FACTORY CALIBRATION PROCEDURE

CONTENTS:

410

INTRODUCTION:

This is the guide for calibrating brand-new instruments, it therefore, calls out many procedures and adjustments that are rarely required for subsequent recalibration. *This procedure is company confidential.* In this procedure, all front panel control labels or Tektronix equipment names are in capital letters (VOLTS/DIV, etc.) internal adjustment labels are capitalized only (Gain Adj, etc.).

Tek form number:

0-441
October 1967

For all serial numbers.

FACTORY TEST LIMITS:

We initially calibrate the instrument to Factory Test Limits. These limits are often more stringent than advertised performance requirements. This helps insure that the instrument will meet advertised requirements after shipment, allows for inaccuracies of test equipment used, and may allow for changes in environmental conditions.

QUALIFICATION:

Factory test limits are qualified by the conditions specified in the main body of the calibration procedure. The numbers and letters to the left of the limits correspond to the factory calibration procedure steps where the check or adjustment is made. Instruments may not meet factory test limits if calibration or check-out methods and test equipment differ substantially from those in this procedure.

ABBREVIATIONS:

Abbreviations in this procedure will be found listed in TEKTRONIX STANDARD A-100.

CHANGE INFORMATION:

This procedure has been prepared by Product Manufacturing Staff Engineering. For information on changes that have been made to this procedure, to make suggestions for changing this procedure, or to order additional copies: please contact PMSE, 47-261. (DC)

EQUIPMENT REQUIRED:

The following equipment is necessary to complete this procedure:

a. TEKTRONIX Instruments

1	TYPE 547 OSILLOSCOPE
1	TYPE 1A7 PLUG-IN UNIT
1	TYPE 575 MOD 122C TRANSISTOR CURVE TRACER
*1	TYPE 184 TIME-MARK GENERATOR
2	TYPE P6011 1X PASSIVE PROBES
1	TYPE P6006 10X PASSIVE PROBE
1	TYPE 410 PATIENT CABLE (012-0120-00)

b. Test Fixtures and Accessories

*1	Standard Amplitude Calibrator (SAC) (067-0502-00)
*1	DC Voltage Bridge (DCVB) (067-0543-99)
1	LF Sine Wave Generator (067-0542-99)
1	410 Test Power Supply (067-0550-99)
1	410 Input Adapter (067-0549-00)
1	410 Continuity Checker (067-0551-99)
1	410 Earphone jack test cable (PMPE Dwg. No. 1691-A)
5	Patch Cords 18" banana plug to banana plug (012-0031-00)
2	BNC Dual Binding Post Adapter (103-0035-00)
1	CRT Spanner Wrench (003-0600-00)

c. Other Equipment

1	20,000Ω/volt multimeter, Tripplet 630NA, or equivalent

* This equipment must be traceable to NBS for instrument certification.

Substitute test equipment may be used. The Plant Staff Engineer must approve any substitutions. All equipment listed must perform within its manufacturer's specifications, unless otherwise stated.

It is assumed that all equipment is provided with BNC connectors; if equipment used has other than BNC connectors, adapters, not listed, may be needed.

QUALIFICATION

Factory test limits are qualified by the conditions specified in the main body of the calibration procedure. The numbers and letters to the left of the limits correspond to the factory calibration procedure steps where the check or adjustment is made. Instruments may not meet factory test limits if calibration or checkout methods and test equipment differ substantially from those in this procedure.

1. PRELIMINARY

2. PRESETS

3. POWER SUPPLIES

b. Adjust +17V, R502: 17V ±1.5%, max
c. Adjust collector volts, R212: 9V ±2.5%, max
d. Check Power supply voltages and regulation

Supply	Voltage Limits
+17V	16.75V to 17.5V
-11.4V	10.83V to 11.97V
-50V	45V to 55V
+175V	168V to 182V
+3650V	3504V to 3796V

e. Check decoupled +17V ripple: 10mV total, max
g. Measure battery current: I+ and I- less than 155ma

4. INPUT/PATIENT PROTECTION

b. Check B103 striking voltage: 85V, max
c. Check input/patient protection: I_{D1}, I_{D2}, I_{D3}, I_{D4} = 300ma, max
V_{D1}, V_{D2}, V_{D3}, V_{D4} = 100V, min
d. Check neons B 106 and B 206: striking voltage 85V, min.

5. TRACE ALIGNMENT

b. Adjust horizontal alignment tilt: ±1mm, max
c. Adjust centering magnets graticule center ±1.5mm, max
d. Check orthogonality Deviation: ±1.5mm in 7cm, max

6. ECG LEAD SELECTOR

b. Check ECG LEAD SELECTOR Pulse amplitude error: ±0.2cm, max

7. TRIGGER

b. Check triggering on simulated blood pulse: Triggering on 0.5cm or less
c. Check trigger free-run delay: 2 to 4 seconds
d. Check free-run sweep gate period: 0.1s to 0.166s
e. Check trigger level memory decay: sweep start within ±4mm of vertical center
f. Check trigger output pulse width: 94 to 136ms

8. AUDIO

b. Check audio frequency: 2kHz ±25%
c. Check pulse width: 125ms ±20%
d. Check alarm rate: from 6Hz to 10Hz
e. Check AUDIO OUT jack: 4V to 8V with LOUDNESS cw and Ω100 load

9. SWEEP

a. Adjust BATTERY CHECK calibration: spot between red and yellow zones at LO BATT VOLTS setting
b. Adjust Horiz Position, R392 and Sweep Width, R390
Trace start: first graticule line
Sweep length: 10cm ±0.1cm
c. Check sweep start point: no shift
* e. Check linearity. Error: ±20%, max
f. Check BATTERY CHECK scale accuracy: spot between red and yellow zones, ±0.5cm max, at 5.95V ±0.5%

* g. Check heart rate scale timing accuracy

Marker	Seconds from Sweep Start	Reading on heart rate scale	Max Error
.1s & .5s	0.5	120	±5%
.1s & .5s	0.6	100	±5%
50ms & .5s	0.75	80	±.5%
.1s & .5s	1.0	60	±5%
.1s & .5s	1.2	50	±5%
.1s & .5s	1.5	40	±5%

h. Check timing accuracy Error: ±20%, max

10. VERTICAL SIZE

a. Adjust Vert Size Bal, R139: Less than 2mm shift in ECG. Less than 1.5cm shift in EEG

* b. Adjust Gain, R124 Error ±5%, max

c. Check VERTICAL SIZE range: 1:9, min

11. VERTICAL LINEARITY

* b. Check Vertical linearity
Non linearity: ±3%, max within center 6 vertical cm

12. VERTICAL POSITION CONTROL

a. Check VERTICAL POSITION range: + and - 3.7cm, min

b. Check VERTICAL POSITION control electrical center: Graticule center ±1cm, max

13. NOISE: 0.1cm, max P-P in CAL

14. GUARD EFFICIENCY AT 60Hz

b. Check guard efficiency at 60Hz. Less than 5cm of deflection on test scope

15. COMMON MODE REJECTION RATIO

* b. Check common mode rejection ratio with 5kΩ source impedance unbalance: 0.67cm deflection, max

* c. Check common mode rejection ratio with 0Ω source impedance unbalance: 0.2cm deflection, max

* d. Check common mode rejection ratio with DC offset: 0.67cm deflection, max

e. Check common mode dynamic range: +3V to -3V

f. Check differential dynamic range: + or - 100mV, min

16. DIFFERENTIAL OVERDRIVE RECOVERY TIME: Less than 4 seconds

17. DIFFERENTIAL VERTICAL SIGNAL OUT

Amplitude: 6.8V ±1.3V, max

18. ISOLATED SWITCH CLOSURE

* 19. BANDWIDTH

a. Check HF bandwidth

INPUT SELECTOR	HF - 3dB
AUX	212.5Hz to 287.5Hz
ECG	212.5Hz to 287.5Hz
EEG	85Hz to 115 Hz

b. Check LF - 3dB point: 1.1 seconds, min for signal to decay to 50% amplitude

20. AUXILIARY POWER

* Indicates a measurement characteristic; test equipment used must be traceable to NBS for instrument certification.

1. PRELIMINARY INSPECTION

a. Make physical inspection

Check for unsoldered joints, rosin joints, poor lead dress and long leads. Check for loose hardware and protruding parts. Check controls for smooth mechanical operation, proper indexing and clearance between knobs and panel. Correct any defects found.

b. Make continuity checks

Check continuity between the power pack banana plugs at the back of the instrument and Horiz and Audio board pin connectors as in the following table:

Banana Plug	Pin number	SWEEP SPEED Control setting	reading
+	0	POWER OFF	open
+	0	any except POWER OFF	short
—	P	any	short
-	N	POWER OFF	open
-	N	any except POWER OFF	short

2. PRESETS

a. Set TYPE 410 controls as follows:

INPUT SELECTOR	ECG
SWEEP SPEED	POWER OFF
VERT SIZE	ccw
POSITION	midr
ECG LEAD SEL	I
LOUDNESS	full ccw

all internal adjustments midr.
Connect the 410 Input Adapter to the TYPE 410 Patient Cable Connector.

b. Set 410 Input Adapter controls as follows:

(+) ATTEN	X10,000
(-) ATTEN	X10,000
C.M.ON	off
MODE	NORM
INPUT SELECTOR	ECG
ECG LEAD SELECTOR	I

2b. (cont'd)

Connect the 410 Test Power Supply to the TYPE 410.

c. Set 410 Test Power Supply controls as follows:

POWER ON	OFF
BATT VOLTS	CAL
METER SELECTOR	OFF

3. POWER SUPPLIES

a. Setup

Connect the DCVB common lead to TP595 and the DCVB ±INPUT lead to TP527 (Hi voltage board). Turn the 410 Test Power Supply POWER ON and set the TYPE 410 SWEEP SPEED to 50mm/s.

b. Adjust +17V, R502: 17V ±1.5%, max

Adjust R502 for 17V as read on DCVB.

c. Adjust Collector Volts, R212: 9V ±2.5%, max

Move the DCVB ± INPUT lead to the collector of Q119 and adjust R212 for 9V. Repeat step 3b and step 3c as necessary. Check voltage at the collector of Q219, if less than 9V readjust R212.

d. Check power supply voltages and regulation

Check power supply voltages with the DCVB at HI, LO and CAL positions of the Test Power Supply BATT VOLTS control as in the following table:

Supply	Voltage limits	Measurement location
+17V	16.75 to 17.5	TP527 (HV Board)
-11.4V	10.83 to 11.97	HV Board Pin J
-50V	45 to 55	Front lead of R563 (6.8M on HV Board)
+175V	168 to 182	HV Board Pin I
+3650V	3504 to 3796	CRT Anode lead on HV Board

3. (cont'd)

e. Check decoupled +17 ripple: 10mv total, max

Connect a 1X probe from TYPE 410 VA board pin C to test scope TYPE 1A7 + INPUT. Connect the probe ground to TP194.

Set the TYPE 1A7 VOLTS/CM to 5mVOLTS, HIGH FREQ 3dB POINT to 500kHz, LOW FREQ 3dB POINT to DC, + INPUT selector to AC, - INPUT selector to GND. Set the test scope TIME/CM to .1SEC. Check +17V decoupled ripple at HI, LO and CAL positions of the BATT VOLTS control.

f. Adjust Focus, R550

Change the SWEEP SPEED to BATTERY CHECK. Adjust R550 for a well defined spot. Return the SWEEP SPEED to 50mm/s.

g. Measure battery current: I+ and I- less than 155ma

Set the multimeter to .6 DCV and $\frac{\text{V}\cdot\text{A}}{2}$. Connect the meter leads to the Test Power Supply METER jacks. Measure the battery current drawn by the TYPE 410 by measuring the drop across the 1Ω meter shunt in the test power supply.

Supply	METER SELECTOR	Current	Voltage across 1Ω resistor
+6.7	I+	Less than 155ma	Less than 155 V
-6.7	I-	Less than 155ma	Less than 155 V

Turn the METER SELECTOR to OFF and disconnect the multimeter leads.

4. INPUT/PATIENT PROTECTION

a. Setup

Preset TYPE 575 MOD 122C controls as follows:

VERTICAL CURRENT	0.1 Collector Ma
HORIZONTAL VOLTS/DIV	20 Collector Volts
COLLECTOR SWEEP POLARITY	1.5 kV
PEAK VOLTS	ZERO
TRANSISTOR A-B	Disconnected

Set TYPE 410 INPUT SELECTOR to AUX. Remove Q109 from its socket. Connect the TRANSISTOR A COLLECTOR Terminal to the GATE pin of Q109 A socket and the TRANSISTOR A EMITTER to the other GATE pin of Q109 P socket.

Switch TRANSISTOR A-B to TRANSISTOR A. Push the PRESS TO CHECK button and increase PEAK VOLTS until a display similar to Fig. 1 is obtained.

b. Check B103 striking Voltage: 85V, max

Check V_{B103} on the TYPE 575 MOD 122C display. Replace B103 if the striking Voltage is over 85V. Turn PEAK VOLTS to ZERO.

c. Check input/patient protection

I_{D1}, I_{D2}, I_{D3}, I_{D4} = 300μa, max

V_{D1}, V_{D2}, V_{D3}, V_{D4} = 100V, min

Change the HORIZONTAL VOLTS/DIV to 50. Push the PRESS TO CHECK button and increase PEAK VOLTS until a display similar to Fig 2 is obtained. Check Voltages and currents associated with the input diodes as follows.

I_{D1}, I_{D2}, I_{D3}, I_{D4} = 300μa, max

E_{D1}, E_{D2}, E_{D3}, E_{D4} = 100V, min

Turn PEAK VOLTS to ZERO.

d. Check neons B106 and B206 striking Voltage: 85V, max

Remove TYPE 575 MOD 122C EMITTER connection from Q109 gate pin and connect it to ground. Push the PRESS

Diodes D107, D108, D207 and D208 and neons B103, B106 and B206 are designed to protect the TYPE 410 Vertical input circuits from excessive external Voltage. The same diodes and neons will protect a patient from electric shock resulting from a malfunction within the TYPE 410 circuitry.

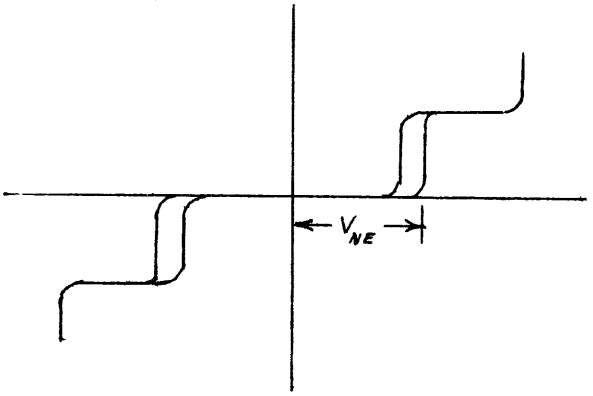

Fig. 1

Diodes are not identified by schematic number in Fig 2, however an individual diode can be isolated quickly in practice by checking diodes individually with the 575 MOD 122C.

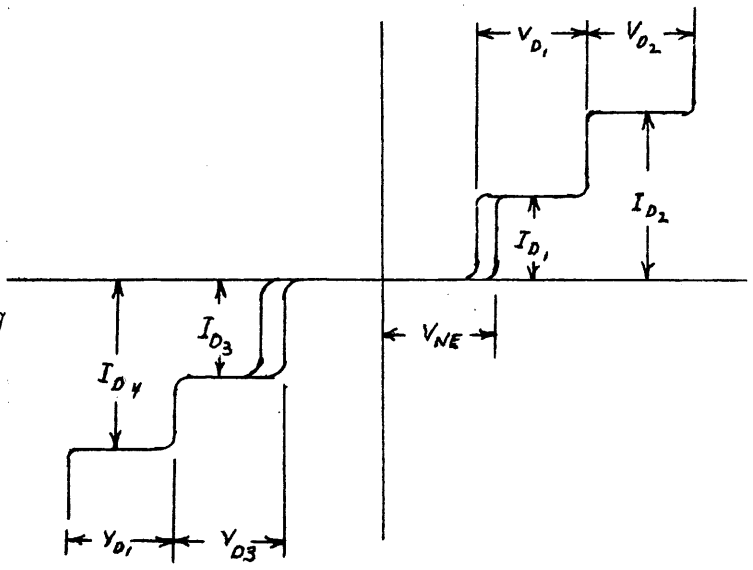

Fig. 2

4.d (cont'd)

TO CHECK button and increase PEAK VOLTS until a display similar to Fig 1 is obtained. Check for 85V, max on TYPE 575 MOD 122C display. Turn PEAK VOLTS to ZERO. Remove the TYPE 575 MOD 122C COLLECTOR connection and connect it to the second gate pin of Q109 socket. Push the PRESS TO CHECK button and increase PEAK VOLTS until a display similar to Fig 1 is again obtained. Check for 85V max on TYPE 575 MOD 122C display. Turn PEAK VOLTS to ZERO and disconnect TYPE 575 MOD 122C from TYPE 410. Replace Q109 in its socket.

5. TRACE ALIGNMENT

a. Setup

Remove two Phillips head screws between the SWEEP SPEED knob and the INPUT SELECTOR knob. Move the CRT shield and front panel out to gain access to the rear of the CRT.

b. Adjust horizontal alignment
Tilt: ±1mm, max

Using a spanner wrench rotate the yoke to align the trace with the center graticule lines.

c. Adjust centering magnets
Graticule center ±1.5mm, max

Remove transistors Q175, Q275, Q401 and Q431. Adjust the two centering magnets to place the spot at CRT center. Replace Q175, Q275, Q401, Q431 and the CRT shield and front panel.

d. Check orthogonality
Deviation: ±1.5mm in 7cm, max

Connect the LF Sine Wave Generator Output to the Input Adapter (+) Input with a 50Ω cable and clip lead adapter. Adjust the LF Sine Wave

d. A small ruler scaled in millimeters is helpful in checking orthogonality.

5.d (cont'd)

generator for 7cm of 5Hz signal. Check that the trace does not deviate from a vertical line by more than 1.5mm in 7cm.

6. ECG LEAD SELECTOR

a. Setup

Remove the 410 Input Adapter and connect the 410 continuity checker to TYPE 410 Patient Cable Input. Set the TYPE 410 INPUT SELECTOR to ECG. Set the TYPE 410 ECG LEAD SELECTOR and continuity checker ECG LEAD TEST to I. Set test scope controls as follows:

HORIZONTAL DISPLAY	A DLY'D
DELAY-TIME MULTIPLIER	5.00

	TIME BASE A	TIME BASE B
MODE	AUTO STABILITY	AUTO STABILITY
SLOPE	+	+
COUPLING	AC	AC
SOURCE	NORM	NORM
TIME/CM	5mSEC	5mSEC
VARIABLE	CAL	CAL

Connect + Gate A to + INPUT of the continuity checker. Connect + Gate B to - INPUT of the continuity checker. Connect test scope ground to GND of the continuity checker.

Adjust 410 continuity checker BALANCE so the alternate wide and narrow pulses are of equal amplitude. Adjust the TYPE 410 VERTICAL SIZE for exactly 3cm of display amplitude.

b. Check ECG LEAD SELECTOR
Pulse amplitude error: ±0.2cm,max

Check the amplitude of the display as in the following table:

6.b (cont'd)

TYPE 410 ECG LEAD SELECTOR	Continuity checker ECG LEAD TEST	Narrow Pulse Amplitude	Wide Pulse Amplitude
I	I	3cm	3cm ±0.2cm
II	II	3cm	3cm ±0.2cm
III	III	3cm	3cm ±0.2cm
aVR	aVR	3cm	1.5cm ±0.2cm
aVL	aVL	3cm	1.5cm ±0.2cm
aVF	aVF-V	3cm	1.5cm ±0.2cm
V	aVF-V	2cm	1cm ±0.2cm
V	V	2cm	1cm ±0.2cm

Remove the 410 continuity checker and connect the 410 Input Adapter to TYPE 410 Patient Cable Input.

7. TRIGGER

a. Setup

Set the 410 INPUT ADAPTER (+) ATTEN to 10,000, TRIG TEST to ON. Set both LEAD SELECTORS to I and both INPUT SELECTORS to ECG. Set TYPE 410 SWEEP SPEED to 50mm/s. Set the LF Sine Wave Generator for 10 volts of 1Hz signal and connect to 410 INPUT ADAPTER TRIGGER TEST INPUT. Set TRIGGER TEST switch ON.

b. Check triggering on simulated blood pulse: Triggering on 0.5cm or less

b. If audio tones sound "chirpy" select Q320 & Q330 for higher β.

Adjust the VERTICAL SIZE control for tones at approximately one second intervals, indicating proper triggering. Reduce the input signal until tones become erratic, indicating loss of triggering. Check for triggering on 0.5cm or less of deflection.

Remove the LF Sine Wave Generator from the TRIGGER TEST INPUT and connect to (+) INPUT. Set the TRIGGER TEST switch OFF. Check for + and - triggering capability by observing one audio beat on the rising portion of the sinewave and another audio beat on the falling portion of the sinewave.

Remove the LF Sine Wave Generator connection fr· · the 410 INPUT ADAPTER.

c. Check trigger free-run delay: 2 to 4 seconds

Connect the test scope + GATE A to 410 Input Adapter (+) INPUT and connect AUDIO OUT to test scope INPUT with 410 earphone jack test cable. Set the VERTICAL SIZE for 3cm of deflection. Set the test scope TIME BASE A TIME/CM to .5SEC. Check the time from the start of the test scope trace to the start of the audio tone, must be from 2 to 4 seconds.

d. Check free-run sweep gate period: 0.1s to 0.166s

Remove all signals from the 410 Input Adapter.

Set the test scope VOLTS/CM to .2 and TIME/CM to 20mSEC. Connect a X10 probe from Pin G to test scope (+) INPUT. Check for a gate pulse period of 0.1s to 0.166s.

e. Check trigger level memory decay: Sweep start within 4mm of vertical center

Connect 1s time marks from the TYPE 184 to the test scope + INPUT. Connect test scope SWEEP A to 410 input adapter (+) INPUT. Set TYPE 410 and 410 Input Adapter INPUT SELECTOR to AUX. Set test scope TIME/CM to 10mSEC and HORIZONTAL DISPLAY to A. Obtain a stable triggered display on the test scope. Adjust the TYPE 410 VERTICAL SIZE for a 4cm display. Position the display baseline 3cm below vertical center and set the TYPE 410 SWEEP SPEED to 100mm/s. Check that the sweep start is within ±4mm of vertical center. (See Fig. 3)

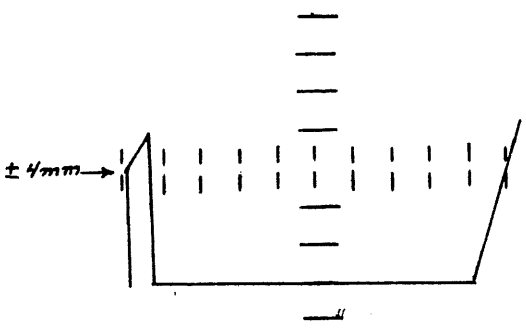

Fig. 3

f. Check trigger output pulse
Width: 94 to 136ms
Amplitude: +5V to 7.5V

Connect a 1X probe from Pin 4 of the TYPE 410 Output connector to test scope + INPUT. A TIME/CM to 20mSEC, TRIGGERING MODE to TRIG and VOLTS/CM to 2. Set the TYPE 410 and 410 Input Adapter INPUT SELECTOR to EEG. Obtain a stable display on the test scope and check the amplitude and duration of the positive pulse. Must be from 2.5cm to 3.75cm in amplitude and from 4.7cm to 7.8cm duration.

8. AUDIO

a. Setup

Connect a 10X probe from the collector of Q341 to test scope vertical input. Set the test scope VOLTS/CM to .2 and TIME/CM to .5mSEC.

b. Check audio frequency: 2KHz ±25%

Check the test scope for a display of 7.5 to 12.5 cycles in 10cm.

c. Check pulse width: 125ms ±20%

Change the test scope TIME/CM to 20mSEC. Move the 10X probe to Pin G of the Horiz and audio board. Check the test scope display for a positive pulse duration of from 5.2 to 7.8cm.

d. Check Alarm rate: From 6Hz to 10Hz

Measure the duration of a complete cycle of the pulse display. 1 ÷ duration = frequency, must be from 6Hz to 10Hz.

e. Check AUDIO OUT jack: 4V to 8V with LOUDNESS cw and 100Ω load

Turn the INPUT SELECTOR to ECG. Check for no sound from the speaker with LOUDNESS ccw and maximum sound with LOUDNESS cw. Connect the AUDIO OUT to test scope vertical input with a 410 earphone jack test cable. Turn the LOUDNESS full cw. Check for no sound from the speaker. Check for a 4V to 8V signal on the test scope.

9. SWEEP

a. Adjust BATTERY CHECK Calibration: spot between red and yellow zones at LO BATT VOLTS setting

Turn the TYPE 410 SWEEP SPEED to BATTERY CHECK. Set the 410 Test Power Supply BATT VOLTS switch to VAR and turn the variable control fully ccw to LO. Adjust the Battery Check Cal, R397 to place the spot between the red and yellow zones on the battery check scale of the TYPE 410 graticule.

b. Adjust Horiz Position, R392 and Sweep Width, R390 Trace Start: First graticule line Sweep Length: 10cm ±0.1cm

Adjust the 410 Test Power Supply variable control to place the spot between the green and yellow zones. Change the SWEEP SPEED to 50mm/S. Adjust Horiz Position, R392 and Sweep Width, R390 for a trace starting on the first graticule line and ending on the tenth graticule line.

c. Check sweep start point: shift ±2mm, max

Check that the starting position of the sweep shift is no greater than 2mm at HI, LO and CAL positions of the 410 Test Power Supply BATT VOLTS. Set the BATT VOLTS to CAL and check that the starting position shifts ≤2mm with SWEEP SPEED set to 25, 50 and 100 mm/s.

d. Adjust Timing, R375

Set the SWEEP SPEED to 50mm/s. Apply .1s and .5s markers from the TYPE 184 to the Input Adapter (+) INPUT.

Adjust R375 to place the second large marker on the 120 and the 4th large marker on the 40 BEATS/MIN position of the heart rate scale.

e. Check linearity Error: ±20%, max

Set the TYPE 184 for 100ms markers. Determine the maximum and the minimum distance between adjacent pairs of markers in millimeters. Apply the following formula to determine linearity.

$$\frac{\text{maximum distance - minimum distance X 100\%}}{\text{maximum distance}}$$

f. Check BATTERY CHECK scale accuracy: Spot between red and yellow zones, ±0.5cm max, 5.95V ±0.5%

Turn the SWEEP SPEED to BATTERY CHECK. Use the DCVB to set the 410 Test Power Supply VAR to exactly 5.95V. Check that the spot is positioned to the junction of the red and yellow zones ±0.5cm, max.

g. Check heart rate scale timing accuracy

Apply .1s and .5s markers from the TYPE 184 to Input Adapter (+) INPUT. Set the SWEEP SPEED to 50mm/s and INPUT SELECTOR to ECG. Check timing accuracy on the heart rate scale as in the following table.

Marker	seconds from sweep start	Reading on heart rate scale	Maximum Error
.1s & .5s	0.5	120	±5% (114 to 126)
.1s & .5s	0.6	100	±5% (95 to 105)
.50ms & .5s	0.75	80	±5% (76 to 84)
.1s & .5s	1.0	60	±5% (57 to 63)
.1s & .5s	1.2	50	±5% (47.5 to 52.5)
.1s & .5s	1.5	40	±5% (38 to 42)

h. Check timing accuracy Error: ±5%, max

Check the distance between the first and last time marker as in the following table:

SWEEP SPEED	Markers	distance	max error
25mm/s	1s	10cm	±0.5cm
50mm/s	1s	10cm	±0.5cm
100mm/s	.5s	10cm	±0.5cm

Remove the TYPE 184 signal from the INput Adapter.

10. VERTICAL SIZE

a. Adjust Vert Size Bal, R139: Less than 2mm shift in ECG, Less than 1.5cm shift in EEG

Set the INPUT SELECTOR to ECG. Adjust R139 for no vertical position shift as the VERTICAL SIZE control is rotated throughout its range. Change the VERTICAL DISPLAY to EEG. Rotate the 410 Test Power Supply BATT VOLTS VAR control to HI. Check for less than 1.5cm of vertical position shift as the VERTICAL SIZE control is rotated throughout its range. Repeat with BATT VOLTS VAR at LO. Change BATT VOLTS to CAL.

10. (cont'd)

b. Adjust Gain, R124 *Range: at least 25° remaining*
Error: ±5%, max

Remove the VERTICAL SIZE knob. Place R249 exactly in the center of its rotation. Replace the VERTICAL SIZE knob so the depression in the knob engages the protrusion on the pot washer and tighten the set screw. Set the SAC MODE to +DC MIXED and AMPLITUDE to 20 VOLTS.

Set the 410 Input Adapter and TYPE 410 INPUT SELECTOR to ECG. Set the (+) ATTEN to 10,000. Connect the SAC OUTPUT to Input Adapter (+) INPUT. Adjust Gain, R124 for exactly 4cm of deflection. Change both INPUT SELECTORS to EEG and SAC AMPLITUDE to 2 VOLTS. Check for 4cm of deflection ±0.2cm. Change the INPUT SELECTORS to AUX and the + ATTEN to X100. Check for 4cm of deflection ±0.2cm.

c. Check VERTICAL SIZE range: 1:9, min

Set the SAC AMPLITUDE to 10 VOLTS. Change the 410 Input Adapter and TYPE 410 INPUT SELECTOR to ECG. Rotate the VERTICAL SIZE fully cw. Check for a minimum deflection of 6cm. Rotate the VERTICAL SIZE fully ccw and change SAC AMPLITUDE to 20 VOLTS. Check for no more than 1.3cm of deflection.

11. VERTICAL LINEARITY

a. Setup

Change the 410 Input Adapter and TYPE 410 INPUT SELECTOR to ECG and set the SAC AMPLITUDE to 5 VOLTS. Adjust TYPE 410 controls for exactly 2cm of display amplitude at the center of the graticule.

b. Check Vertical linearity non-linearity: ±3%, max within the center 6 vertical cm

Position the display between the 1st and 3rd graticule lines above and below the center graticule line. Compression or expansion must not exceed 0.6mm. Remove SAC signal from Input Adapter.

12. VERTICAL POSITION CONTROL

a. Check VERTICAL POSITION control range: + and - 3.7cm, min

Rotate the VERTICAL POSITION from ccw to cw and check that the knob is positioned to approximate center of shaft rotation. Turn the VERTICAL POSITION control fully ccw. Trace must be at least 3.7cm below graticule center. Turn the VERTICAL POSITION control fully cw. Trace must be at least 3.7cm above graticule center.

b. Check VERTICAL POSITION control electrical center: Graticule center ±1cm, max

Set the white mark on the VERTICAL POSITION control to 12:00 o'clock. Trace must be at graticule center ±1cm.

13. NOISE: 0.1cm, max P-P in CAL

Change the 410 Input Adapter and TYPE 410 INPUT SELECTOR to EEG. Connect a jumper from Vertical Amplifier board Pin N to Pin M. Place the VERTICAL SIZE control in the CAL position. Peak to Peak noise must not exceed 0.1cm.

14. GUARD EFFICIENCY AT 60Hz

a. Setup

Connect a jumper from TYPE 410 CASE GND to test scope ground. Connect a X1 probe from TYPE 410 Vert Amp Pin L to test scope TYPE 1A7 (+) INPUT. Connect a X1 probe from the strap between TYPE 410 Vert Amp Pins M and N to TYPE 1A7 (-) INPUT. Connect the probe ground lead to the shorting strap. Set the LF SINE WAVE GENERATOR for 5V P-P of 60Hz signal and connect to 410 Input Adapter CM IN and ±. Set the Input Adapter switch to CM ON and VERTICAL SIZE to CAL. Set the TYPE 1A7 VOLTS/CM to 500μ VOLTS and input selectors to AC.

b. Check guard efficiency at 60 Hz
Requirement: Less than 5cm of deflection on test scope

Check for less than 5cm of deflection on the test scope. Remove the jumper from Pins M and N. Remove the test scope probes.

15. COMMON MODE REJECTION RATIO

a. Adjust Com Mode Bal, R218

Adjust R218 for minimum deflection on the TYPE 410.

b. Check common mode rejection ratio with 5 k source impedance unbalance: 0.6cm deflection, max

Remove square pins from terminals P and O of the Vertical Amp board. Change the 410 Input Adapter MODE to (+) Z_C. Check common mode rejection ratio as in the following table:

15b. (cont'd)

Input	Maximum deflection
EEG	0.67cm
all ECG except V	0.67cm
ECG V and AUX	0.67cm

Change the 410 Input Adapter MODE to (-) Z_c and repeat the above checks.

Input	Maximum deflection
EEG	0.67cm
ECG	0.67cm
AUX	0.67cm

c. *Check common mode rejection ratio with 0Ω source impedance unbalance. Deflection: 0.2cm, max*

Change the MODE to NORM. Check for not more than 0.2cm of deflection in all positions of the INPUT SELECTOR switches, and all positions of the ECG LEAD SELECTOR on ECG.

Replace square pin connectors on terminals P and O.

d. *Check common mode rejection ratio with DC offset. Deflection: 0.67cm, max*

Leave the LF Sine Wave Generator connected to to CM IN. Connect the SAC to (-) INPUT. Set the SAC controls for 100V of +DC signal. Change the TYPE 410 and Input Adapter INPUT SELECTOR to EEG.

Check for no more than 0.67cm of deflection on the TYPE 410.

Repeat Step 15d with -DC signal.

Remove the SAC connection from 410 Input Adapter.

e. *Check common mode dynamic range: +3V to -3V*

Change the LF Sine Wave Generator AMPLITUDE and AMPLITUDE MULTIPLIER controls for a 6V signal. Set the 410 Test Power supply BATT VOLTS to LO. Check for a display amplitude of less than 0.3cm on the TYPE 410.

15. (cont'd)

f. Check differential dynamic range: + or -100mV, min

Connect the LF Sine Wave Generator to (+) INPUT. Set the (+) ATTEN to X10,000, INPUT SELECTORS to ECG and ECG LEAD SELECTORS to I.

Set the LF Sine Wave Generator for a 6cm display of 60 Hz signal. Connect the SAC OUTPUT to (-) INPUT. Set the (-) ATTEN to X1000.

Set the SAC for -100VDC. Check for display amplitude greater than 5.6cm.

16. DIFFERENTIAL OVERDRIVE RECOVERY TIME: Less than 4 seconds

Change the 410 Input Adapter and TYPE 410 INPUT SELECTOR to EEG. Adjust the LF Sine-Wave Generator for 2cm of deflection at the center of the TYPE 410 graticule. Connect the SAC OUTPUT to 410 Input Adapter (-) INPUT. Set the (-) ATTEN to X1000 and SAC to 100V -DC. Change the SAC MODE to +DC and check the time required for return of a 2cm amplitude display. Remove the SAC connection from the (-) INPUT of the 410 Input Adapter.

17. DIFFERENTIAL VERTICAL SIGNAL OUT

amplitude: 6.8V ±1.3V, max

Connect a X1 probe from TYPE 410 Horiz and Audio board Pin C to test scope TYPE 1A7 (+) INPUT. Connect another X1 probe from TYPE 410 Pin D to TYPE 1A7 (-) INPUT. Adjust the LF Sine Wave Generator for a 4cm display of 10 Hz signal on the TYPE 410. The signal displayed on the test scope must have an amplitude of from 5.5V to 8.1V.

18. ISOLATED SWITCH CLOSURE

Connect a multimeter between OUTPUT connector Pins 5 and 6. Set multimeter to ΩX1.

18. (cont'd)

Check continuity between Pins 5 and 6 as in the following table:

INPUT SELECTOR	Continuity
ECG	yes
AUX	yes
EEG	no

19. BANDWIDTH

a. Check HF bandwidth

Set the LF Sine Wave Generator for 6cm of 10 Hz signal. Set the TYPE 410 SWEEP SPEED to 25mm/s. Center the display and increase LF Sine Wave Generator Frequency until the display amplitude decreases to 4.2cm.

In a similar manner, check EEG, ECG and AUX positions of the INPUT SELECTOR as in the following table:

INPUT SELECTOR	HF -3dB
AUX	212.5Hz to 287.5Hz
ECG	212.5Hz to 287.5Hz
EEG	85 Hz to 115 Hz

Remove the LF Sine Wave Generator from the 410 Input Adapter.

b. Check LF -3dB point: 1.1 seconds, min for signal to decay to 50% amplitude

Set the SAC for 5 VOLTS -DC and connect SAC OUTPUT to 410 Input Adapter (+) INPUT. Set the (+) ATTEN to 10,000 and both INPUT SELECTORS to ECG. Set the SWEEP TIME to 25mm/s. Turn the VERTICAL SIZE full cw and position the trace 3cm below graticule center. Change the SAC MODE from -DC to +DC and check for 2.75cm or more of horizontal movement before the trace returns to graticule center. (see Fig. 4)

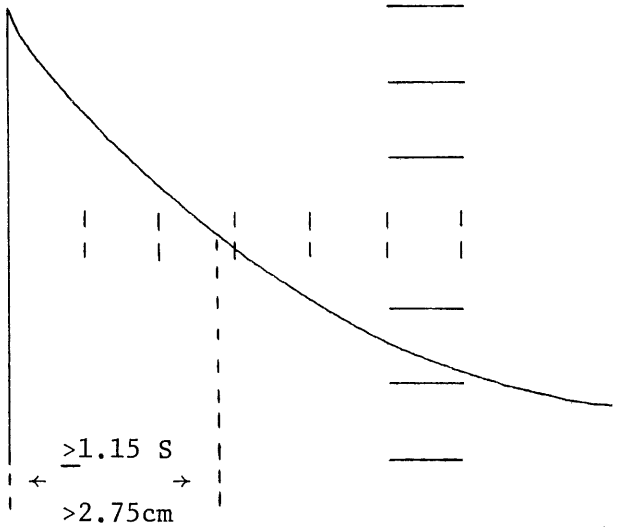

Fig. 4

20. AUXILIARY POWER

a. Setup

Remove the 410 Input adapter and connect a 410 Patient Cable to TYPE 410 Patient Cable Input. Set the INPUT SELECTOR to AUX and SWEEP SPEED to any position except POWER OFF.

b. Check aux power

Set the multimeter to a range suitable to measure 6.2 volts DC and check for approximately 6.2 VDC between the + and - PWR pins of the patient cable and the ⏚ pin. Remove the Patient Cable.

THE END