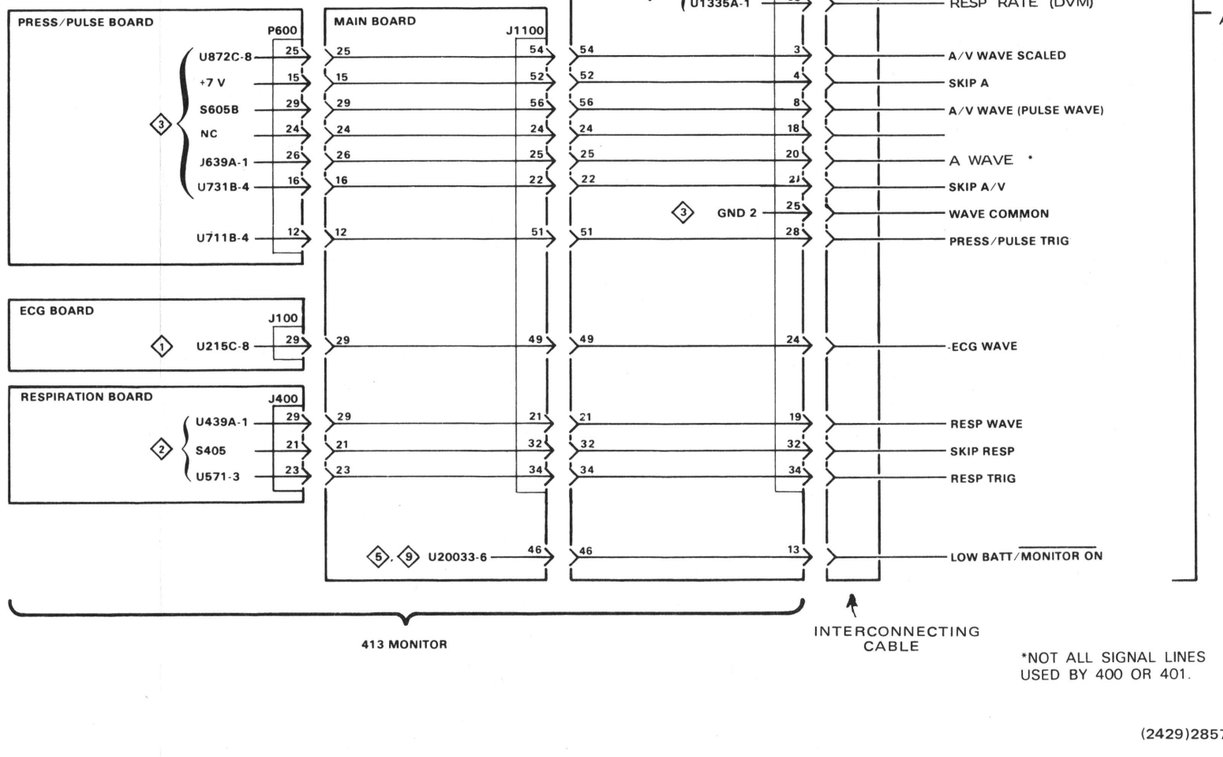


413/413 OPT 20



* SIGNALS NOT USED BY 400 RECORDER, BUT WHICH MAY BE USED BY OTHER DEVICES CONNECTED TO THE INTERCONNECTING CABLE.





413/413 OPT 20

(2429)2857-35

(2497)2857-34

Fig. 11-5. Monitor-system signal interconnections.