VECTORSURGE III

SERVICE MANUAL

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SPECIFICATIONS

Mains supply voltage	110/120/200/220/240 volts AC
Mains supply frequency	50/60 Hz
Power	70 V.A. Nominal
Primary Fuses	2 x 500 mA DA 205
Secondary Fuses	2 x 500 mA DA 205 1 x 1.5 amp DA 205

Power Transformer Secondary Voltages

1 (Chassis mounted)	30V at 1.5 amps 15V at 500 mA 15V at 500 mA

Outputs

Maximum patient current each circuit (1k Ω load, both channels driven)	60 mA
Maximum patient voltage each circuit	80 V
Current waveform	rectangular
Pulse width	50, 125 or 250 µs
Pulse frequency	2, 4 or 10 kHz
Beat frequency	0-150 Hz (nominal) 0-300 Hz (maximum)

Dimensions

Length	418 mm
Height	134 mm
Depth	280 mm

Weight

Unpacked	8.5 kg.
Packed	9 kg.

BRIEF OUTLINE

The Metron **vectorsurge** Interferential Therapy Unit comprises a control circuit which produces two rectangular pulse waveforms (frequency 2, 4 or 10 kHz, symmetrical AC). The waveforms are fed to two power amplifiers with the output stages operated in class B mode. Output of the power amplifiers is coupled to each patient circuit with a step-up transformer which also serves to isolate the patient circuit. A high-power resistor in the patient circuit limits the current output, which is measured directly by the patient-current meters. Additional limiting of output current is provided by the regulated protected power supply of the power amplifiers. Separate supplies are used to power the control circuit and timer.

A digital electronic timer is used to control the patient treatment time. At the end of the selected time period the timer triggers an SCR, disconnecting the drive to the output transformers. The same SCR is used to isolate the transformer drive signal if the apparatus is switched on with the intensity control advanced or if the carrier frequency is changed during operation. The timer and digital displays have a power supply derived from the same transformer as the power amplifiers.

Schematic diagrams of the unit are shown on pages 4 and 10.

The internal layout of the unit is shown on page 31.

WARNING

- **The output current available at each patient circuit is of a high enough intensity to be potentially dangerous.**
- **As a therapy device, the machine may only be used by qualified personnel.**
- **The machine is not for trans-thoracic use (the electrodes must not be positioned such that a current may flow through the chest area).**
- **The machine should not be used on a person with an implanted cardiac pacemaker.**

TECHNICAL DESCRIPTION

PART 1 - THE CONTROL CIRCUIT

The control circuit produces two rectangular symmetrical waveforms with a user-selectable frequency of 2, 4 or 10 kHz.

The two waveforms are switched in and out of phase at a selected frequency (the 'beat frequency'). The beat frequency may be set to a fixed value or set to sweep over a particular frequency range.

One of the waveforms is amplitude modulated at a frequency of approximately 250 Hz to a depth of 50% of maximum and the envelope has a triangular modulation. This amplitude modulation produces 'vector rotation' of the patient stimulation current.

The circuit may also be set to 'surge' the output signals. 'Surging' refers to in-phase amplitude modulation of the signals. The modulation is 100%. The surge frequency may be varied in the range approximately 0.05 Hz to 1 Hz.

A schematic diagram of the control circuit is shown on page 4.

THE CONTROL CIRCUIT - IN MORE DETAIL

The control circuit comprises four sub-sections:

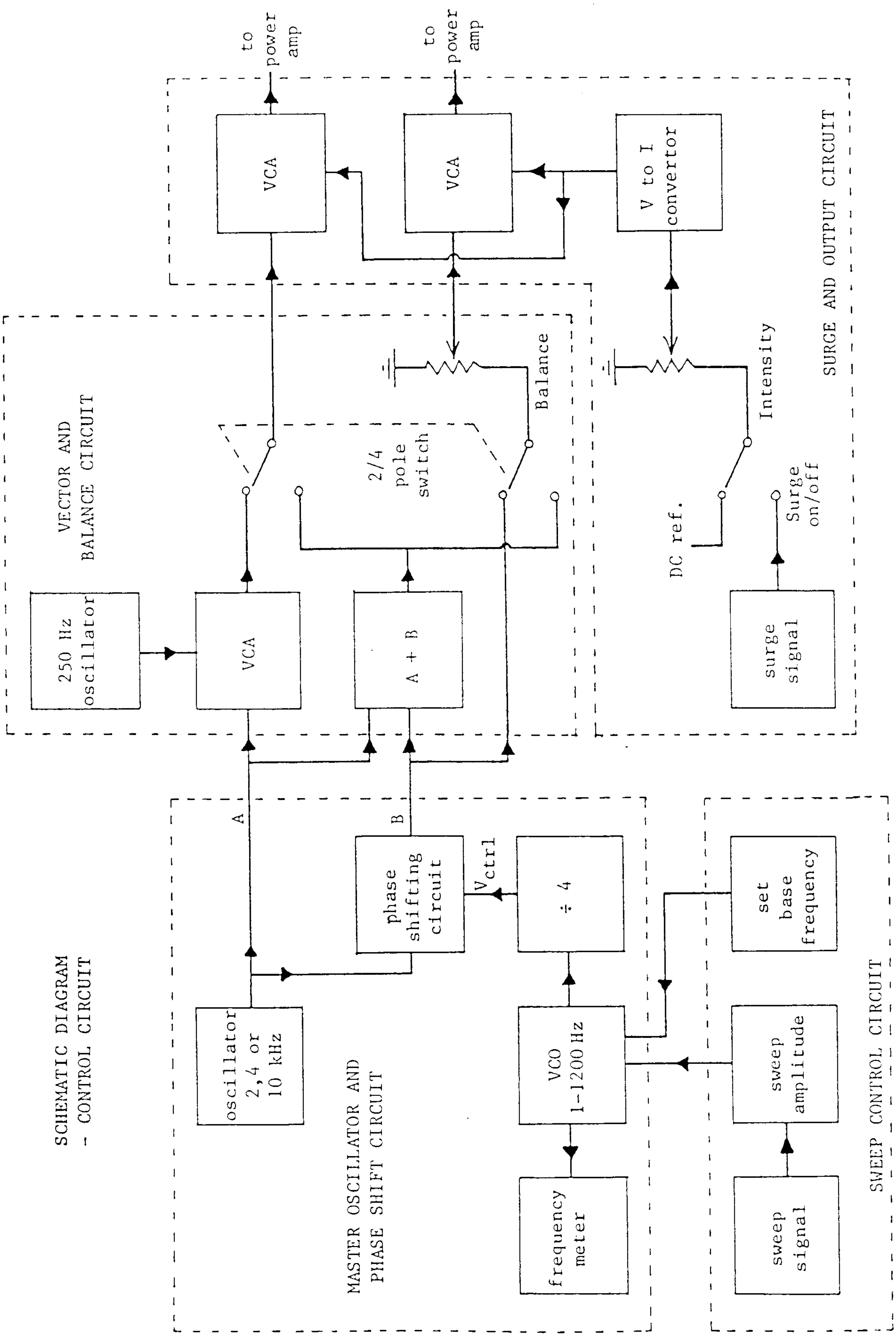
* the master oscillator and phase shift circuit
* the sweep control circuit
* the vector and balance circuit
* the surge and output circuit

1.1 THE MASTER OSCILLATOR AND PHASE SHIFT CIRCUIT

The complete circuit is shown in circuit diagram sheet 2. An astable multivibrator (IC9(a)) produces a train of rectangular pulses. The pulse frequency may be set to 2, 4 or 10 kHz by operating a switch on the front panel of the machine.

Signals from the multivibrator are fed to a combination of gates (IC6, IC7) which split the signal into two (A and B). The channel A signal is of fixed phase. The channel B signal is switched in and out of phase with respect to the channel A signal at a frequency determined by IC4, a voltage controlled oscillator (VCO).

The VCO (IC4) operates over a frequency range of approximately 1 Hz to 1200 Hz. Signals from IC4 are supplied to the frequency meter circuit (see following) which is strobed and reset at 4 Hz and also to a divide by four circuit (IC5). The output of IC5 is used to switch the phase of the channel B signal. Thus the frequency meter displays the phase shift frequency of the channel B signal (the beat frequency) and the display is refreshed four times per second.


SCHEMATIC DIAGRAM
- CONTROL CIRCUIT
MASTER OSCILLATOR AND
PHASE SHIFT CIRCUIT
oscillator
2,4 or
10 kHz
phase
shifting
circuit
A
B
V_{ctrl}
÷ 4
VCO
1-1200 Hz
frequency
meter
SWEEP CONTROL CIRCUIT
set
base
frequency
sweep
amplitude
sweep
signal
VECTOR AND
BALANCE CIRCUIT
250 Hz
oscillator
VCA
A + B
2/4
pole
switch
Balance
SURGE AND OUTPUT CIRCUIT
VCA
VCA
V to I
convertor
Intensity
DC ref.
Surge
on/off
surge
signal
to
power
amp
to
power
amp

The beat frequency is controlled by the DC signal at the output of IC3(a): this is applied to pin 9 of IC4, the VCO. This DC signal is determined by voltages applied to each input of IC3(a). The voltage applied to pin 3 of IC3(a) determines the lowest frequency of the VCO. The voltage applied to pin 2 is generated by the sweep control circuit (see 1.4 following) and has a very low frequency triangular waveform. This is used to ramp the VCO frequency - in other words, to determine the sweep range over which the beat frequency varies.

1.11 TESTING THE MASTER OSCILLATOR

Connect a CRO to test point B and change the carrier frequency from 2 kHz to 4 kHz and then 10 kHz. The CRO should display a rectangular pulse waveform of period 250 µs, 125 µs and then 50 µs.

1.12 TESTING THE PHASE SHIFT CIRCUIT

Connect a CRO to test point D and set the beat frequency selector switch to the 'base and sweep' position. Set the sweep control to minimum and the base control to approximately 50 Hz. The CRO display should show a rectangular pulse waveform of amplitude close to 12 V and a frequency of approximately 200 Hz, i.e. a period of 5 ms. Next connect the CRO (dual channel) to test points C and E. Two rectangular pulse waveforms of amplitude close to 12 V and frequency 2, 4 or 10 kHz (depending on the setting of the 'carrier frequency' switch) should be seen. The waveform at point E should shift in and out of phase with the point C signal at the beat frequency. Set the CRO to display the sum (A + B) or difference (A - B) between the two channels. An amplitude modulated signal with a rectangular envelope should be seen.

1.2 THE VECTOR AND BALANCE CIRCUIT

The complete circuit is shown in circuit diagram sheet 3.

When the 2/4 pole switch is in the '4 pole' position, the channel A and B signals produced by the phase shift circuit are each processed differently. The channel B signal is pulsed DC. This signal is depolarized by a 10 µF elecrolytic capacitor to give an AC waveform which is applied to the balance control.

The channel A signal is depolarized and applied to a voltage controlled amplifier (VCA), IC8. The control signal applied to pin 5 of IC8 is derived from IC9(b). IC9(b) generates a triangular waveform of frequency approximately 250 Hz. The waveform ramps between 4 V and 8 V. This signal is buffered by IC3(b) and applied to a V to I converter comprising IC3(d) and a BC557 transistor. Trimpot 'h' determines the gain of IC8 and is adjusted to provide signals of equal amplitude at the outputs of the vector and balance circuit. Since the signal generated by IC9(b) ramps between 4V and 8V, the output of IC8 is an amplitude modulated signal with a 50% depth of modulation.

The modulation envelope of the IC8 output should vary between approximately 4 V and 8 V peak to peak. Thus the time averaged voltage is 6 V peak to peak, which is the same value as the channel B signal at the output of the balance control when it is set to the mid-position.

The depolarized channel A and channel B signals are added by IC3(b) to produce an amplitude modulated signal with a rectangular envelope. The envelope is at the beat frequency and the amplitude switches between zero and +6 V. When the 2/4 pole switch is in the '2 pole' position the same amplitude modulated signal is applied to both the A and B channel outputs. A 10 kΩ trimpot (j) is used to equalize the signals in each channel.

1.21 TESTING THE VECTOR CIRCUIT

A CRO connected to pin 8 of IC3(c) should show a triangular DC waveform of frequency approximately 250 Hz. The signal varies between 4 V and 8 V, i.e. 6 V ± 2 V.

Connect the CRO to test point F. An amplitude modulated signal should be seen. The envelope amplitude is 6 V peak to peak average i.e. it varies between 4 V PP and 8 V PP at a frequency of 250 Hz.

1.22 ADJUSTING THE CHANNEL BALANCE

Set the 2/4 pole switch to the '4 pole' position and the balance control on the front panel to the mid position. The surge switch should be off and a 470 Ω, 5 W dummy load should be connected to each output of the machine.

A dual beam CRO connected to display both outputs should show equal amplitude signals.

Rotate the intensity control for a channel B output intensity of ± 20 V. Adjust trimpot h for a channel A intensity of ± 20 V average. Note that the reading of ± 20 V is taken from the mid-point of the amplitude modulation and that if the output meters are correctly calibrated the current meter readings should be equal (see calibration procedure, step 10).

Next set the 2/4 pole switch to the '2 pole' position and set the beat frequency to a fixed frequency of approximately 50 Hz. Rotate the intensity control for a channel B output of ± 20 V. Adjust trimpot j for equal amplitude signals in channels A and B (see calibration procedure, step 11).

1.3 THE SURGING CIRCUIT

The surging circuit comprises a triangle waveform generator (IC10) which feeds via IC11(a) and IC11(b) to a V to I convertor (IC11(c)). The output of the V to I convertor is applied to the control voltage inputs (pin 5) of two VCAs (IC12 and IC13) via the 'intensity' control.

When the surge selector switch is set to the 'on' position the output of the surging circuit is applied to the 'intensity' control.

When the surge selector switch is set to the 'off' position the input to the 'intensity' control is a fixed 4.3 V reference signal. The setting of the 'intensity' control determines the voltage applied to the V to I convertor and so determines the amplitude of the signals supplied to the power amplifiers.

Output of the VCAs (IC12 and IC13) are fed to the main amplifiers.

The triangular waveform produced by IC10 is of very low frequency (0.05 Hz to 1 Hz), which is determined by the setting of the surge rate control on the front panel. IC11(a) is needed to present a high impedance load to IC10.

N.B. A CRO connected to IC10 pin 6 is likely to change the surge frequency or prevent IC10 from oscillating unless the input impedance is sufficiently high (over 10 MΩ).

IC11(b) is used to offset the signal produced by IC10 so that the voltage applied to the intensity control sweeps from approximately 0 V to exactly 4.3 V.

1.31 ADJUSTING THE SURGING CIRCUIT

A CRO should be connected to the output of IC11(b) (test point G). The surge rate control on the front panel should be set to maximum (fully clockwise). The CRO timebase should be set to 500 ms/div.

The 10 kΩ offset adjust potentiometer, i, (circuit diagram sheet 4) should be adjusted so that the voltage fluctuates between approximately 0 V and exactly 4.3 V.

The CRO is then connected to the machine output and the timebase set to 20 μs/div. The maximum signal observed should have an amplitude which is equal to the amplitude when the surge is switched off.

1.4 THE SWEEP CONTROL CIRCUIT

The beat frequency of the apparatus is the frequency of the VCO in the master oscillator and phase shift circuit (1.1 above). The VCO frequency is determined by the control voltage applied to pins 2 and 3 of IC3(a), (circuit diagram sheet 2).

The frequency selector switch, mounted on the front panel, is used either to select preset frequency sweeps or to select a 'base and sweep' setting where the frequency sweep can be determined by the operator. Operation of this switch changes the control voltage applied to IC3(a).

A steady DC signal applied to pin 3 of IC3(a) determines the base frequency of the VCO, IC4. A negative going, triangular DC waveform of very low frequency is applied to pin 2 of IC3(a): this determines the sweep range of the VCO. The triangular waveform is generated by the sweep control circuit (circuit diagram sheet 1).

IC1 generates a DC signal which sweeps slowly between 4 V and 8 V. This signal is buffered by IC2(b) and applied to IC2(a). A 10 kΩ trimpot (a) connected to pin 3 of IC2(a) applies an offset voltage to this signal. The output of IC2(a) is thus a triangular waveform, sweeping between 0 V and 4 V. IC2(d) inverts this signal and the 5 kΩ trimpot (b) determines its amplitude. A resistive divider network connected to the frequency selector switch provides fixed sweep ranges of 150 Hz, 40 Hz or 15 Hz. A variable sweep range, determined by the setting of a front panel mounted 10 kΩ potentiometer, can also be selected.

1.41 CALIBRATING THE SWEEP RANGES

Calibration of the sweep ranges is performed by first adjusting trimpot 'a' so that the sweep control signal, measured at test point A, varies from negative to exactly zero volts (see calibration procedure, step 1).

Next the lowest frequency of the VCO (IC4) is set to 2 Hz by adjusting trimpot 'g' (see calibration procedure, step 2). This sets the lowest beat frequency to 0.5 Hz. Note that the VCO frequency is four times the beat frequency and that the beat frequency indicator is strobed at a frequency of 4 Hz so as to give a correct beat frequency reading, updated four times per second.

Once the lowest VCO frequency has been set, the base and sweep control signals are calibrated by adjusting trimpots b, c, d, e, f and g. The sequence of adjustments is described in calibration procedure steps 2 to 8. Note that the steps described should be followed in correct sequence as resetting one frequency may affect calibration of the others.

PART 2 - THE POWER AMPLIFIERS, POWER SUPPLIES AND FREQUENCY METER

Output signals from the control circuit are fed to two power amplifiers operating in class B mode. A relay switches the power amplifier output between a 56 Ω 5 W dummy load and an output transformer.

The 56 Ω load is connected when either -

* the unit is switched off **or**
* the timer is not in operation **or**
* the carrier frequency switch is operated **or**
* the power is switched on with the intensity control advanced.

If the power is switched on with the intensity control at minimum and the timer is set there will be a brief (approximately one second) delay before the relay switches from the 56 Ω load to the output transformer. The delay is incorporated to ensure that no switch-on current pulses are applied to the patient circuit when the mains power switch is operated.

The output transformers supplying the patient circuit are double insulated and constructed in accordance with Australian Standard AS3208. The transformers have a voltage step-up ratio of 6.6:1. A 5 W series resistor in the patient circuit is used to limit the output current. A metering circuit connected in parallel with the 5 W resistor is calibrated to indicate the patient current.

A short-circuit protected 30 V, 1.5 A power supply is used to power the power amplifiers. A +12 V, 500 mA supply is used to power the timer, frequency meter and output relay. A ±12 V, 500 mA supply is used to power the control circuit. The mains transformer has three separate windings: two rated at 15 V, 500 mA and one rated at 30 V, 1.5 A.

The frequency meter is a simple 3 digit count and display circuit. Rectangular pulses generated by the control circuit VCO are counted. Gating for count and display is by 4 Hz pulses generated by the timer circuit. Since the VCO frequency is four times the beat frequency, a quarter second count of the VCO output gives the beat frequency reading in Hz.

A schematic diagram is shown on page 10.

THE POWER AND FREQUENCY METER CIRCUITS - IN MORE DETAIL

The power and frequency meter circuits comprise five sub-sections:

* the power amplifiers
* the timer control and delay circuit
* the +30 V supply
* the +12 V supply
* the ±12 V supply
* the frequency meter

2.1 THE POWER AMPLIFIERS

The power amplifier outputs have a complementary push-pull arrangement. The voltage gain of the amplifiers, of approximately 8 times, is set by the ratio of the feedback resistor (1500 Ω) to the BC 547 emitter resistor (180 Ω). The amplifiers are operated in class B mode: this produces good reproduction of square wave signals, with excellent transient response and negligible crossover distortion with a square input waveform. See circuit diagram sheet 5.

Output of each power amplifier is fed to a relay which switches between a 56 Ω , 5 W load resistor and the output transformer. The relay coil is energised by the timer control and delay circuit (see 2.2 below). A 2.5 mH inductor is connected to the amplifier output ahead of the relay so as to maintain the negative side of the 220 µF output coupling capacitor at 0 volts potential regardless of the relay position.

No calibration or adjustment of the power amplifiers is necessary and trouble-shooting is by standard procedures.

2.2 THE TIMER CONTROL AND DELAY CIRCUIT

The timer control and delay circuit serves four roles:

* to switch the patient current according to the timer output
* to prevent patient current being supplied if the unit is switched on with the intensity control advanced
* to prevent transient currents being supplied to the patient circuit when power is switched on
* to prevent patient current being supplied if the carrier frequency is changed with the intensity control advanced.

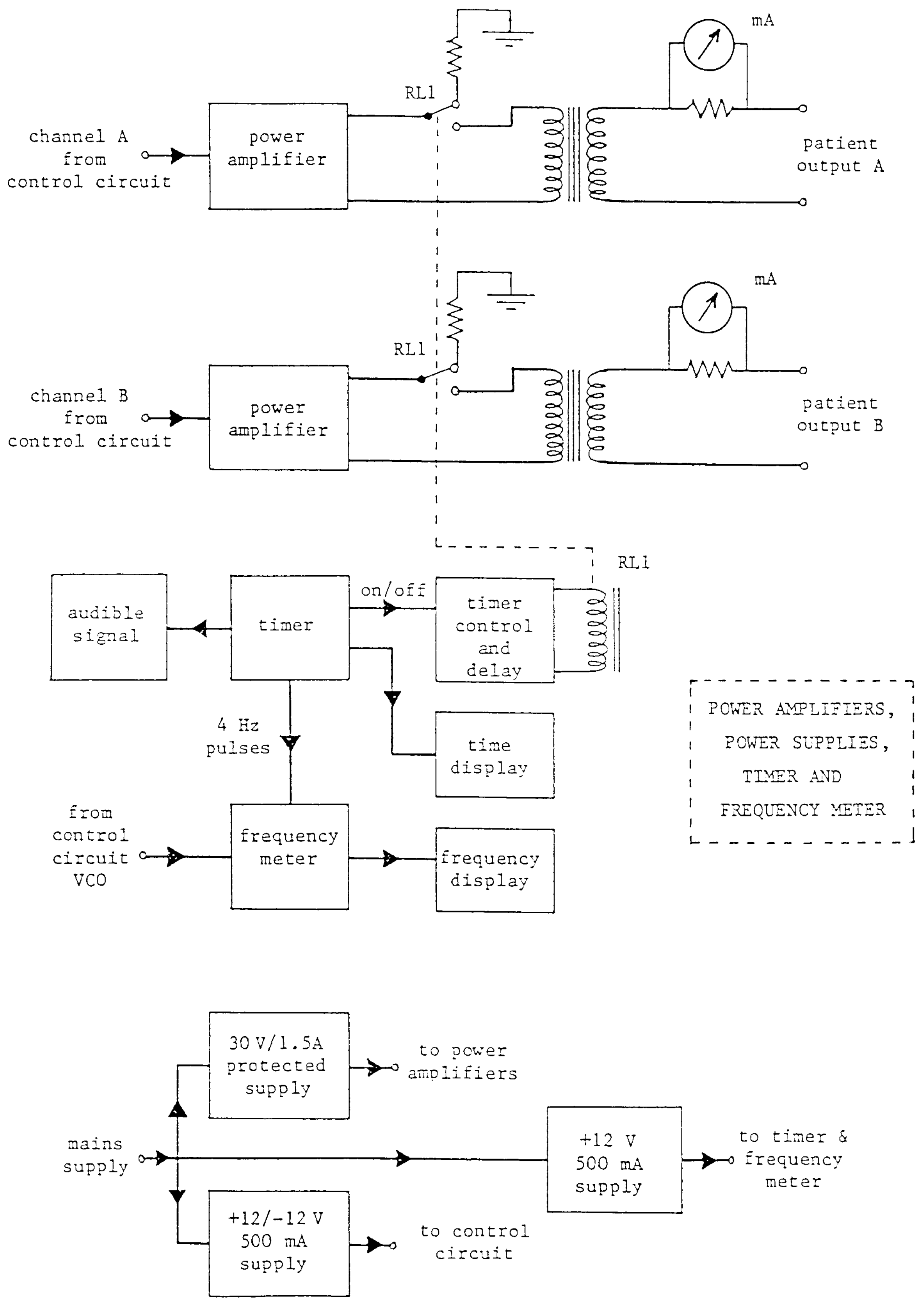
See circuit diagram sheet 9.

Output from the timer (section 3 following) is coupled to the gate of SCR C103B. Triggering of the SCR supplies current to the output delay circuit and the relay RL1 is not energised. Thus output from the power amplifiers (sheet 5) is diverted to 56 Ω load resistors.

When the SCR is latched (not conducting) no current is supplied to the output delay circuit. Relay RL1 will energise and output from each of the power amplifiers will be supplied to the output transformers.

When the unit is switched on a transient pulse is supplied to the SCR gate by charging of the 10 µF 35 V capacitor (sheet 9) connected to the +12 V supply rail and the SCR conducts. The timer output is initially high so the SCR is held in conduction. Manual setting of the timer makes the timer output low and the SCR can then be latched by rotating the intensity control to minimum. This allows the relay to energise and current is supplied to the patient circuit.

If the carrier frequency switch is operated, the input to IC14(a) is briefly reduced to zero. IC14(a) acts as an invertor and produces a transient 12 V pulse which is applied to the SCR gate, triggering the SCR into conduction. The SCR can be latched by rotating the intensity control to minimum. The relay then energises and current is supplied to the patient circuit.


mA
RL1
channel A
from
control circuit
power
amplifier
patient
output A
mA
RL1
channel B
from
control circuit
power
amplifier
patient
output B
RL1
audible
signal
timer
on/off
timer
control
and
delay
4 Hz
pulses
time
display
from
control
circuit
VCO
frequency
meter
frequency
display
POWER AMPLIFIERS,
POWER SUPPLIES,
TIMER AND
FREQUENCY METER
30 V/1.5A
protected
supply
to power
amplifiers
mains
supply
+12 V
500 mA
supply
to timer &
frequency
meter
+12/-12 V
500 mA
supply
to control
circuit

Thus the relay can only energise if:

(a) the timer has been set and

(b) the intensity control is set to a low position

and the relay will de-energise if the carrier frequency is changed.

An RC combination (4.7 kΩ and 10 μF) in the output delay circuit introduces a delay before the relay is energised. This prevents current being supplied to the patient circuit before the power supplies have stabilized when first switched on.

A front panel mounted LED (the patient current indicator) is connected in parallel with the relay. This LED is thus illuminated whenever the relay is operating and energy can be supplied to the patient circuit.

No adjustment of the timer control and delay circuit is necessary and trouble-shooting is by standard procedures.

2.3 THE +30 V SUPPLY

The +30 V supply for the power amplifiers is shown in circuit diagram sheet 11.

A 1.5 A slow-blow fuse protects the 30 V supply which uses a series regulator circuit comprising a BD647 darlington transistor heat-sunk to the chassis and a 30 V, 1 W zener diode.

Current limiting is provided by a BD139 transistor which has its collector connected to the cathode of the 30 V zener. The 0.68 Ω, 2 W resistor in the supply return between base and emitter of the BD139 determines the limiting current value.

No adjustment of the power supply is needed and trouble-shooting is by standard procedures.

2.4 THE +12 V SUPPLY

The +12 V supply for the timer, frequency meter and output relay is shown in circuit diagram sheet 12.

Full wave rectified AC is smoothed by a 470 μF capacitor and supplied to a 12 V series regulator IC. The supply is protected by a 500 mA slow-blow fuse.

No adjustment of the power supply is needed and trouble-shooting is by standard procedures.

2.5 THE ±12 V SUPPLY

The ±12 V supply for the control circuitry is shown in circuit diagram sheet 10. A single 15 V winding is used to generate two half-wave rectified signals: one positive and one negative.

A 500 mA fuse protects the supply which uses a series regulator IC for both the positive supply and the (lower current) negative supply. The positive supply normally experiences approximately 120 mA current drain and the negative supply, approximately 25 mA.

No adjustment of the power supply is needed and trouble-shooting is by standard procedures.

2.6 THE FREQUENCY METER

The frequency meter circuit is shown in circuit diagram sheet 6.

The rectangular AC waveform from the VCO in the control circuit (section 1.1 previously) is applied directly to the 'clock' input of the 4553 counter/multiplexer, IC15.

4 Hz pulses from the the timebase circuit (section 3 following) control the strobe and reset functions of IC15. The 4 Hz pulses are inverted by IC14(b), differentiated by the 270 pF/10 kΩ combination and applied to the 'strobe' input of IC15 as negative going spikes on a 12 V DC signal.

A 33 kΩ/270 pF combination delays the signal applied to IC14(c). The delayed signal is inverted and fed to IC14(d) where it is again inverted and differentiated by the 270 pF/1 kΩ combination. The 100 kΩ/18 kΩ resistor combination around IC14(d) provides a DC bias necessary to ensure that the output pulses are sufficient to trigger the 'reset' function. Thus the pulses applied to the 'reset' input are positive spikes superimposed on a rectangular positive DC signal. The 'reset' pulse is delayed by approximately 10 microseconds with respect to the 'clock' pulse.

The BCD output of IC15 is fed to a 4511 decoder/driver IC (IC16) which powers three seven segment displays (Stanley type NKR 163, 263) via a 1 kΩ, 1/4 W resistor network. Multiplex drive from IC15 is fed to three BC557 transistors which display or blank the relevant seven-segment display.

No adjustment of the frequency meter is necessary and trouble-shooting is by standard procedure.

PART 3 - THE TIMER AND TIMEBASE GENERATOR CIRCUIT

The timebase generator derives various low frequency pulse waveforms from a quartz crystal with a resonant frequency of 32.896 kHz. Two signals of frequency 2048 Hz and 1024 Hz are used to drive the two-tone audible alarm which operates at the end of the treatment time. 4 Hz pulses are used to strobe the audio signal and the frequency meter: the same frequency is used for rapid count-up and count-down of the timer. 1 Hz and 1/60 Hz (i.e. 1 minute) pulses are used by the timer.

The timer can be set to any treatment time between 1 and 40 minutes.

A front panel mounted switch is used to set the timer. When the power is switched on the time display is initially blank and a control signal from the timer prevents the timer control circuit (section 2.2 previously) from supplying any current to the patient circuit.

If the front panel mounted switch is depressed to the left the timer begins to count down rapidly from 40 minutes. Releasing the switch sets the treatment time. If the front panel mounted switch is depressed to the right the timer will rapidly count up. Thus the treatment time can be set by counting down from 40 minutes or counting up from 1 minute. Adjustment of the treatment time can also be performed at any time by depressing the switch in the appropriate direction.

Once the timer is activated the time display is illuminated and no signal is supplied to the timer control. Thus activation of the timer allows current to be supplied to the patient circuits. Note, however, that the intensity control setting overrides the timer and no patient current will be supplied unless the intensity control is first set to minimum (see section 2.2 previously).

3.1 THE TIMEBASE GENERATOR - IN MORE DETAIL

The timebase generator circuit is shown in circuit diagram sheet 7.

Two binary ripple counters, IC1t and IC2t, are used to frequency divide the 32.896 kHz signal produced by the quartz crystal. IC1t operates continuously to provide 4 Hz, 2048 Hz and 1024 Hz pulses.

The combination of IC2t and IC3t divides 64 Hz pulses from IC1t to produce 1/60 Hz pulses i.e. 1 pulse per minute. Feedback to pin 11 of IC2t is used to reset the count at the completion of each 1 minute interval. A control signal from the timer circuit also resets the count whenever the timer switch is used to count up or down. Thus releasing the timer switch sets the start of a full one-minute time period and guarantees accuracy of the selected treatment time.

3.2 THE TIMER CIRCUIT - IN MORE DETAIL

The timer circuit is shown in circuit diagram sheet 8.

The circuit comprises two NKR263 seven segment displays, each driven by a 74C48 BCD to 7-segment decoder which is in turn driven by a 74C192 up/down decade counter. Signals to the decade counters are controlled by a 4093 quad schmitt trigger IC.

When power is first switched on a pulse is applied to the pin 14 (reset) input of IC8 and IC9. Thus the display is blanked and pin 4 of IC11 is low. With a low input to IC6(d), its output is high and a signal is applied to the timer control circuit (circuit diagram sheet 9). This prevents the relay RL1 from energising and no current is supplied to the patient circuit.

If the timer switch is depressed to the left IC5(a) applies 4 Hz pulses to pin 4 of IC9. Pin 11 of IC8 is momentarily brought low and decimal 4 is loaded into the counter register. Pulses applied to pin 4 of IC9 thus cause it to count down from 40. While the switch remains depressed the output to the timebase generator (sheet 7) is kept high so the reset function of the timebase generator is activated. Releasing the switch sends the output low and the timebase generator starts counting to 1 minute.

If the switch is depressed to the right, IC5(d) applies 4 Hz pulses to pin 5 of IC9. Pin 11 of IC8 remains high so the counter registers start with both at decimal zero. Pulses applied to pin 5 of IC9 thus cause it to count up from zero. While the switch remains depressed the output to the timebase generator is kept high. Releasing the switch sends the output low and the timebase generator starts counting to 1 minute.

When the timer is operating, i.e. a count time is showing on the seven-segment displays, pin 4 of IC11 is high and the output of IC6(d) is low. This allows the relay RL1 (circuit diagram sheet 9) to operate and current is supplied to the patient circuit.

IC6(a) and IC6(b) serve to reset counters IC8 and IC9. When IC8 reaches a count of decimal 4 and IC9 reaches a count of 1, Pins 1 and 2 of IC6(a) go high. This results in a high output on IC6(b) taking pin 14 (the reset pin) high which resets counters IC8 and IC9 to zero. When the display is blanked, pin 4 of IC11 is low so the output of IC6(d) is high and relay RL1 disconnects output from the patient circuits.

A delay circuit comprising a BC549 transistor with an associated 4.7 µF/180 kΩ RC combination is used to introduce a brief pause between counts of 1 and 40. If the switch is held depressed to the left the timer will rapidly count down to zero and blank the displays. The displays will remain blanked briefly before re-commencing a rapid count up from 1. The delay is incorporated to make it easy to manually switch off the timer and terminate treatment without using the mains power switch.

The output of IC6(d) is used to control a two-tone audio signal circuit. When the timer is switched on by depressing or elevating the switch, the output of IC6(d) is brought low. This switches pin 10 of IC6(c) high and allows the 10 µF capacitor connected to pin 6 of IC4(b) to charge slowly to +12 volts. With a low input to pin 5 of IC4(b), its output is high and the output of IC4(c) is low. This keeps the outputs of IC7(a) and IC7(b) high and the output of IC7(c) is low.

With no drive to the BC547, the piezo transducer is silent. At the end of the treatment time, pin 11 of IC6(d) goes high, sending pin 4 of IC4(b) low. The 10 µF capacitor discharges slowly through the 1 MΩ resistor and pin 4 of IC4(b) remains low for several seconds. For this time period, pin 10 of IC4(c) is high and drive is applied to the BC547 transistor. The 4 Hz pulses applied to IC4(d) and pin 4 of IC7(b) switch the drive to the BC547 alternately from 1024 Hz to 2048 Hz. Thus a two-tone audible signal is produced by the PKM24 transducer. The tone switches at a frequency of 4 Hz and terminates after a time period determined by the RC components connected to pin 6 of IC4(b). Re-setting the timer brings the output of IC6(d) low, keeping the transducer silent and allowing the 10 µF capacitor to recharge.

3.21 TESTING THE TIMER CIRCUIT

No adjustment of the timer circuit is necessary. Correct operation of the timer can be verified as follows:

* When the power is switched on the displays should be blank, the output of IC6(d) should be high and the output to the timebase generator should be low.

* Depressing the front panel switch to the right should result in the displays counting upwards from 1 to 40. Pin 11 of IC6(d) should be low and remain low while the switch is elevated and subsequently while the displays are illuminated.

* Depressing the switch to the left should make the displays count downwards. While the switch is depressed the output (Pin 11) of IC6(d) is low and remains low as long as the displays are illuminated.

* Moving the switch from depressed to elevated should produce a smooth transition from counting down to counting up. A 100 nF capacitor on each of the contacts provides a switching delay to prevent transient jumps in the time setting.

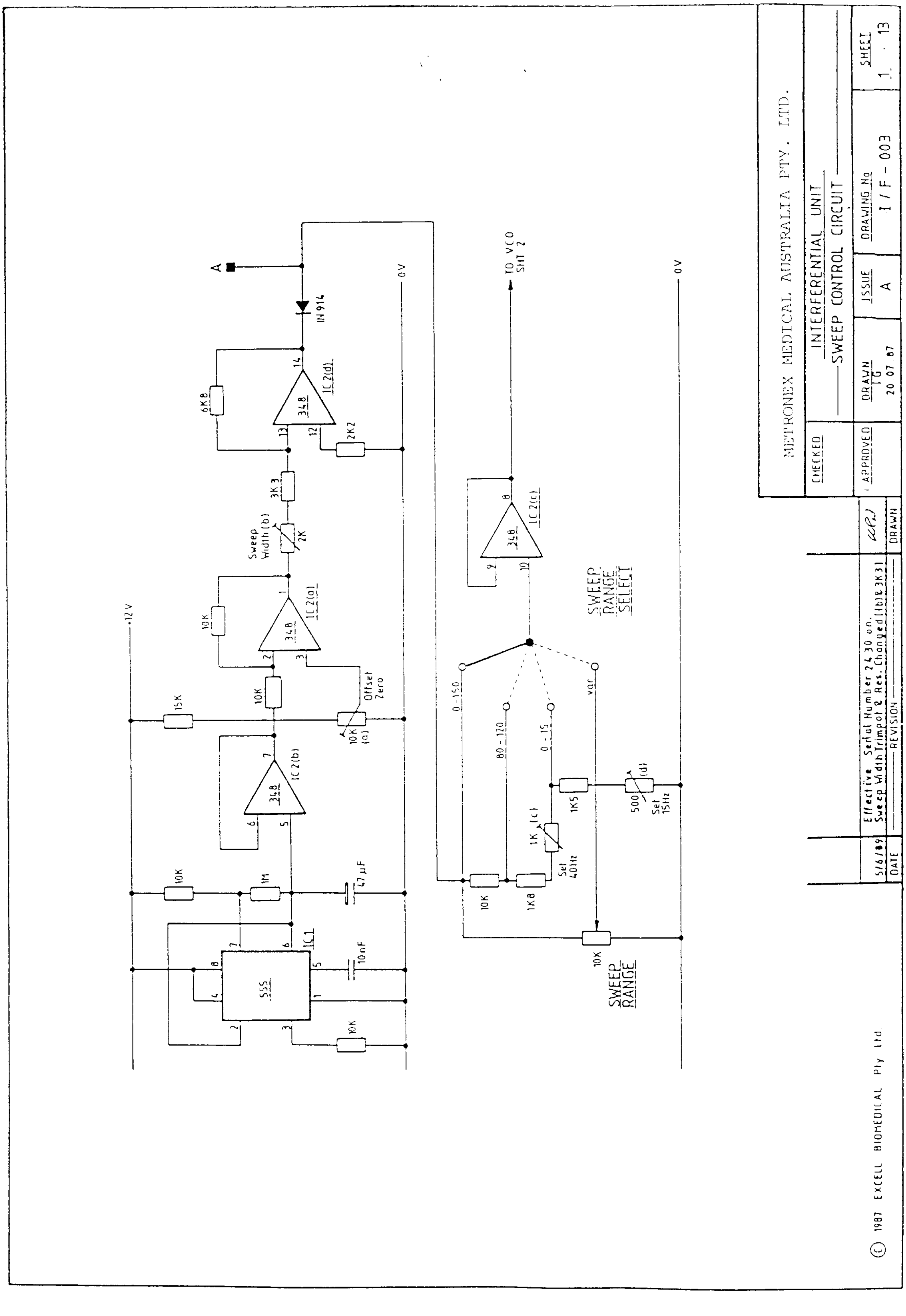
* When the timer has counted down to zero the displays should blank, the transducer should sound and the relay RL1 should switch, disconnecting drive from the patient circuits. The patient current indicator lamp should extinguish. Note that the audio signal will only operate for the required duration (several seconds) if the timer has been on long enough for the 10 µF capacitor on pin 6 of IC4(b) to charge fully.

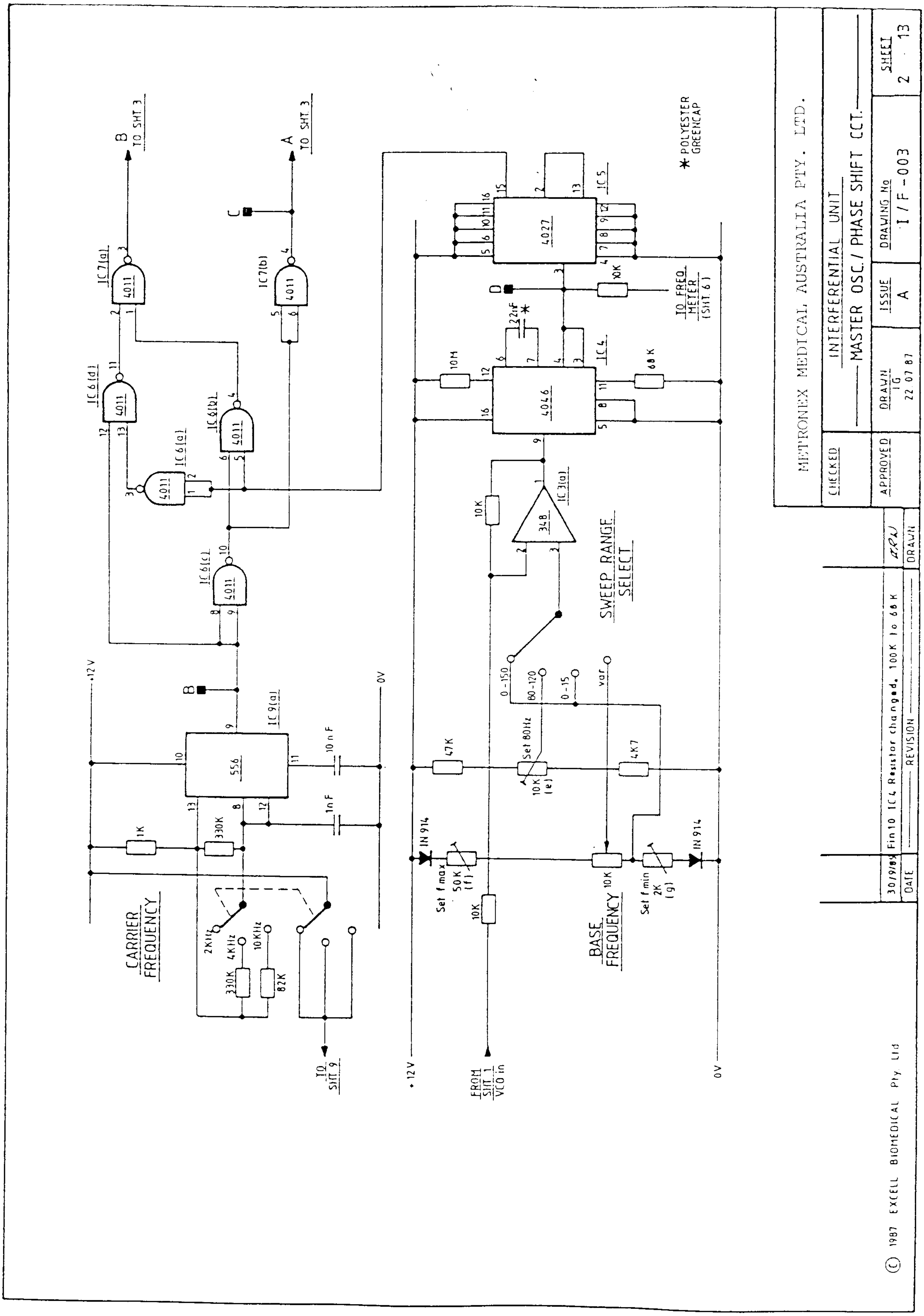
If the above tests are positive and if the time base generator is verified as producing pulses at a frequency of 1 per minute, then the timer and timebase generator are functioning correctly.

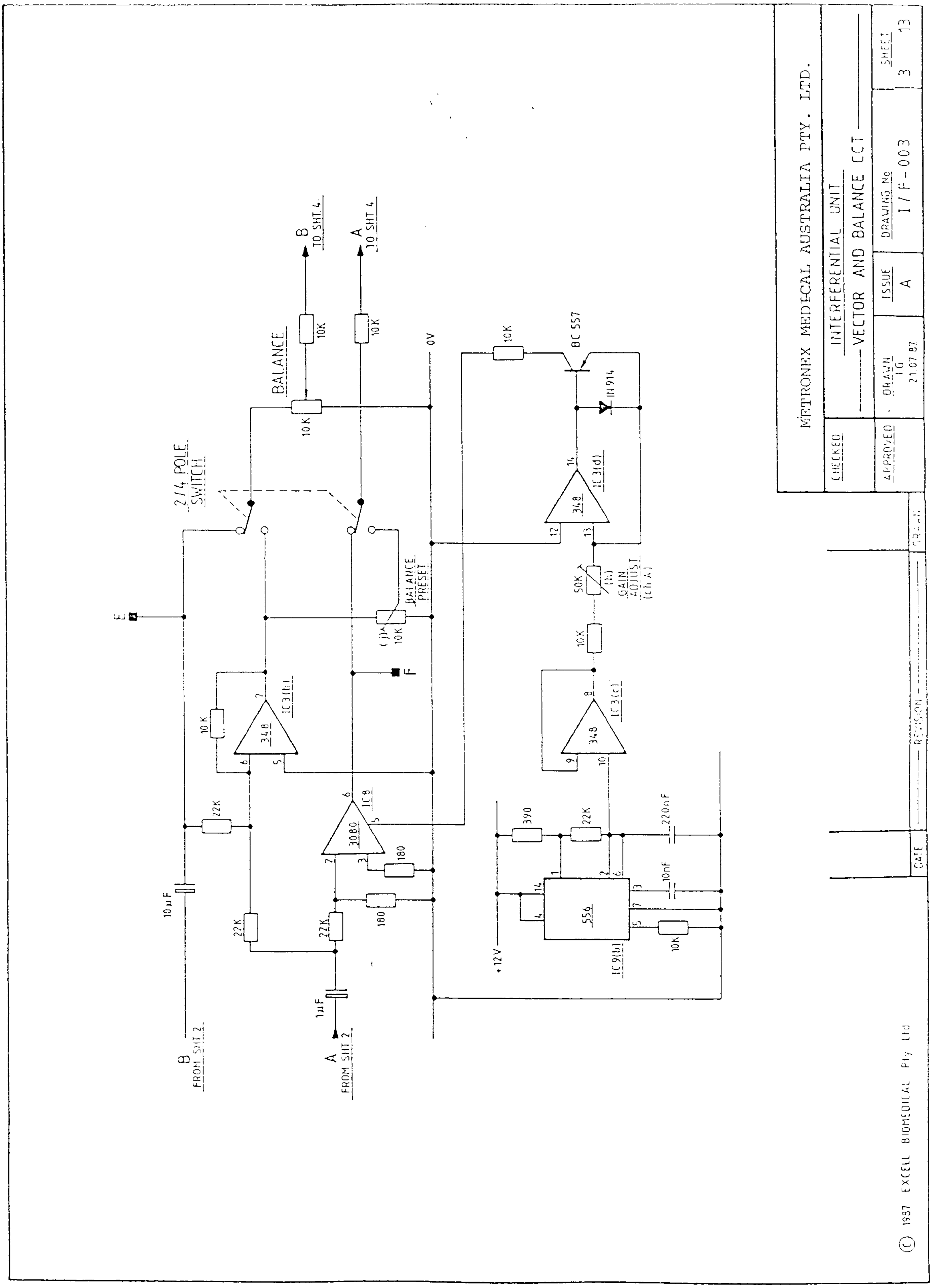
CALIBRATION PROCEDURE: VECTORSURGE III

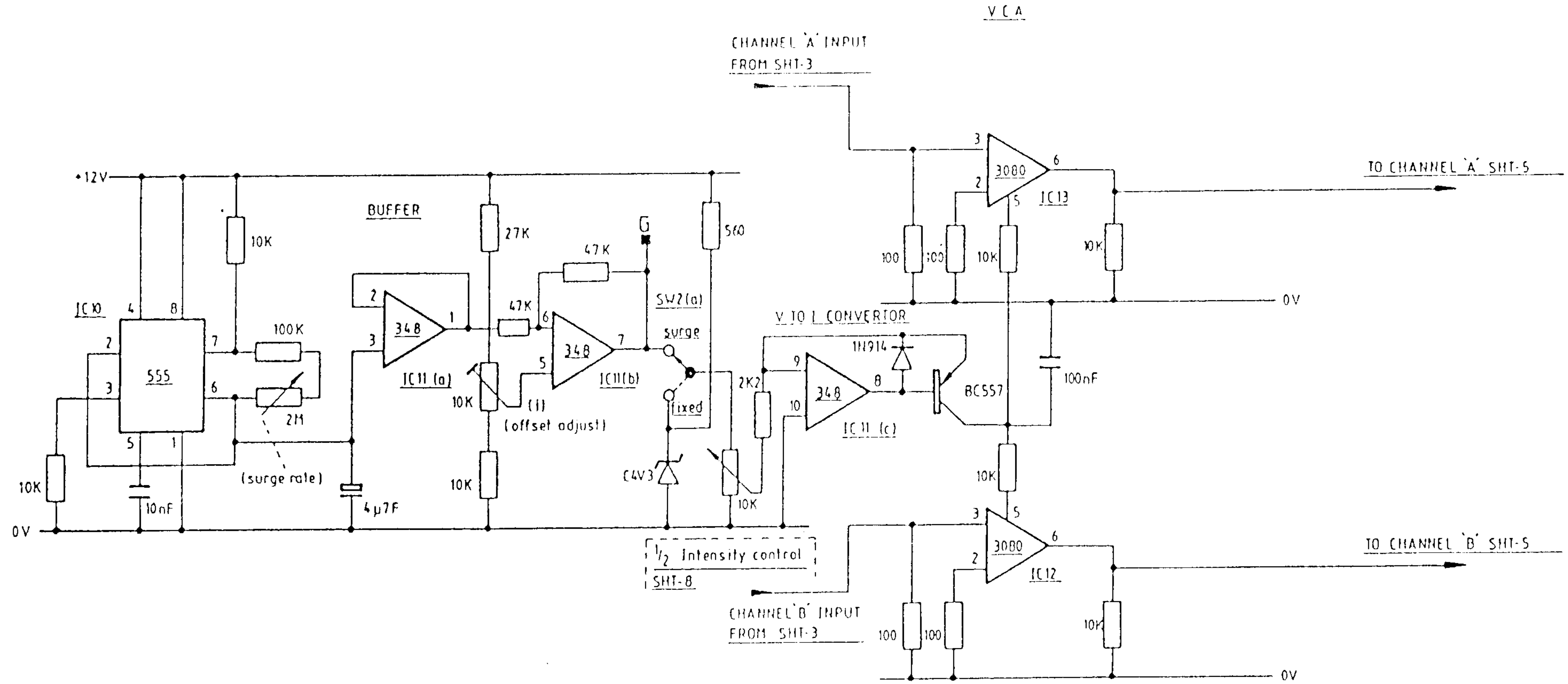
Step	Test Point	CRO Setting V/div	CRO Setting Time/Div	Procedure
0	-	-	-	* Set all trimpots to mid-position * Switch power on
1	A	5V	0.5 s	* Connect 100 kΩ resistor in parallel with 1 MΩ (IC1) * Adjust 'a' for (negative) sweep to zero volts * Remove 100 kΩ resistor
2	D	5 V	0.5 s	* Set selector to 'variable' position * Set base & sweep controls to minimum * Adjust 'g' for frequency of 2 Hz on CRO display
3	-	-	-	* Set base control to maximum * Adjust 'f' for frequency display of 150 Hz * Repeat step 2 if necessary
4	-	-	-	Set selector to 0-150 Hz & adjust 'b' for sweep to 150 Hz (max)
5	-	-	-	Set selector to 0-15 Hz & adjust 'd' for sweep to 15 Hz (max)
6	-	-	-	* Set selector to 80-120 Hz * Adjust 'e' for sweep to 80 Hz (min) * Adjust 'c' for sweep to 120 Hz (max)
7	-	-	-	* Set selector to 'variable' * Set sweep control to minimum * Set base control for a frequency display of 90 Hz & reposition knob/pointer if necessary

Step	Test Point	CRO Setting V/div	CRO Setting Time/Div	Procedure
8	-	-	-	* Set base control to minimum * Set sweep control to 90 Hz * Check sweep & reposition knob/pointer if necessary
9	B	5 V	50 µs	* Set carrier switch to 4 kHz * Check that period = 250 µs ± 10% * If > 10% high add 100 pF in parallel with 1 nF IC9(a) * Check that 2 kHz, 10 kHz frequencies are within 10% tolerance
10	Outputs	10 V dual	5 ms	* Connect 470 ohm 5W dummy loads * Set surge switch to 'off' position * Set balance control to mid position * Set 2/4 pole switch to '4 pole' * Switch timer on * Adjust intensity for ± 1.9 divisions signal (channel A) on CRO * Adjust 'x' for 40 mA meter reading * Adjust 'h' for ±1.9 divisions signal from channel B. (Note ±1.9 divisions is to centre of modulation on this (vectored) channel) * Adjust 'y' for 40 mA meter reading
11	-	-	-	* Set frequency to 60 Hz (fixed) * Set 2/4 pole switch to '2 pole' * Adjust 'j' for equal meter readings
12	-	-	-	* Set surge switch to 'on' position * Set surging control to mid position * Adjust 'i' for surging to peak intensity equal to intensity when surge switched off
13	-	-	-	Check operation of timer, SCR protection and all controls, switches and indicators.


METRONEX MEDICAL AUSTRALIA PTY. LTD.
INTERFERENTIAL UNIT
SWEEP CONTROL CIRCUIT
CHECKED
APPROVED
DRAWN TG 20 07 87
ISSUE A
DRAWING No I / F - 003
SHEET 1 . 13
5/6/89
Effective Serial Number 24 30 on.
Sweep Width Trimpot & Res. Changed (1(b) & 3K3)
DATE
REVISION
DRAWN
SWEEP RANGE SELECT
SWEEP RANGE
TO VCO SHT 2
0V
+12V
555
IC1
IC 2(a)
IC 2(b)
IC 2(c)
IC 2(d)
348
1N914
Sweep Width (b)
Offset Zero
Set 40Hz
Set 15Hz
0 - 150
80 - 120
0 - 15
var
© 1987 EXCELL BIOMEDICAL Pty Ltd


METRONEX MEDICAL AUSTRALIA PTY. LTD.
INTERFERENTIAL UNIT
MASTER OSC. / PHASE SHIFT CCT.
CHECKED
APPROVED
DRAWN IG 22 07 87
ISSUE A
DRAWING No I / F - 003
SHEET 2 13
30/9/85 Fin10 IC4 Resistor changed. 100K to 68K
DATE REVISION DRAWN
© 1987 EXCELL BIOMEDICAL Pty Ltd
CARRIER FREQUENCY
BASE FREQUENCY
SWEEP RANGE SELECT
TO FREQ METER (SHT. 6)
TO SHT 9
FROM SHT 1 VCO in
B TO SHT 3
A TO SHT 3
* POLYESTER GREENCAP
+12V
0V
IC 9(a)
556
IC 6(a)
IC 6(b)
IC 6(c)
IC 6(d)
IC 7(a)
IC 7(b)
4011
IC 3(a)
348
IC 4
4046
IC 5
4027
Set f max 50K (f)
Set f min 2K (g)
Set 80Hz 10K (e)
IN 914
0-150
80-120
0-15
var
2KHz
4KHz
10KHz
330K
82K
1K
10nF
1nF
47K
4K7
10M
68K
10K
22nF

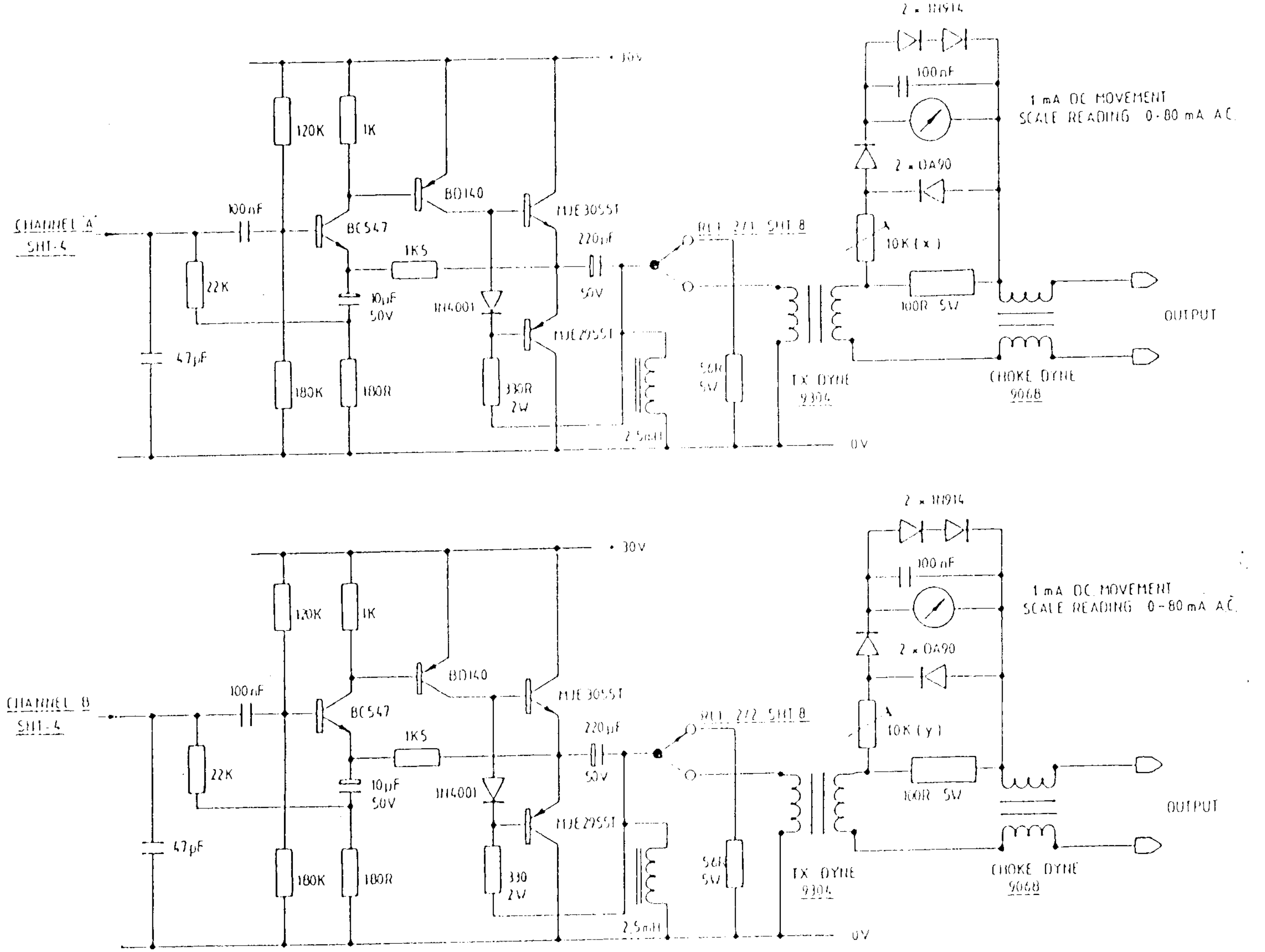

METRONEX MEDICAL AUSTRALIA PTY. LTD.
INTERFERENTIAL UNIT
VECTOR AND BALANCE CCT
CHECKED
APPROVED
DRAWN
TG
21 07 87
ISSUE
A
DRAWING No
I / F - 003
SHEET
3
13
DATE
REVISION
© 1987 EXCELL BIOMEDICAL Pty Ltd
B
TO SHT 4
A
TO SHT 4
BALANCE
10K
0V
BC 557
IN914
2/4 POLE SWITCH
BALANCE PRESET
(j)
50K
(h)
GAIN ADJUST (ch A)
IC3(d)
348
IC3(b)
IC3(c)
IC8
3080
556
IC9(b)
22K
390
220nF
10nF
180
10µF
1µF
+12V
E
F
B
FROM SHT 2
A
FROM SHT 2



METRONEX MEDICAL AUSTRALIA PTY. LTD.

CHECKED	INTERFERENTIAL UNIT SURGING CCT.			
APPROVED	DRAWN M IVERSEN 21-2-83	ISSUE A	DRAWING No I/F-003	SHEET 4 OF 13

7/87	CCT UPDATE - NOW VECTOR SURGE III	I G
10/85	CCT. UPDATE - NOW VECTOR SURGE II DRG I/F-003	M IVERSEN
10/83	REDRAWN - DRG No CHANGED FROM I/F-CC1 TO I/F-CC2	M IVERSEN
DATE	REVISION	DRAWN



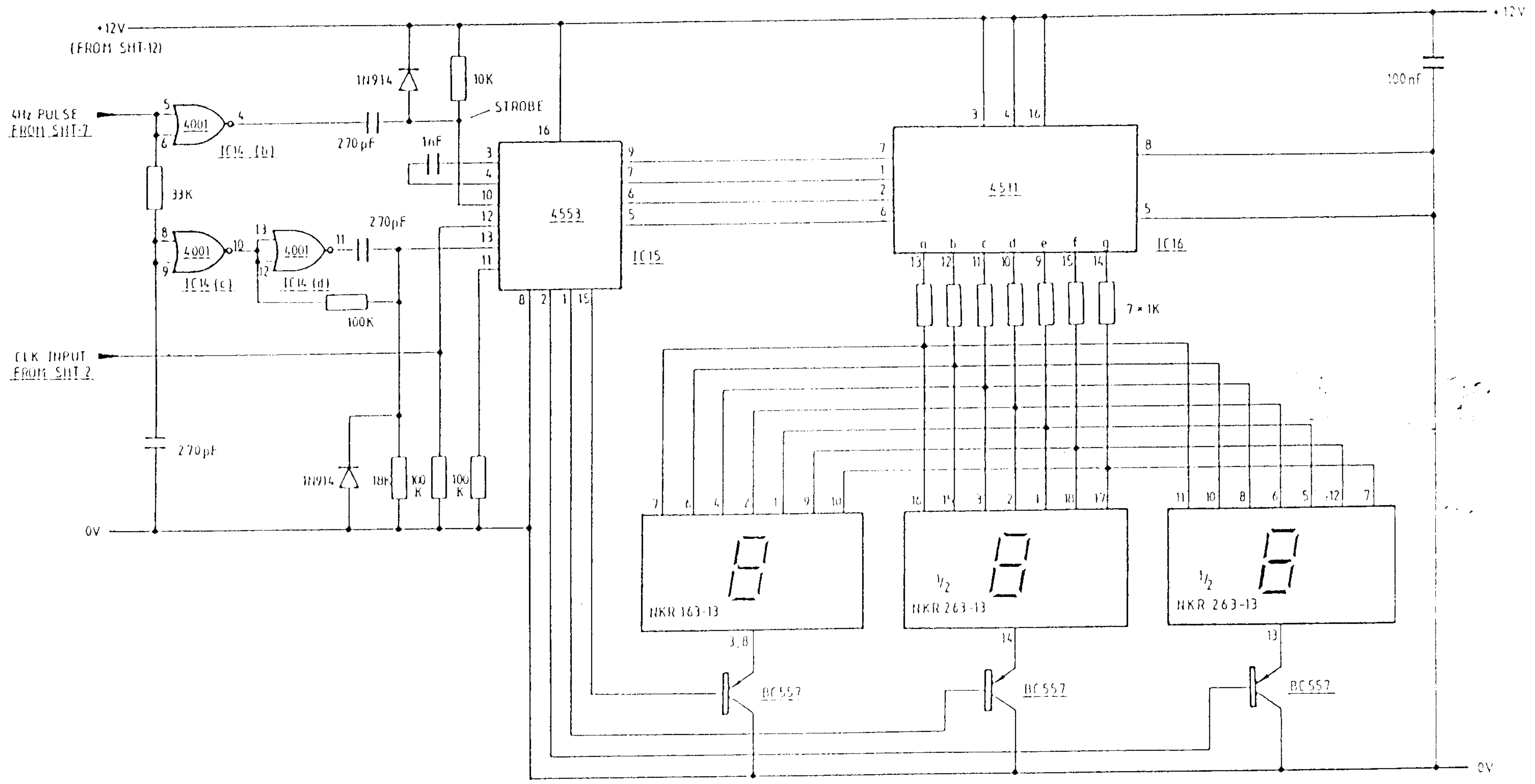
METROHEX MEDICAL AUSTRALIA PTY. LTD.

INTERFERENTIAL UNIT

— POWER AMPLIFIERS AND OUTPUT CIRCUIT —

CHECKED	DRAWN	ISSUE	DRAWING No	SHEET
APPROVED	H. IVERSEN 22-10-85	A	I/F-003	5 OF 13

7/87	CCT UPDATE - NOW VECTOR SURGE 1B	1G
5/86	10K Trimpots replacing 50K types (x,y) 1 mA FSD Meters replacing 200uA types	A
DATE	REVISION	DRAWN



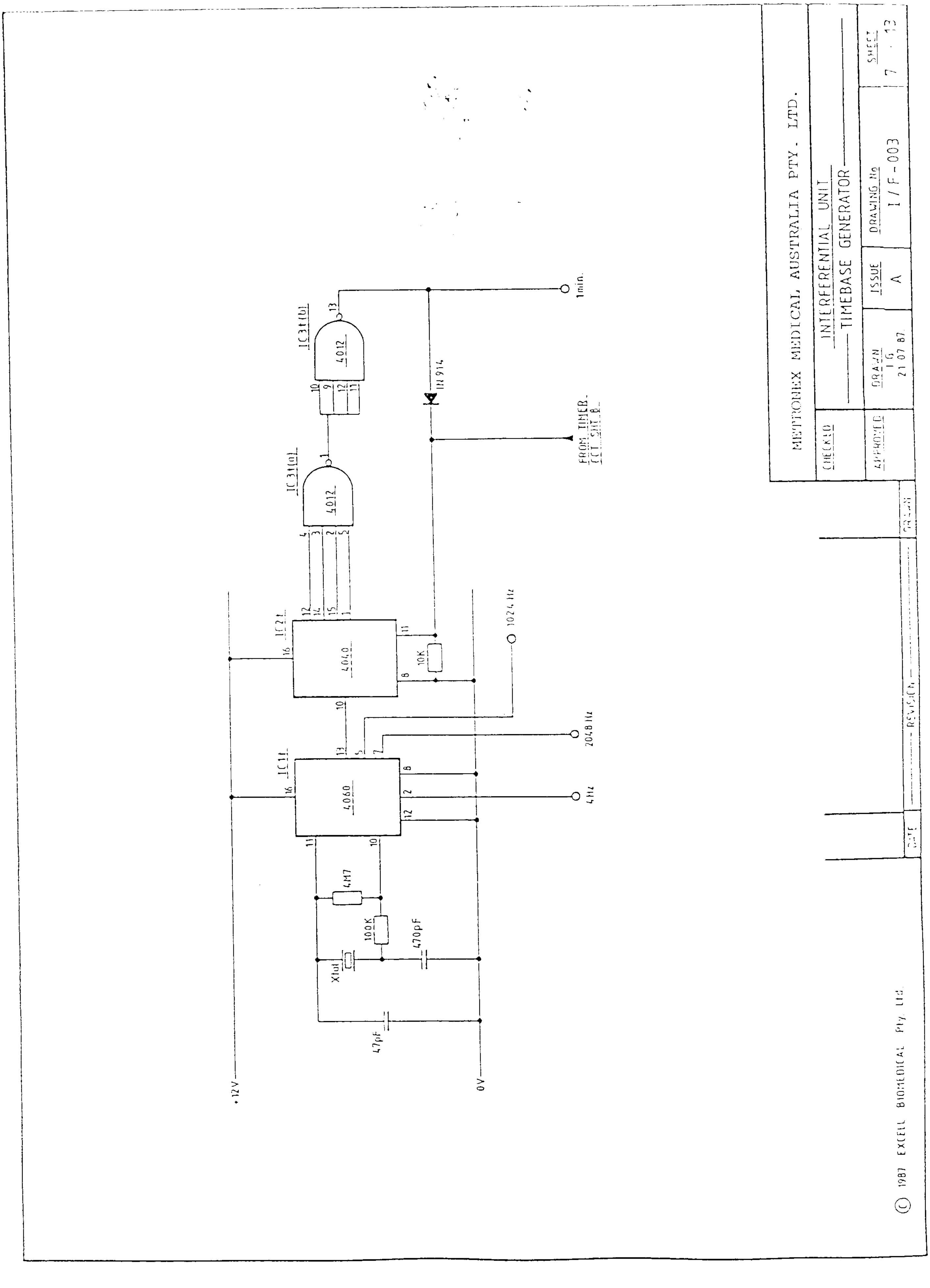
METRONEX MEDICAL AUSTRALIA PTY. LTD.

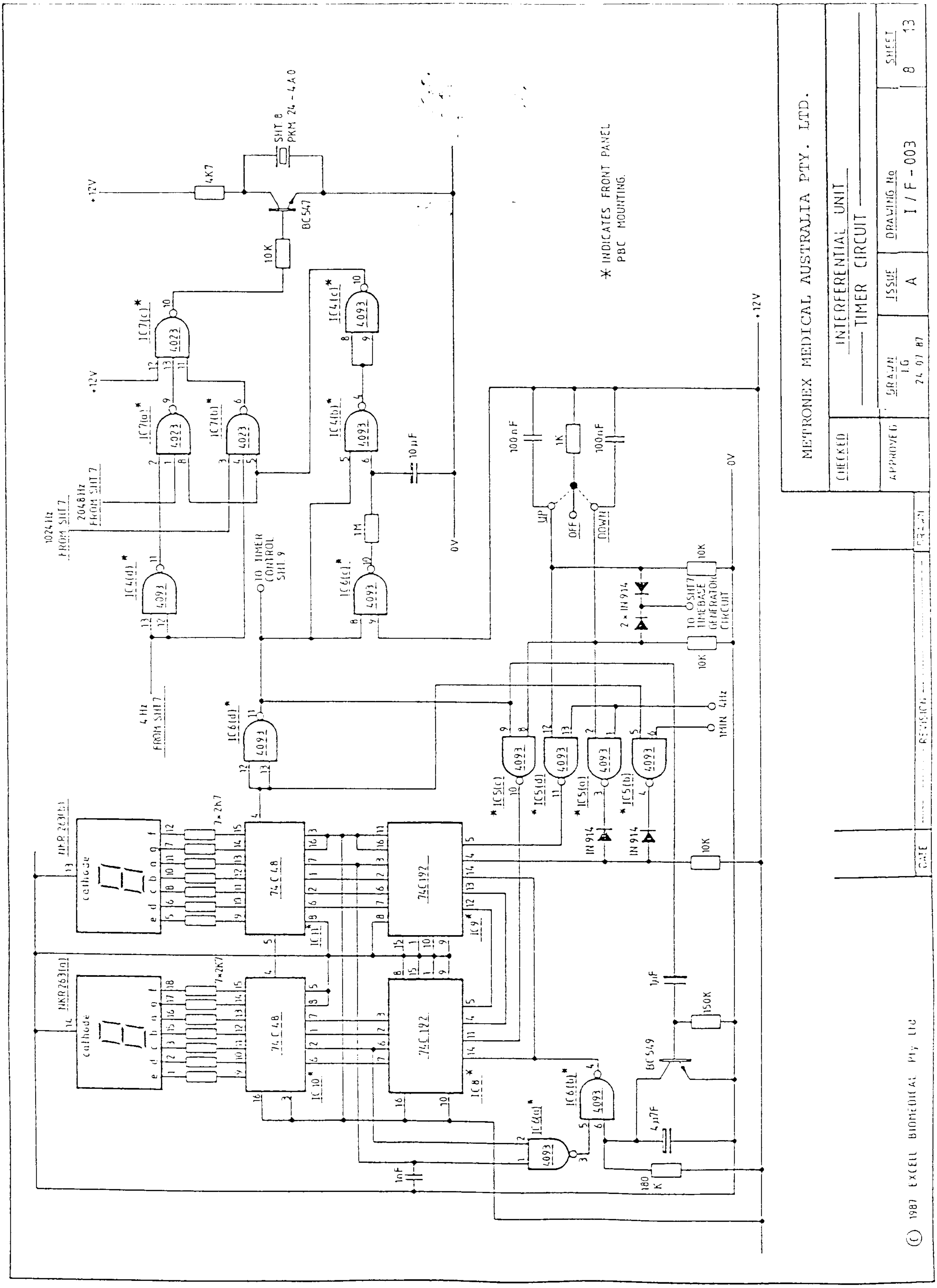
INTERFERENTIAL UNIT

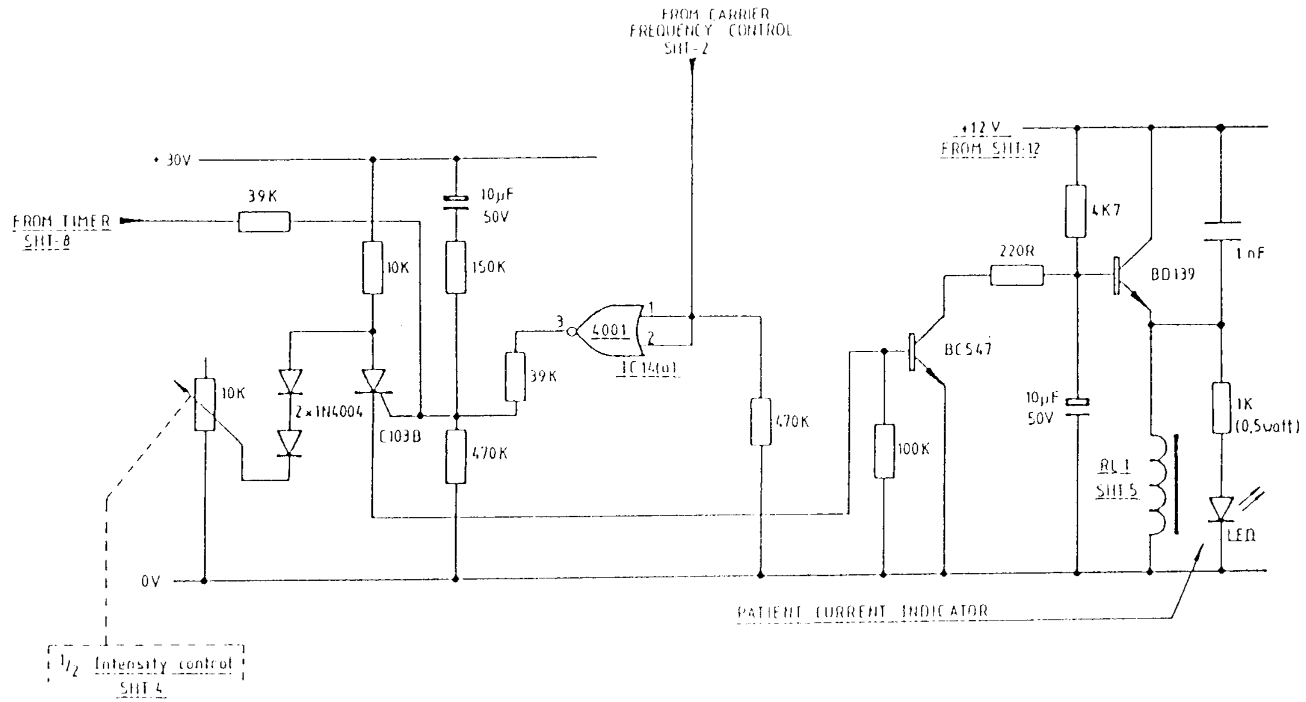
BEAT FREQUENCY INDICATOR CIRCUIT

CHECKED				
APPROVED	DRAWN M IVERSEN 21-2-83	ISSUE A	DRAWING No I/F-003	SHEET 6 OF 13

DATE	REVISION	
7/87	CCT UPDATE - NOW VECTOR SURGE III	I.G.
10/85	CCT UPDATE NOW VECTOR SURGE II DRG I/F-003	M IVERSEN
10/83	REDRAWN - DRG No CHANGED FROM I/F 001 TO I/F-002	M IVERSEN


METROTEX MEDICAL AUSTRALIA PTY. LTD.
INTERFERENTIAL UNIT
TIMEBASE GENERATOR
CHECKED
APPROVED
DRAWN
I G
21 07 87
ISSUE
A
DRAWING No
I / F - 003
SHEET
7 13
DATE
REVISION
DRAWN
IC 3 1 (b)
4012
IC 3 1 (a)
4012
IC 2 1
4040
IC 1 1
4060
1N 914
FROM TIMER
CCT SHT B
1 min.
1024 Hz
2048 Hz
4 Hz
10K
4M7
100K
470pF
Xtal
47pF
+12V
0V
© 1987 EXCELL BIOMEDICAL Pty Ltd


METRONEX MEDICAL AUSTRALIA PTY. LTD.
INTERFERENTIAL UNIT
TIMER CIRCUIT
DRAWING No I/F-003
ISSUE A
SHEET 8 13
DRAWN I.G. 24.07.87
CHECKED
APPROVED
DATE
REVISION
* INDICATES FRONT PANEL PBC MOUNTING.
© 1987 EXCELL BIOMEDICAL Pty Ltd
+12V
0V
4K7
10K
BC547
SHT 8 PKM 24-4A0
IC7(a)* 4023
IC7(b)* 4023
IC7(c)* 4023
IC4(a)* 4093
IC4(b)* 4093
IC4(c)* 4093
IC4(d)* 4093
IC6(a)* 4093
IC6(b)* 4093
IC6(c)* 4093
IC6(d)* 4093
IC5(a) 4093
IC5(b) 4093
IC5(c) 4093
IC5(d) 4093
1024Hz FROM SHT 7
2048Hz FROM SHT 7
4Hz FROM SHT 7
TO TIMER CONTROL SHT 9
TO SHT 7 TIMEBASE GENERATOR CIRCUIT
1M
10µF
100nF
1K
UP
OFF
DOWN
2×1N914
1N914
1MIN
4Hz
150K
1µF
BC549
4.7µF
180K
1nF
HKR 263(a)
HKR 263(b)
cathode
7×2K7
74C48
74C192
IC10*
IC11*
IC8*
IC9*



METRONEX MEDICAL AUSTRALIA PTY. LTD.

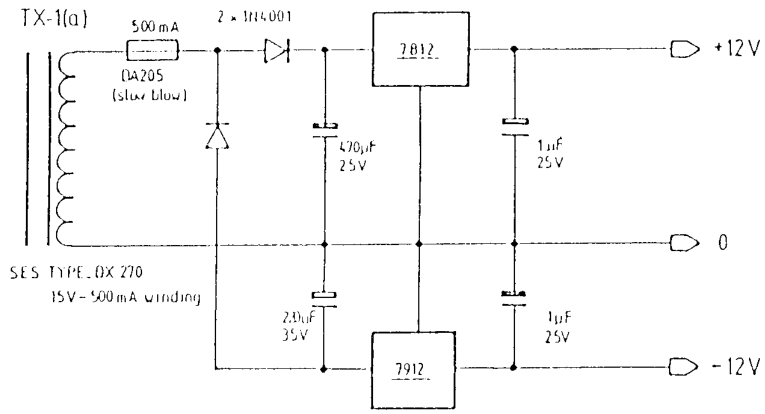
7/87	CCT UPDATE - NOW VECTOR SURGE III	I.G.
5/86	1 nF added, 4K7 replacing 12 K in relay cct. Relay cct supply changed to +12 V	
10/85	CCT UPDATE NOW VECTOR SURGE II. DRG I/F 003	M IVERSEN
10/83	REDRAWN. DRG No CHANGED FROM I/F.001 TO I/F.002	M IVERSEN
DATE	REVISION	DRAWN

CHECKED

INTERFERENTIAL UNIT

OUTPUT CONTROL CIRCUIT

APPROVED	DRAWN	ISSUE	DRAWING No	SHEET
	M IVERSEN 21-2-83	A	I/F - 003	9 OF 13



SUPPLY CONNECTIONS

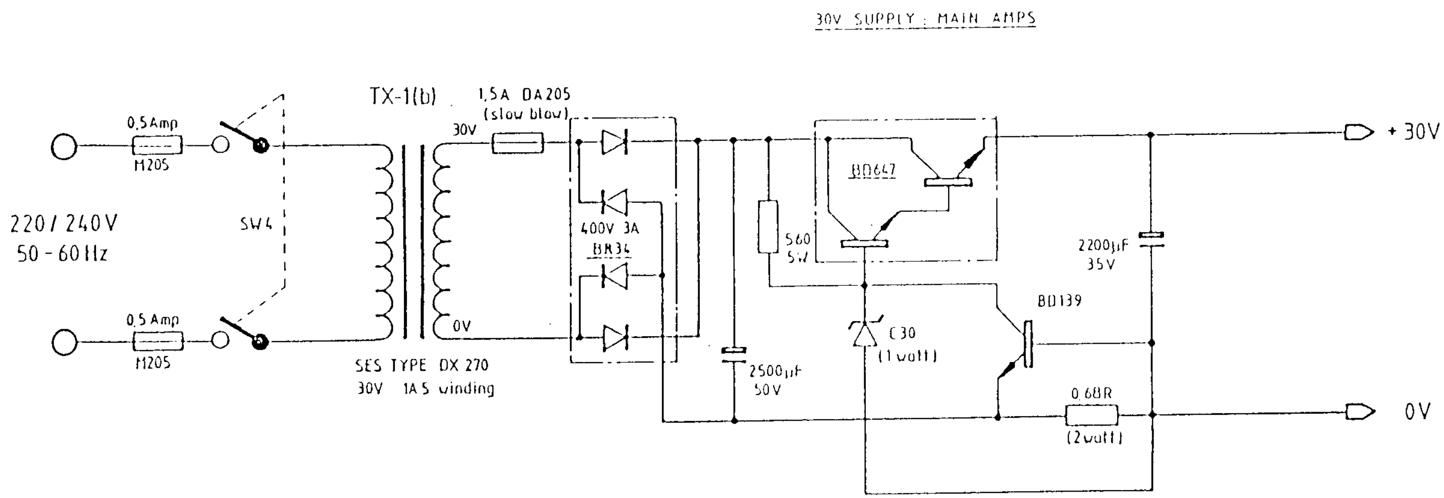
+12V to pin 4 LM348, pin 7, CA 3080
-12V to pin 11 LM348, pin 4, CA 3080

DATE	REVISION	DRAWN
7/87	CCT UPDATE - NOW VECTOR SURGE II	I.G
10/85	CCT UPDATE NOW VECTOR SURGE II DRG I/F-003	M IVERSEN
10/83	REDRAWN - DRG No CHANGED FROM I/F CCT TO I/F-002	M IVERSEN

METRONEX MEDICAL AUSTRALIA PTY. LTD.

INTERFERENTIAL UNIT
- POWER SUPPLY - FOR SHTS 1-4

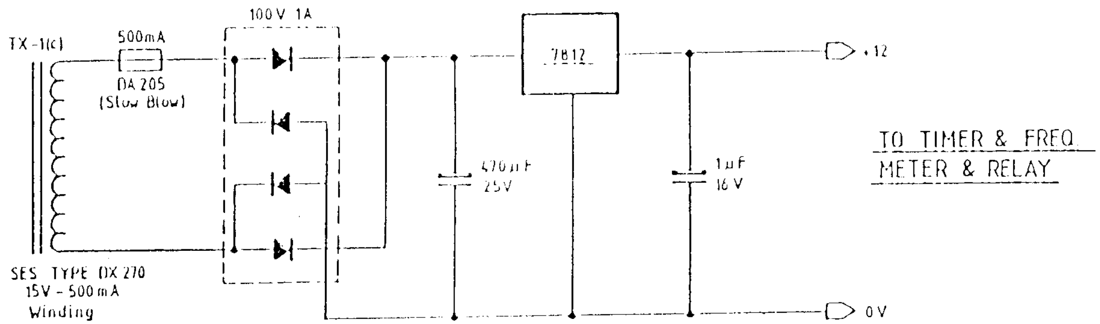
CHECKED	APPROVED	DRAWN	ISSUE	DRAWING No	SHEET
		M IVERSEN 21-2-83	A	I/F-003	10 OF 13



7 / 87	CCT UPDATE NOW VECTORSURGE III	I G
4 / 86	1R2 1W & 15V Tap to sht 8 Deleted	A R WARD
2 / 86	1R2 1W ADDED IN SERIES WITH 15V CT OF TX	A R WARD
10 / 85	CCT UPDATE. NOW VECTOR SURGE II. DRG I/F-003	M IVERSEN
10 / 83	REDRAWN DRG No CHANGED FROM I/F-001 TO I/F-002	M IVERSEN
DATE	REVISION	DRAWN

METRONEX MEDICAL AUSTRALIA PTY. LTD.

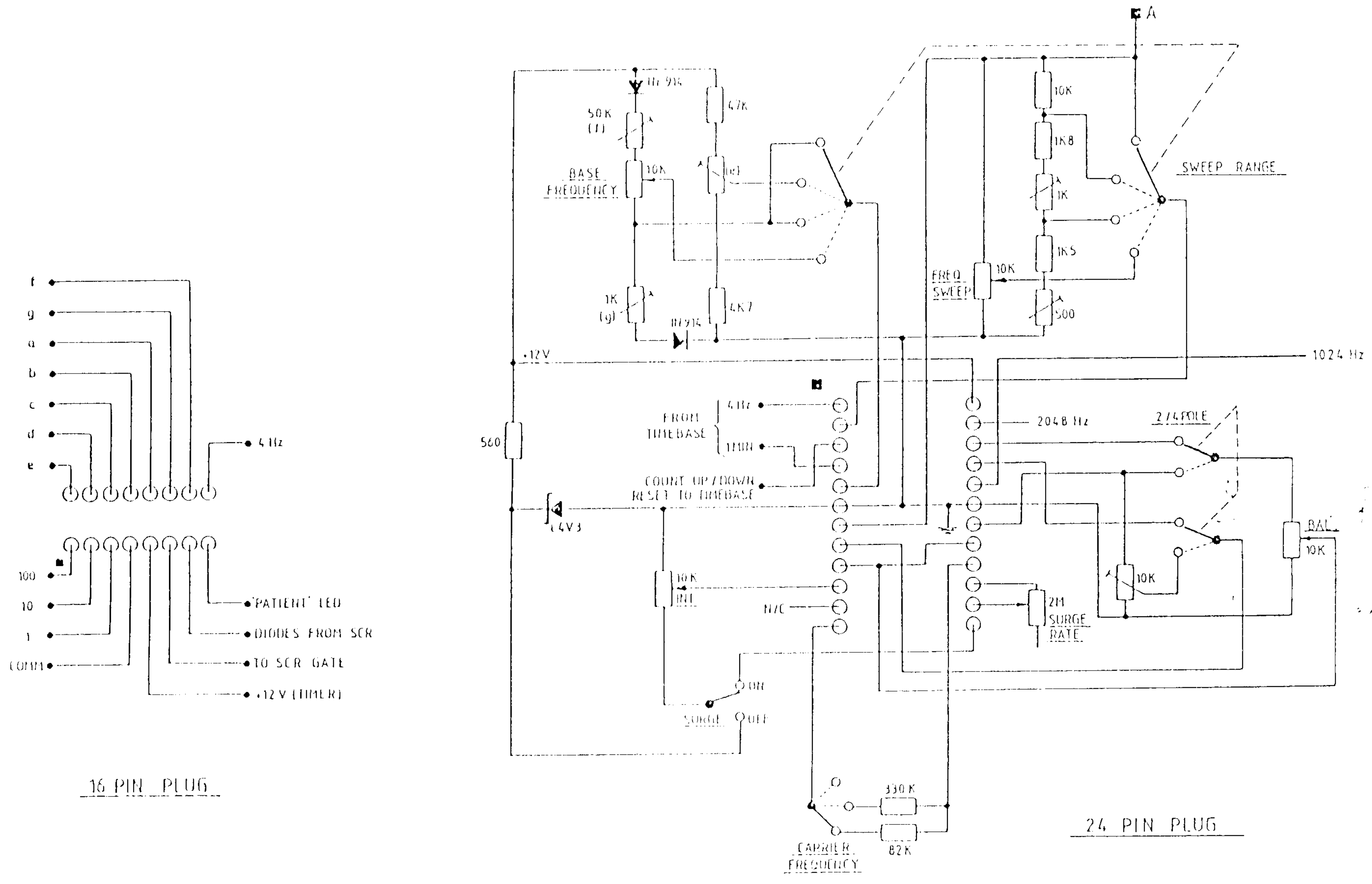
CHECKED	INTERFERENTIAL UNIT — POWER SUPPLY FOR SHEET 5			
APPROVED	DRAWN M IVERSEN. 21-2-83	ISSUE A	DRAWING No I / F-003	SHEET 11 OF 13



METRONEX ENGINEERING Pty. Ltd.

CHECKED	INTERFERENTIAL UNIT POWER SUPPLY FOR SHEETS 6,7,9 & 10		
APPROVED	DRAWN T.G. 21 07 87	ISSUE A	DRAWING No I/F-003	SHEET 12 · 13

DATE	REVISION	DRAWN



METRONEX MEDICAL AUSTRALIA PTY. LTD.

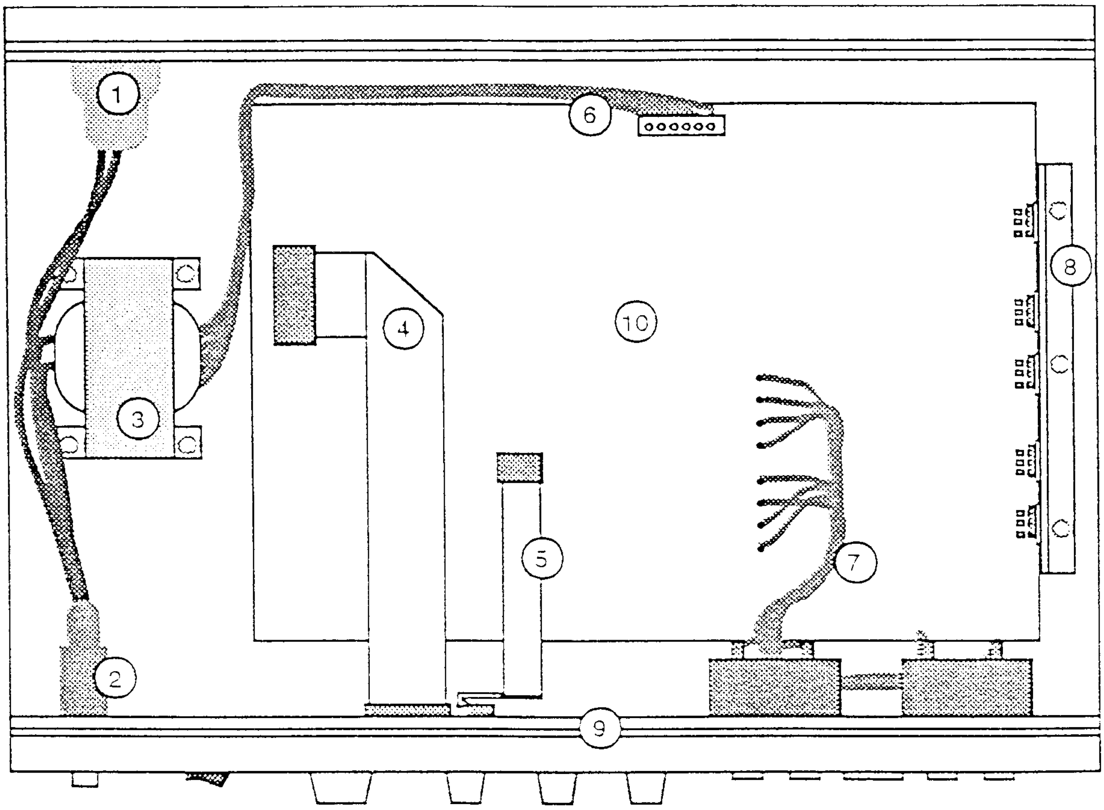
CHECKED	INTERFERENTIAL UNIT PLUG CONNECTIONS			
APPROVED	DRAWN TG 23/07/87	ISSUE A	DRAWING No I/F - 003	SHEET 13 13

DATE | REVISION | DRAWN

Vectorsurge III

INTERNAL LAYOUT

View from above (top cover panel removed)



1 - Power inlet and fuses
2 - Power on/off switch
3 - Power transformer
4 - Connector (1) - main P.C. board to front panel P.C.B.
5 - Connector (2) - main P.C. board to front panel P.C.B.
6 - Low voltage supply to main P.C. board
7 - Output and current meter connections
8 - Regulator and output transistors and main heatsink
9 - Front panel P.C.B. (vertical)
10 - Main P.C.B.

PRODUCT - VECTORSURGE 3

ASSEMBLY - MAIN PCB. No: XLB-187 (10)

PART DESCRIPTION			QTY
RESISTORS	.25 Watt 5% or less.	10K	23
		100K	6
		4M7	1
		2K2	2
		33K	1
		10M	1
		68K	1
		1M	1
		15K	1
		4K7	2
		6K8	1
		22K	6
		180R	4
		390R	1
		100R	4
		1K	3
		220R	1
		39K	2
		18K	1
		47K	2
		27K	1
		330K	1
		470K	1
		150K	1
		120K	2
		180K	2
		1K5	2
RESISTOR	.5 Watt 5% or less	1K	1
RESISTOR NETWORK	D.I.L. .25 Watt	1K5	1
RESISTORS	5 Watt 10%	560R	1
		100R	2
		56R	2
		R56	1
		330R	2
DIODES	SILICONE SIGNAL TYPE	IN914	10
	SILICONE 400V, 1A	IN4004	6
	GERMANIUM SIGNAL	OA90	4
	ZENER 30V, 1A	IN5936	1
I.C. SOCKETS	D.I.L.	24 PIN	1
I.C. SOCKETS	D.I.L.	16 PIN	1

PRODUCT - VECTORSURGE 3

ASSEMBLY - MAIN PCB. No. XLB-187 (10)

PARTS DESCRIPTION				QTY
INTEGRATED CIRCUITS			4511	1
			556	1
			3080	3
			4553	1
			4011	2
			4027	1
			4012	1
			4040	1
			4060	1
			555	2
		PHILIPS	4046	1
			4001	1
			LM348	3
POTENTIOMETER	CERMET TRIM HDKV		2K	1
			10K	4
			50K	1
CAPACITOR	CERAMIC 50V		47pf	3
	MONOLITHIC 50V		.22M	1
	MONOLITHIC 50V		.1M	9
	CERAMIC 50V		270pf	3
	CERAMIC 50V		470pf	1
	CERAMIC 50V		.001M	2
	CERAMIC 50V		.01M	4
CAPACITOR	TANTALUM 35V		1MFD	5
	16V		47MFD	1
	35V		4.7MFD	1
	35V		10MFD	1
CAPACITOR	ELECTROLYTIC 35V RB		10MFD	4
	50V RB		220MFD	2
	35V RB		220MFD	1
	35V RB		2,200MFD	1
	35V RB		470MFD	2
CAPACITOR	GREENCAP 100V/50V		.001MFD	1
			.022MFD	1

PRODUCT - VECTORSURGE 3

ASSEMBLY - MAIN PCB. No.XLB-187 (10)

PARTS DESCRIPTION			QTY
TRANSISTOR		BC547	3
		BC557	5
		BD139	2
		BD140	2
		MJE2955	2
		MJE3055	2
TRANSISTOR	DARLINGTON PHILIPS	BDX53C or BD649	1
VOLATAGE REGULATOR	TO220	7812	2
		7912	1
CRYSTAL	32.896KHz	FOX NC-388	1
RELAY	12 VOLT	M4	1
BRIDGE RECTIFIER	3A, 400V	BR34	1
	1.5A, 400V	RB154	1
FUSE HOLDER		TYPE PFT 15	3
FUSE	DA205	500mA	2
	DA205	1.5A	1
CHOKE	DYNE	9068	2
	2.5mH	C4	2
TERMINAL BLOCK		3 WAY	2
HEATSINK		6073B	2
TRANSFORMER	OUTPUT DYNE	9304	2

PRODUCT - VECTORSURGE 3

ASSEMBLY - FRONT PCB. No. XLB-287 (9)

PART DESCRIPTION			QTY
RESISTORS	.25 Watt 5% or less	1K	2
		1K5	1
		1M	1
		2K7	2
		10K	5
		47K	1
		82K	1
		100K	1
		150K	1
		180K	1
		330K	1
RESISTOR	NETWORK D.I.L. .25 Watt	2K7	2
DIODE	SILICONE SIGNAL TYPE	IN914	6
DIODE	ZENER 4.3V. 400mW	IN749	1
CAPACITOR	TANTALUM 35V	1MFD	2
		10MFD	1
		4.7MFD	1
CAPACITOR	MONOLITHIC 50V	.1MFD	3
CAPACITOR	CERAMIC 50V	.001MFD	1
TRANSISTOR		BC547	1
		BC549	1
I.C. SOCKET		14 PIN	4
		16 PIN	5
		24 PIN	1
POTENTIOMETER	CERMET TRIM HDKV	500R	1
		1K	1
		2K	1
		10K	2
BUZZER	PIEZO	PKM22EPP4001	1

PRODUCT - VECTORSURGE 3

ASSEMBLY - FRONT PCB.No. XLB-287 (9)

PART DESCRIPTION			QTY
SWITCH	C & K	7101	1
		7201	1
		7411	1
		7105	1
SWITCH	ROTARY 3 POLE 4 POSITION	1046	1
DISPLAY	DUAL	NKR-263 or C562SR	2
	SINGLE	NKR-163 or C561SR	1
DISPLAY	L.E.D. GREEN	LTL4233	1
INTEGRATED CIRCUIT		74C48	2
		40192	2
		4023	1
		4093	3
POTENTIOMETER	LINEAR V.C.U.	10K	3
		2M	1
POTENTIOMETER	LINEAR DUAL GANG V.G.U.	10K	1
PANEL METER	TD66-251	0-1mA	2
PANEL METER SPACERS		3.5mm	4

PRODUCT - VECTORSURGE 3

ASSEMBLY - BASE PANEL

PART DESCRIPTION			QTY
BASE PANEL	PAINTED BLUE		1
CABINET FEET		3265-00-00	4
MAINS TRANSFORMER		DX-270	1
SOLDER LUG	UTILUX	H256	1
HEATSINK		MIFHEATSINK	1
SPACER	8 x 13 x 4.4mm	SP8134	7
TRANSISTOR BUSH PLASTIC		TRANSBUSH	5
SILICONE TRANSISTOR PAD	TO-220		5

PRODUCT - VECTORSURGE 3

ASSEMBLY - OUTER CASE

PART DESCRIPTION				QTY
BACK PANEL				1
MAINS INLET	SOCKET			1
	DRAW			1
	COVER			1
SOLDER LUG			H256	1
SIDE PANEL				2
LID				1
ALUMINIUM EXTRUSION		FRONT TOP		1
		FRONT BOTTOM		1
		REAR		2

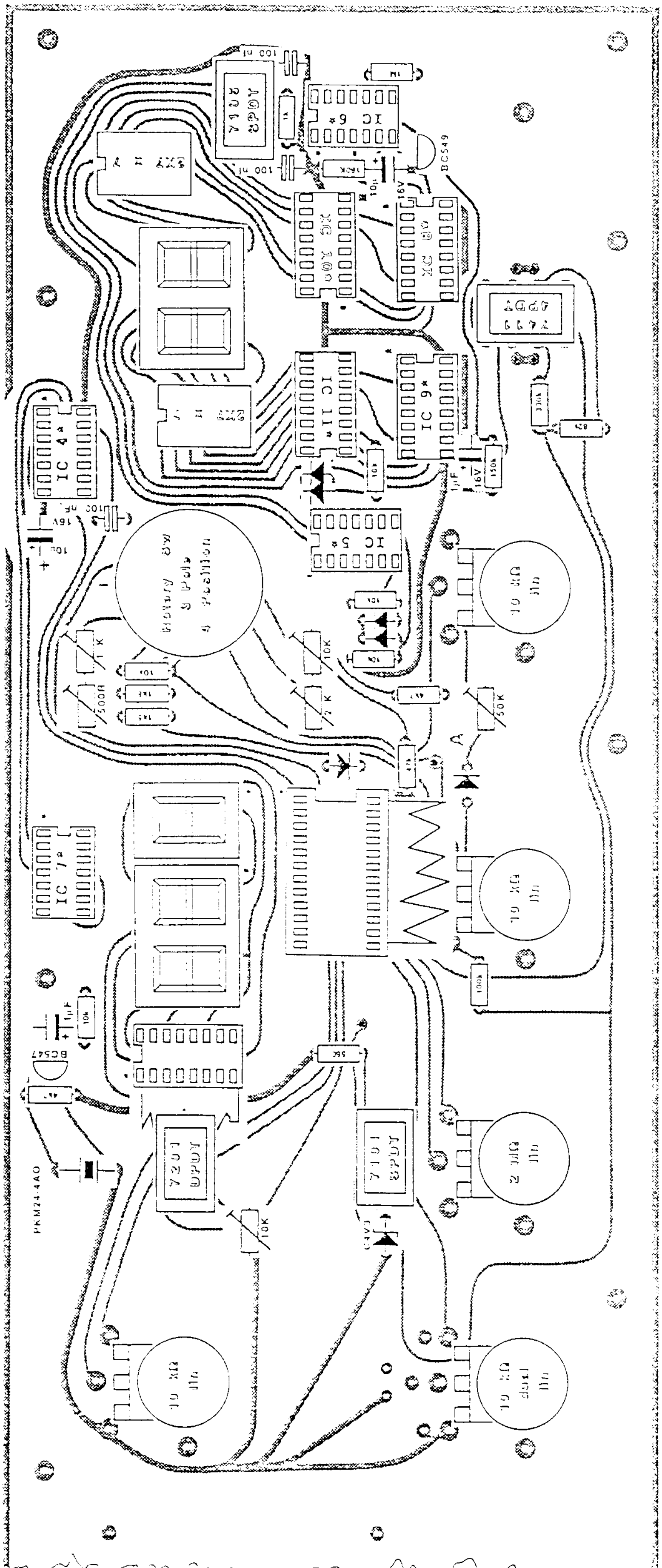
PRODUCT - VECTORSURGE 3

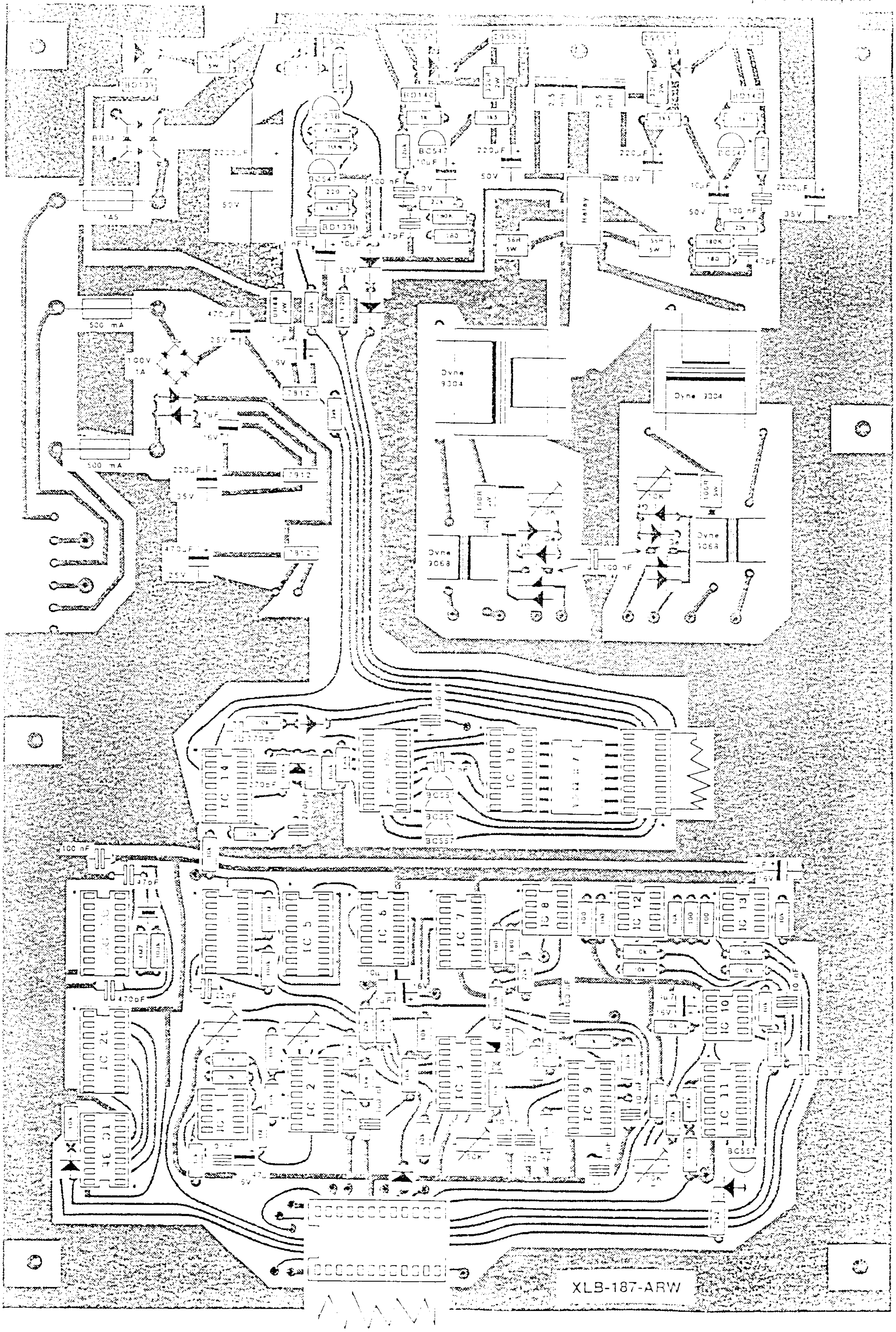
ASSEMBLY - FRONT PANEL

PART DESCRIPTION				QTY
FRONT PANEL				1
SWITCH BEZEL	BLACK		4527	4
FILTER	RED		40 x 40 x 3	1
			60 x 40 x 3	1
CLIPLITE	GREEN		CLF280G	1
SOCKET	4 PIN		L1904	1
BLUE	SOCKET		S446	2
BLACK	SOCKET		S446	2
MAINS	SWITCH		ZFA NE18	1
	BEZEL		ZFA NE15	1
	BUTTON /	WHITE	ZFA NE15	1
	BUSH	BOTTOM	ZFA NE15	1
	BUSH	TOP	ZFA NE15	1
	NUT		ZFA NE15	1
	SPRING WASHER		ZFA NE15	1
SPACERS	PLASTIC		8 x 5 x 4	10
KNOB	GREY	21mm		5
POINTER	GREY	21mm		5
COVER	BLUE	21mm		5
KNOB	GREY	29mm		1
POINTER	GREY	29mm		1
COVER	BLUE	29mm		1

Front P.C. board : Components Layout

XLB-287-ARW




XLB-187-ARW
Dyne 9304
Dyne 9068
Relay
IC 14
IC 16
IC 5
IC 6
IC 7
IC 8
IC 12
IC 13
IC 10
IC 11
IC 9
IC 3
IC 2
IC 1
BC557
BC547
BD139
1A5
500 mA
2200µF
7912
50V
35V
100 nF
470pF
47pF