ENTERING SERVICE MODE ON

DATEX CARDIOCAP 11

Allow Unit to carry out startup Sequence.

Press Buttons **1, 2, 3, 4** then press and hold **Return to Monitor** button.

When **"S"** appears to top Left corner of screen, Press button **4**

Select preference then press **Return to Monitor** button.

To Adjust Date, Time

Press and hold Mark/Reset button and turn unit on

CARDIOCAP™ II
CG-SERIES

SERVICE MANUAL

All specifications subject to change without notice

Manual No. 879040

November 15th, 1990

Datex/Division of Instrumentarium Corp.
P.O.Box 446 SF-00101 Helsinki Finland
Tel. +358 0 39411 Fax +358 0 1463310 Telex 126252 datex sf

List of Figures .... PAGE

List of Tables .... PAGE

2 WARNINGS AND CAUTIONS

WARNINGS

A WARNING indicates that there is a possibility of injury to yourself or others.

PROPER GROUNDING: For protection against shock hazards:

a) Connect this monitor to a three-wire, grounded, hospital grade receptacle.

b) The power cord and plug must be intact and undamaged.

Do not remove the grounding prong from the power plug. Do not use extension cords or adapters of any type.

Replace the power cord if it becomes cracked, frayed, broken or otherwise damaged.

c) Confirm that AC-operated equipment used with the monitor is properly grounded.

d) Do not perform any testing or maintenance on medical instruments while they are being used to monitor a patient.

e) Do not break or bypass the patient isolation barrier when testing ECG, Invasive-Pleth-Temp, or SpO_2 measuring boards.

Use only defibrillation protected invasive pressure sensors on DATEX monitors.

EXPLOSION HAZARD: Do not use this monitor in the presence of flammable anesthetics.

FUSE REPLACEMENT: Replace the fuse with a fuse of the same type and with the same rating.

PATIENT SAFETY: Do not modify patient cables.

Use only patient cables and accessories approved by DATEX. Other cables and accessories may damage the monitor or interfere with measurement.

ELECTRIC SHOCK HAZARDS:

a) High Voltage is present within the CRT display unit.

b) In case of mechanical damage, inspect the integrity of the patient isolation circuits, CRT unit, the power supply transformer and power entry module.

c) Do not immerse the monitor in any liquid.

d) Do not immerse the SpO_2 probe in any liquid.

Do not use a probe that is suspected of being immersed in liquid. It may cause burns during electrosurgery.

e) Switch the power off and unplug the power cord before cleaning or service.

Do not touch any exposed wiring or conductive surface while the cover is off and the monitor is energized. The voltages present when the electric power is connected to the monitor can cause injury or death.

f) Perform a final electrical safety check and current leakage test after doing any repair or calibration procedure to the monitor.

g) The manufacturer accepts no responsibility for any modifications made to the monitor outside the factory.

CAUTIONS

A CAUTION indicates a condition that may lead to equipment damage or malfunction.

a) The tests and repairs described in this manual should only be done by trained personnel with proper tools and test equipment. Unauthorized service may void the monitor warranty.

b) Check the rear panel voltage setting before connecting the monitor to AC mains power outlet.

c) Leave space behind the monitor to allow for proper ventilation.

Clean or replace the fan filter regularly.

d) Before use, allow five minutes for warm-up and note any error messages or deviations from expected operation. See the Operator's Manual.

e) Switch the monitor off before making any connections with external equipment.

f) Do not use ammonia-, phenol-, or acetone-based cleaners. These cleaners may damage the monitor surface.

g) Electrostatic discharge through the PC boards may damage the components.

Before replacing and repairing PC boards, wear a static control wrist strap.

Handle all PC boards by their non-conductive edges and use anti-static containers when transporting them.

h) Connect sample gas outlet on the monitor's rear panel to scavenging system to prevent room air pollution.

The diameter of the scavenging system tubing must be 2 to 3 times larger than that of sample out tubing to avoid changing the operating pressure within the monitor. Inaccurate readings or internal damage may result.

i) The diameter of the calibration gas delivery tube must be 2 to 3 times larger than that of the sampling line to avoid overpressurization of the sensors. Inaccurate calibration or internal damage of the monitor may result.

j) Check the oxygen sensor after servicing the monitor. Breathe into the sampling line and confirm that the O_2 waveform changes after each breath.

k) When removing or inserting any part into the monitor, be careful not to kink or damage the gas sample tubes. Leakages in the gas sampling system will affect accuracy of measurement and are difficult to detect.

l) When servicing the sampling system, make sure not to leave any tubes touching the sampling pump. Abrasion may damage the tubes.

m) Do not apply tension to the power cord.

n) Do not autoclave the monitor nor the probes.

o) Do not gas sterilize the monitor.

3 INTRODUCTION AND APPLICABILITY OF THIS MANUAL

3.1 Introduction and applicability of this manual

This service manual (Doc. No. 879040) and the Panasonic CRT Data Display Model M-K9101NB service manual (available from DATEX, order code 572760) provide information required to maintain and repair the DATEX CARDIOCAP™ II CG-series monitors. This manual is applicable for the current production revision of the monitors. Differences between monitor revisions are summarized in Section 3.2 and the technical details of earlier revisions given in Chapter 11. Section 3.3 lists the technical (hardware) changes made to the monitor and Section 3.4 the software changes.

The revision of a monitor is changed when technical changes are made to the monitor resulting in new spare parts that are incompatible with earlier units. The last two digits of the monitor type designation denote the revision of the monitor (e.g. CG-1GS-23-00 is a revision -00 unit).

Functional units of the monitor (PC boards) will have ID code stickers indicating the modification level of the production documentation. The code is shown as xxxxxx-y, where the "xx..." represents the part number and "y" the revision level, which is referred to when hardware changes are indicated in this manual.

The following list shows the models and their monitoring parameters.

MODEL	MONITORING PARAMETERS
CG-CS	ECG, NIBP, Temp, SpO_2, CO_2
CG-2CS	ECG, NIBP, Temp, SpO_2, 2 x invBP, CO_2
CG-1G	ECG, NIBP, 2 x Temp, invBP, CO_2, O_2, N_2O
CG-2G	ECG, NIBP, Temp, 2 x invBP, CO_2, O_2, N_2O
CG-1GS	ECG, NIBP, 2 x Temp, invBP, SpO_2, CO_2, O_2, N_2O
CG-2GS	ECG, NIBP, Temp, 2 x invBP, SpO_2, CO_2, O_2, N_2O

This manual describes all the functions offered by the CARDIOCAP™ II CG-series monitors. Some of the functions may not be available in the monitor you are using.

Please review the Operator's Manual to obtain a clear understanding of the monitor.

The manufacturer reserves the right to make changes in product specifications at any time and without prior notice. The information in this document is believed to be accurate and reliable; however the manufacturer assumes no responsibility for its use.

3.2 Summary of revision changes

Revision -00

Initial production revision of the monitor.

Revision -01

Production revision 01 of the monitor. The main differences to the revision -00 are:

- Main software

- NIBP software

- SpO_2 software

- NIBP tubing redesigned

- One of the NIBP measurement patient groups, NEONATAL is changed to INFANT. The specification of INFANT is 5 kg or more, one to twelve months old.

Revision -02

Current production revision of the monitor. The main differences to the revision -01 are:

- Main software

- NIBP software (except for Germany)

- SpO_2 software

- High speed main CPU board (p/n 880523) installed to replace the existing board (p/n 878822)

- Enlarged fan airway inlet and larger dust filter

- Power supply board modified

- ECG board modified

- NIBP pneumatic unit modified

3.3 Manual updates

3.3.1 CARDIOCAP™ II CG-series service manual changes

This is update number 2. Carry out the update by making the changes shown under this update number in the list below:

- replace pages which already exist in the manual.

- insert pages which do not exist yet in the manual after the previous entry in numerical or an alphabetical order.

- of all the pages removed from the manual, the following pages should be filed in Chapter 11. All other pages are thrown away.

5-24, 24a, 56...61, 68, 68a, 69, 69a

After having made the changes required, replace Section 3.3.1 of the manual with this one and sign the record of updates in Section 3.3.2.

No.	Page	Change	Date
1	1-5...10	List of Figures changed.	15th May 1991
	3-3	Revision 01 introduced.	
	3-7,8	Revision 01 software described.	
	4-1...6	Typical performance pages revised.	
	4-9	Rise times of CO_2 and O_2 changed.	
	4-13	Note on neonatal NIBP changed.	
	4-17	Figures changed.	
	5-5,5a,6	Gas sampling system changed.	
	5-24a	ECG board changed.	
	5-40	Neonatal is changed to infant.	
	5-41a,42a	NIBP board changed.	
	5-43...45	Neonatal is changed to infant.	
	5-49a,50a	SpO_2 measuring board changed.	
	5-61	Jumper configuration table revised.	
	5-68a,69a	Power supply board changed.	
	6-6	Cuff occlusion message added.	
	6-9	Response time text revised.	
	Section 9	Spare parts list updated.	
		Pneumatic unit illustration revised.	
		Pages in Section 9 renumbered.	
2	3-3	Revision 02 introduced.	20th March 1992
	3-7, 9...11	Text revised. Revision 02 software described.	

4-6	Trends table revised.
4-13...15	Principles of measurement revised.
4-23	Pin order table revised.
5-5...7	Tubing system revised.
5-24,24a	ECG board modified.
5-45	Pediatric cuff renamed to Child.
5-56...61	High speed CPU board introduced.
5-68,69	Power supply board modified.
6-23	CPU board troubleshooting text revised.
6-27,28	Service mode text modified.
7-1	Adjustment table revised.
7-18	R31 corrected to R6 in NIBP board adjustment
7-19	CPU board adjustment text revised.
9-1...5	Spare parts list revised.
9-8	Pneumatic unit parts layout changed.
12-1...5	Appendices pages revised.

3.3.2 Record of manual updates carried out

Update number	Carried out by Name	Date
1	DATEX	15th May 1991
2	DATEX	20th March 1992
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

3.4 Software changes

The software code (six numbers) and revision number (if other than initial revision) are displayed on the screen during the startup sequence.

The initial production software versions are as follows.

ITEM DESCRIPTION		ORDER No.
CPU board		
Software EPROM	(1G, 1GS) (English)	877921
	(1G, 1GS) (German)	877923
	(1G, 1GS) (French)	877922
	(1G, 1GS) (Germany)	877924
	(2G, 2GS) (English)	877666
	(2G, 2GS) (German)	877717
	(2G, 2GS) (French)	877716
	(2G, 2GS) (Germany)	877718
	(CS, 2CS) (English)	878115
	(CS, 2CS) (German)	878116
	(CS, 2CS) (French)	878117
	(CS, 2CS) (Germany)	878118
NIBP board		
NIBP software	EPROM	877039
	EPROM (Germany)	877040
SpO_2 processor board		
SpO_2 software EPROM		874630

The production revision 01 software versions (-01) are as follows.

ITEM DESCRIPTION		ORDER No.
CPU board		
Software EPROM	(1G, 1GS) (English)	879433
	(1G, 1GS) (German)	879434
	(1G, 1GS) (French)	879435
	(1G, 1GS) (Germany)	879436
	(2G, 2GS) (English)	879437
	(2G, 2GS) (German)	879438
	(2G, 2GS) (French)	879439
	(2G, 2GS) (Germany)	879440
	(CS, 2CS) (English)	879441
	(CS, 2CS) (German)	879442
	(CS, 2CS) (French)	879443
	(CS, 2CS) (Germany)	879444
NIBP board		
NIBP software	EPROM	879808
	EPROM (Germany)	879809
SpO_2 processor board		
SpO_2 software EPROM		878106

The following changes have been made to the initial software version.

Main software

- Graphic trends are available in two pages:
  First page: HR, SpO_2, NIBP, invBP1, invBP2
  Second page: SpO_2, O_2, CO_2, RR

- 4 and 8 hour trends added. Trends also in numeric form (HR, NIBP, invBP1, SpO_2, FiO_2, $EtCO_2$).

- Numeric trends printed in CCP printer.

- Real time ECG waveform displayed while viewing the trend.

- PROBE OFF/NO PROBE alarm sequences revised.

- Audible ECG leads off alarms added.

- Return from deeper menu levels to the first menu level can be short cut by hitting the respective menu hardkey.

- Straight access from a parameter menu to another is possible without pressing the RETURN TO MONITOR key.

- ECG displayed in cascade form if pleth waveform is selected to the lowest display field.

- Audible indication of NIBP measurement readiness is available.

NIBP software

- NIBP autocycling mode is interrupted if a cuff loose state is detected.

- Cuff occlusion alarm is added.

SpO_2 software

- Two level measuring light intensity adjustment is done automatically.

- Averaging time is selectable between 5 and 10 seconds.

NOTE: To upgrade CARDIOCAP II monitors from 00 to 01 revision, all three new software (CPU, NIBP, and SpO_2) should be installed simultaneously because none of the revision 00 software is compatible with revision 01 software.

NOTE: All three new software (CPU, NIBP, and SpO_2) can be installed in revision 00 monitors simply by replacing the software EPROMs and shorting the jumper X2 pins 1 and 2 on the CPU board.

The current production revision 02 software versions (-02) are as follows.

ITEM DESCRIPTION		ORDER No.
CPU board		
Software EPROM	(1G, 1GS) (English)	880776
	(1G, 1GS) (German)	880777
	(1G, 1GS) (French)	880778
	(1G, 1GS) (Germany)	880779
	(2G, 2GS) (English)	880772
	(2G, 2GS) (German)	880773
	(2G, 2GS) (French)	880774
	(2G, 2GS) (Germany)	880775
	(CS, 2CS) (English)	880780
	(CS, 2CS) (German)	880781
	(CS, 2CS) (French)	880782
	(CS, 2CS) (Germany)	880783
NIBP board		
NIBP software	EPROM	879808
	EPROM (Germany)	879809
SpO_2 processor board		
SpO_2 software EPROM		878106

The following changes have been made to the revision 01 software version.

Main software

- More complete numeric trends presentation

- More complete real time waveform presentation

- Capable of recognizing the hardware and software levels of the main CPU board, NIBP and SpO_2 modules of the monitor:

* 16 MHz CPU board or 11.7 MHz CPU board

* NIBP hardware of CARDIOCAP II or NIBP of CARDIOCAP I

* SpO_2 hardware of CARDIOCAP II or SpO_2 of CARDIOCAP I

- Automatically, when setting the system up, adjusts the intermodular communication protocols and menu structures on the screen accordingly. That is why this software can be installed also into CARDIOCAP II revisions 00 and 01 units as well as into CARDIOCAP I units (with the main CPU board p/n 878822).

- The patient group PEDIATRIC is renamed to CHILD.

> **NOTE:** This new software can be installed into all CARDIOCAP II revision 01 units without any modifications. **Note that some new features need the new high speed main CPU board to be activated.**

> **NOTE:** This new software can be installed into all CARDIOCAP II revision 00 units with main CPU board jumper modifications (pins 1 and 2 shorted in jumpers X2 and X4).

NIBP software

- Improved performance in cases like small children, moving and shivering patients, high blood pressures, low blood pressures, strong and weak pulses.

> **NOTE:** This new software can be installed into all CARDIOCAP II revision 00 and 01 units without any modifications.

SpO_2 software

- Improved performance in NO PROBE conditions.

> **NOTE:** This new software can be installed into all CARDIOCAP II revision 01 units without any modifications.

> **NOTE:** This new software can be installed into all CARDIOCAP II revision 00 units together with rev 01 or 02 main software after the CPU board jumper modifications (pins 1 and 2 shorted in jumpers X2 and X4).

Upgrading

To upgrade CARDIOCAP II units from 00/01 to 02 revision, all three new software (CPU, NIBP, and SpO_2) should be installed simultaneously as well as the high speed CPU board.

If the new high speed CPU board is not desired, the three new softwares can simply be installed into CARDIOCAP II units 01 revision monitors. All three new softwares (CPU, NIBP, and SpO_2) should be installed simultaneously.

If the new high speed CPU board is not desired, the three new softwares can be installed into CARDIOCAP II units 00 revision monitors with the CPU board jumper modification. All three new software (CPU, NIBP, and SpO_2) should be installed simultaneously.

> **NOTE:** All three new softwares have to be installed at the same time. None of the previous revision softwares are compatible with the new softwares.

4 GENERAL DESCRIPTION

4.1 Typical performance of CARDIOCAP™ II CG-SERIES monitor

<u>ECG</u>

Measurement method

3- or 5-lead ECG

Lead selection

I, II, III with standard 3-lead cable, V connection with optional 5-lead cable.

Measuring range

QRS detection	0.5 - 5 mV, 40 - 200 ms
Allowable offset	±300 mV

Waveform display

Frequency response	0.5 - 30 Hz
Sweep speeds	12.5 and 25 mm/s
Gain range	0.2 - 4.0 mV/cm

Numerical display (heart rate)

Range	30 - 250 beats/min
Accuracy	±1 %
Resolution	1 beat/min
Averaging	10 s
Update interval	5 s

Alarms

Asystole		no QRS detected in 7 s
Heart rate		
	high limit	adjustable 30 - 250 beats/min
	low limit	adjustable 30 - 250 beats/min
	alarm delay	10 s after limit violation

INVASIVE BLOOD PRESSURE

Measurement method		Transducer 50 uV/cmHg/V, 20 mA max. current
Measuring range		-40 - 260* mmHg
Zero adjustment range		±100 mmHg
Calibration range		±50 %
Waveform display		
	Frequency response	0 - 20 Hz
	Sweep speeds	12.5 or 25 mm/s
	Scales	-10 - 65 mmHg -10 - 130 mmHg -40 - 260* mmHg
Numerical display		
	Range	-40 - 260* mmHg
	Resolution	1 mmHg
	Averaging	10 s
	Update interval	5 s
Alarms		
	Systolic pressure	
	high limit	adjustable -40 - 260* mmHg
	low limit	adjustable -40 - 260* mmHg
	alarm delay	10 s after limit violation

* 230 mmHg in Germany

TEMPERATURE

The temperature channel is YSI 400 series probes compatible

Numerical display in °C or °F

Update interval	24 s
Amplifier accuracy	±0.1°C (25.0 - 45.0°C) / ±0.2°F (77.0 - 113.0°F) ±0.2°C (15.0 - 24.9°C) / ±0.4°F (59.0 - 76.8°F)
Sensor accuracy (YSI 400 series)	±0.1°C (15 - 45°C)/ ±0.2°F (59.0 - 113.0°F)

NON-INVASIVE BLOOD PRESSURE

Measurement method	Oscillometric
Measuring range	Adult 25 to 260* mmHg Pediatric 25 to 195 mmHg Infant 15 to 145 mmHg

Accuracy
Compared to auscultatory method in adults (slow deflation speed): systolic ±5 mmHg, STD < 8 mmHg, diastolic ±4 mmHg, STD < 8 mmHg

Compared to auscultatory method in neonates (normal deflation speed):
systolic ±5 mmHg, STD < 8 mmHg, diastolic ±4 mmHg, STD < 8 mmHg

Accepted heart rate	30 to 255 beats/min
Measurement intervals	manual, continuous for 5 min, 1, 2, 3, 5, 10, 15, 30, 60 min

Measurement time

typical	adult	infant
slow mode	35 s	30 s
normal mode	25 s	20 s
fast mode	20 s	15 s

Safety Limits	Adult	Pediatric	Infant
Max. measurement time	2 min	2 min	1 min
Max. inflation pressure	280 mmHg	200 mmHg	150 mmHg
Overpressure limit, stops measurement	320 mmHg	220 mmHg	165 mmHg
Initial inflation pressure	185 mmHg	185 mmHg	120 mmHg
Successive infl. pressures	syst + 40	syst + 40	syst + 40
Next infl. pressure after 'low infl press' message	+50 mmHg	+50 mmHg	+40 mmHg
Stasis time	2 min	2 min	1 min
Stasis pressure	80 mmHg	60 mmHg	40 mmHg

Mechanical safety valve limits max. cuff pressure to 330 mmHg.
Independent timing circuit limits pressurization to max. 5 min.

Alarms

Systolic pressure
high limit OFF, adjustable 15 - 260* mmHg
low limit OFF, adjustable 15 - 260* mmHg

* 230 mmHg in Germany

OXYGEN SATURATION

Measurement method: Red and infrared light absorption

Numerical display

Range	40 - 100 %
Accuracy	100 - 80 %, ±2 % SpO_2 (±1 STD)
Resolution	1 %
Averaging	6 s
Update interval	2 s

Alarms

SpO_2

high limit	adjustable 40 - 99 %, OFF
low limit	adjustable 40 - 99 %
alarm delay	10 s after limit violation

Pulse beep pitch corresponds to SpO_2 level

PLETH

Automatic scale setting when probe is attached.
User-adjustable scale during operation.

Heart rate

Range	30 - 250 bpm
Accuracy	±1 %, ±1 bpm
Resolution	1 bpm
Averaging	10 s
Update interval	5 s

Alarms

Heart rate

high limit	adjustable 30 - 250 beats/min
low limit	adjustable 30 - 250 beats/min
alarm delay	10 s after limit violation

AIRWAY GASES

Gas sampling flow rate 180 ml/min

Automatic compensation for atmospheric pressure variation, CO_2/N_2O and CO_2/O_2 collision broadening effects

Warm-up time 5 min to operation, 30 min to full specifications

CO_2	Measurement method	Infrared absorption technique
	Range	0 - 10 % (0 - 76 mmHg)
	Rise time	<270 ms
	Accuracy *)	<0.2 vol %, 1.5 mmHg
	Numerical display	$ETCO_2$ updated breath-to-breath
	Waveform display	sweep speed 6.25 mm/s
	Alarms	Apnea (no breaths detected in 20 s)
		$ETCO_2$ HIGH (adjustable 9.9 - 0.0)
		$ETCO_2$ LOW (adjustable 0.0 - 9.9)
		CO_2 rebreathing (1 %, 2 %, 3 %)

O_2	Measurement method	fast response paramagnetic oxygen analyzer
	Range	0 - 100 %
	Rise time	<430 ms
	Accuracy *)	<2 vol %
	Numerical display	FiO_2 and ETO_2 updated breath-to-breath

	Waveform display	sweep speed 6.25 mm/s
	Alarms	FiO_2 HIGH (OFF, adjustable 99 - 18 %) FiO_2 LOW (adjustable 18 - 100 %)
N_2O	Measurement method	Infrared absorption technique
	Range	0 - 100 %
	Rise time	<500 ms
	Accuracy *)	<2 vol %
	Numerical display	FiN_2O updated breath-to-breath
Respiratory rate		
	Range	4 - 60 breaths/min
	Detection	1 % (7.6 mmHg) variation in CO_2 baseline level

*) This performance corresponds to patient monitoring when circumstances are the same as during calibration, gas concentrations are N_2O 0 - 70 %, O_2 0 - 100 %, and the amount of air in the circuit is less than 10 %, calibration is checked within 2 weeks, respiratory rate is ≤30 breaths per minute and the monitor has been turned on for at least 30 minutes.

TRENDS

Revision 00

2 hours graphic trends of Heart Rate, Respiration Rate, Systolic and Diastolic Pressures, SpO_2, Pleth Amplitude, $FiCO_2$, $EtCO_2$, FiO_2, and EtO_2. Sampled every 10 s except NIBP.

Revision 01 and up

0.5, 2, 4, 8 hours of graphic and numerical trends of Heart Rate, Respiration Rate, Systolic and Diastolic Pressures, SpO_2, Pleth Amplitude, $FiCO_2$, $EtCO_2$, FiO_2, and EtO_2. Sampled as follows except NIBP.

Trend Time	Sampling Rate	Display Rate
0.5 h	HR (10 s), RR (20 s)	every 10 s value
2 h	SpO_2 (30 s) Pleth (30 s)	every 10 s value
4 h	P1 (40 s, 20 s if no P2)	every 20 s average
8 h	P2 (40 s) CO_2 and O_2 (20 s)	every 40 s average

4.2 Technical specifications of CARDIOCAP™ II CG-SERIES monitor

Subject to change without notice

<u>ECG</u>

Defibrillation protection	5000 V, 400 J
Input impedance	>2.5 Mohms/10 Hz
System noise	<40 μV (p-p, RTI)
Allowable offset	±300 mV DC
Gain range	0.2 to 4.0 mV/cm
Display bandwidth	0.4 to 30 Hz (-3dB)
Pacemaker pulse detection	5 - 500 mV, 0.5 - 2 ms pulses
Patient Safety	Type CF isolation

The ECG channel features an integral electrosurgery filter, defibrillator protection and pacemaker pulse detection and rejection.

<u>INVASIVE BLOOD PRESSURE</u>

Amplifier

Transducer and input sensitivity	50 μV/cmHg/V, 5 Vdc 20 mA maximum current
Input resistance	10^{10} ohms
Zero drift	<1 mmHg/10°C
Zero drift (pressure channel 2 only)	<2 mmHg/10°C
Nonlinearity	<1 %, 0-200 mmHg
Gain drift	<0.5 % f.s./10°C
Bandwidth	0 to 20 Hz (-3dB)
Zero adjustment range	±100 mmHg
Calibration range	±50 %
Zero set accuracy	±1 mmHg
Calibration resolution	±1 mmHg

Patient Safety	Type CF isolation

TEMPERATURE

The temperature channel is YSI 400 series probes compatible

Amplifier accuracy	±0.1°C (25.0 - 45.0°C) / ±0.2°F (77.0 - 113.0°F) ±0.2°C (15.0 - 24.9°C) / ±0.4°F (59.0 - 76.8°F)
Sensor accuracy (YSI 400 series)	±0.1°C (15 - 45°C) / ±0.2°F (59.0 - 113.0°F)
Patient Safety	Type CF isolation

NON-INVASIVE BLOOD PRESSURE

Pressure transducer accuracy	better than ±3 mmHg or ±2 % (whichever greater)
Patient Safety	Type BF isolation

OXYGEN SATURATION

The pulse oximeter accuracy measurements are statistically derived and correlated to simultaneous SpO_2 measured on an Instrumentation Laboratory IL/282 CO-oximeter.

Accuracy	100 - 80 %, ±2 % SpO_2 (±1 STD) 80 - 50 %, ±3 % SpO_2 (±1 STD) 50 - 40 %, unspecified
Patient Safety	Type BF isolation

PLETH

Automatic scale setting when probe is attached.
User-adjustable scale during operation.

Amplifier	Bandwidth	0.8 to 15 Hz (-3 dB)
Patient Safety		Type BF isolation

CO_2

Measurement range	0 - 10 % or 0 - 76 mmHg
Measurement rise time	<270 ms
Gain stability	<2 % f.s./4 days
Zero point drift	<2 % f.s./24 hours
Zero temperature drift	<0.2 % f.s./°C
Gain temperature drift	<0.2 % f.s./°C
Nonlinearity error	<2 % f.s.
N_2O compensation accuracy	<2 % f.s.

O_2

Measurement range	0 - 100 %
Measurement rise time	<430 ms
21 % O_2 drift	<2 %/24 hours
21 % O_2 temperature drift	<0.2 %/°C
Gain stability	<2 %/24 hours
Gain temperature drift	<0.3 %/°C
Nonlinearity error	<2 %

N_2O

Measurement range	0 - 100 %
Measurement rise time	<500 ms
Zero point drift	<2 %/24 hours
Zero point temperature drift	<0.4 %/°C
Gain temperature drift	<0.3 %/°C
Nonlinearity error	<2 %

ALARMS

Adjustable audio alarm sound, rear panel loudspeaker (approximately 900 Hz)
Adjustable high/low alarm limits for heart rate, systolic pressures, SpO_2, $ETCO_2$, FiO_2
Alarms for apnea, asystole, CO_2 rebreathing, PROBE OFF, OCCLUSION, AIR LEAK, CUFF OCCLUSION
ECG LEADS OFF and REPLACE WATER TRAP warnings

DISPLAY

9" green monochrome picture tube
Resolution 1024 x 256 pixels

Clock

GENERAL DATA

Standards fulfilled	IEC 601-1, safety class I CSA 22.2 No 125-M1984
Operating temperature	10 - 35°C/50 - 95°F
Storage temperature	-5 - 50°C/23 - 122°F
Power requirements	100/115/220/240 V 50/60 Hz 120 W, 600 mA
Grounding	hospital grade
Interruptibility	15 min
D x W x H	391 x 330 x 210 mm 15.3 x 13.0 x 8.3 inches
Weight	14 kg / 31 lbs

EXTERNAL CONNECTIONS

Serial data output for computer interface (SERIAL & ANALOG I/O connector) and graphics printer (AUX I/O connector)
Composite video output
ECG, PLETHYSMOGRAPH or PRESS1, PRESS2, CO_2 and O_2 analog waveform output (SERIAL & ANALOG I/O connector)
ECG test signal
AC, DC power supply connection
Alarm signal (Nurse call)

4.3 Principle of operation

4.3.1 Principle of CO_2/N_2O measurement

The CO_2 and N_2O gas measurements are based on absorption of infrared light as it passes through the gas sample in measuring chamber in the photometer. The light absorption is measured at two wavelengths using an infrared detector. One of the wavelengths is that of the CO_2 absorption peak at 4.3 micrometers and the other is that of the N_2O absorption peak at 3.9 micrometers. The signal processing electronics receive the signals from the IR detector and demodulate it to get DC components out of these signals which correspond to the content of each gas in the sample.

Figure 4.1 shows the CO_2/N_2O gas absorption spectra.

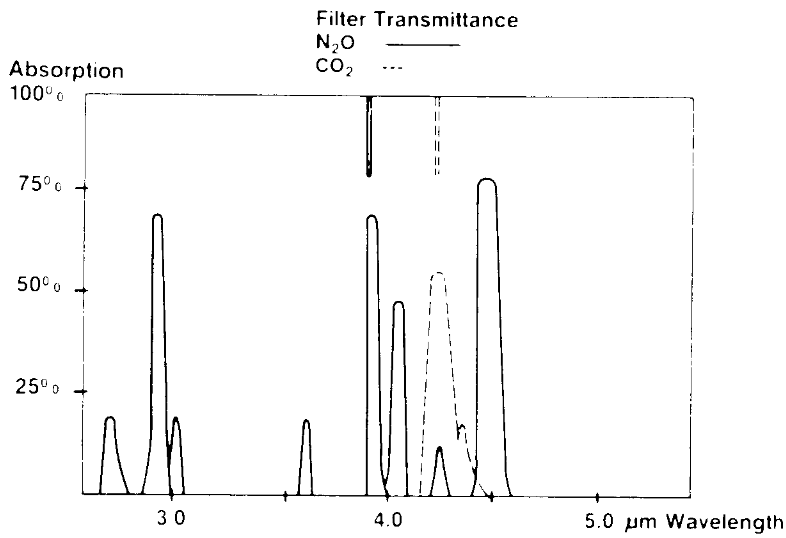


Figure 4.1 CO_2/N_2O gas absorption spectra

4.3.2 Principle of O_2 measurement

The differential oxygen measuring unit uses the paramagnetic principle in a pneumatic bridge configuration. The signal picked up with a differential pressure transducer is generated in a measuring cell with a strong magnetic field that is switched on and off at a frequency of 165 Hz. The output signal is a DC voltage proportional to the O_2 concentration difference between the two gases to be measured.

4.3.3 Principle of ECG measurement

Electrocardiography is the process of analyzing the electrical activity of the heart by measuring the electrical potential produced with electrodes placed on the surface of the body.

ECG reflects:
Electrical activity of the heart
Normal/abnormal function of the heart
Effects of anesthesia on heart function
Effects of surgery on heart function

See the Operator's Manual for electrodes positions and other information.

4.3.4 Principle of NIBP measurement

NIBP (Non-Invasive-Blood-Pressure) is an indirect method for measuring blood pressure.

The NIBP measurement uses the oscillometric measuring principle. The cuff is inflated with a pressure slightly higher than the presumed systolic pressure, then slowly deflated at a speed based on the patient's heart rate, collecting data from the oscillations caused by the pulsating artery. Based on these oscillations, the monitor calculates values for systolic, mean, and diastolic pressures.

The NIBP measuring unit is a fully automatic, self-contained non-invasive blood pressure measuring system which communicates with the main CPU via an asynchronous serial channel. All NIBP functions are controlled by the NIBP's CPU in the NIBP board. The NIBP system contains the following main parts:

- NIBP board
- Pneumatic
- NIBP air pump
- Safety valve
- NIBP tubing
- Twin hose
- Blood pressure cuff

The NIBP board contains the pressure transducer and the electronic parts of the system.

The pneumatic contains two damping chambers, two magnetic valves, and tubes (see Figure 9.3).

4.3.5 Principle of SpO_2 measurement

SpO_2

Oxygen is the most acutely necessary substrate for survival. A major concern during anesthesia is the prevention of tissue hypoxia. Thus immediate and direct information about tissue oxygenation is needed. When oxygen diffuses from the alveolus into the blood it dissolves into the plasma and binds to hemoglobin. Most of the oxygen needed by the body is transported bound to hemoglobin. The total hemoglobin in the blood is composed of oxygenated oxyhemoglobin (HbO_2), reduced or deoxygenated hemoglobin (Hb) and other forms of hemoglobin such as Dyshemoglobins: carboxyhemoglobin (HbCO) and methemoglobin (MetHb).

Pulse Oxymetry determines noninvasively the oxygen saturation of hemoglobin (SpO_2) on the basis of light absorption at only two wavelengths. The limitation is that correspondingly only two hemoglobin species can be discriminated by the measurement. In principle, Pulse Oxymetry can be calibrated either against fractional saturation SaO_{2frac},

$$SaO_{2frac} = HbO_2 / (HbO_2 + Hb + Dyshemoglobin)$$

or against functional saturation SaO_{2func},

$$SaO_{2func} = HbO_2 / (HbO_2 + Hb),$$

which is less sensitive to changes of Dyshemoglobin concentrations in blood.

The oxygen saturation percentage measured by the DATEX CARDIOCAP II monitor is calibrated against the functional saturation SaO_{2func}. The advantage of this method is that the accuracy of SpO_2 measurement can be maintained even at rather high concentrations of carboxyhemoglobin in blood. Independent of the calibration method pulse oxymetry is not able to correctly measure oxygen content of the arterial blood at elevated Dyshemoglobin levels, which clinically may be harmful for patient.

The absorption of light of normal human blood at different wavelengths is mainly determined by oxygenated oxyhemoglobin and by deoxygenated deoxyhemoglobin (see Figure 4.2). The monitor measures the relative absorption of light at two wavelengths, one in the near infrared (about 900 nm) and the other in the red region (about 660 nm) of light spectrum. These wavelengths are emitted by LEDs and detected by a PIN-diode in the probe. The total absorption can be divided into components of tissue, venous blood, arterial blood, and the pulse added volume of arterial blood. Only the last component gives variations synchronous with heart beat into the transmitted light intensity. This fact is most essential for Pulse Oxymetry and eventually makes feasible the measurement of oxygen saturation noninvasively.

Plethysmographic pulse wave

The plethysmographic waveform is derived from the IR signal and reflects the blood pulsation at the measuring site. Thus the amplitude of the waveform represents the perfusion.

Pulse rate

The pulse rate calculation is done by peak detection of the plethysmographic pulse wave. The signals are filtered to reduce noise and checked to separate artifacts.

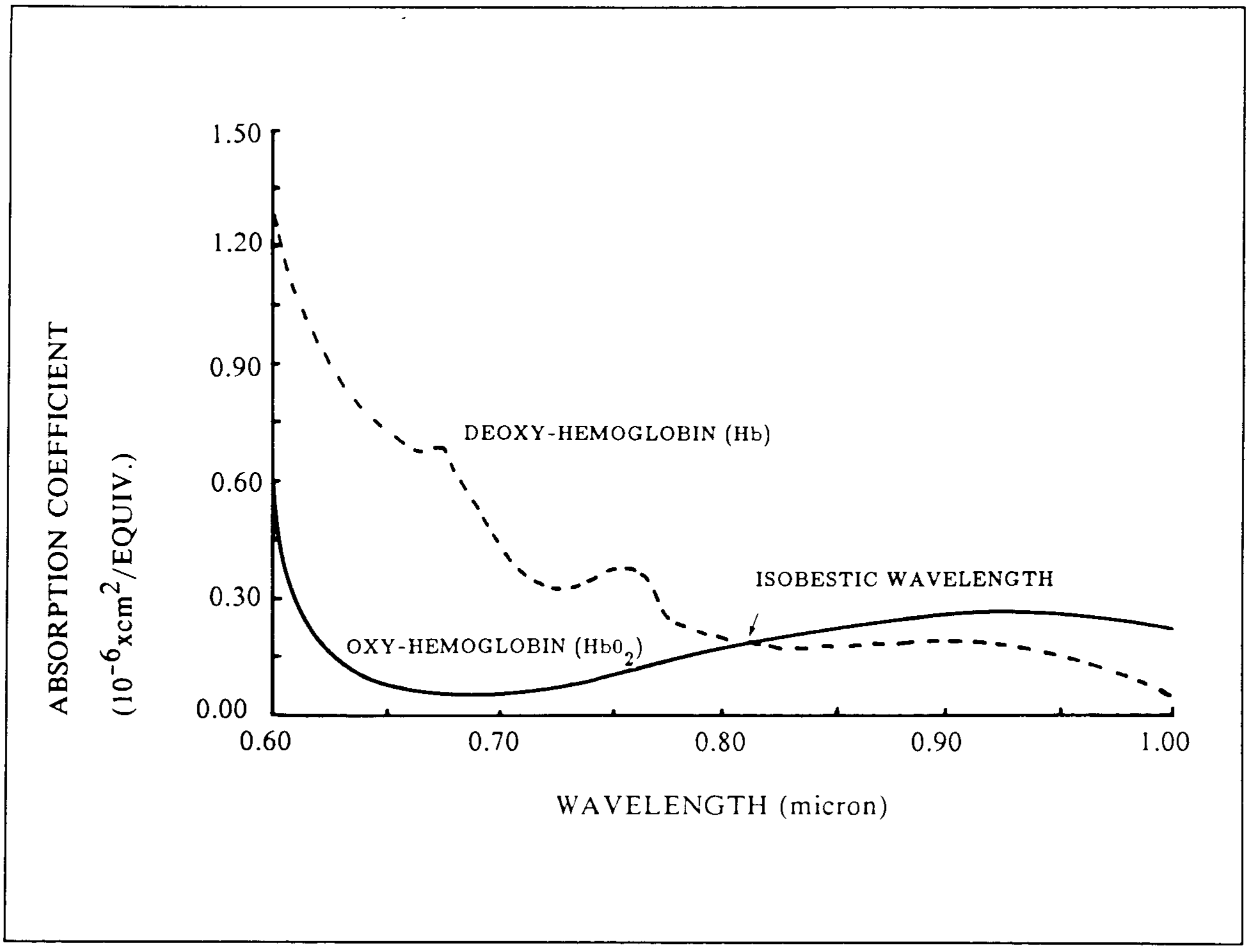


Figure 4.2 **Absorption coefficients of oxy- and deoxy-hemoglobin in the red and near-infrared regions**

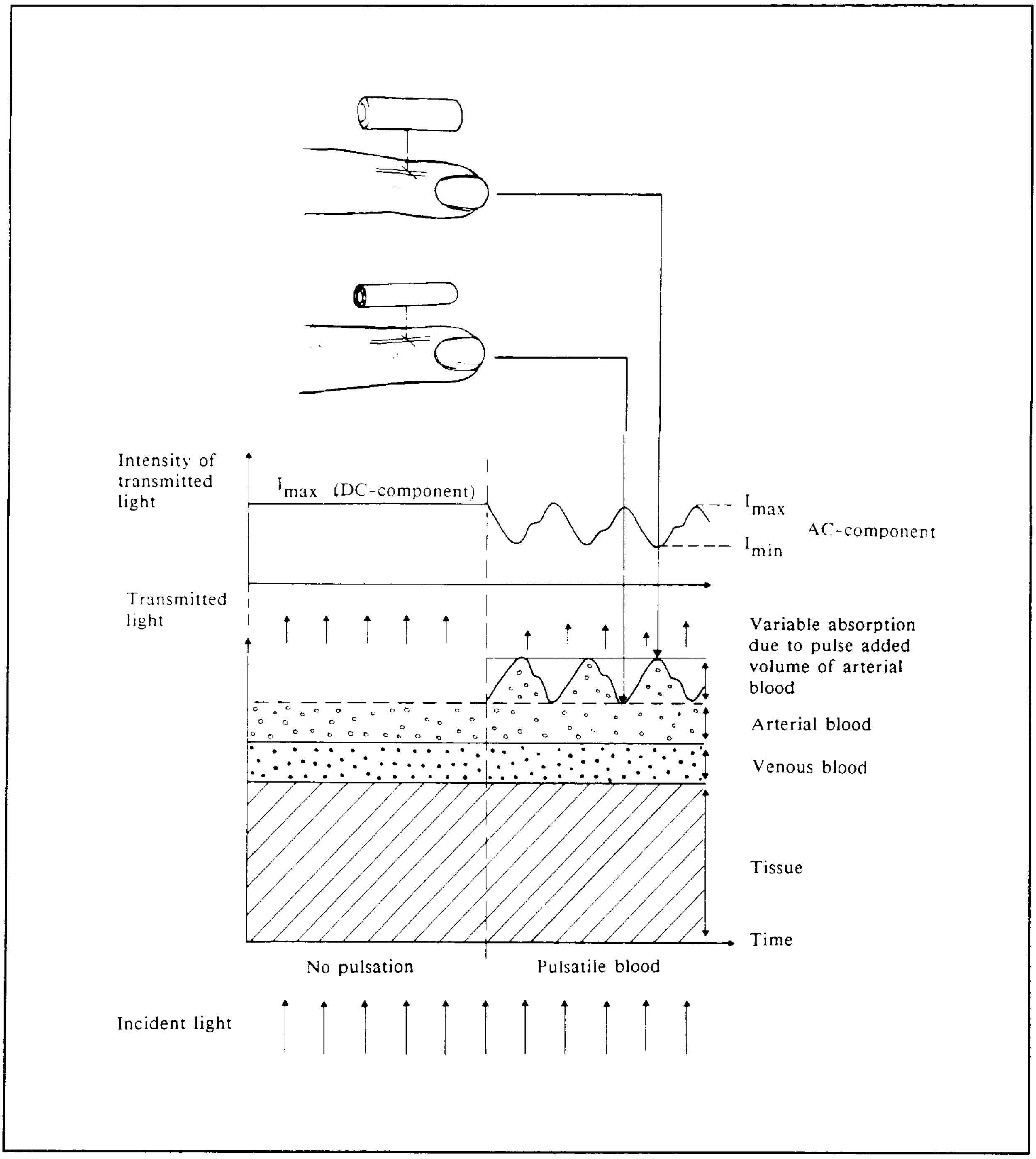


Figure 4.3 Absorption of infrared light in the finger

Probe

The standard probe is a finger clamp probe which measures through the finger (see Figure 4.4) and contains the light source LEDs in one half and the photodiode detector in the other half. Different kinds of probe are also available from DATEX.

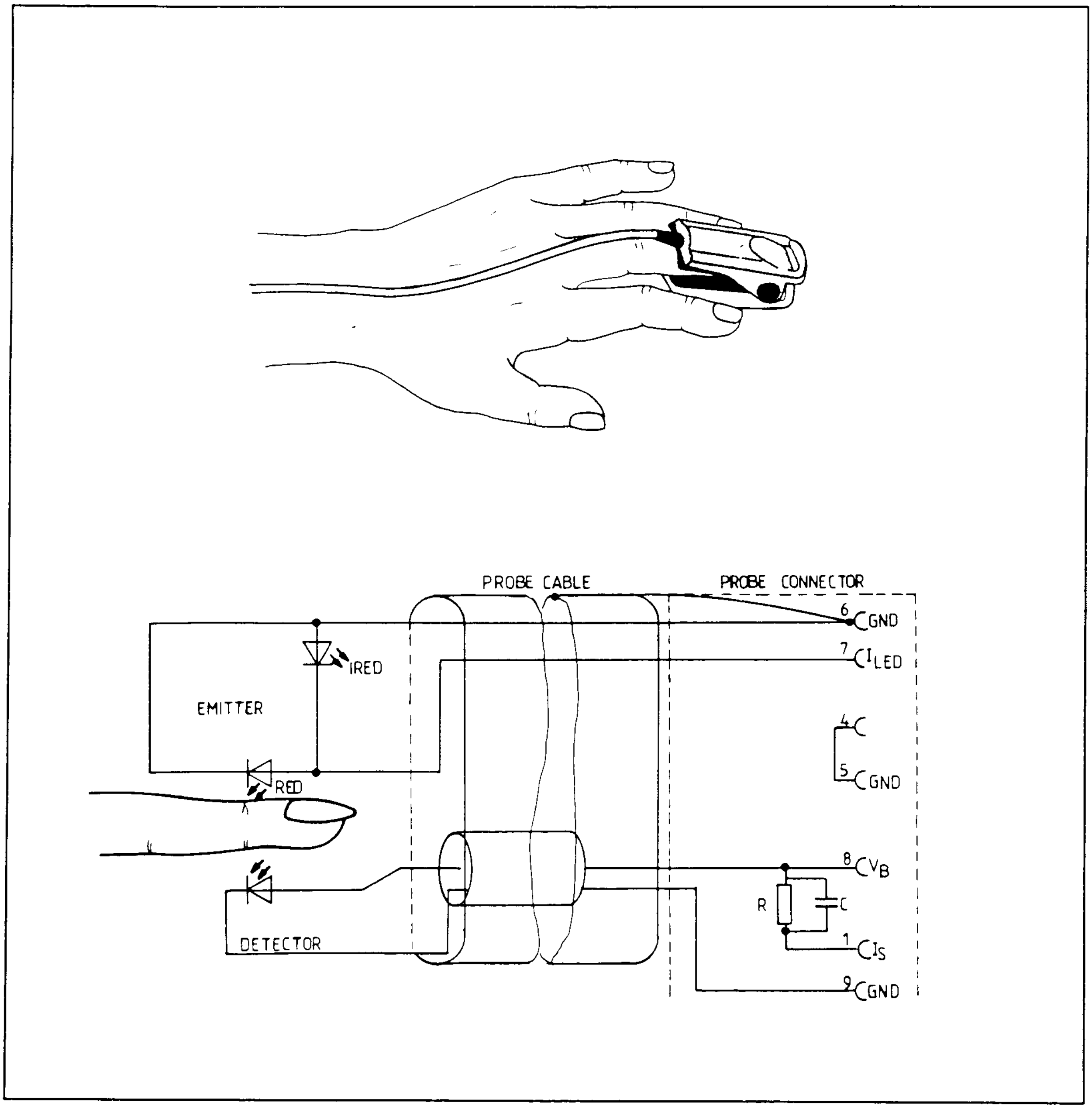


Figure 4.4 Cliplite™ probe parts layout and schematic diagram

4.4 General block diagram

The monitor consists of the following modular parts (see page 3-2 for the parts included in the monitor you are using):

- ECG measuring electronics
- Invasive BP and temperature measuring electronics
- NIBP measuring electronics, pump, and tubing
- Probe and SpO_2/pulse oximeter measuring board
- CO_2/N_2O measuring unit
- Oxygen measuring unit
- Gas measuring electronics
- Main processor board including analog signal multiplexer, A/D converter, and real time clock
- Video control board to convert the CPU commands into video signal
- Video display module
- Transformer and power supply board to generate necessary voltages and I/O functions
- Mother board including signal buses and analog input signal buffers
- Tactile membrane keyboard
- Loudspeaker unit

See Figure 4.5 for the monitor block diagram.

For monitor parts locations see the exploded view (Figure 9.1) in Chapter 9.

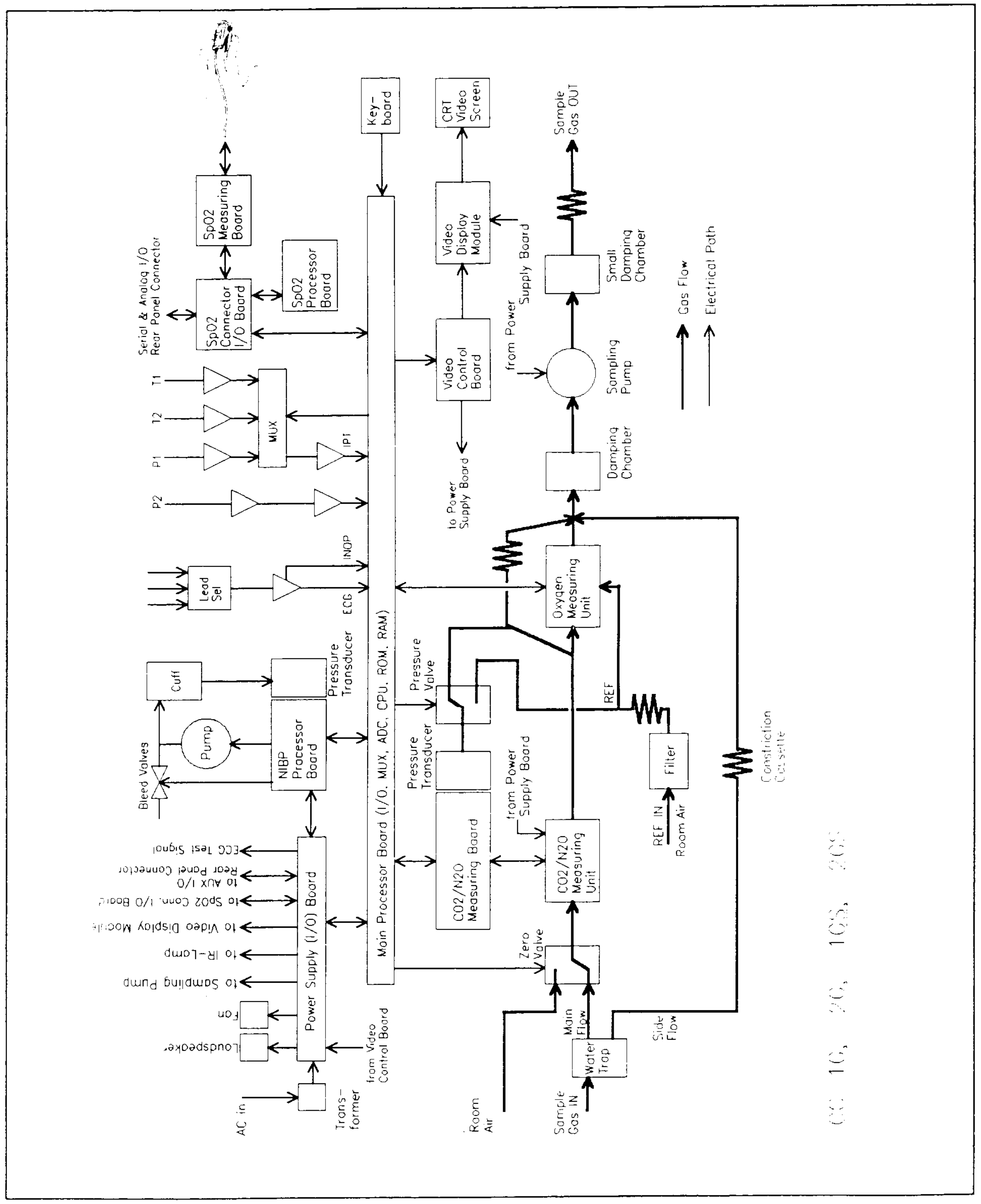
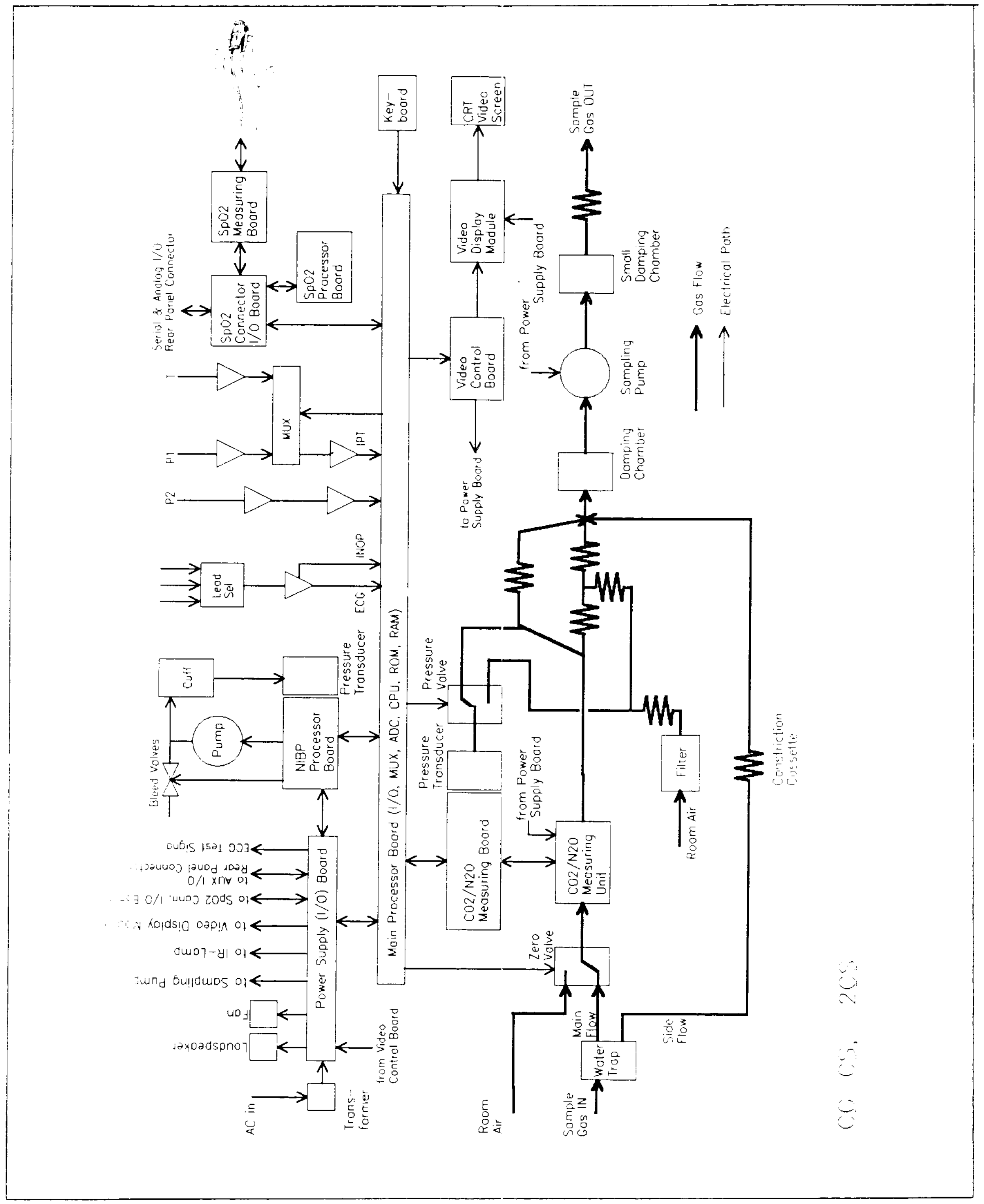


Figure 4.5 General block diagram



4.5 Wiring diagram

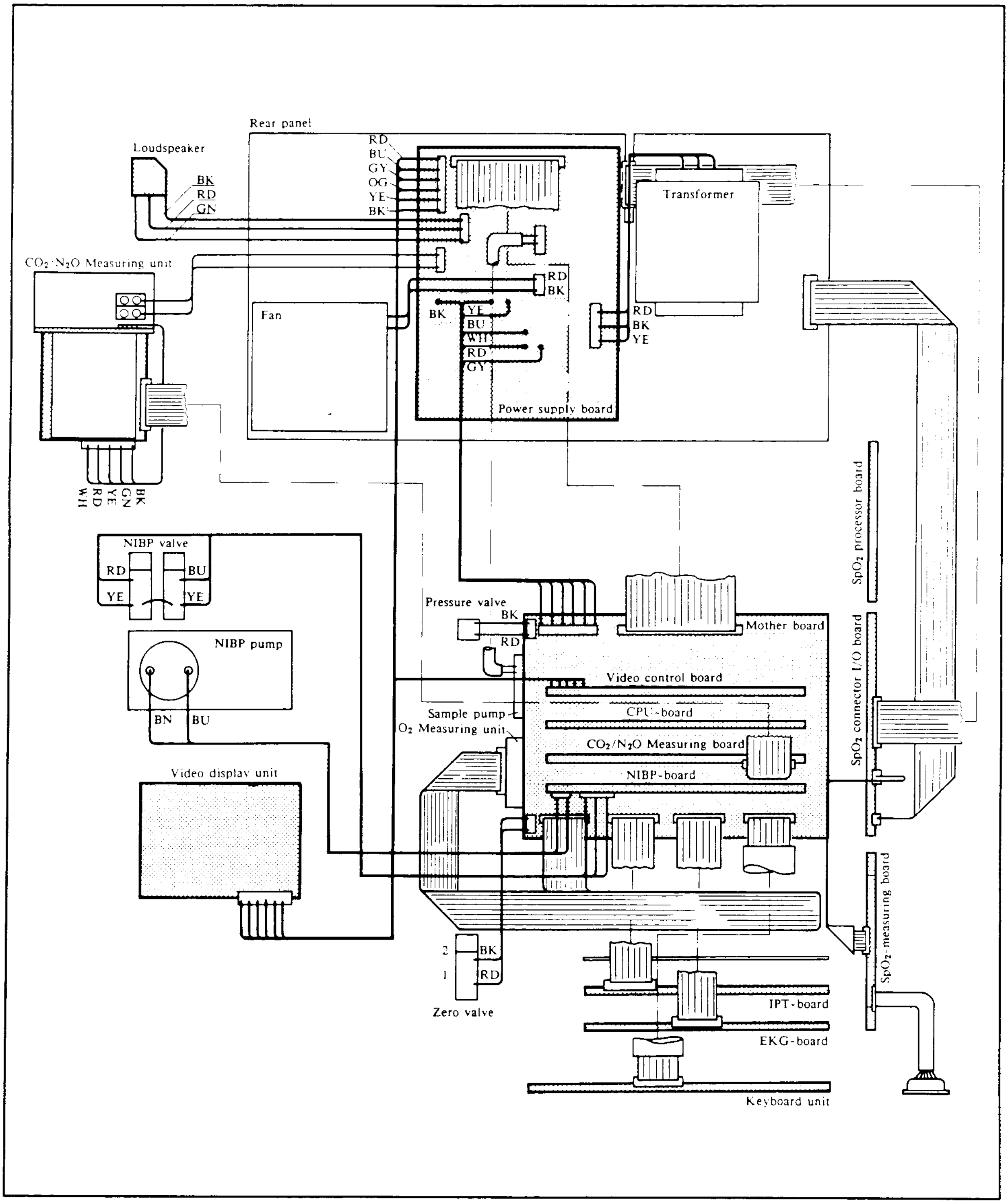


Figure 4.6 Wiring diagram

4.6 External connector configurations

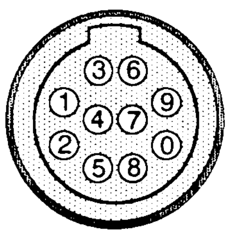
4.6.1 Input/Output specifications

Serial data output for computer interface (SERIAL & ANALOG I/O connector)
Serial Output for Graphics Printer (AUX I/O connector)
Composite video output

ECG, PLETHYSMOGRAPH or PRESS1, PRESS2 analog waveform output (SERIAL & ANALOG I/O connector)
ECG test signal
AC, DC power supply connection
Alarm signal (Nurse call)

4.6.2 Connectors

Table 4.1 Pin order of the ECG connector

	PIN	SIGNAL (IEC standard)
Front view 	1	R
	2	L
	3	N (I, II, III) or N (V-5)
	4	F (V-5)
	5	C (V-5)
	6	Cable shield
	7	not connected
	8	not connected
	9	not connected
	0	not connected

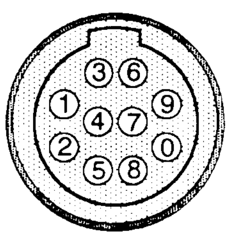
	PIN	SIGNAL (AAMI)
Front view 	1	RA
	2	LA
	3	LL (I, II, III) or RL(V-5)
	4	LL (V-5)
	5	V (V-5)
	6	Cable shield
	7	not connected
	8	not connected
	9	not connected
	0	not connected

Table 4.2 Pin order of the invasive pressure connector (PRESSURE 1)

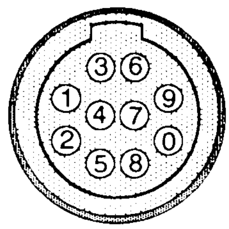
	PIN	SIGNAL
Front view	1	P+
	2	P-
	3	Excitation voltage -
	4	Excitation voltage +
	5	not connected
	6	LED Ground
	7	LED
	8	Pleth in
	9	Pleth Ground
	0	-Invbpflg

Table 4.3 Pin order of the invasive pressure connector (PRESSURE 2)

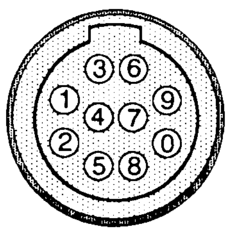
	PIN	SIGNAL
Front view	1	P+
	2	P-
	3	Excitation voltage -
	4	Excitation voltage +
	5	not connected
	6	not connected
	7	not connected
	8	not connected
	9	P Ground
	0	-Invbpflg

Table 4.4 Pin order of the pulse oximeter probe connector (SpO_2)

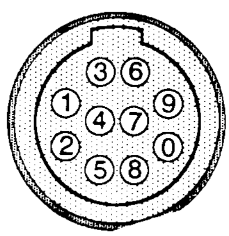
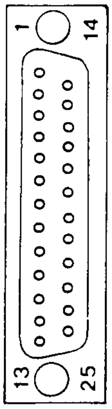
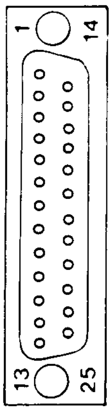
	PIN	SIGNAL
Front view	1	Is
	2	Ib
	3	no connection
	4	Probe identification
	5	Probe identification
	6	Ground
	7	Iled
	8	Vb (-4 ±0.3 V)
	9	Ground
	0	+12 Vp

Table 4.5 Pin order of the SERIAL & ANALOG connector



PIN NO.	I/O	SIGNAL
1		Protective ground
2	O	TXD0 (RS232C)
3	I	RXD0 -"-
4	O	RTS0 -"-
5	I	CTS0 -"-
6	I	Gas freeze (TTL) (Do not connect)
7		Signal ground
8	I	Test (TTL) (Do not connect)
9	O	+12 VDC 50 mA max
10	O	-12 VDC -"-
11	O	+15 VDC 100 mA max
12	O	-15 VDC -"-
13	O	SpO_2, 10 V = 100 %
14	O	O_2, 10 V = 100 %
15	O	5 VDC 300 mA max
16	O	SpO_2, 10 V = 100 %
17	O	Inv. BP2 -40 - 255 mmHg, 0 - 10 V
18	O	ECG (Gain = 1660)
19	O	Inv. BP 255 mmHg approx 10 V
20	O	CO_2, 10 V = 10 %
21	O	+22 VDC 500 mA max
22	O	Infrared signal, 0 - 10 V
23	O	-22 VDC 500 mA max
24	O	20 VAC 500 mA max
25		20 VAC 500 mA max

Table 4.6 Pin order of the AUX I/O connector



PIN NO.	I/O	SIGNAL
1		Protective ground
2	O	TXD1 (RS 232)
3	I	RXD1 -"-
4	O	RTS1 -"-
5	I	CTS1 -"-
6	I	(PB1)
7		Signal ground
8	I	(PB0)
9		+12 VDC
10		-12 VDC
11		Not connected
12		Not connected
13	I	CTS2 (TTL) (not used)
14	O	TXD2 (TTL) (CPU -> NIBP)
15		+5 VDC
16	O	RXD2 (TTL) (NIPB -> CPU)
17	O	(PA5)
18	O	(PA6)
19	O	RTS2 (TTL) (not used)
20	O	(PA7) (Alarm)
21		+26 VDC 1 A max
22		not connected
23		+29 VDC 1 A max
24		22 VAC 1 A max
25		22 VAC 1 A max

NOTES:

- CTS = clear to send (+12 V = enable transmission)

- RTS = request to send (not in use)

- no serial inputs in use
- serial channel 2 is unbuffered TTL. It is used for internal communication between main CPU and NIBP unit. DO NOT CONNECT EXTERNALLY. For test purpose only.

Video connector output

1 Vpp, 24 MHz, 75 ohm, hsync 15.75 kHz, vsync 50 Hz

For internal connector pin configurations see Tables 5.3 - 5.25.

Table 4.7 System bus

Pin	C	B digital	anal.bus	A
1	GND A analog	KBØ (keyboard) X1	Motor-	+15V, 0,2A analog
2	+10Vref.	KB1 X2	sync	-15V, 0,2A analog
3	DAC6	KB2 X3	T+	DAC7 (selftest)
4	DAC4 (ECG el.test)	KB3 X4	T-	DAC5 (alarm)
5	DAC2 ext Pleth	KB4 Y2	$\overline{\text{TIME OUT}}$	DAC3 (ext)
6	DACØ ext CO_2	KB5 Y1	+6.5V/CD	DAC1 (ext) O_2
7	ADC6 (mux.,bp2)	KB6 Y3	N_2O zero	ADC7 (ext,selftest)
8	ADC4 (pulse & temp)	KB7 Y4	N_2O zero	ADC5 (GASPRESS)
9	ADC2 (ECG)	PBØ<-$\overline{\text{DEC1}}$	CO_2 zero	ADC3 (O_2)
10	ADCØ (CO_2)	PB1<-$\overline{\text{DECØ}}$	CO_2 zero	ADC1 (N_2O)
11	A6	PB2<-	N_2O cal/WR zero	A7
12	A4 up addr	PB3<-$\overline{\text{EXT.DEC1}}$	CO_2 cal	A5
13	A2 bus	PB4<-$\overline{\text{EXT.DECØ}}$	LAMP_ON	A3
14	AØ	PB5<-CTS2 (CTSB)	6.5V/AA	A1
15	T1 (CTSØ)*	PB6<-CTS1 (CTSA)		$\overline{\text{IORQ}}$
16	$\overline{\text{WR}}$	PB7<-CTSØ		$\overline{\text{RD}}$
17	TØ (RTSØ)*	PCØ<-$\overline{\text{ECG inop}}$		$\overline{\text{Reset}}$ (0.1-5V)
18	SER IN Ø (8031)	PC1<-(PB2 $\overline{\text{inop}}$)		SER OUT Ø (8031)
19	P1.Ø*	PC2<-		P1.1*
20	INTØ (video cntrl)	PC3<-		RTS A (OP Ø)
21	SER IN 1 (RxD $\overline{\text{A}}$)	PC4->Pressure mag. valve		SER OUT 1 (TxD $\overline{\text{A}}$)
22	TIMER IN Ø (IP 2)	PC5->PUMP OSC		RTSB (OP 1)
23	SER IN 2 (RxD $\overline{\text{B}}$)	PC6->Gas zero mag. valve		SER OUT 2 (TxD $\overline{\text{B}}$)
24	D6	PC7->RTSØ		D7
25	D4 data bus	PAØ->IPT addr. Ø		D5
26	D2	PA1->IPT addr. 1		D3
27	DØ	PA2->IPT addr. 2		D1
28	$\overline{\text{INT3}}$	PA3->IPT addr. 3 (gain)		$\overline{\text{INT 1}}$
29	+5V 2A digital	PA4->		+5V data retention
30	+5V 2A (dirty)	PA5->		+15V 2A (dirty)
31	19Vac 0.1A	PA6->		+12V 1A (video)
32	GND D (digital)	PA7->		GND D (dirty)

* not used PPI Mode Ø contr. ω≠83H

5 DETAILED DESCRIPTION OF MODULES

5.1 Gas sampling system

The function of the gas sampling system is to draw sample gas into the monitor gas sensors at a fixed rate and to separate impurities and condensed water from the gas stream.

Water trap

The sample gas enters the monitor through the water trap, where it is divided into two flows, main flow and side flow (see Figure 5.1). The main flow goes into the measuring system (described in Section 5.2). This flow is separated from the sample in flow by a hydrophobic filter.

The side flow creates a slight sub-atmospheric pressure within the collection bottle which causes fluid removed by the hydrophobic filter to collect in the bottle.

Sampling line

The sampling line is an integral part of the total sampling system. The resistance established by the sampling line is used by the software to set the flows and pressures during the turn on sequence.

The small inner diameter causes fluids such as blood or mucus not to propagate within the tube, so that when the line is clogged, it is replaced.

The Nafion™ tube

A special tube (tube A, see Figure 5.2 and Table 5.1) is used to balance the sample gas humidity with that of ambient air. The tube will prevent errors caused by the effect of water vapor on gas partial pressure when humid gases are measured after calibration with dry gases. It is inserted between the water trap and the zero valve.

Zero valve

The main flow passes through a magnetic valve before proceeding to the CO_2/N_2O measuring unit. This valve is activated to establish the zero points for the CO_2/N_2O and O_2 measuring units at five minutes and thirty minutes after turn on. When the valve is activated, room air is drawn into the internal system and the gas sensors.

Gas measuring unit

After the zero valve, the gas passes through the CO_2/N_2O and O_2 measuring units. In the CO_2/N_2O measuring unit, infrared light is passed through chambers containing the main flow gas (measurement) and a chamber containing reference gas. The measurement is made by determining the ratio between the two light intensities. See Section 5.2.2 for a detailed description of this unit.

The oxygen sensor has two inputs. One input accepts the main flow and the other draws in room air for reference. The sensor uses a pressure differential transducer to compare the pressure gradient produced when both gases are exposed to an oscillating magnetic field. See Section 5.2.5. Both gas flows exit from a single port.

Pressure valve

The pressure valve is used to measure the pressure gradient between the O_2 measurement flow and the O_2 reference flow. This pressure gradient reflects the condition of the D-FEND™ water trap filter. The measurement is performed 2 minutes after start-up then once an hour.

Normally the pressure gradient between the O_2 measurement flow and the reference flow is approximately +8 mmHg. If the software detects a gradient between 0 and -5 mmHg, the pressure valve will initiate a pressure measurement every 15 minutes. If the gradient is greater than -5 mmHg, the software causes the message "REPLACE WATER TRAP" to be displayed.

Flow cassettes

The internal flow rates are set using flow cassettes. These cassettes are used to set the side flow rate and the O_2 reference flow rate, the flow rate into the measurement side of the O_2 sensor and the total flow rate of the sampling system.

In CS and 2CS models, The O_2 sensor is compensated by three extra cassettes.

Sampling pump and damping chambers

The sampling pump is a vibrating membrane pump driven by a 50 Hz/12 V/0.4 A square wave current.

The damping chambers are used to even out the pulsating flow and silence the exhaust flow.

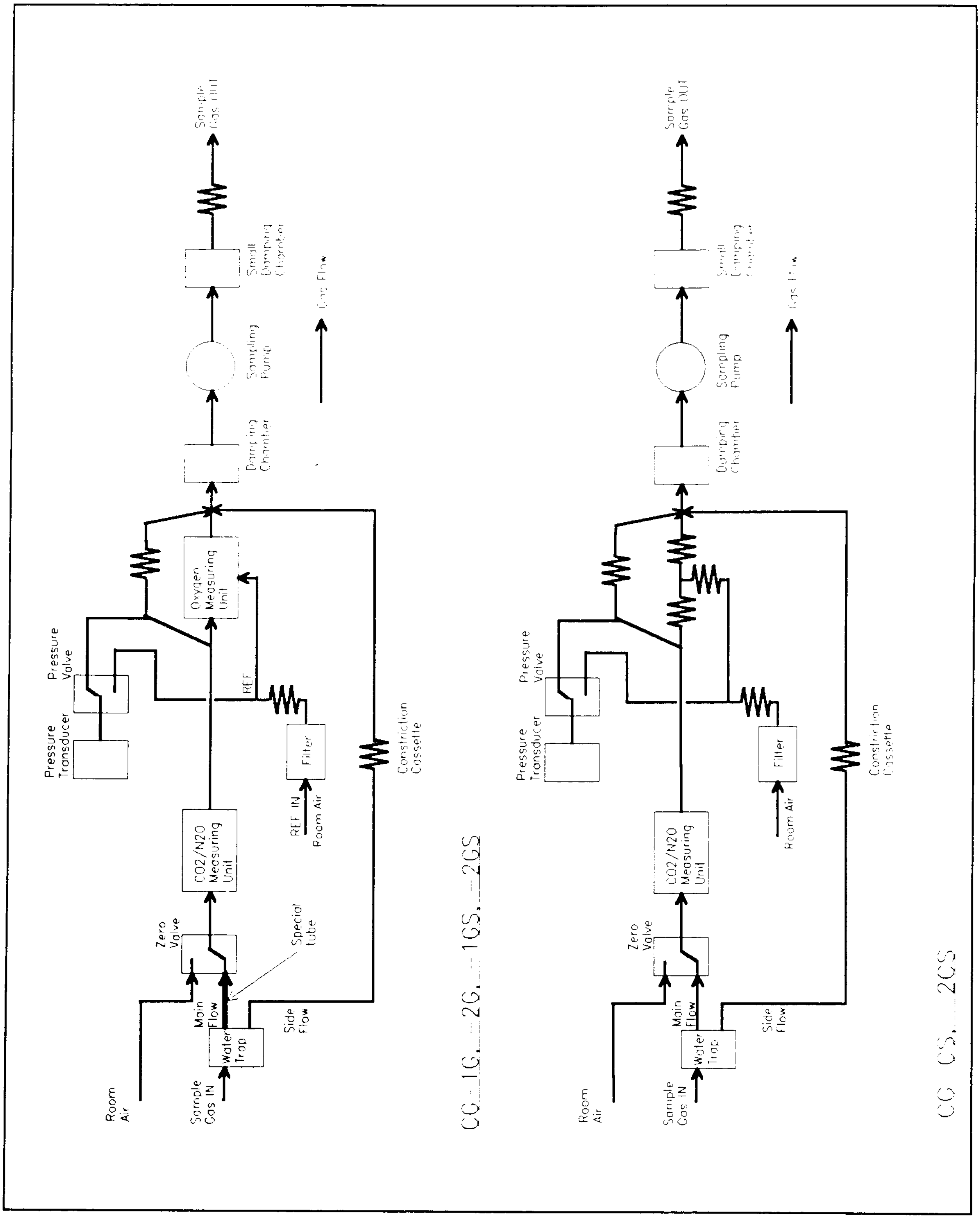
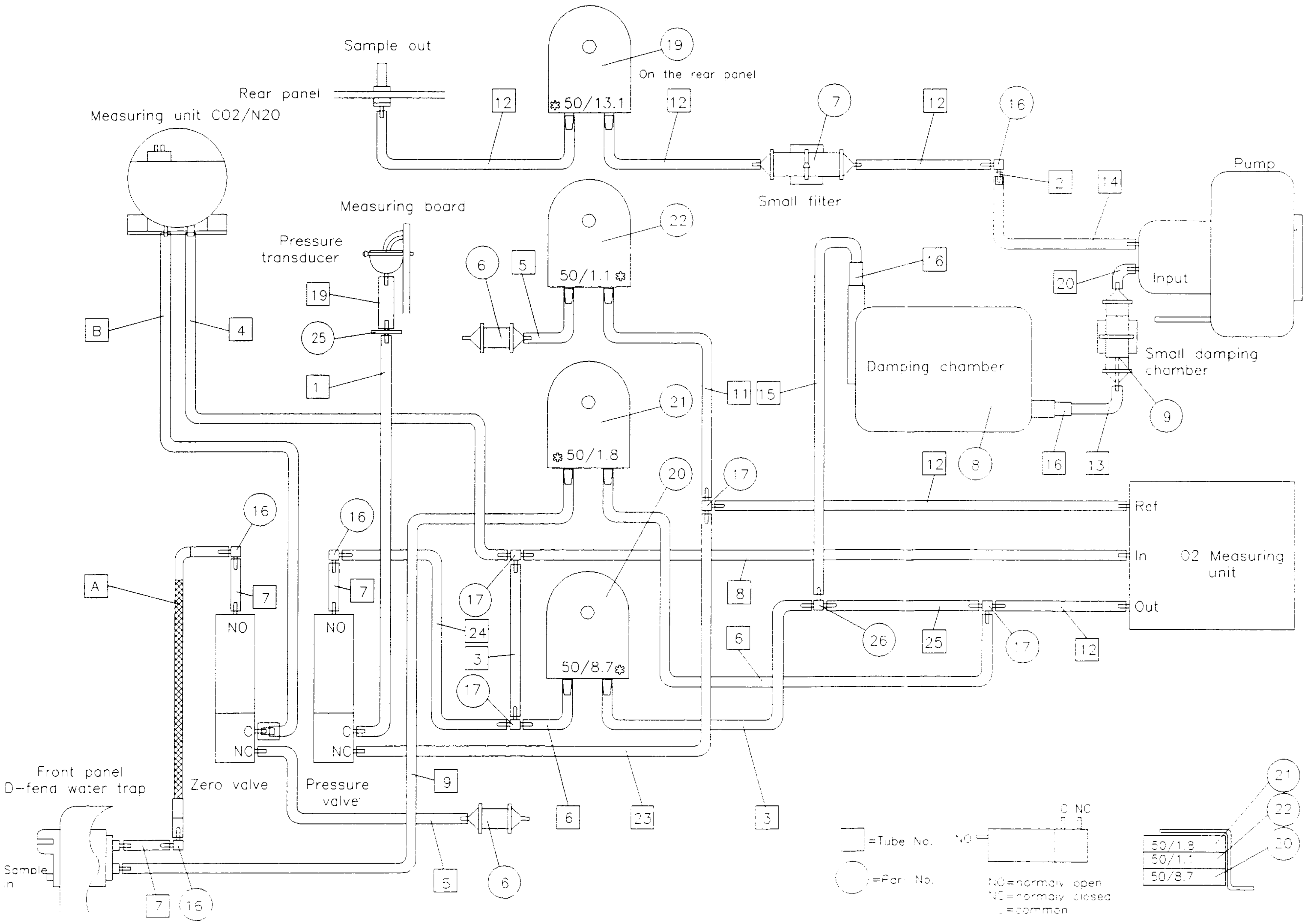


Figure 5.1 Gas sampling system schematic diagram

Figure 5.2 Gas sampling system layout
(modification level 6 and higher)



In CG-CS and CG-2CS monitors,
O2 measuring unit is compensated by
three extra cassettes shown below.

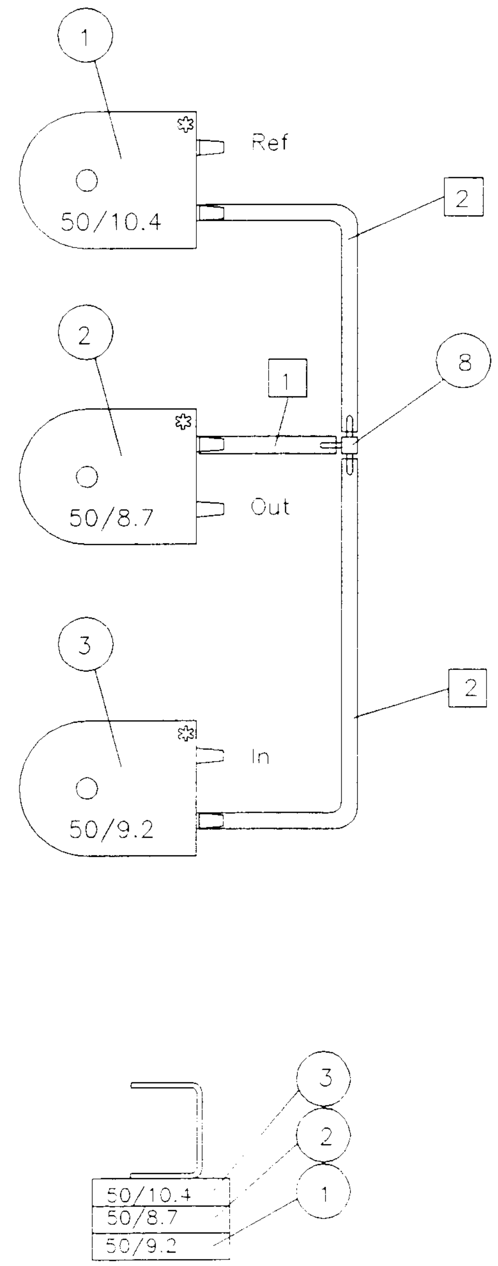


Table 5.1 Tube lengths

TUBE NO.	DESCRIPTION	CODE	PCS	LENGTH/mm
A	Special sample tube	876432	1	300±10
B	Sample tube	878868	1	430
1	1.7/1.05 mm Silicone	73373	1	265
2	1.7/1.05 mm Silicone	73373	1	10
3	1.7/1.05 mm Silicone	73373	2	20
4	1.7/1.05 mm Silicone	73373	1	325
5	1.7/1.05 mm Silicone	73373	1	100
6	1.7/1.05 mm Silicone	73373	3	30
7	1.7/1.05 mm Silicone	73373	6	20
8	1.7/1.05 mm Silicone	73373	1	110
9	1.7/1.05 mm Silicone	73373	1	590
10	1.7/1.05 mm Silicone	73373	1	85
11	1.7/1.05 mm Silicone	73373	1	35
12	1.7/1.05 mm Silicone	73373	5	120
13	3.18x6.35 mm Silicone	73375	1	110
14	3.18x6.35 mm Silicone	73375	1	240
15	3.18x6.35 mm Silicone	73375	1	125
16	4.8x9.5 mm Silicone	73376	2	25
17	10/2.5 mm Silicone	73377	1	30
18	d=2/hole 1 translu vinyl	73341	1	430
19	3.18x6.35 mm Silicone	73375	1	70
20	3.18x6.35 mm Silicone	73375	1	100
21	10/2.5 mm Silicone	73377	1	50
22	0.5x0.2 mm Polyester	73352	1	40
23	1.7/1.05 mm Silicone	73373	1	25
24	1.7/1.05 mm Silicone	73373	1	90
25	1.7/1.05 mm Silicone	73373	1	40

Table 5.2 Other sampling system parts

PART NO.	PART	CODE
19	Constriction cassette	Selected individually,
20	Constriction cassette	see Table 5.2 for
21	Constriction cassette	alternatives
22	Constriction cassette	
8	Damping chamber	57150
16	L-piece	733811
17	T-piece	733821
6	Dust filter	86901
7	Small filter	879354
9	Small damping chamber	879355
26	T-piece	73384
25	Adapter piece	73388

NOTE: Constriction cassettes are selected to adjust proper flow rates. See the following page for alternatives.

Additionally in CS and 2CS models

PART NO.	PART	CODE	PCS	LENGTH/mm
1	1.7/1.05 mm Silicone	73373	1	25
2	1.7/1.05 mm Silicone	73373	2	75
8	T-piece	733821		
2*	Constriction cassette 50/8.7	873804	1	
1*	Constriction cassette 50/10.4	873803	1	
3*	Constriction cassette 50/9.2	873509	1	

* Factory set cassettes. These cassettes cannot be changed to adjust flow rates.

CONSTRICTION CASSETTE	CODE
50/26.0	878048
50/19.0	873800
50/16.3	878047
50/15.3	873801
50/14.1	878046
50/13.1	873802
50/12.4	878045
50/11.2	874770
50/10.4	873803
50/9.2	874509
50/8.7	873804
50/7.4	873805
50/6.5	878044
50/5.8	873806
50/5.1	878043
50/4.4	873807
50/3.8	878042
50/3.2	873808
50/3.0	878040
50/2.8	878039
50/2.5	878038
50/2.3	873809
50/2.0	878037
50/1.8	873810
50/1.6	878036
50/1.4	873811
50/1.1	873812

NOTE: The number on the cassette represents relative flow when a specific pressure is applied. Therefore 50/26.0 presents the least resistance and 50/1.1 the most.

5.2 CO_2/N_2O measurements

5.2.1 Introduction

The CO_2/N_2O measurement is accomplished using the CO_2/N_2O measuring unit with its related preamplifier board and the CO_2/N_2O measuring board that processes the CO_2/N_2O data. The measuring electronics block diagrams are in Figures 5.3.

5.2.2 Photometer

The CO_2/N_2O photometer is of dual path type. Infrared light passes through a measuring chamber containing the gas to be analyzed, and a reference chamber, which is free of CO_2 and N_2O. The measurement is made by determining the ratio between the two light intensities.

The CO_2/N_2O photometer is shown in Figure 5.4.

A filter wheel is used to control the light that passes through the photometer. The filters are arranged so that the light is passed sequentially:

- first at the CO_2 absorption wavelength through the reference chamber
- then through the measuring chamber
- finally it is blocked completely

The same sequence is repeated at the N_2O absorption wavelength.

After passing through the filters the light is reflected and focused by a mirror onto the infrared detector. This detector measures the three light levels for each gas described above.

There is an optical sensor incorporated in the photometer which produces a light which is reflected off of a reflective surface on the filter wheel and then detected once every revolution. The pulses from this sensor are used to synchronize the electronics to the signal from the infrared detector.

An NTC resistor is used to create a temperature dependant current, which is needed to compensate for thermal drifts. The optical sensor and the NTC resistor are mounted on the synchronizing board (see Figure 5.5).

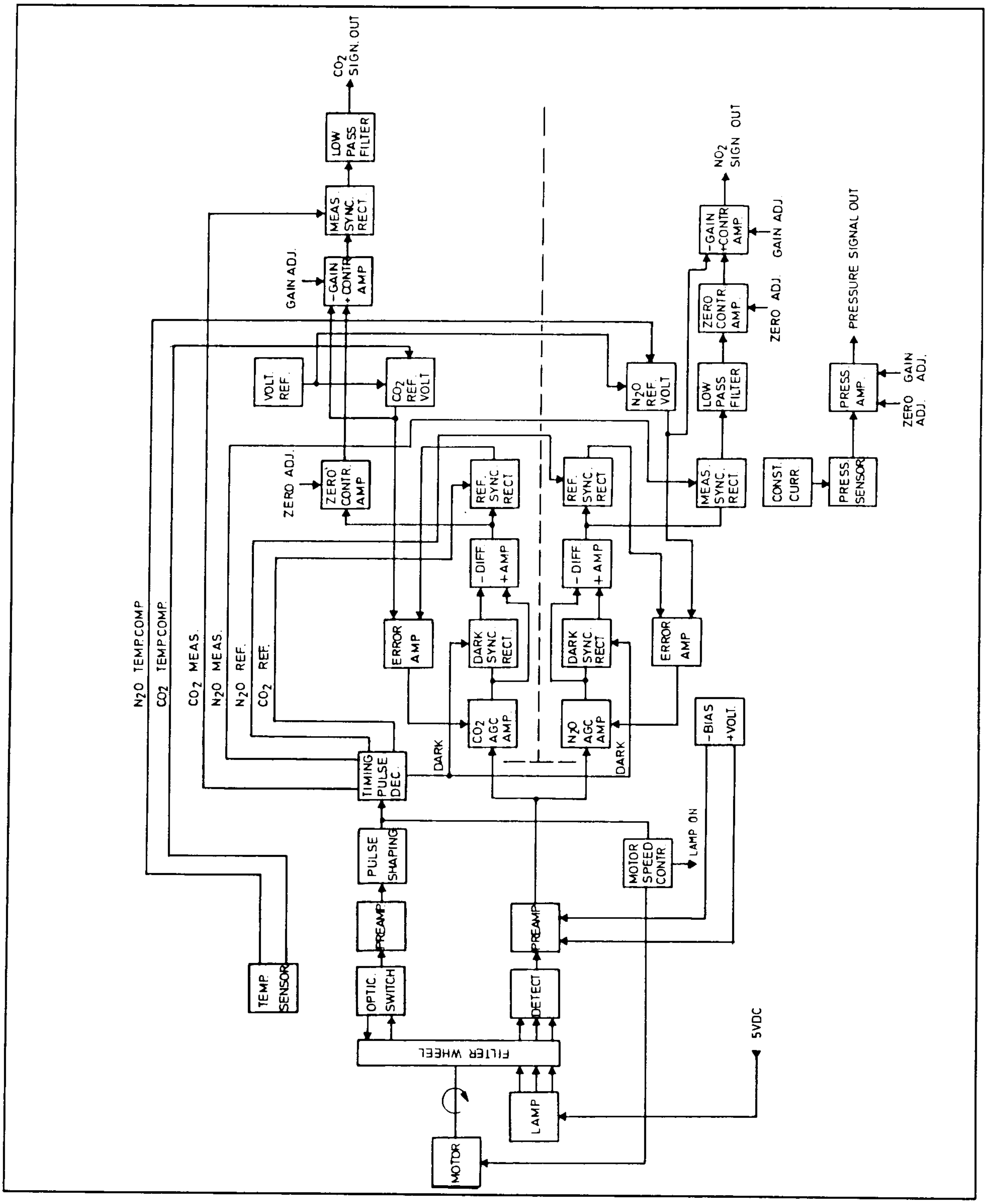


Figure 5.3 CO_2/N_2O measuring system block diagram

Figure 5.4 Photometer

CAUTION: When disassembling the photometer, the focusing mirror has to be removed before lifting off the chopper motor (in order to avoid damaging the chopper wheel).

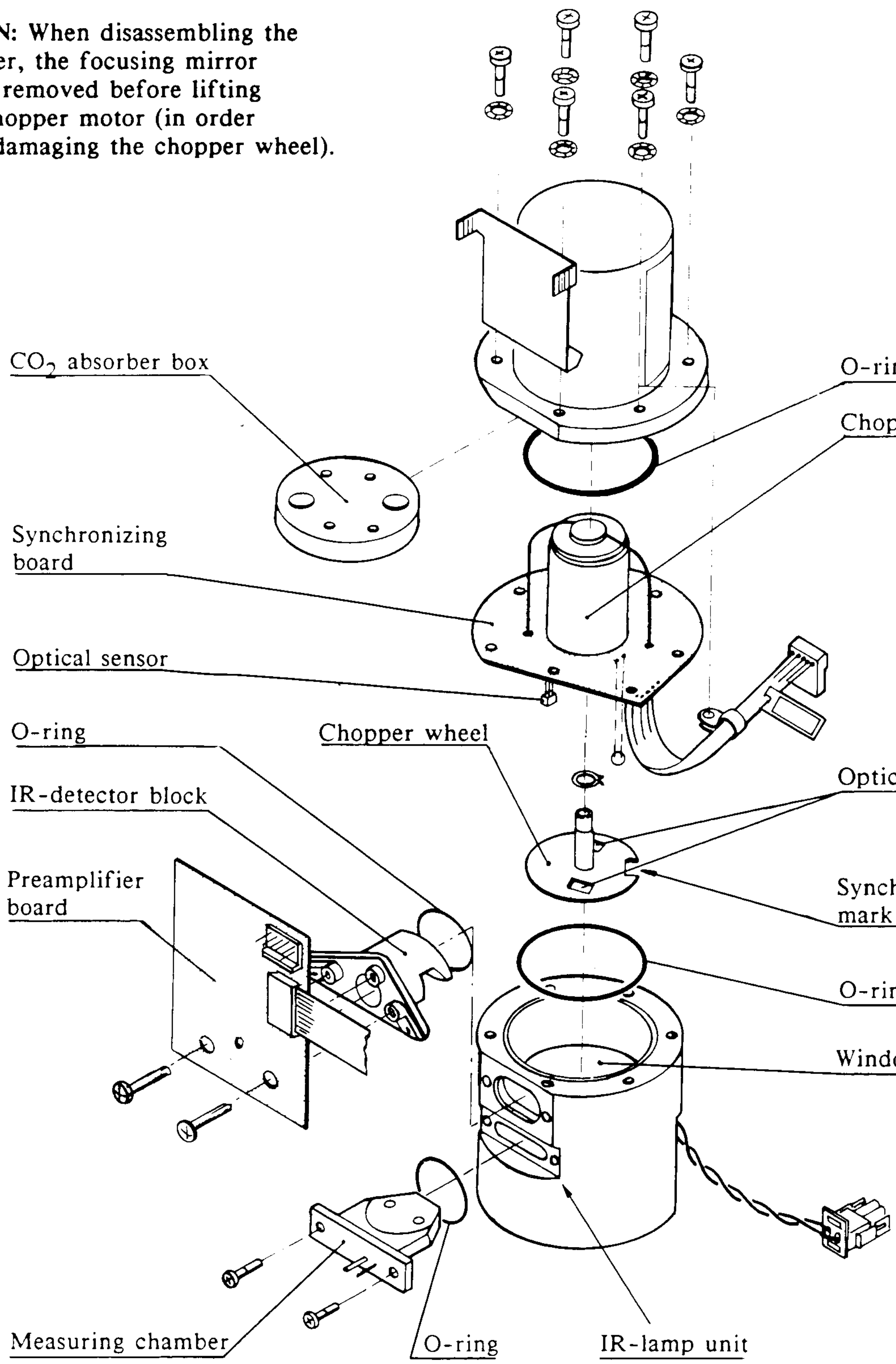
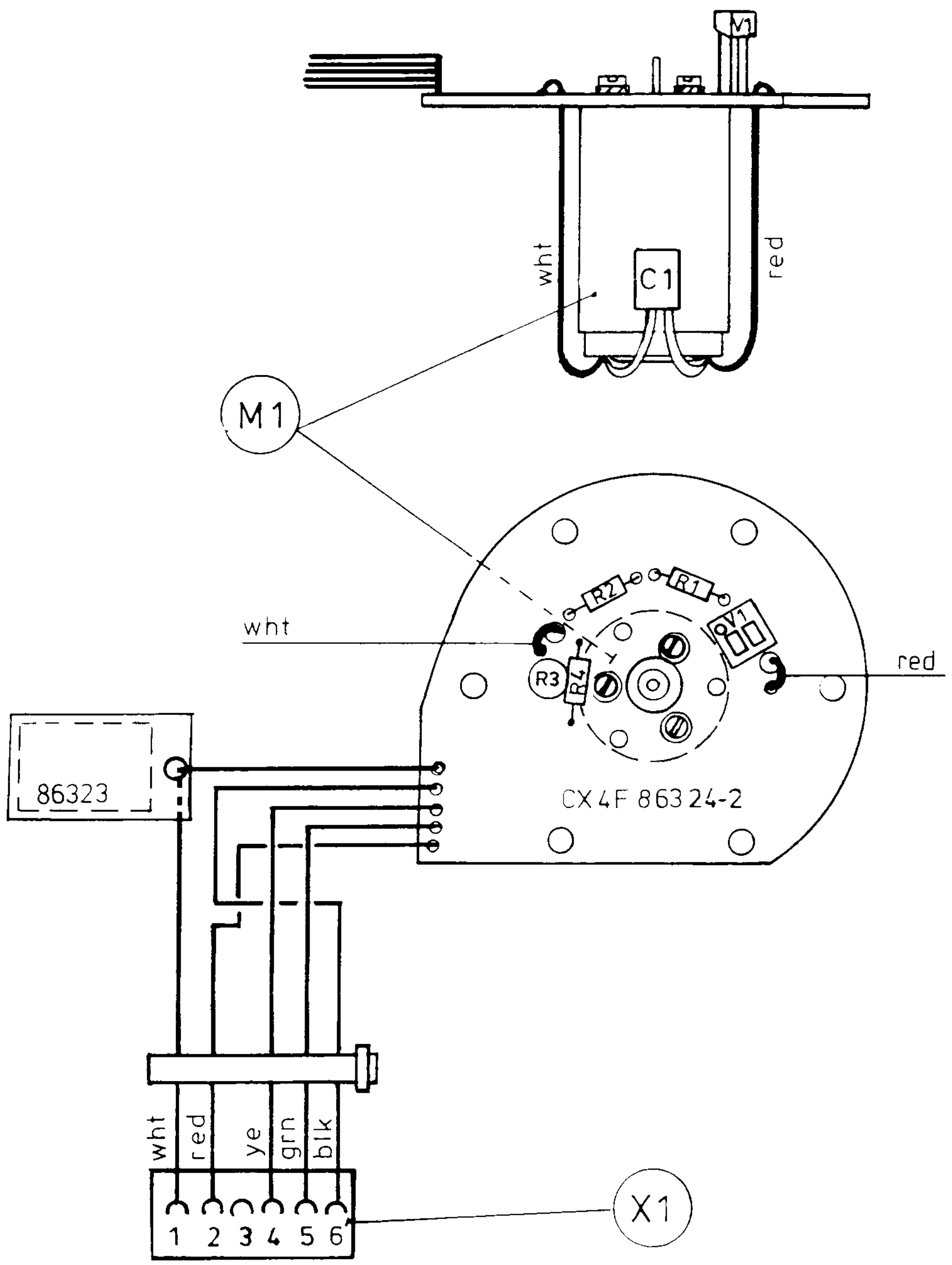


Figure 5.5 Synchronizing board parts layout and schematic diagram
(modification level 6 and lower)



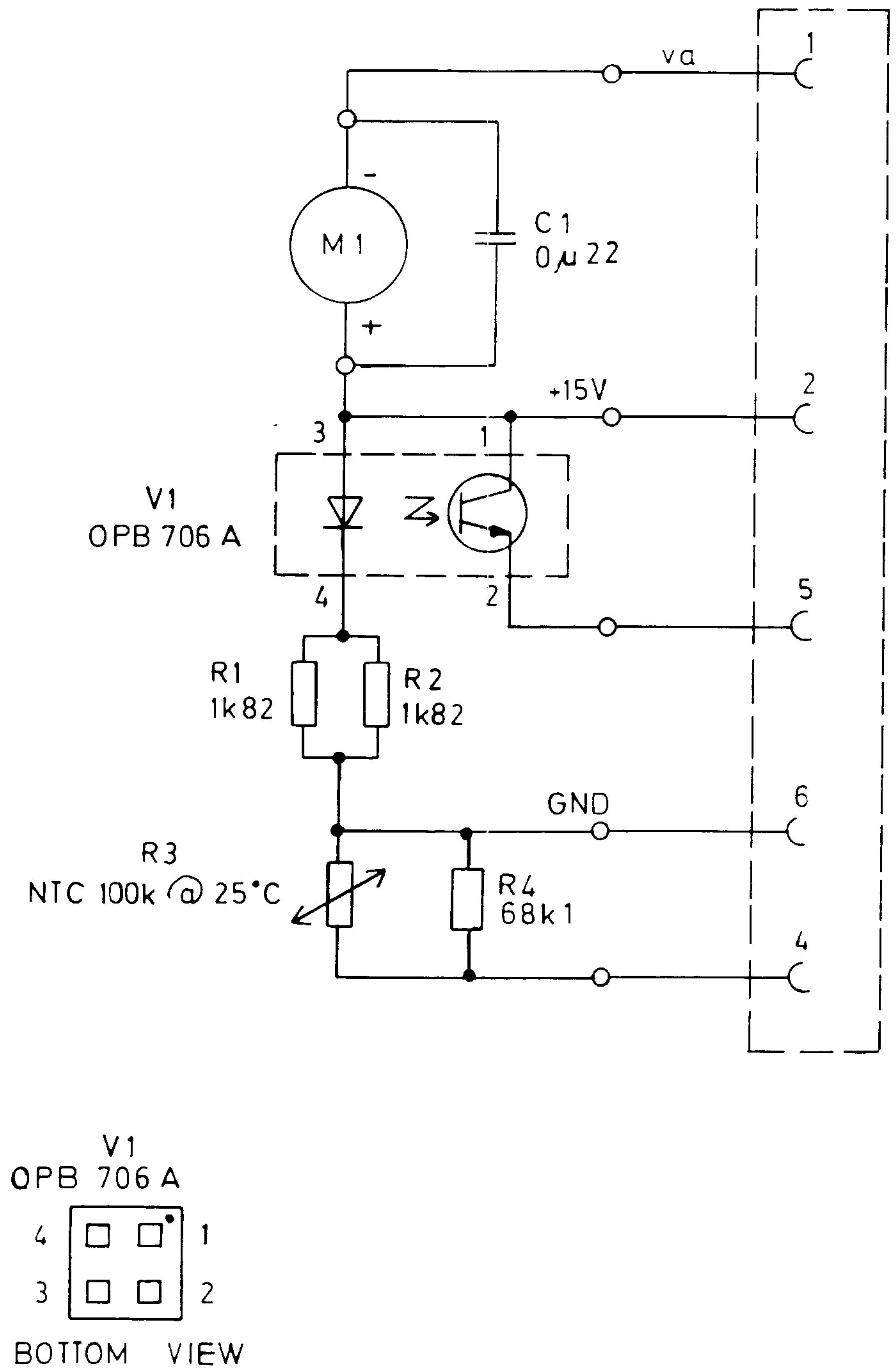
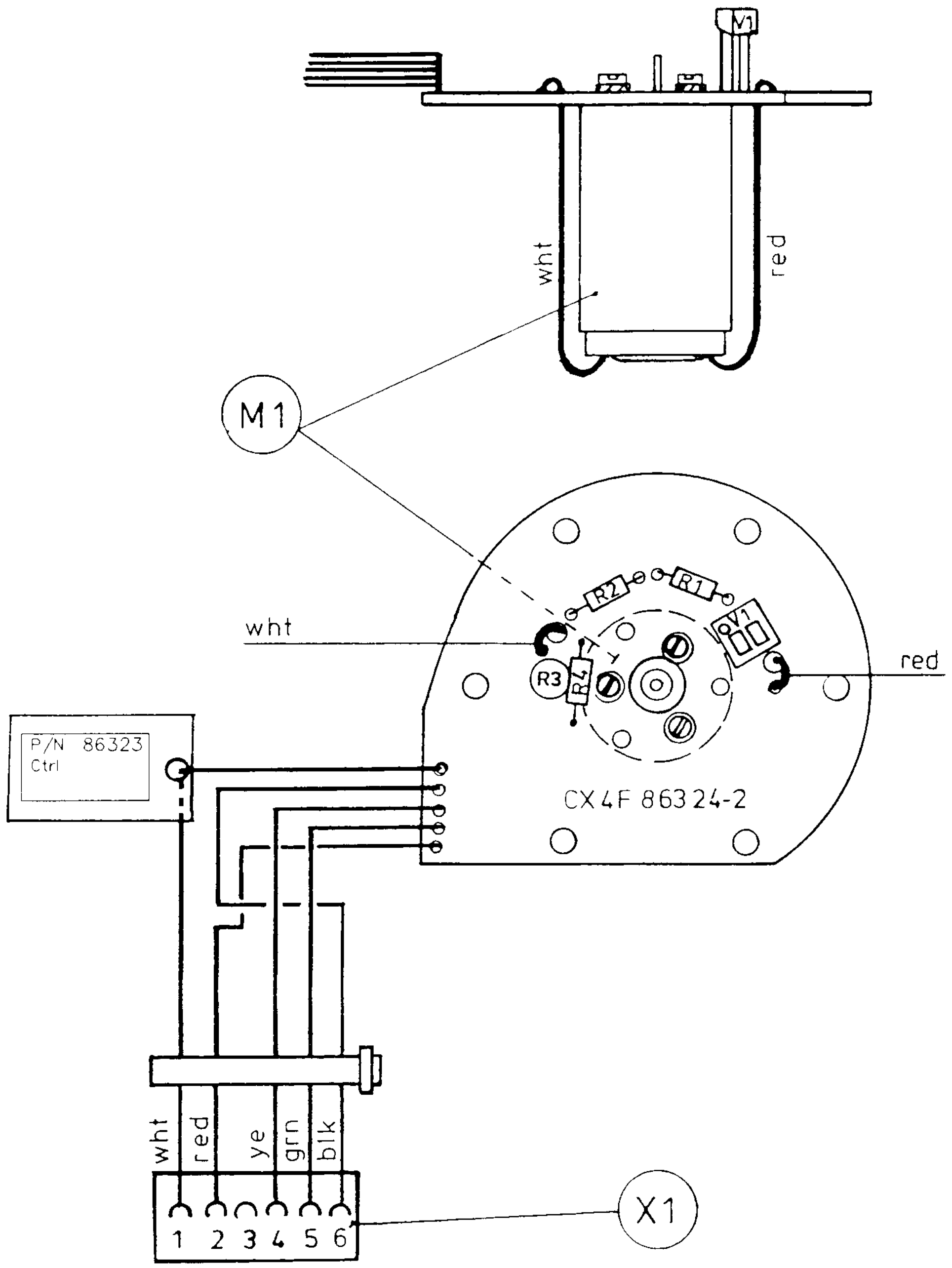
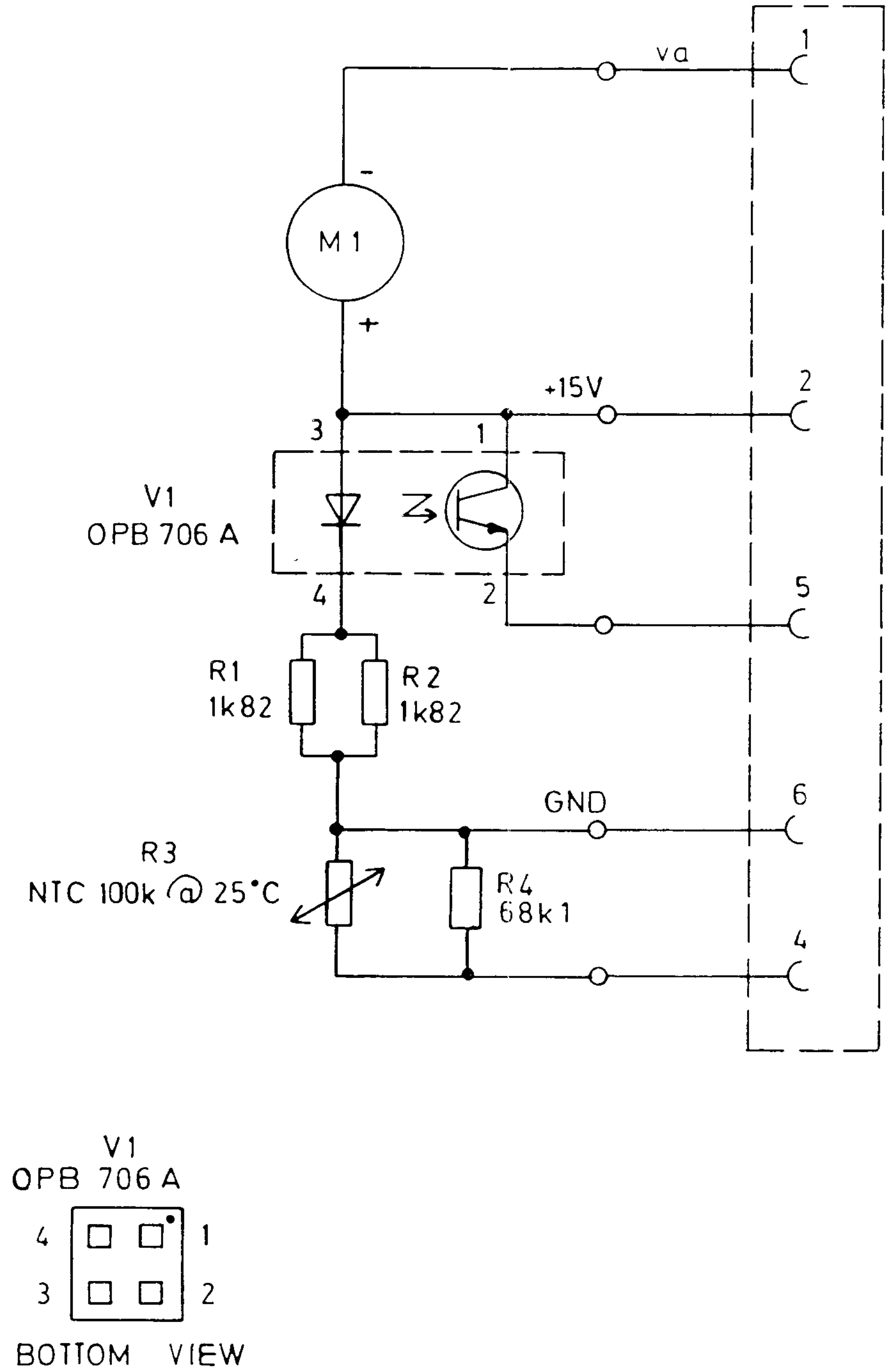


Figure 5.5a Synchronizing board parts layout and schematic diagram
(modification level 7 and higher)





5.2.3 Preamplifier board

The parts layout and schematic diagram of the preamplifier board are shown in Figure 5.6.

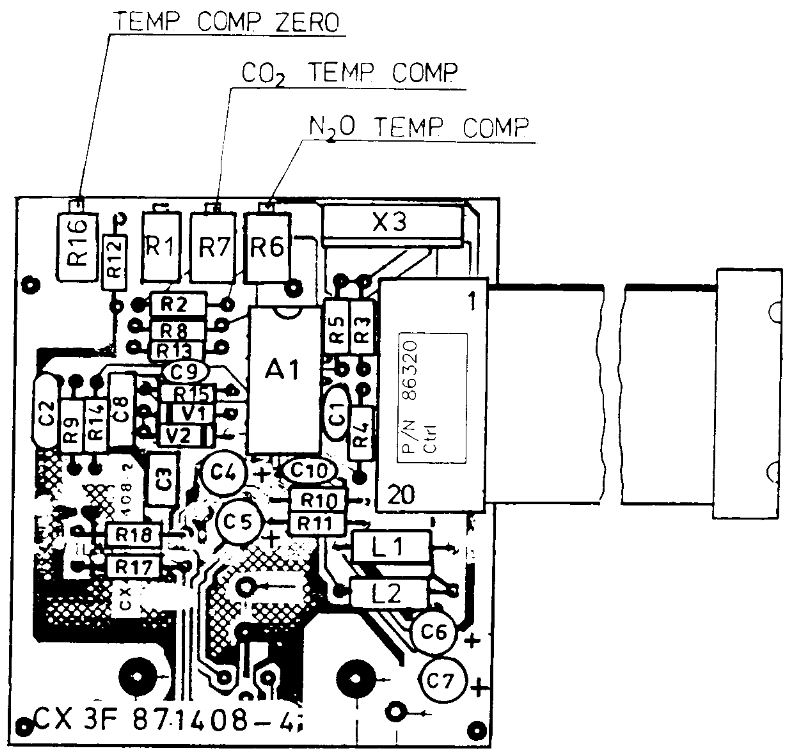
The purpose of preamplifier board is to amplify the signals from the infrared detector, timing sensor, and thermistor and to provide a low impedance input for the next stage.

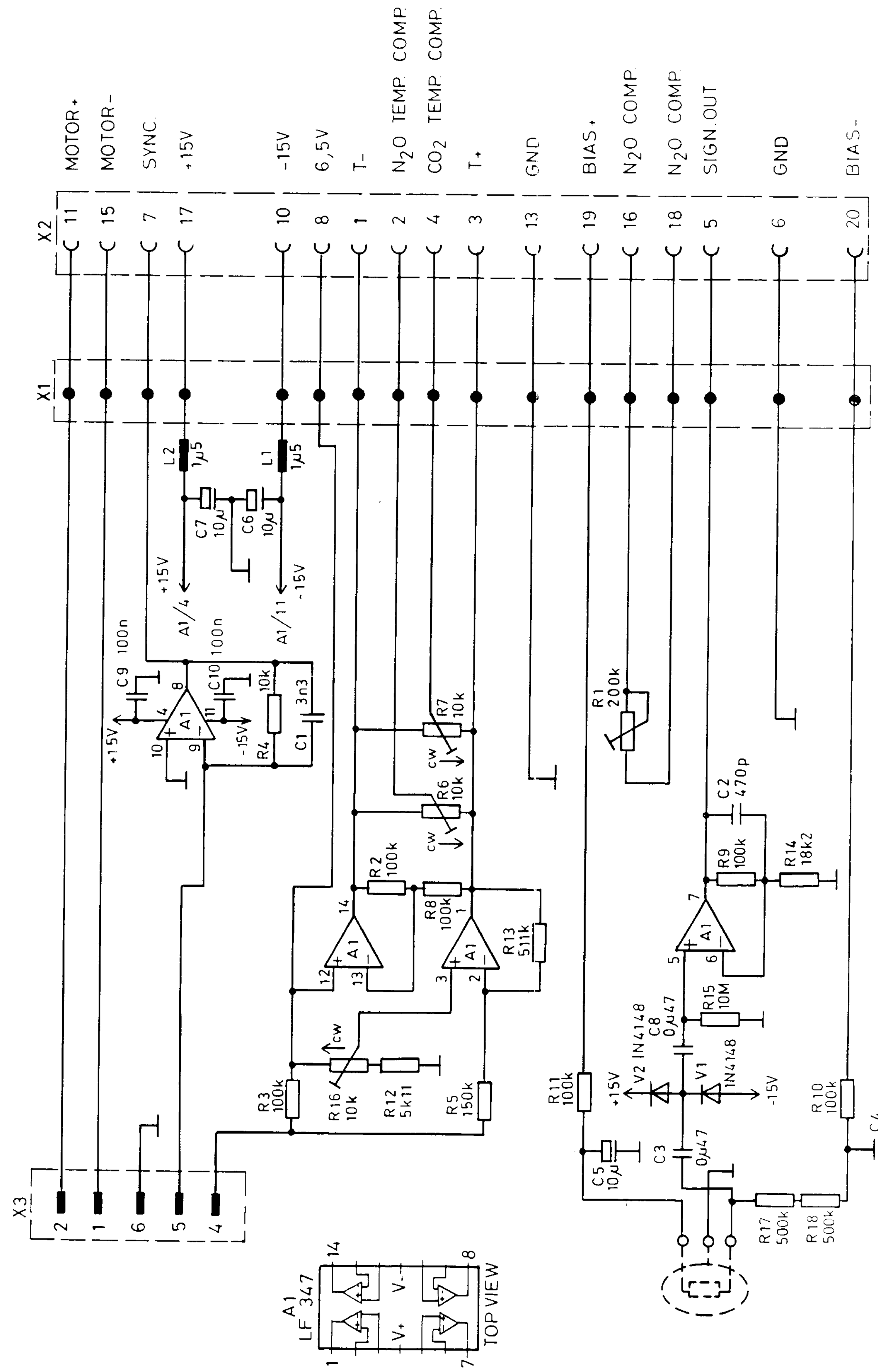
The amplifier for the infrared detector is a non-inverting AC amplifier.

The temperature signal from the NTC thermistor is sent to two amplifiers in parallel, one inverting, and the other non-inverting. The output of the inverting amplifier, (T+) is a voltage that will increase as temperature increases. The output of the non-inverting amplifier, (T-) is a voltage that will decrease as the temperature decreases. The 'zero' level of the signals is set using R16 and the individual compensation signals for CO_2 and N_2O with R7 and R6 respectively.

The current signal from the timing sensor is converted to a voltage with the remaining section of A1.

Figure 5.6 Preamplifier board parts layout and schematic diagram





5.2.4 CO_2/N_2O measuring board

The measuring electronics can be divided into a few functional blocks, which are described below.

Detector bias generator

The lead selenide detector is basically a resistor, whose resistance decreases in infrared light. For this reason it is advantageous to supply the detector with a high bias voltage, as a higher signal is then achieved.

The bias voltage generator utilizes one section of A8, which is connected as a square wave oscillator, and a conventional voltage doubler built of diodes V6 to V9 and capacitors C34, C35, C37, and C38. The circuit gives an output voltage of approximately $\pm$22 V.

Timing electronics

The timing electronics consists of a pulse shaping circuit built of three sections of A8, and logic circuits D3 to D7. See Figure 5.7.

The phase locked loop gives an output frequency, which equals the signal frequency multiplied by 40. This output is divided by the counters D7 and D5 to reconstruct the original frequency. From the outputs of these counters the control pulses for the synchronous rectifiers are decoded with the multiplexers D3 and D4.

The timing pulse produced by the optical sensor on the photometer is transmitted from the photometer and preamplifier board to A8 on the measuring board. A8 and its related electronics are pulse shaping circuits whose output is a square wave pulse for the counter and multiplexer as well as for the motor speed control circuits.

CO_2 measuring electronics

The signal from the preamplifier board comes into the measuring board through X2 pin 5. It is first amplified by the 'electronic potentiometer' circuit A4, one half of which is used for the CO_2 automatic gain control.

From this IC output samples of the dark phase are taken by an analog switch (1/4 D1) to capacitor C3. The dark level is subtracted from the original signal with a differential amplifier (1/4 A2, R4 to R7), so that at the output of this amplifier the dark level is at ground potential.

Another analog switch takes samples of the CO_2 reference level to C10. This voltage is compared to a standard voltage by 1/4 A2 and the output of this amplifier is used to control the gain of A4 so that the reference voltage is kept equal to the standard voltage. The standard voltage is initially supplied by V2. To compensate for effécts of temperature on the CO_2 measurement, a temperature dependent voltage from the photometer is connected to the summing point at A2 input 10 to affect the standard voltage and consequently the gain of the AGC amplifier.

The signal from the output of A2 (pin 7) is transmitted to the input of another operational amplifier (1/4 A3). The gain of this amplifier is adjusted using the trim potentiometer R23 (CO_2 coarse zero) so that the standard voltage and the signal cancel each other at A1 input 3 when there is no CO_2 in the measuring chamber. The span of the CO_2 measurement is adjusted using R16 (CO_2 coarse gain).

The measuring phase of the signal is sampled with the analog switch 1/4 D1, and finally the DC signal is low-pass filtered to reduce noise and switching ripple.

N_2O measuring electronics

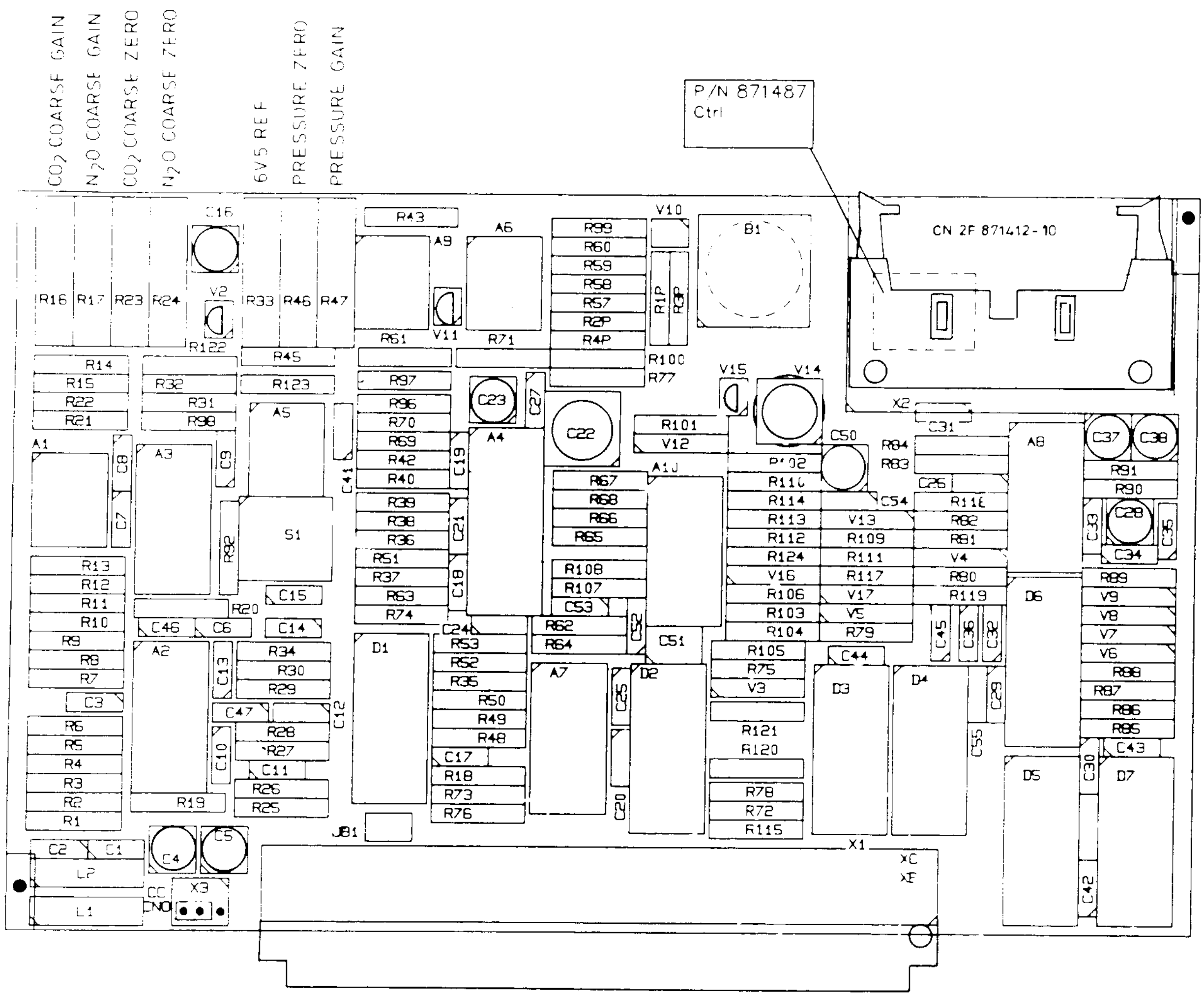
The N_2O signal is processed the same way as CO_2. The N_2O measuring electronics are similar to the CO_2 measurement circuit. The only difference is that the sampling of the measuring phase and low pass filter in the N_2O circuit are placed before the zero and gain adjustment circuits, to facilitate the adjustments in spite of the longer time constant of the low pass filter.

Motor speed control circuit

The speed of the chopper motor is stabilized by the circuit consisting of a one shot and an integrator/comparator. The pulses from the timing electronics trigger the one shot at a frequency that corresponds to the speed of the motor.

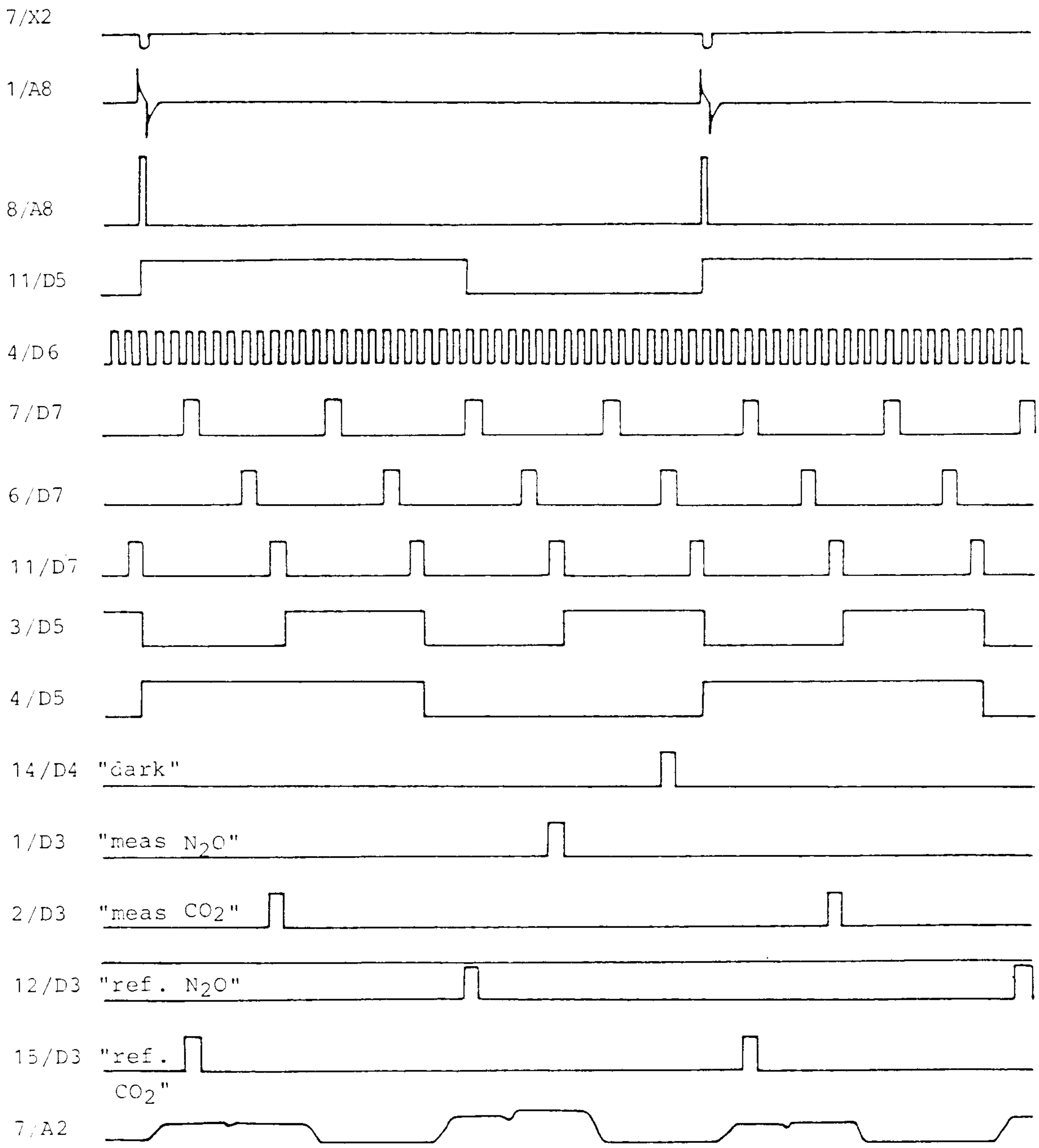
The output pulses from the one shot are fed into the integrator/comparator. The voltage at the output of this circuit depends on the difference between the mean of the pulse train and the DC voltage at its other input. This voltage is inverted and used to control the transistor V14, which in turn drives the chopper motor. The circuit tends to keep the duty cycle of the pulse train constant, and consequently stabilize the speed of rotation of the motor. The transistor V15 limits the motor current to approximately 50 mA.

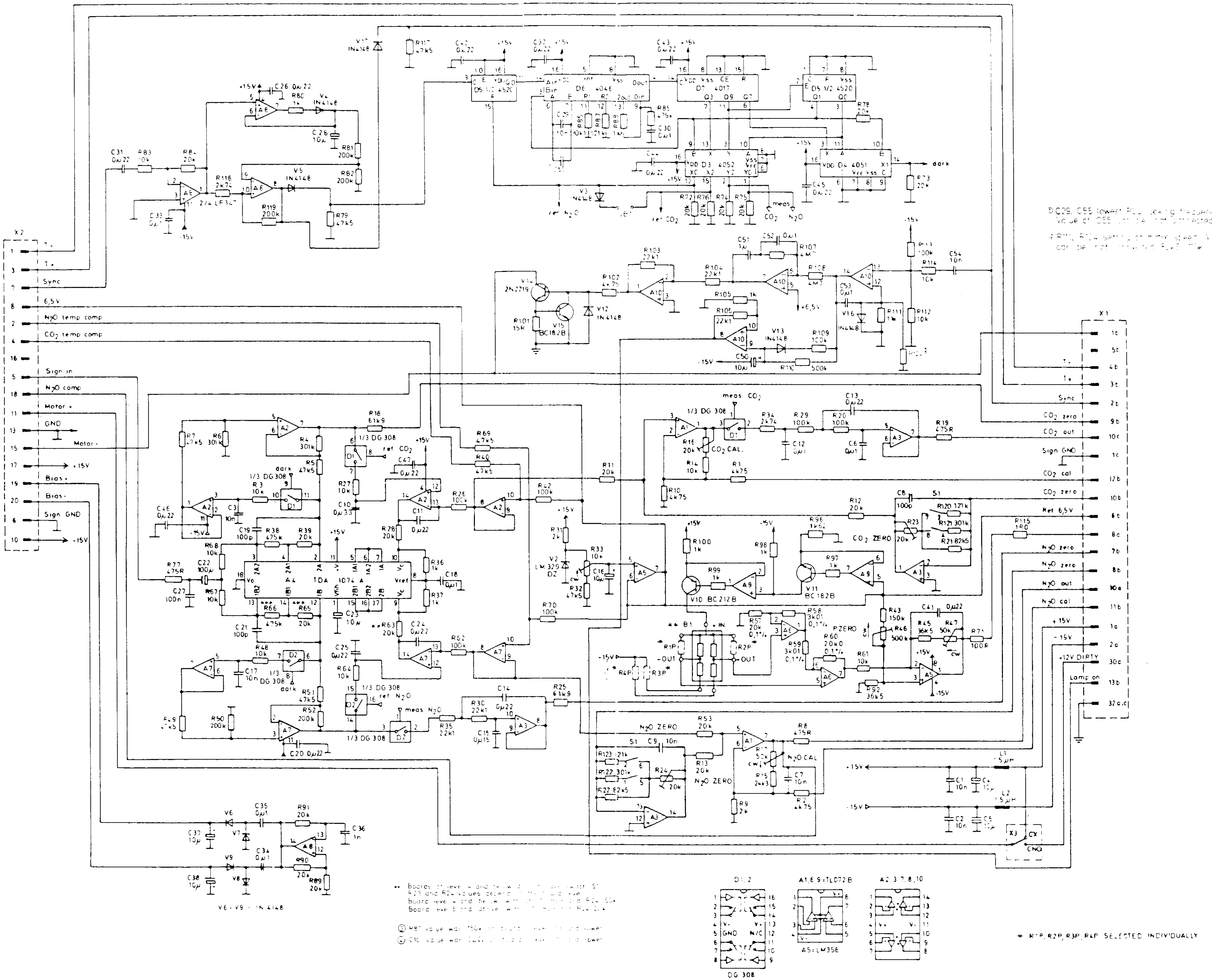
Figure 5.7 CO_2/N_2O measuring board parts layout



NOTE! BOARD LEVELS 4 AND BELOW DON'T HAVE SWITCH S1

Figure 5.8 CO_2/N_2O measuring board timing diagram and schematic diagram





X2
T-
T+
Sync
6,5V
N2O temp comp
CO2 temp comp
Sign in
N2O comp
Motor +
GND
Motor -
+15V
Bias+
Bias-
Sign GND
-15V
X1
Sync
CO2 zero
CO2 out
Sign GND
CO2 cal
CO2 zero
Ref 6,5V
N2O zero
N2O zero
N2O out
N2O cal
+15V
-15V
+12V DIPTY
Lamp on
TDA 1074 A
DG 308
A1,6,9=TL072B
A5=LM358
A2,3,7,8,10
V6-V9 = 1N 4148
* R1P, R2P, R3P, R4P SELECTED INDIVIDUALLY

5.2.5 O_2 measurement

The oxygen measurement is based on the paramagnetic susceptibility, which is a unique property of oxygen among all gases generally present in a breathing gas mixture. The gas to be measured and the reference gas (room air), are conducted into a gap in an electromagnet with a strong magnetic field switched on and off at a frequency of approximately 165 Hz.

A differential pressure gradient is generated between the sample and reference inputs due to forces acting on the oxygen molecules within the magnetic field.

The pressure is measured with a sensitive differential transducer, rectified with a synchronous detector and amplified to produce a DC voltage proportional to the oxygen partial pressure difference of the two gases.

CAUTION: Due to the complicated and sensitive mechanical construction any service inside the O_2 measuring unit should not be attempted, and therefore the detailed description of the circuitry and layout of the transducer is omitted from this manual.

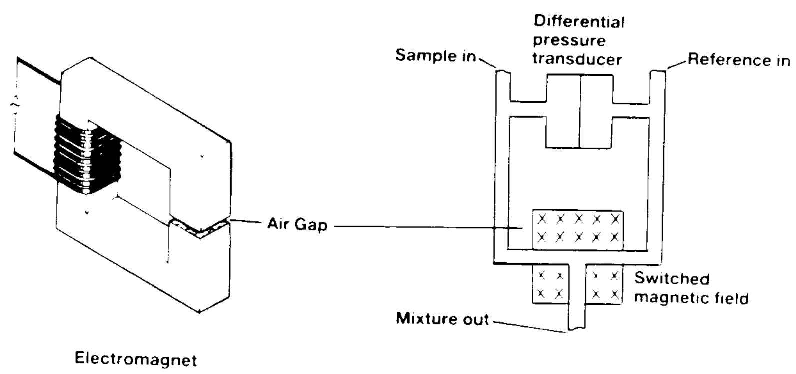


Figure 5.9 O_2 measurement principle

5.3 ECG board

The ECG board is an isolated amplifier that accepts the low level (approx. 1 mV) signal from the patient cable via the protection circuitry and the lead selector. The signal is filtered and amplified to A/D-conversion levels.

ECG input

The input circuit has a four position switch for selecting the desired patient lead configuration and directing the signal into the preamplifier input.

Defibrillation and ESU protection

Input protection against defibrillation pulses (typically 5 kV/400 J) is established by 4.7 kohm/1 W resistors and 6800 uH coils in each patient cable lead and by the spark gap F2.

At the input there is also the electrosurgery interference (ESU) filter (R22, R23, R28, R29 and C6-C8) and a diode circuit that serves as input limiter and provides input amplifier saturation bias if the patient connection is broken, (LEADS OFF).

The patient isolation section is shielded by a metal enclosure to prevent high frequency ESU interference. A second spark gap is connected across the isolation barrier to allow a controlled passage for static voltages which otherwise would destroy the isolation components.

Amplification

Each input is amplified by standard non-inverting amplifiers which drive a differential amplifier, whose output is sent to a pulse width modulator operating at approximately 5 kHz. The pulse width modulated signal drives an optocoupler that transmits the ECG signal across the isolation barrier.

ECG output

The output stage consists of a pulse width demodulator, low pass filter and an adjustable 50/60 Hz notch filter. The signal is demodulated, filtered and sent to an analog multiplexer on the CPU board.

Leads off/Pacemaker pulses

Input amplifier saturation caused by a lead off or by a high slew rate pulse is detected by the IN-OP comparators. In case of LEADS OFF, the INOP output is a steady low voltage state. When a pacemaker pulse is detected, a fast (0.5 - 2 ms) low pulse is produced.

These signals are transmitted across the isolation barrier using an optocoupler. The signals are sent to port C of the 8255 PPI on the CPU board. The constant low signal will produce the LEADS OFF message on the display and output data string and pacemaker pulse will be clipped from the ECG waveform.

ECG power supply

Isolated power is generated by a small 100 kHz switching converter (D1, V24, V25 and T1) the output of which is a regulated +/-12 V, using zener diodes.

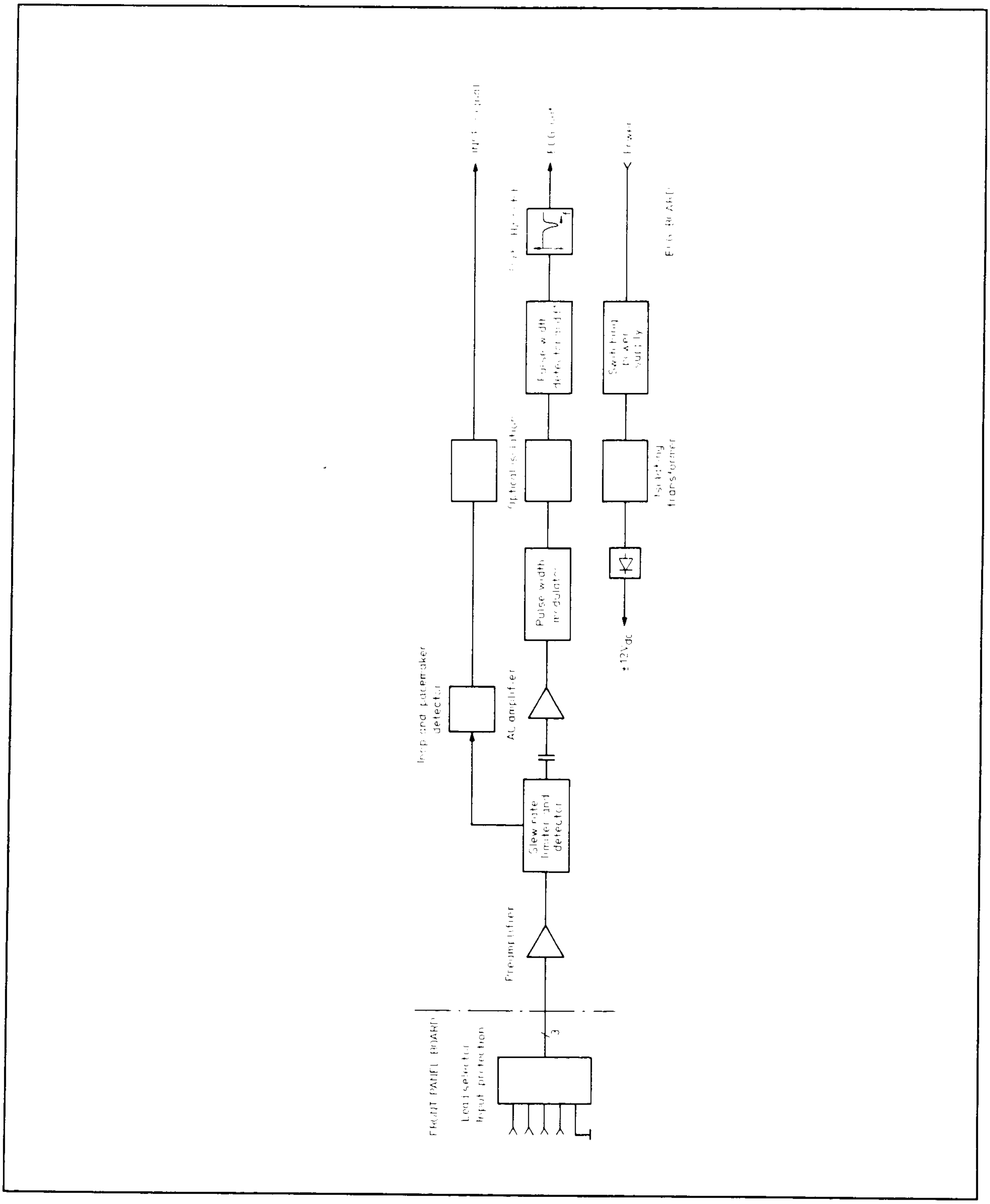
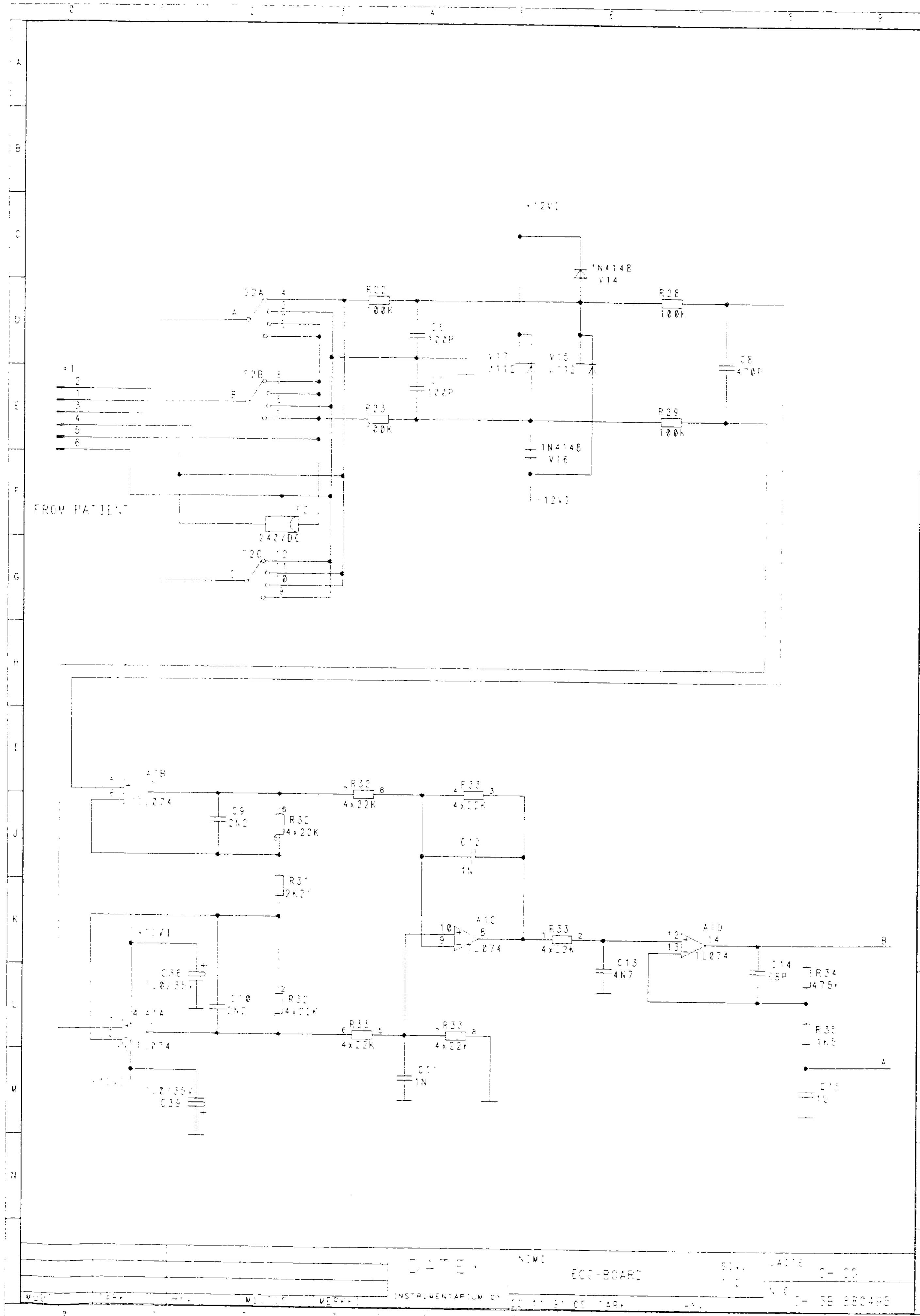
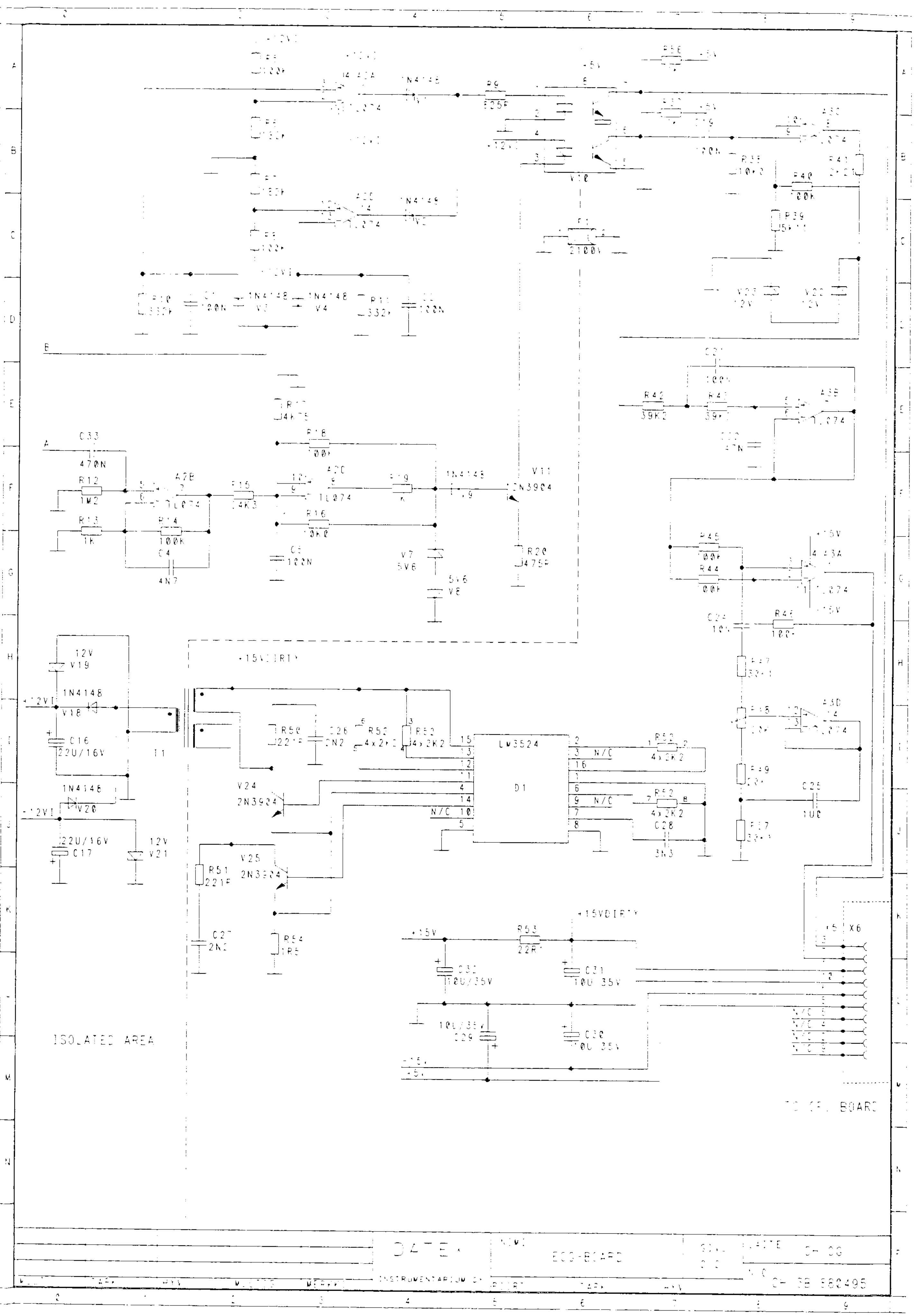


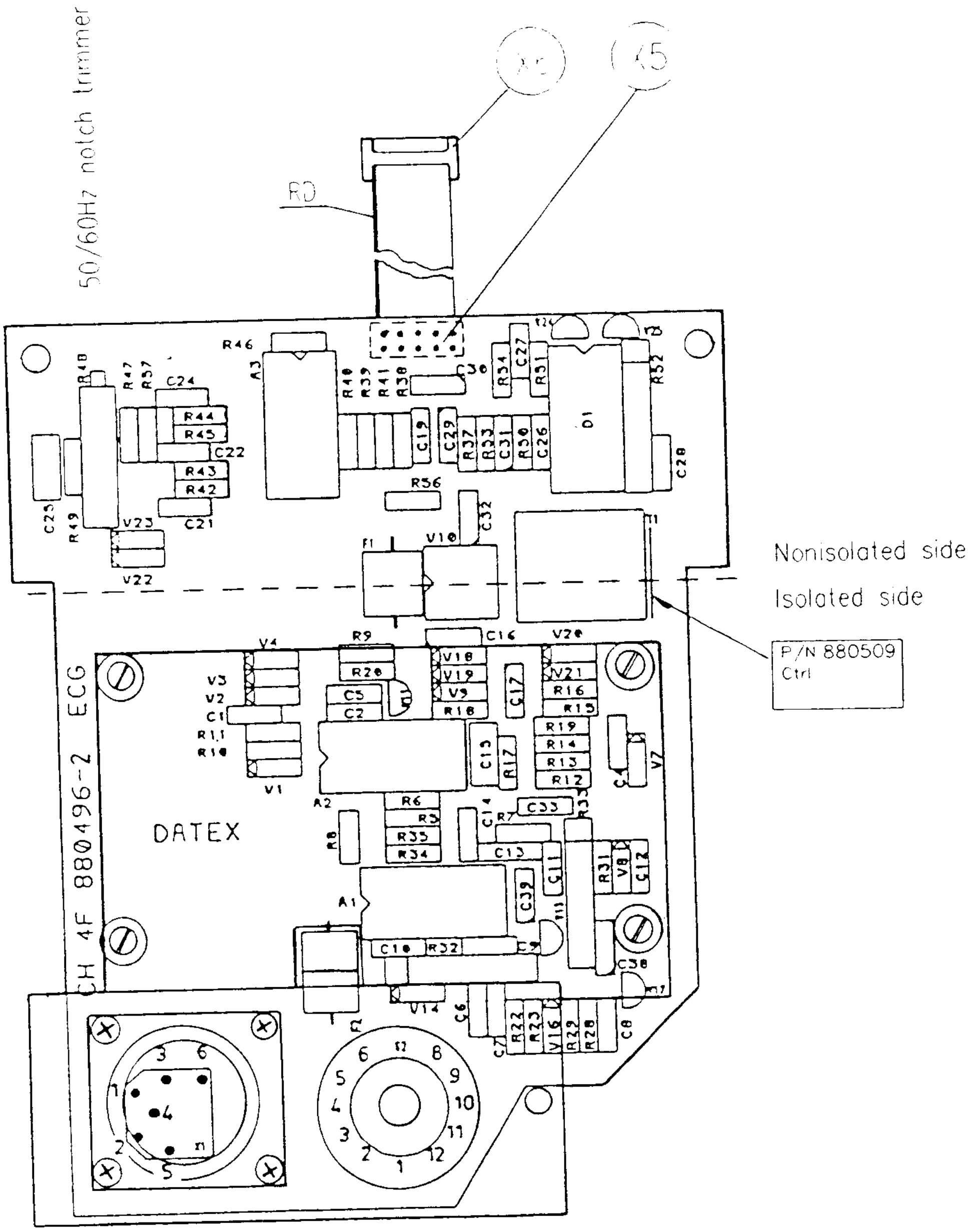
Figure 5.10 ECG board block diagram


FROM PATIENT
ECG-BOARD
DATEX
INSTRUMENTARIUM OY


ISOLATED AREA
TO CPU BOARD
+15VDIRTY
LM3524
ECG-BOARD
DATEX
INSTRUMENTARIUM OY

2/2

Figure 5.11 ECG board parts layout



5.4 IPT (Invasive-Pleth-Temperature) board

The IPT board is designed to support two pressure channels and one temperature channel. However, in models CG-1G and CG-1GS, one pressure channel and two temperature channels are available.

The boards have two common features with the ECG board; the isolating power switcher and the pulse width modulator/ optoisolator/demodulator chain.

The two-pressure channel IPT board generates two real time waveforms:

1. Either a plethysmographic pulse or invasive pressure P1 waveform.

2. Invasive pressure P2 waveform.

The single invasive channel monitors will display either a plethysmographic pulse or invasive pressure waveform.

Temperature

The temperature signal(s) are produced by voltage divider(s), part of which is the patient probe (YSI 400-series thermistor). The output is amplified by the calibrated amplifiers. Offset adjustment and linearization is done by software.

Invasive pressure

The monitor provides +5 V excitation voltage and a ground reference. The transducer output is sent to a single differential amplifier IC. The excitation voltage is sourced from the isolated power supply on the IPT board and all variations in this voltage are compensated for by software.

The Cardiocap senses when a pressure sensor has been inserted into a connector by providing a line on each connector that is held high (pressure flag) by a pull-up resistor. The line is shorted to ground when a pressure transducer is plugged into the monitor. The pressure flag lines are polled by the multiplexer and when the CPU senses the line is grounded, the pressure display is activated.

Plethysmograph

The optical plethysmograph consists of two parts, a LED oscillator and driver, which produce 300 Hz 50 us infrared light pulses to the finger probe attached to the patient, and a phototransistor that picks up the light attenuated by the digit. This light is amplified and its peak value is sampled and filtered. An automatic gain control circuit adjusts the amplifier gain to yield a constant average pulse height at pin 7/A2. The AC-component with a frequency in the heart rate range (0.8 - 10 Hz) is further amplified to yield the pleth pulse waveform.

Signal output

The following signals are multiplexed to a pulse width modulator:

- the temperature channel
- pleth DC
- two pressure flags
- zero and +5 V reference
- pressure differential signal

The multiplexer control is provided by the CPU.

If a second pressure is provided, its differential output is directed to its own pulse width modulator.

After all signals are transmitted across the isolation barrier, they are demodulated, low-pass filtered and transmitted to the analog multiplexer resident on the CPU board.

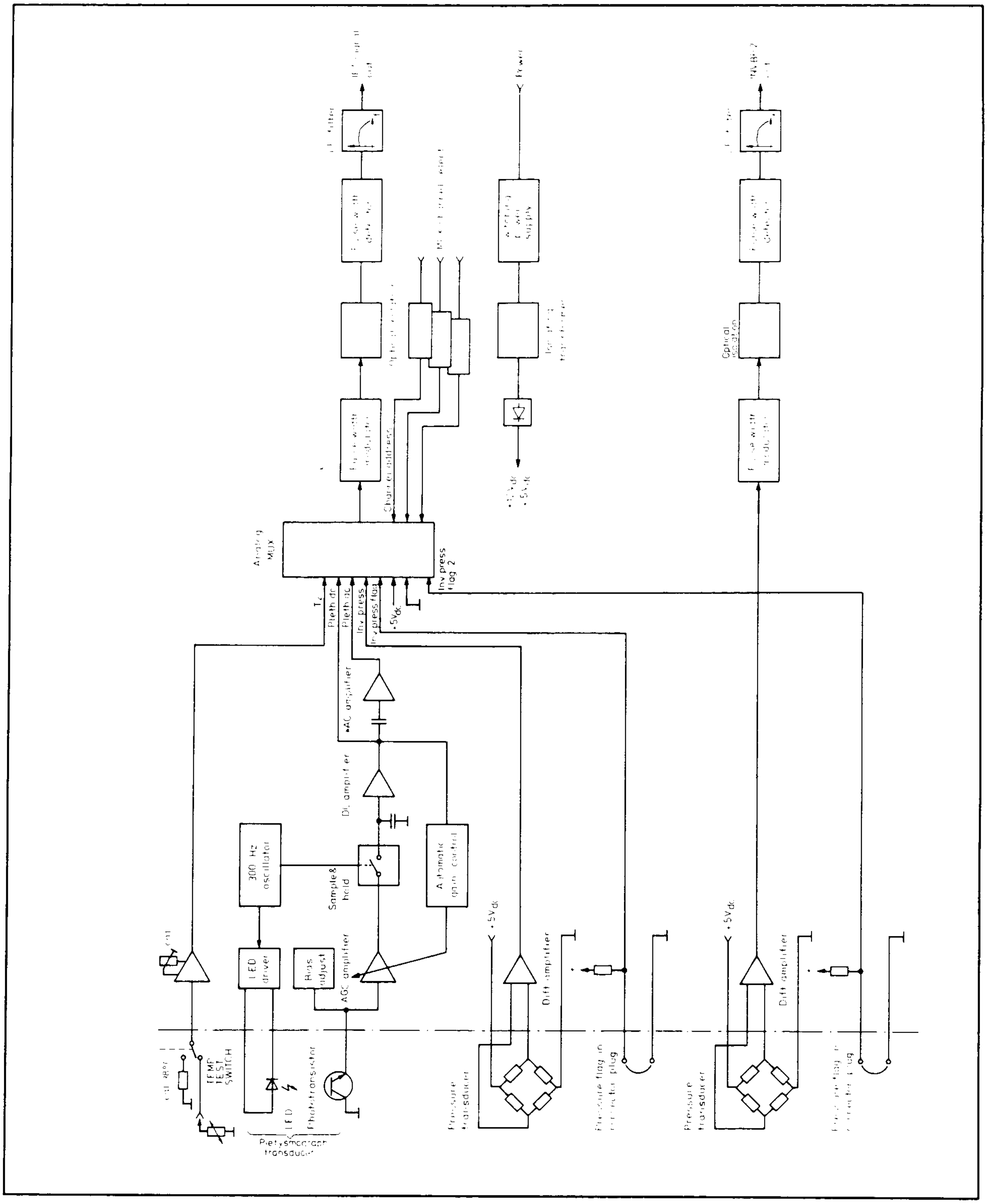
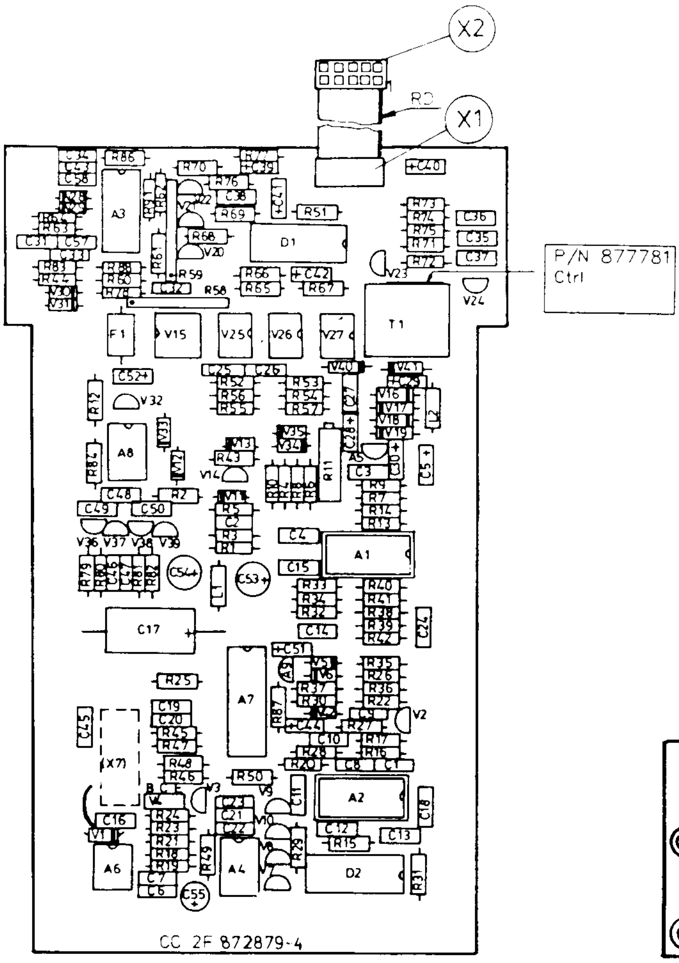
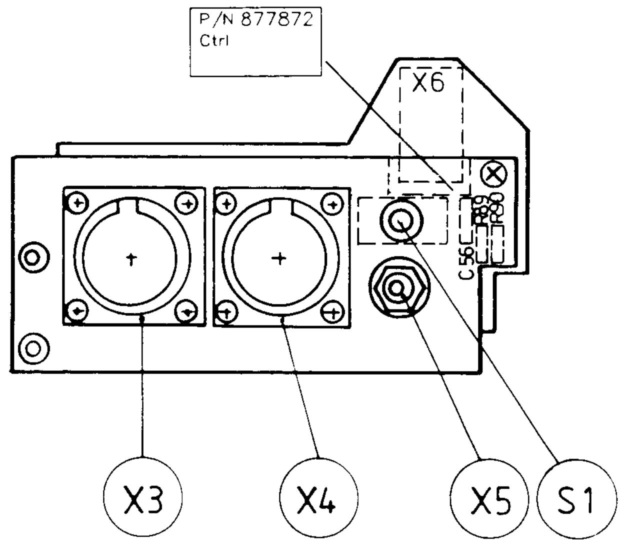


Figure 5.12 IPT board block diagram (CS, 2CS, 2G, 2GS)

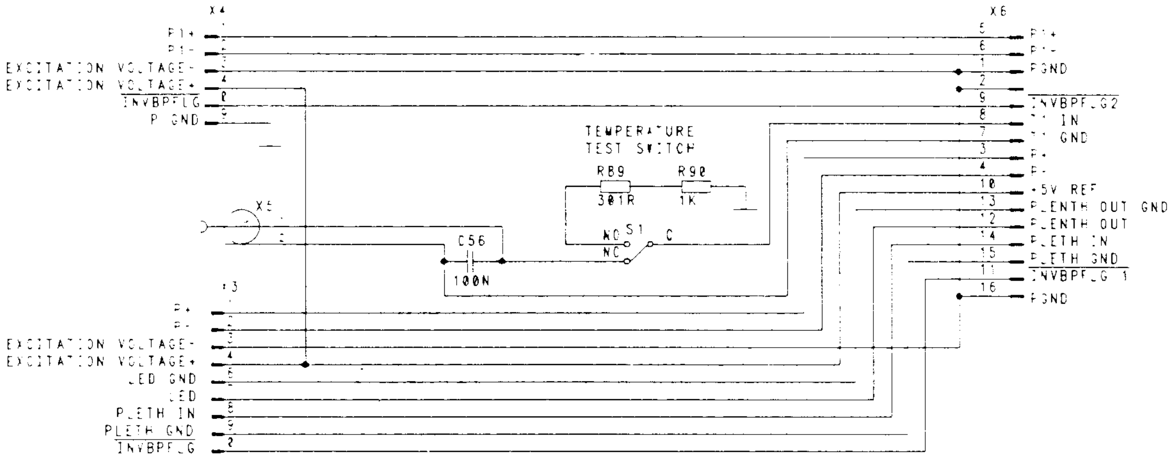
Figure 5.13 IPT board parts layout (CS, 2CS, 2G, 2GS)



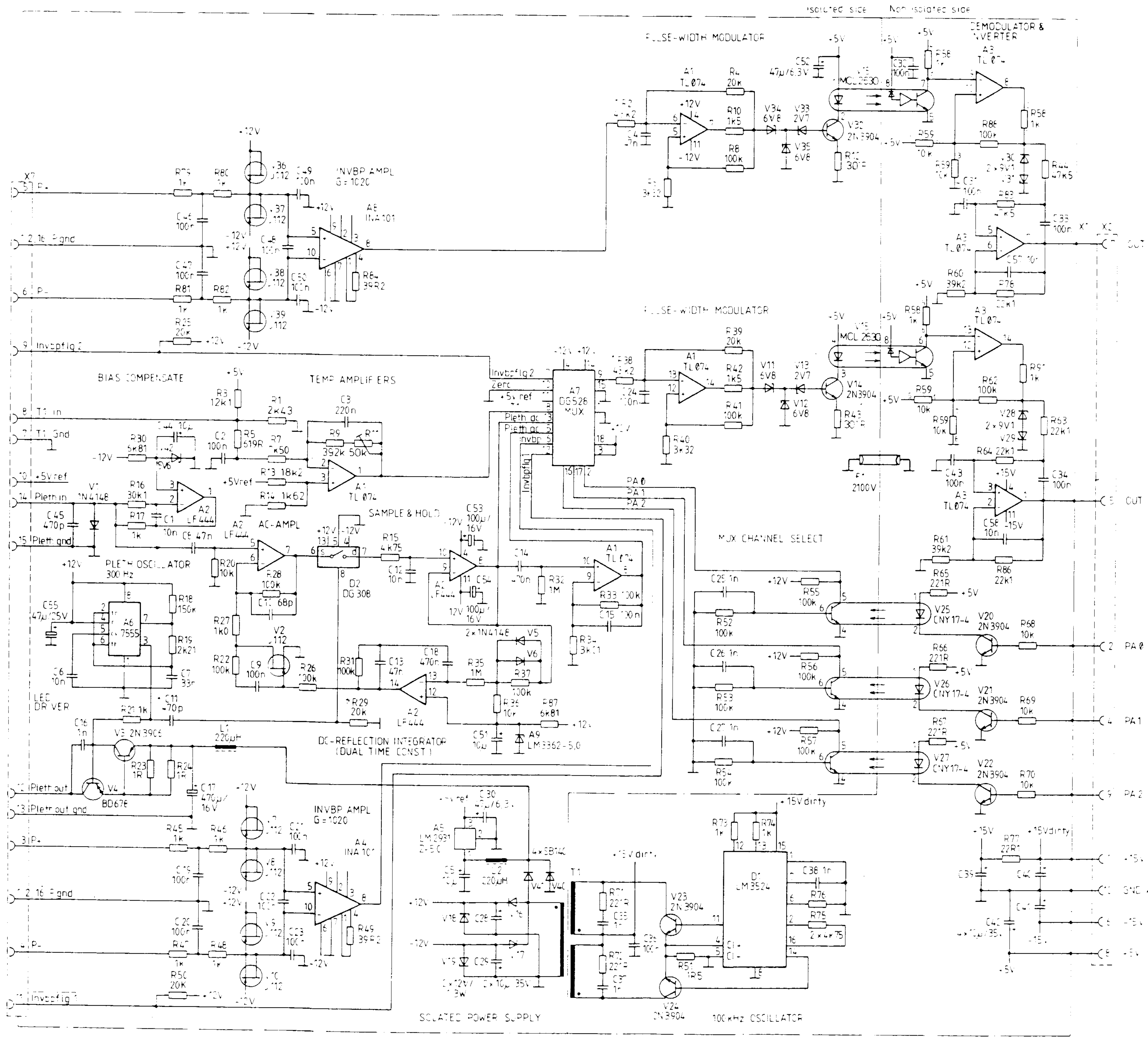


(Connectors both X3 and X4 not included in CS model)

Figure 5.14 IPT connector board and IPT board schematic diagrams (CS, 2CS, 2G, 2GS)



IPT unit 877605 X3 and X4 are not connected.
IPT unit 877606 X4 is not connected.


Isolated side
Non isolated side
PULSE-WIDTH MODULATOR
DEMODULATOR & INVERTER
INVBP AMPL G=1020
BIAS COMPENSATE
TEMP AMPLIFIERS
SAMPLE & HOLD
AC-AMPL
PLETH OSCILLATOR 300 Hz
LED DRIVER
DC-REFLECTION INTEGRATOR (DUAL TIME CONST)
MUX CHANNEL SELECT
ISOLATED POWER SUPPLY
100kHz OSCILLATOR
OUT INVBP2
OUT
PA0
PA1
PA2

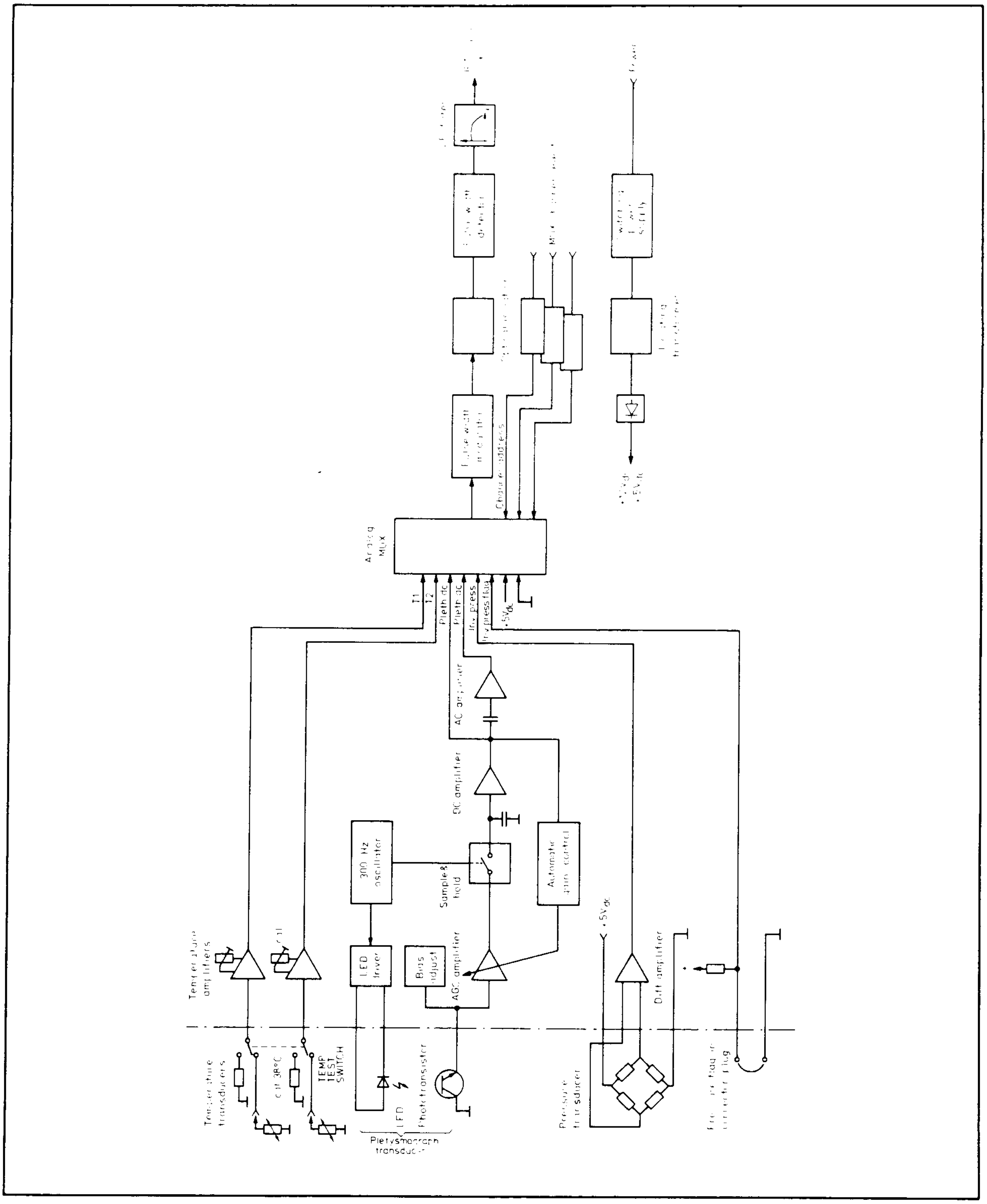
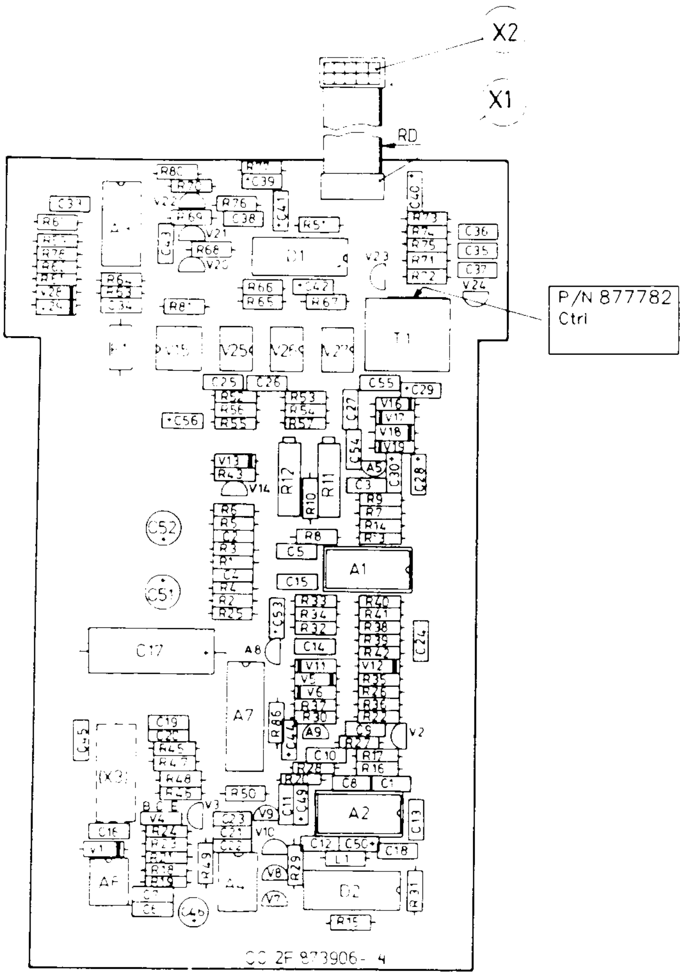


Figure 5.15 IPT board block diagram (1G, 1GS)

Figure 5.16 IPT board parts layout (1G, 1GS)



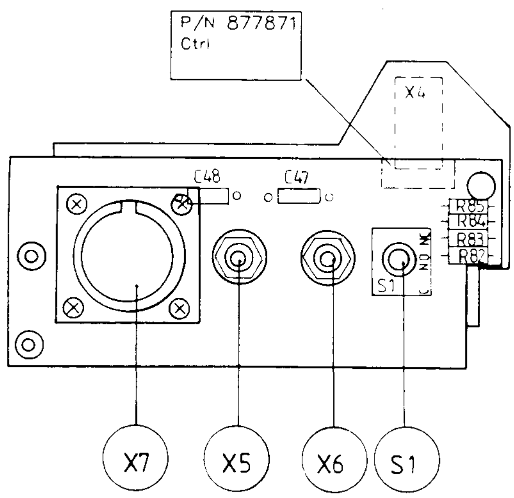
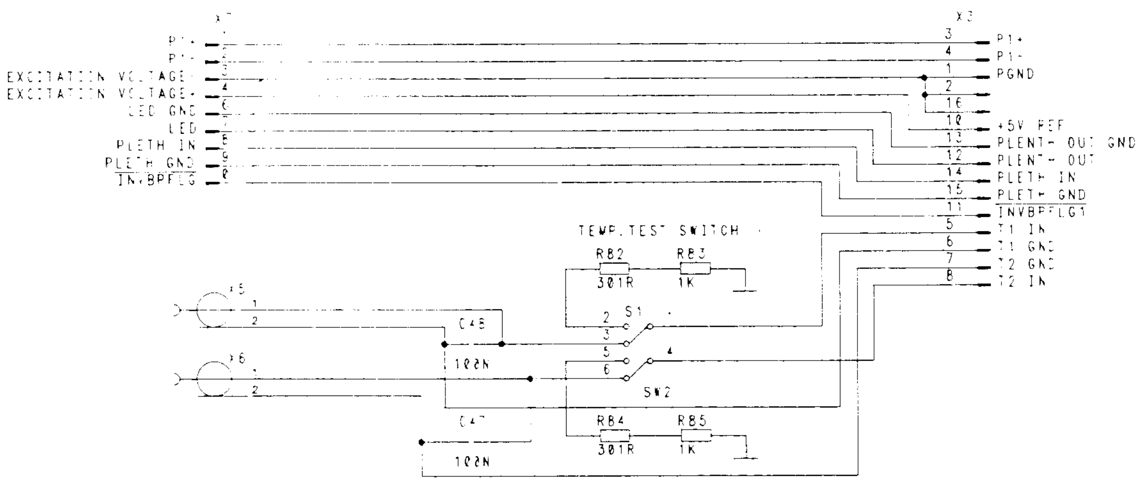
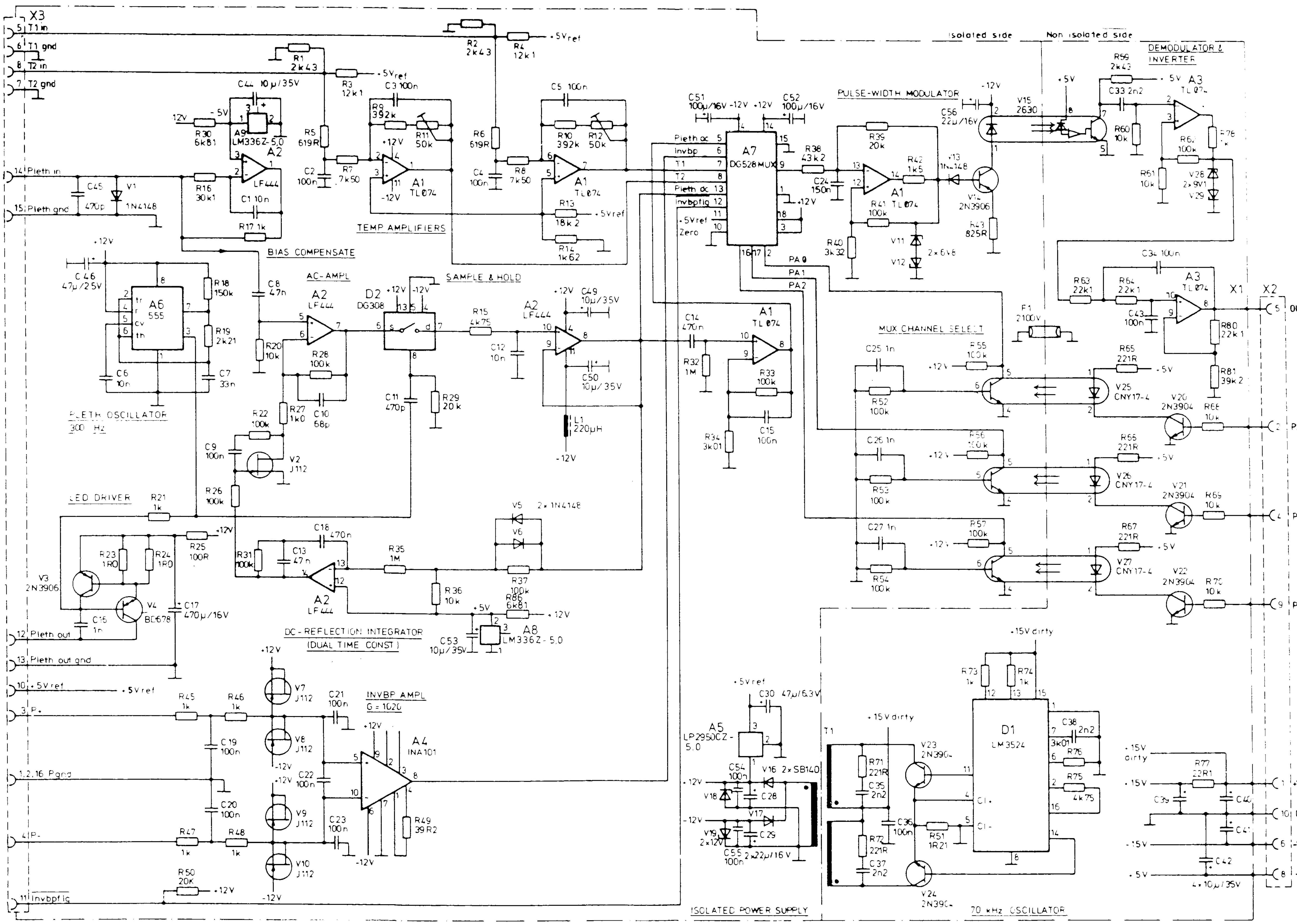


Figure 5.17 IPT connector board and IPT board schematic diagrams (1G, 1GS)





X3
T1 in
T1 gnd
T2 in
T2 gnd
Pleth in
Pleth gnd
Pleth out
Pleth out gnd
+5V ref
P+
1,2,16 Pgnd
P-
Invbpfic
BIAS COMPENSATE
TEMP AMPLIFIERS
PLETH OSCILLATOR
300 Hz
AC-AMPL
SAMPLE & HOLD
LED DRIVER
DC-REFLECTION INTEGRATOR
(DUAL TIME CONST.)
INVBP AMPL
G = 1020
PULSE-WIDTH MODULATOR
Isolated side
Non isolated side
DEMODULATOR & INVERTER
MUX CHANNEL SELECT
ISOLATED POWER SUPPLY
70 kHz OSCILLATOR
A7
DG528 MUX
A6
555
D2
DG308
A4
INA101
A5
LP2950CZ-5.0
A8
LM336Z-5.0
A9
LM336Z-5.0
D1
LM3524
V25
CNY17-4
V26
CNY17-4
V27
CNY17-4
V15
2630
X1
X2
OUT
PA0
PA1
PA2
+15V dirty
GND A
-15V
+5V

5.5 NIBP measurement

5.5.1 NIBP board

PNEUMATIC SYSTEM

The NIBP board consists of the following pneumatic parts:

- Pressure transducer
- Bleed system
- Exhaust valve

See Figures 5.19 and 20 for NIBP board parts layout and schematic diagram.

Pressure transducer

The piezoresistive pressure transducer (B1) is connected to the cuff. It measures the absolute pressure of the blood pressure cuff and the pressure fluctuations caused by arterial wall movement.

Bleed system

Bleed valve (Y2) releases the cuff pressure. The opening of the valve is pulse-width controlled between 100% and 0%. When the pulse-width ratio is 100% the signal is constantly high and the valve is open all the time. When the ratio is 0% the signal is constantly low and the valve is closed all the time. The driving signal frequency is 40 Hz.

Exhaust valve

Valve Y1 is used as an exhaust valve to quickly deflate the cuff.

ANALOG CIRCUITS

Pressure transducer excitation

The pressure transducer B1 is excited by a 4 mA constant current source. This is produced by floating constant voltage of 1.200 V that is produced by the voltage reference diode V7. Operational amplifiers A5A and A5B are used as voltage followers. The voltage difference through resistor R5 (TP X8/7, X8/8) is 1.200 V, producing a current of 4 mA through the resistor for the pressure transducer. The excitation voltage of B1 is about 12 V (TP X8/8, X6/5).

Differential amplifier

The output of the pressure transducer B1 is a differential signal between the midpoints of the pressure sensing resistor bridge legs (TP X8/2, X8/3). This signal is fed to a differential amplifier (operational amplifiers A4A and A4B, and resistors R12, 13, 14, and 15) that produces a gain of 31.1 (TP X8/4).

Pressure zero and gain control

At zero pressure, the output voltage difference of the pressure transducer B1 may be up to 100 mV. This zero pressure voltage is compensated for by R6 (TP X8/5) in the amplifier stage A4C. This stage is an inverting amplifier with unity gain and low pass filtering.

The next stage, A4D, is an inverting amplifier whose gain can be adjusted with trimmer R11. The gain is adjusted to compensate for pressure transducer gain differences, so that a linear signal is produced throughout the transducers range (TP X8/6).

Pressure DC channel range and bias circuits

The DC channel is used to measure the static or non-oscillating pressure of the blood pressure cuff. The static signal from A4D has a 5 V range (0 to -5 V). This voltage is sent to A2A which limits the voltage range to 1 V (+0.755 V to -0.755 volts) for the A/D converter.

Two input ports of the analog multiplexer (A3) are dedicated to the DC channel. The microprocessor selects the desired port depending on the cuff pressure required for best resolution. If the cuff pressure is between 0 and 255 mmHg the signal produced by A2A is sent directly to the multiplexer port 6, because the pressure corresponds directly to the 8 bit range of the A/D converter.

If the cuff pressure exceeds 255 mmHg, the signal is directed through a voltage divider network (R30/1-2 and R30/3-4) to port 5 of the multiplexer. This doubles the pressure range represented by the 1 volt signal and since the voltage measured at the divider is referenced to ground the pressures represented are between -128 and +382 mmHg.

To allow for a certain amount of zero pressure drift, the pressure zero points are actually set at 0 to 235 mmHg and -108 to 362 mmHg respectively.

Pressure AC channel filters

The AC component of the cuff pressure data is amplified to allow the processor to analyze the small cuff pressure fluctuations which are used as a basis for blood pressure determination. This additional amplifier is AC coupled. The first stage, A2B, is a second order high pass filter to effectively block out the DC component of the pressure data (TP X9/2). The second stage, A2C, is the amplifier stage (G = 73) and low pass filter (TP X9/3). The third stage A2D blocks the offset voltages of the previous two stages (TP X9/4).

AC reset

During cuff inflation or if an abnormal situation arises, the AC signal is sent to ground through D6A and D6B with AC reset signal P16 from the processor.

AC channel range selection

The output from A2D is connected to a voltage divider chain (R24 through 28). The 5 outputs of this resistor chain make up a binary division chain. The division ratio is selected by the analog multiplexer (A3). If voltage at the beginning of the chain is 1 volt the following outputs have voltages 1/2, 1/4, 1/8 and 1/16 volts. The processor selects the proper division ratio according to the incoming signal level. This effectively extends the dynamic range of the A/D converter from 8 bits to 12 bits.

Multiplexer and A/D converter

The analog multiplexer circuit A3 is used to select either the DC or AC channel to the A/D converter. The same multiplexer is also used to select suitable ranges for both channels. As described previously, the DC channel has two different ranges and the AC channel has 5 different ranges. The multiplexer inputs are allocated according to the following table.

INPUT DESCRIPTION	DIVISION RATIO
0 AC component	1/16
1 "	1/8
2 "	1/4
3 "	1/2
4 "	1/1
5 DC component	1/2
6 "	1/1
7 (not in use)	---

The operational amplifier A1C is a non-inverting gain stage (G = 6.62), which amplifies the incoming signals to -5 V to +5 V level (TP X9/5). Resistor network R30/5-6 and 7-8 shifts the -5 to +5 V range to 0 - 5 V for the A/D converter U1. U1 is an 8 bit successive approximation A/D converter. The converter is timed by its own internal clock (TP X6/2), the conversion rate is determined by the external RC circuit (R29, C34), conversion time is about 200 us. The converted signal is led to buffer D13 output when ADCRD-signal is activated. Decoder D5 activates the ADCRD-signal when A15 and RD-signal are active.

Reference voltage source

The reference voltages are generated with the reference diode V6 and operational amplifiers A5C and A5D. The reference voltages are typically +5.30 V (TP X6/4) and -10.6 V (TP X6/5).

JUMPERS

The NIBP board contains two jumpers.

Jumper X13 selects the watchdog time. Normally the time is adjusted to 5 minutes (no jumper). In test purpose the time can be changed to 5 seconds (X13 short-circuited).

Jumper X10 selects the RAM memory capacity used.

PIN	RAM CAPACITY SELECTED
1-2	32 kbytes
2-3	8 kbytes

PUMP AND VALVE DRIVERS

The magnetic valves and the air pump are controlled by the open collector darlington driver circuit D11. A separate power source (+15 V) is used to drive these circuits. An additional power switch (V1, V3), controlled by the processor, connects power to valve circuits. The watchdog timer prevents a prolonged inflation.

SAFETY CIRCUITS

Pressure control switch

A comparator circuit A1A compares cuff pressure to a fixed reference level. If cuff is inflated the circuit prevents CPU from zeroing the watchdog circuit (TP X9/6).

Watchdog timer

The watchdog timer circuit (D8, D9) controls the power of the magnetic valves and the air pump. Normally, power to the valves is not connected. The CPU is able to reset the watchdog circuit and connect power to the pump only when the cuff is not inflated. If the cuff is inflated, the CPU cannot control the watchdog circuit, which will deflate the cuff after 5 minutes.

PROCESSOR CIRCUITS

The NIBP board contains its own 8051FA CPU and memory circuits to allow independent operation. The 64 kbyte code memory resides in D2 (EPROM) and the 8 kbyte data memory in D3 (RAM). Ports P3 and P1 are used to control directly various operations of the NIBP.

Port P3 also provides RS-232 output which is used to transmit NIBP data to the main CPU.

Memory organization

The code memory and the external data memory both start from zero. The decoded address space is 64 kbytes.

ADDRESS RANGE	FUNCTION
0000 - 7FFF	32 kbyte external data memory
8000 -	A/D converter

CPU Control ports

CPU ports P3 and P1 are used to directly control several NIBP functions.

PORT P3	FUNCTION
P 3.0	RXD/
P 3.1	TXD/
P 3.2	Mux address 0
P 3.3	Mux address 1
P 3.4	Mux address 2
P 3.5	15 V power sense
P 3.6	WR/
P 3.7	RD/

PORT P1	FUNCTION
P 1.0	Shunt valve I
P 1.1	Shunt valve II
P 1.2	Exhaust valve
P 1.3	Bleed valve
P 1.4	Pump control
P 1.5	Watchdog reset
P 1.6	AC reset
P 1.7	+15 V power control

Reset circuit

The reset line is connected to the common reset line RESET to guarantee simultaneous resetting with the main processor at power down conditions.

TEST POINT SIGNALS

PIN	SIGNAL
X8/1	AGND
/2	Differential output of pressure
/3	transducer
/4	Differential output (A4) output
/5	Used for pressure zeroing
/6	Used for pressure gain adjustment
/7	Voltage difference depending on
/8	pressure transducer current
	(4 mA = 1.20 V)

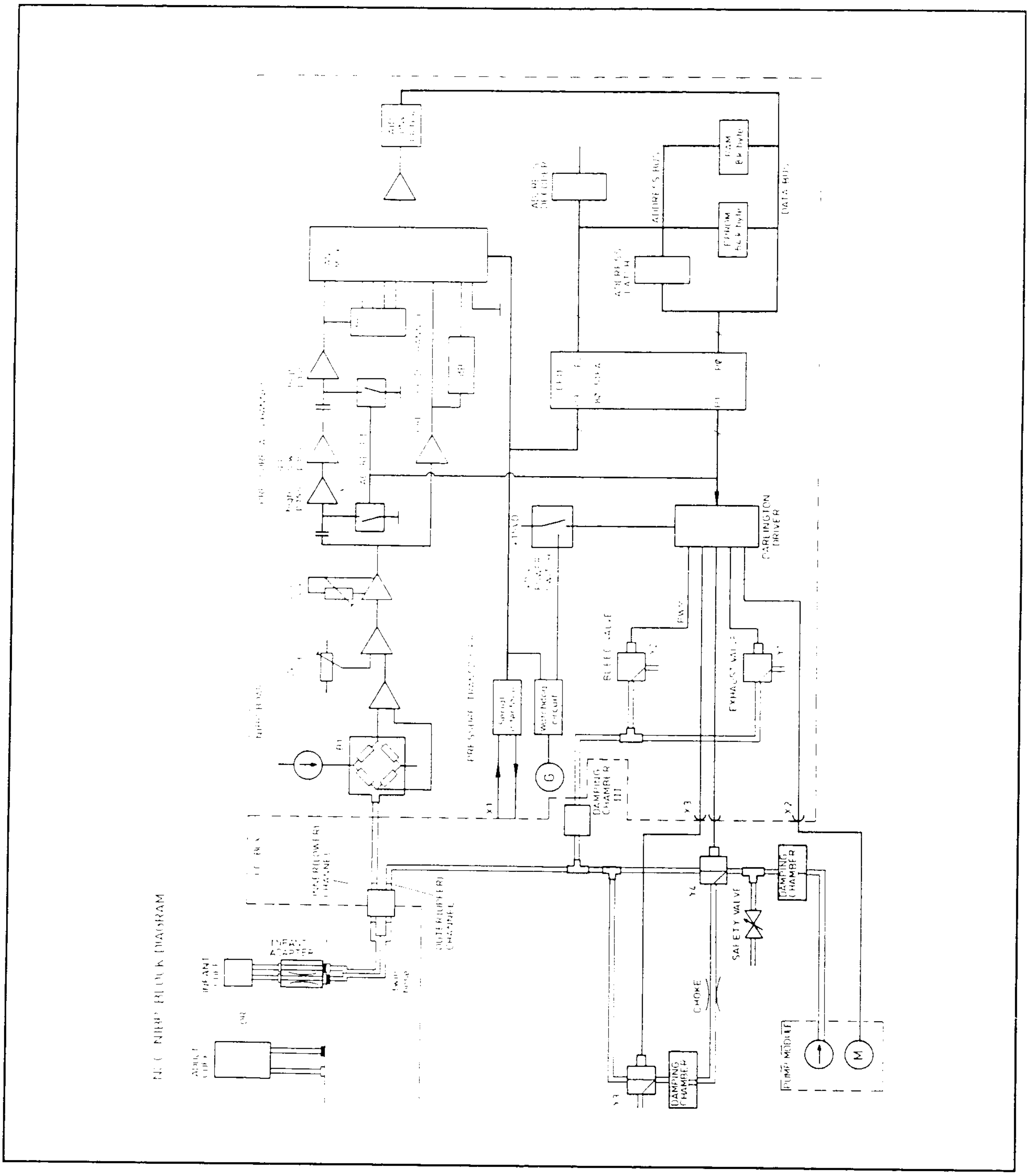
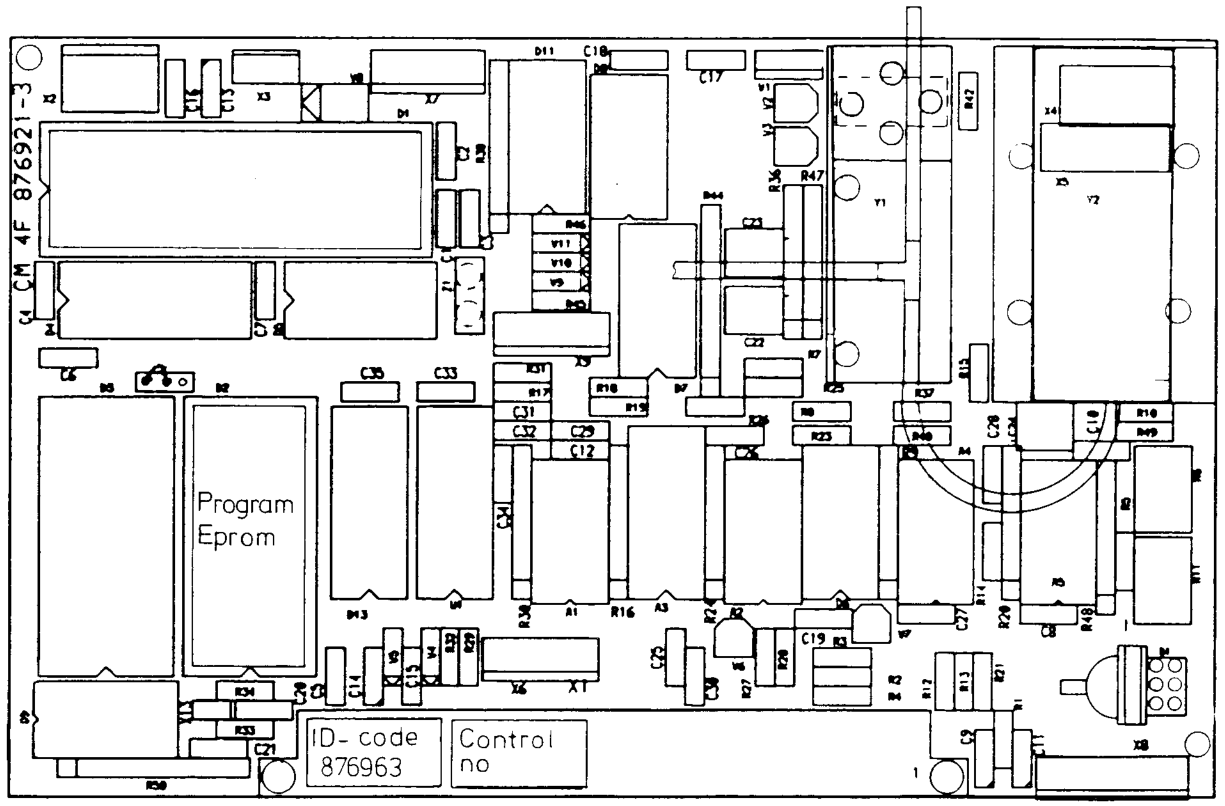


Figure 5.18 Block Diagram of NIBP System (USA Version)

In all other versions, two different kinds of twin hose are used: one for standard adult cuff and another which contains a built-in choke for infant cuff.

Figure 5.19 NIBP board parts layout and schematic diagram (part 1)



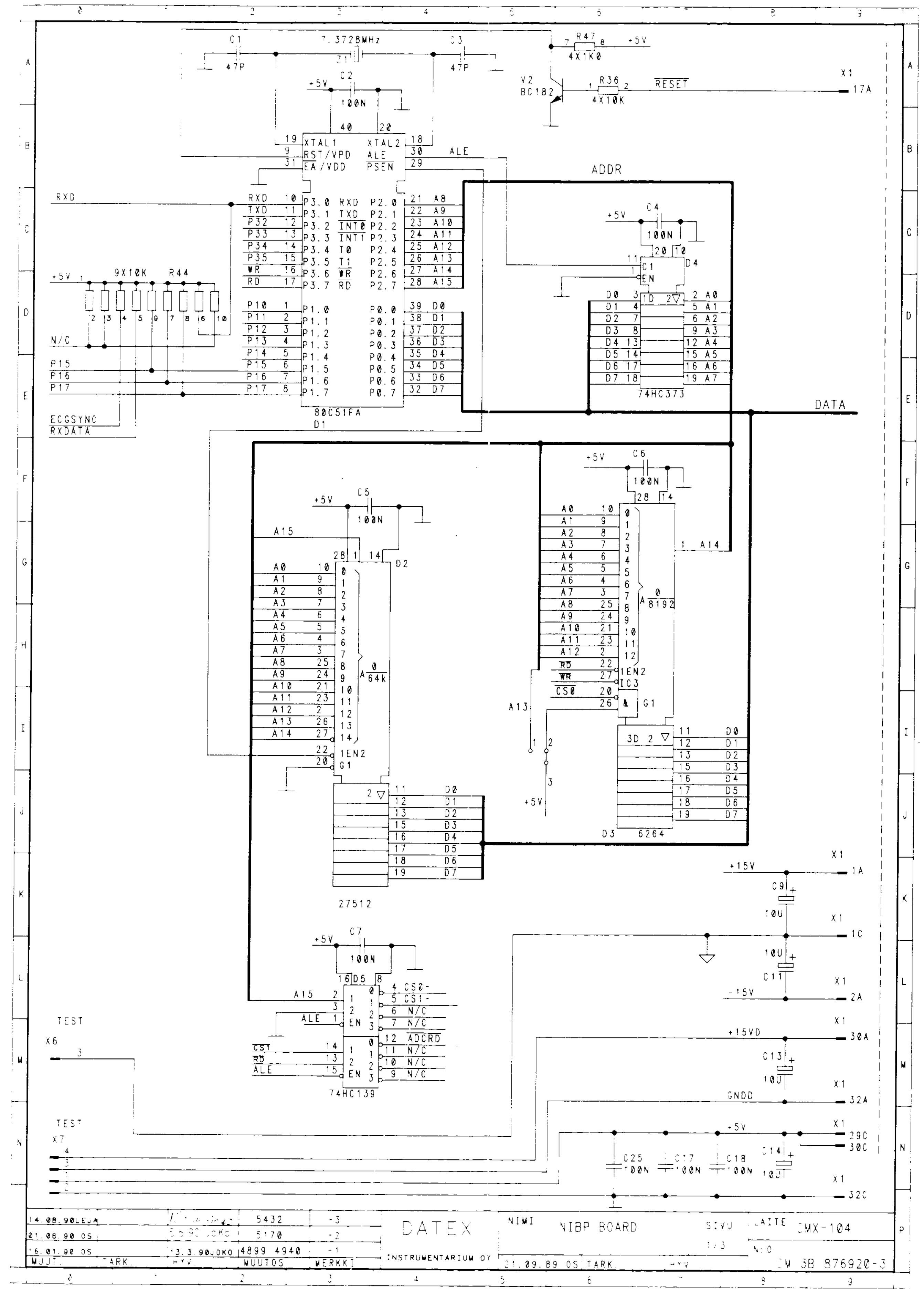
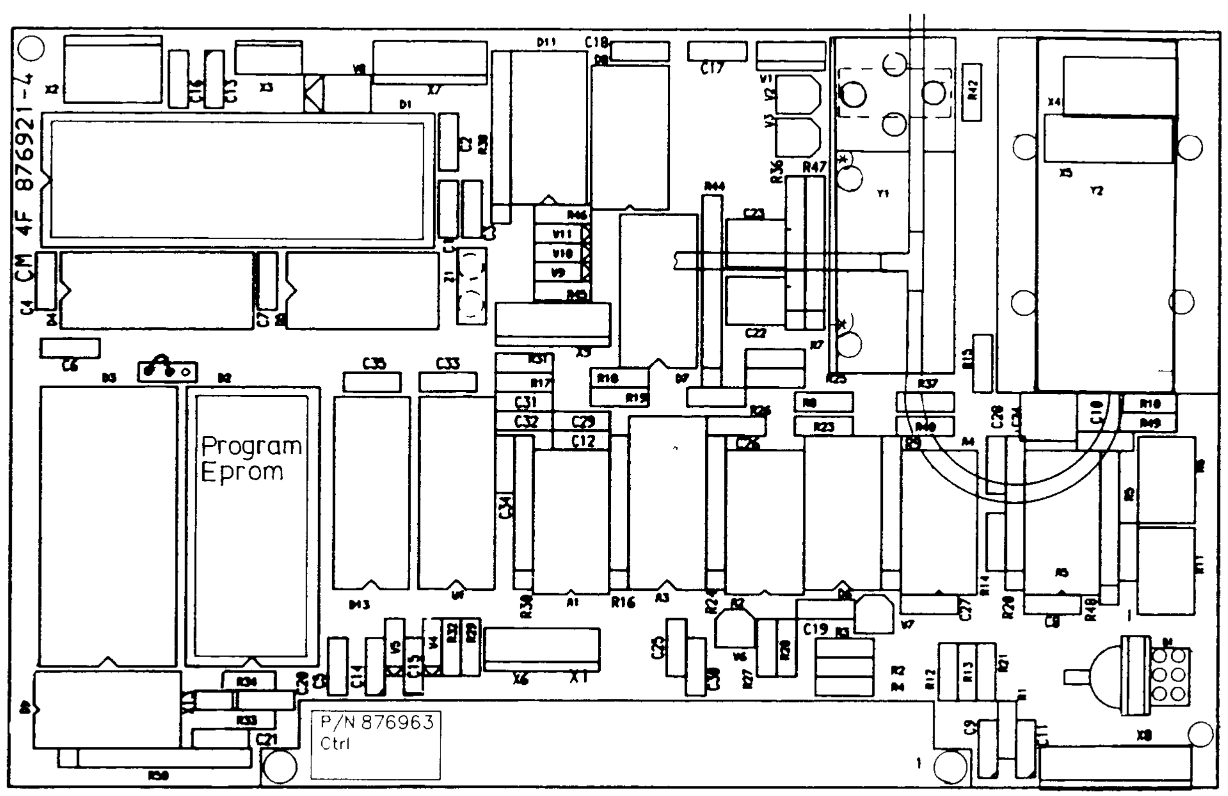


Figure 5.19a NIBP board parts layout and schematic diagram (part 1) (board modification level 5 and higher)



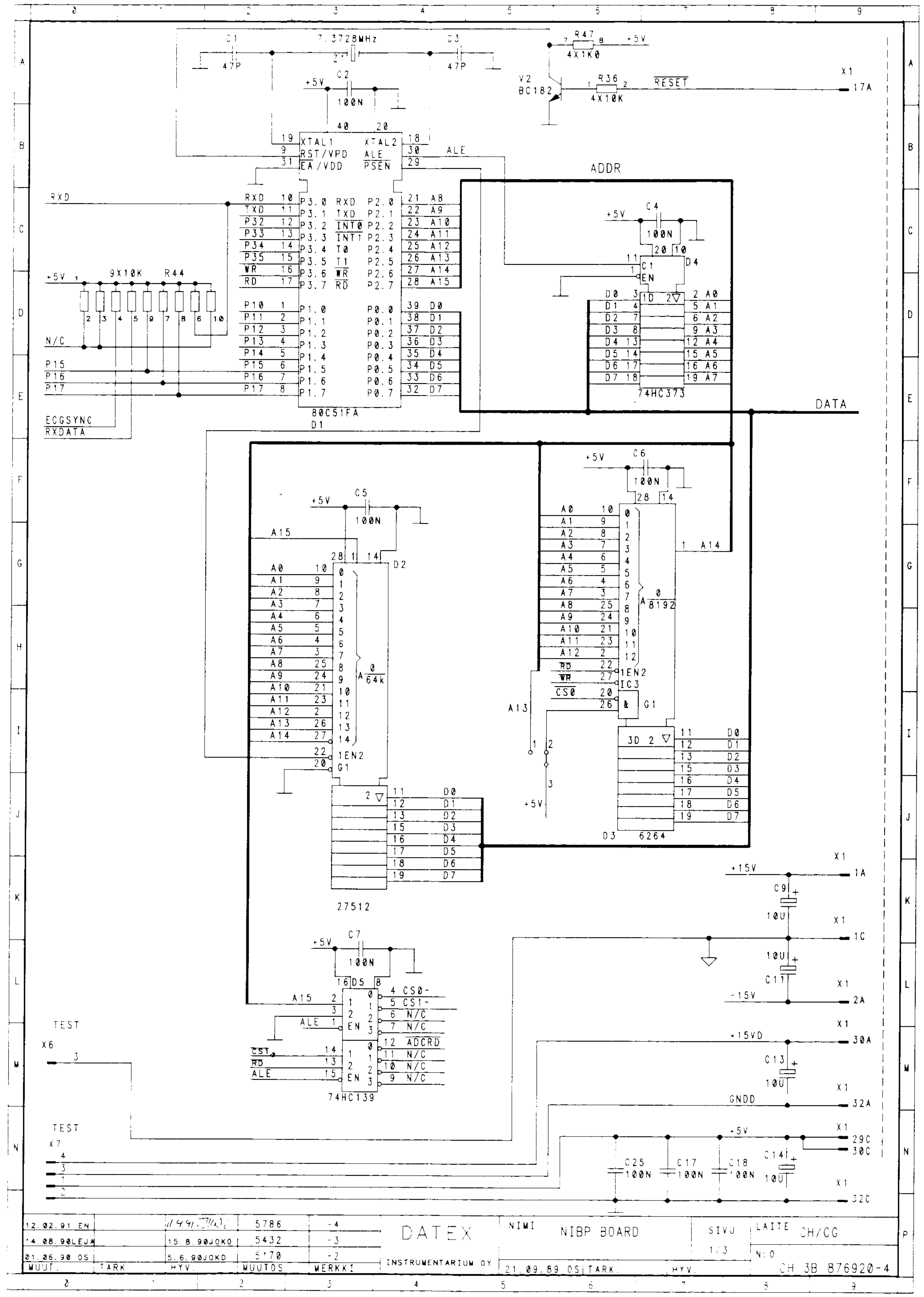
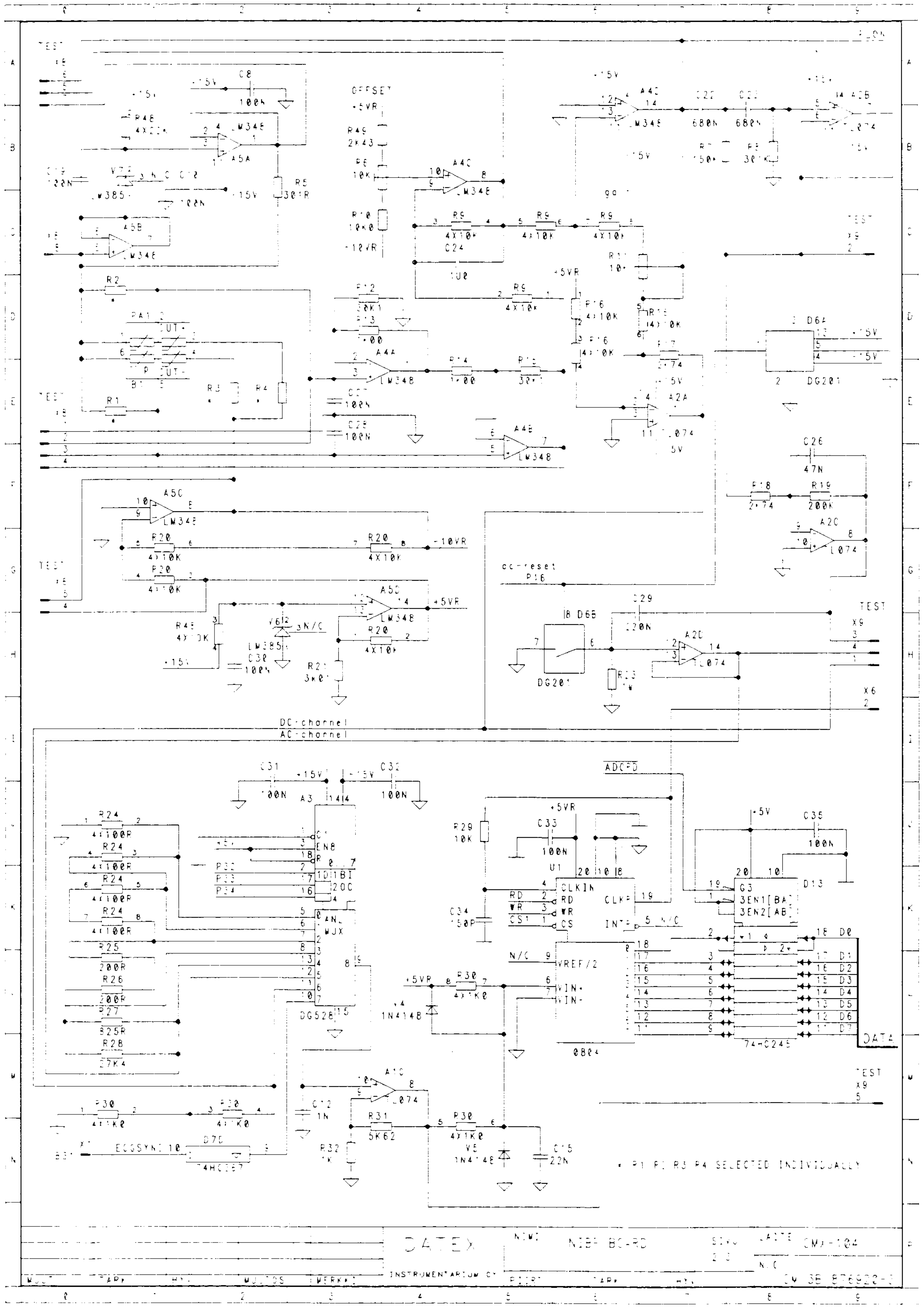


Figure 5.20 NIBP board schematic diagram (part 2)


DATEX
NIBP BOARD
CMX-104
INSTRUMENTARIUM OY

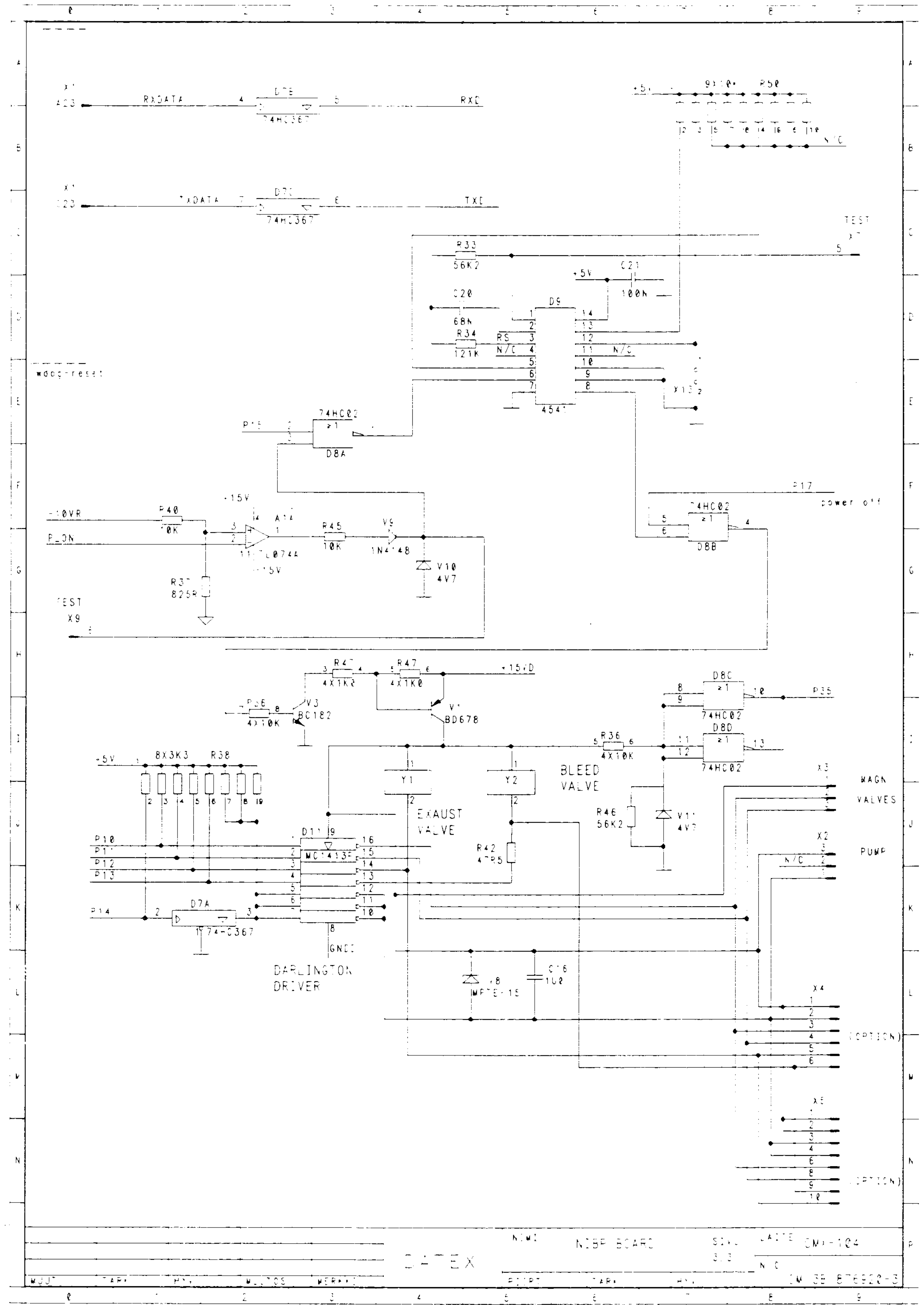
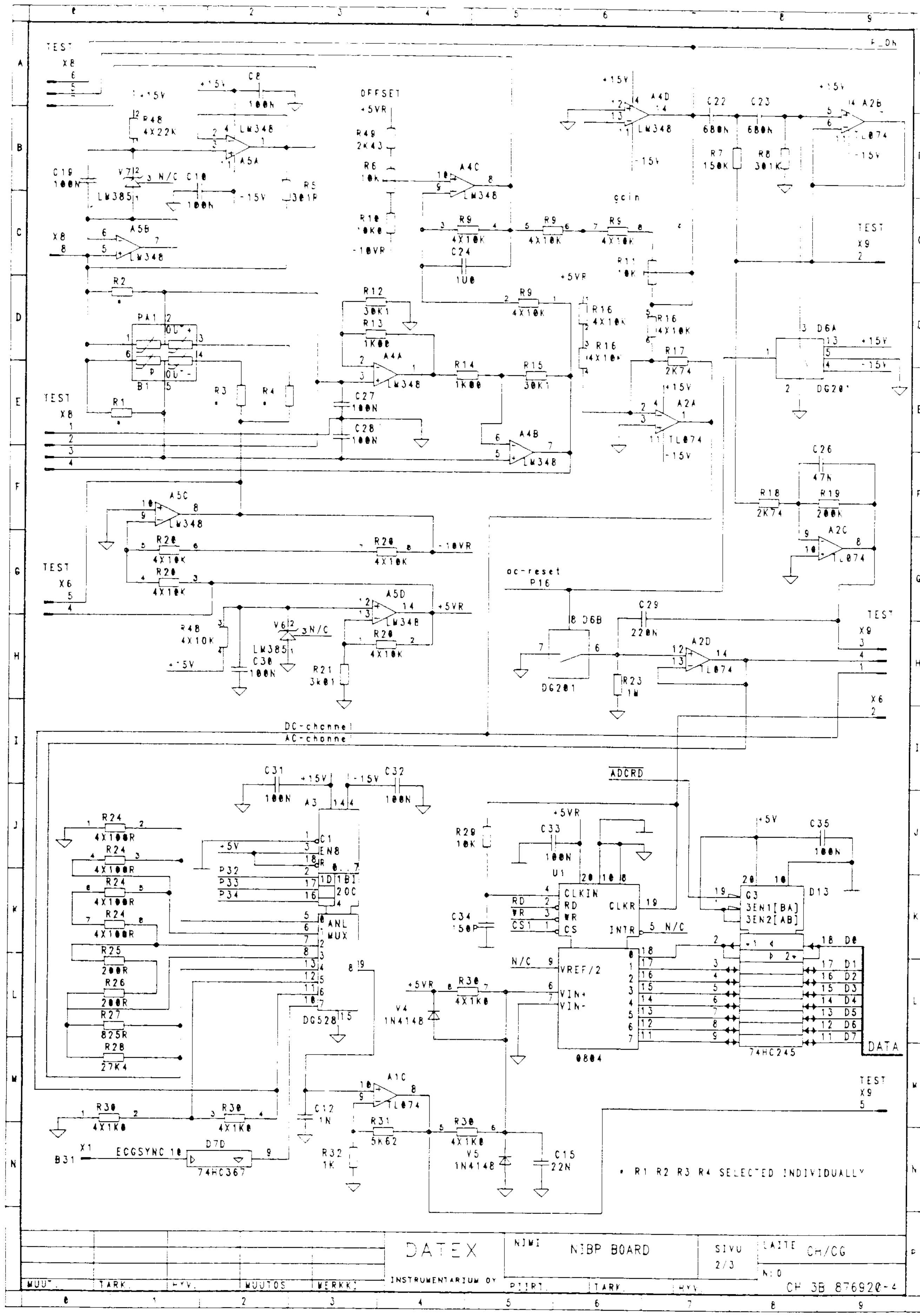
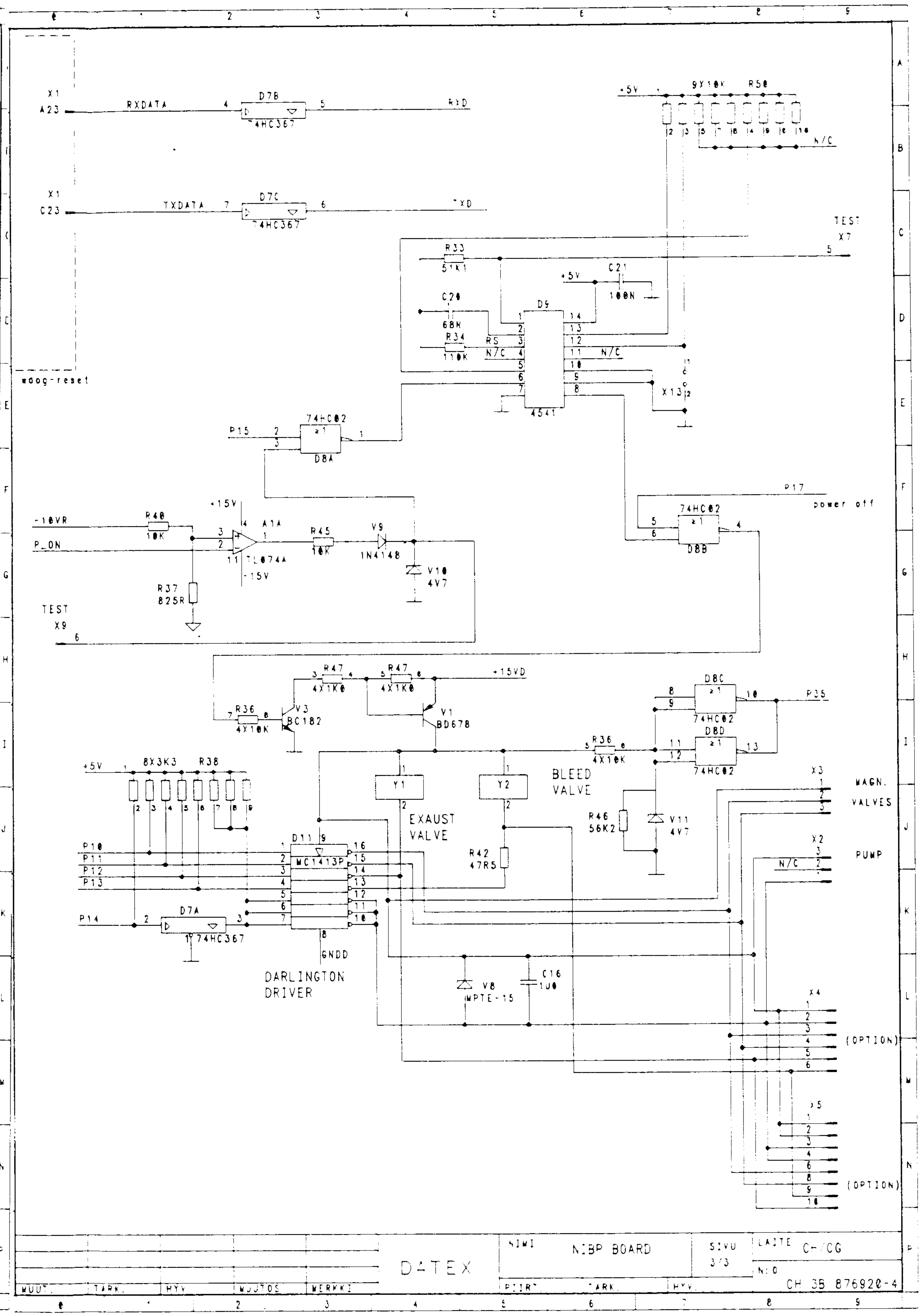

DATEX
NIBP BOARD
CMX-104
EXAUST VALVE
BLEED VALVE
DARLINGTON DRIVER

Figure 5.20a NIBP board schematic diagram
(part 2) (board modification level 5 and higher)


DATEX
INSTRUMENTARIUM OY
NIMI NIBP BOARD
SIVU 2/3
LAITE CH/CG
N:O CH 3B 876920-4
* R1 R2 R3 R4 SELECTED INDIVIDUALLY


DATEX
NIMI NIBP BOARD
SIVU 3/3
LAITE CH/CG
N:O CH 3B 876920-4
DARLINGTON DRIVER
EXAUST VALVE
BLEED VALVE
MAGN. VALVES
PUMP
(OPTION)

5.5.2 Pneumatic unit

The pneumatic unit includes three damping chambers and two magnetic valves.

Damping chamber I

The damping chamber I prevents a rapid increase of pressure caused by the pump.

Choke

A choke is used to slow down the pressure change in infant measurement.

Damping chamber II

The damping chamber II is used with small cuff sizes to increase volume so that the pressure can be precisely adjusted.

Damping chamber III

The damping chamber III smooths down rapid pressure pulses caused by the bleed valve.

Shunt valves

If the cuff volume is too small, the two shunt valves open and connect damping chamber II to the blood pressure circuit.

5.5.3 NIBP air pump

The NIBP air pump module contains a membrane type pump and a DC motor. The module is enclosed in a separate foam rubber-filled case to attenuate noise.

5.5.4 Safety valve

The NIBP is equipped with a separate mechanical safety valve to prevent accidental cuff over-pressurization. The valve operates nominally at 330 mmHg.

5.5.5 NIBP tubing

The pneumatic components are assembled together as shown in Figure 9.3.

> WARNING: PATIENT SAFETY It is important to attach the tube from pressure transducer to the inner connector of the NIBP-connector and the tube from the pneumatic unit is attached to the outer connector of the NIBP-connector. Reversing the tubes will inhibit deflation of the infant cuff.

5.5.6 Twin hose

The twin hose is used to connect cuffs to the monitor. The choke which is designed for infant measurement is located in the infant adapter (USA) or inside the input port of the infant twin hose (all others). The monitor automatically detects the hose type in use.

5.5.7 Blood pressure cuff

The NIBP measuring unit is designed to operate with seven different standard blood pressure cuffs. The cuff sizes are as follows:

CUFF	CUFF SIZE
LARGE ADULT	15 cm
NORMAL ADULT	12 cm
SMALL ADULT	9 cm
CHILD	6 cm
INFANT	5 cm
INFANT	3 cm

5.6 SpO_2 measurement

SpO_2 measurement is included in models CS, 2CS, 1GS, and 2GS.

5.6.1 SpO_2 measuring board

note if SpO_2 takes too long to detect
Replace SpO_2 software P/N 882882-20
F.H.

The board is intended to perform the following tasks:

- Control the LED light sources of the probe.
- Amplify the signal coming from the detector and separate the red and infrared signal components to respective channels.
- Multiplex in both channels the alternating component of the signal (plethysmographic pulse) with the signal proportional to the total intensity measured with the respective wavelength.
- Provide isolated output from the multiplexer channels (red channel and IR channel) to the SpO_2 processor board.

Power supply

The isolated power supply uses a switcher controller circuit D1, which is used without any feedback from the secondary of T1. D1 performs as an oscillator operating at 45 kHz. It also limits the current through T1 if overloading occurs.

The isolated supply voltages of +12 V and -12 V are regulated by zener diodes V18 and V19. +5 V supply is generated by a regulator A6 (see Figure 5.22).

Timing/LED control

The timing pulses are produced by a PAL (Programmable Array Logic) D3. The input signal for D3 (SYNC.) is taken from the switching power supply as a 45 kHz square wave. All timing signals are synchronized at this switching frequency. The timing circuit controls the LED driver circuitry (signals LED_R and LED_{IR}), the RC time constants in amplifier chain (MEASURE) and sampling ($SAMPLE_R$, $SAMPLE_{IR}$) (Figure 5.22).

Referring to Figures 5.22 and 5.23, the LEDs in the probe are driven with constant current pulses, (250 to 300 mA). The pulse duration and duty cycle can be seen in timing diagram in Figure 5.12. A positive voltage pulse at 1/X1 corresponds to the red LED current and a negative one to the IR-LED, respectively.

Detector signal processing

The signal produced by the detector is a current. The first amplifier stage is a current-to-voltage converter. A signal current passes through the resistors between pins 9 and 8 of A3 and produces a negative voltage pulse at 8/A3. Notice that the part of the feedback resistance is located in the probe connector.

Another resistor in the connector is connected to 6/X1 in order to form a bias current sink for the detector. At 5/X1 there is a constant bias voltage of about -4 V.

At 7/A3 the detected voltage pulses are inverted to positive value.

The digitally controlled amplifier is a Digital to Analog Converter (DAC), D5. The signal is fed to the reference input of D5. The 8-bit digital control word is transferred over the patient isolation barrier in serial mode (PA2) and is converted into parallel mode by a shift register D4. The signal level at the output, 14/A3, is adjusted to 3 to 8 V by the CPU.

The amplified signal pulses are separated to red and infrared channels by sample-and-hold circuitry (S/H). Voltages V_R and V_{IR} are proportional to the total intensity of the light detected at the respective wavelength. V_{Rac} and V_{IRac} are the amplified alternating components (plethysmographic pulses).

The signals are multiplexed into two channels by a 2 x 4 MUX, A5. Also +5 V and GND are connected to MUX input. The value of the resistor R_C in the probe connector can be read through the red channel, if needed.

The two output channels of MUX A5 are transferred across the patient isolation by two identical pulse width modulator/optoisolator/demodulator-chains. The frequency of the pulse width modulator is about 20 kHz. The demodulated signal is inverted.

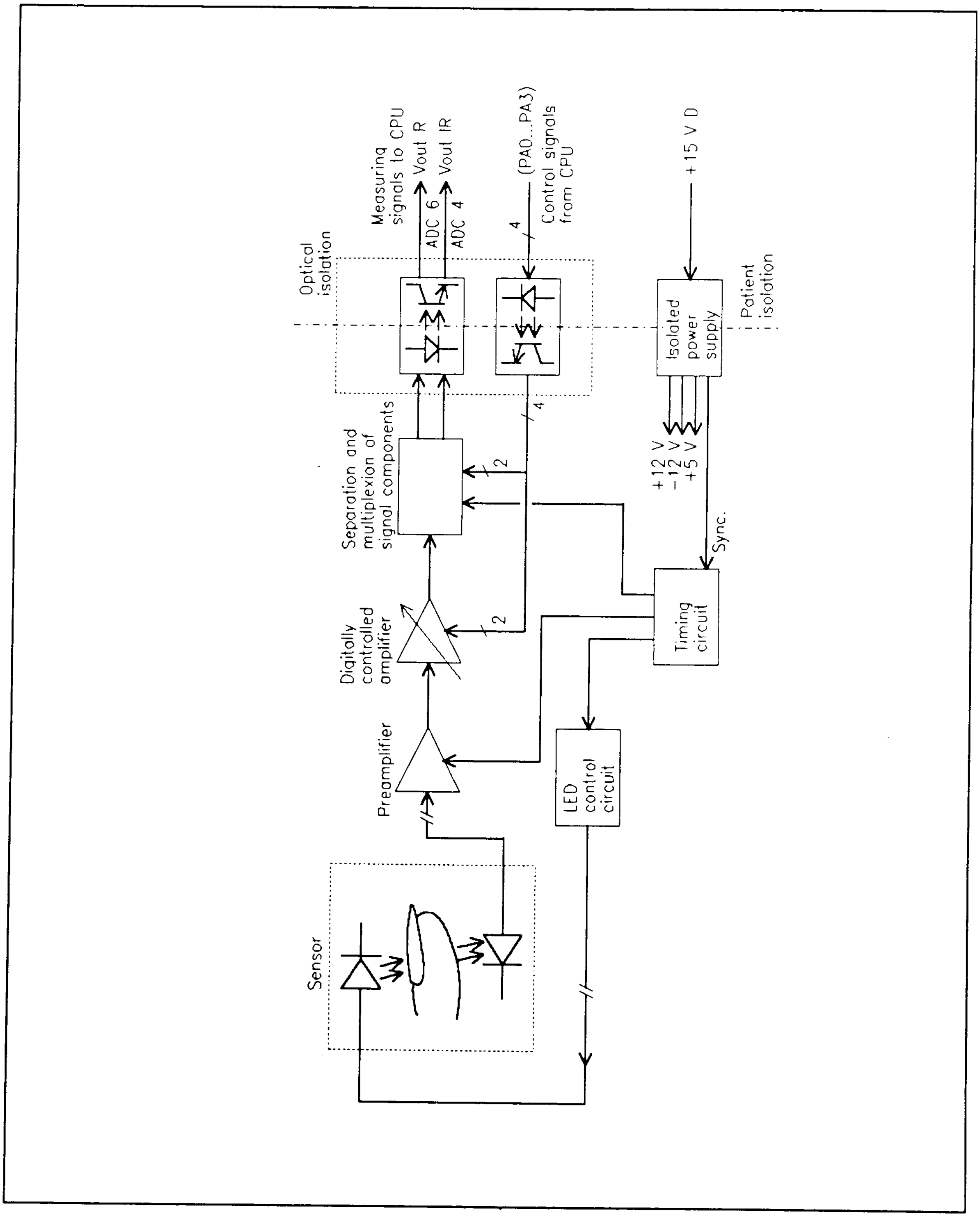
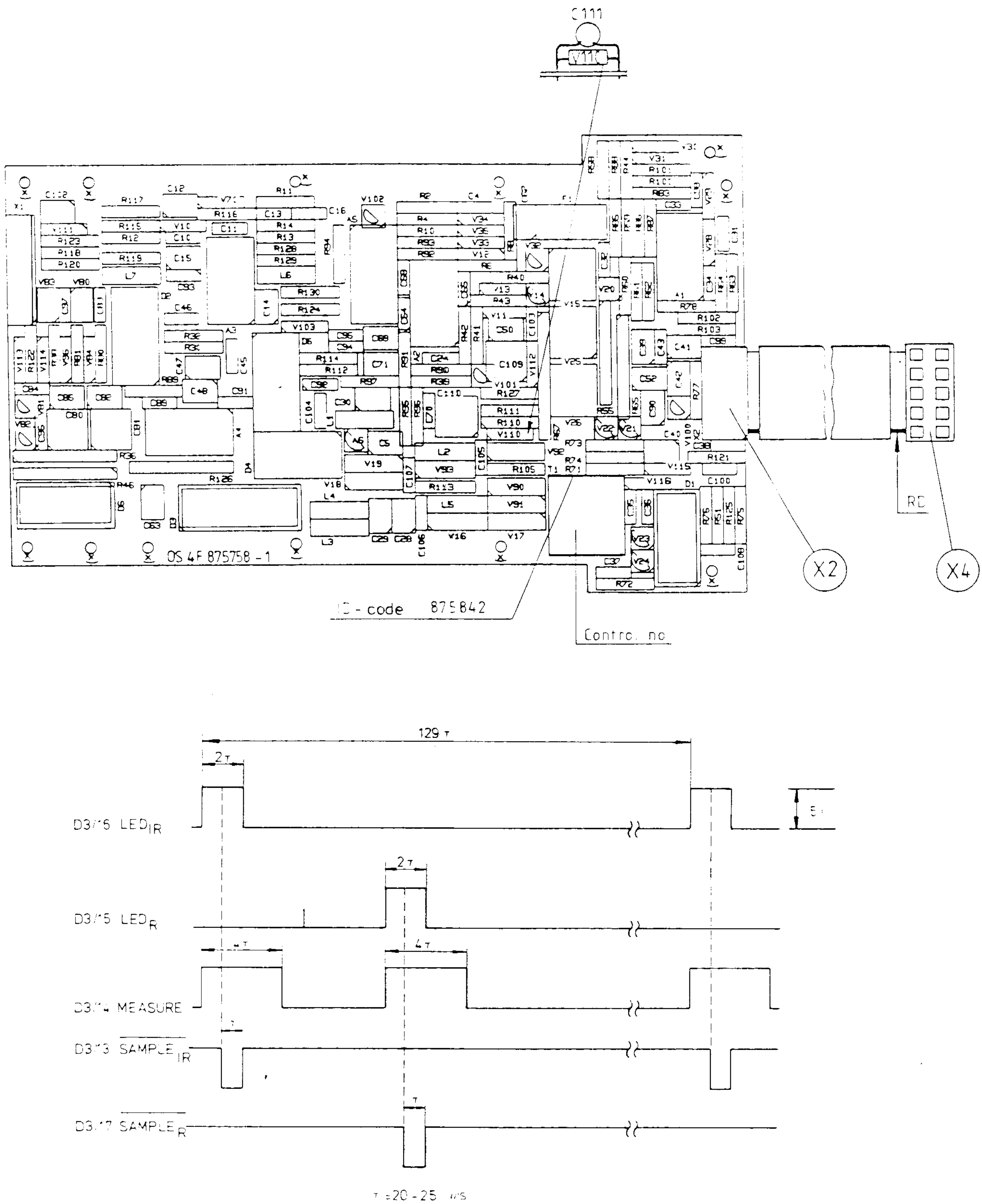
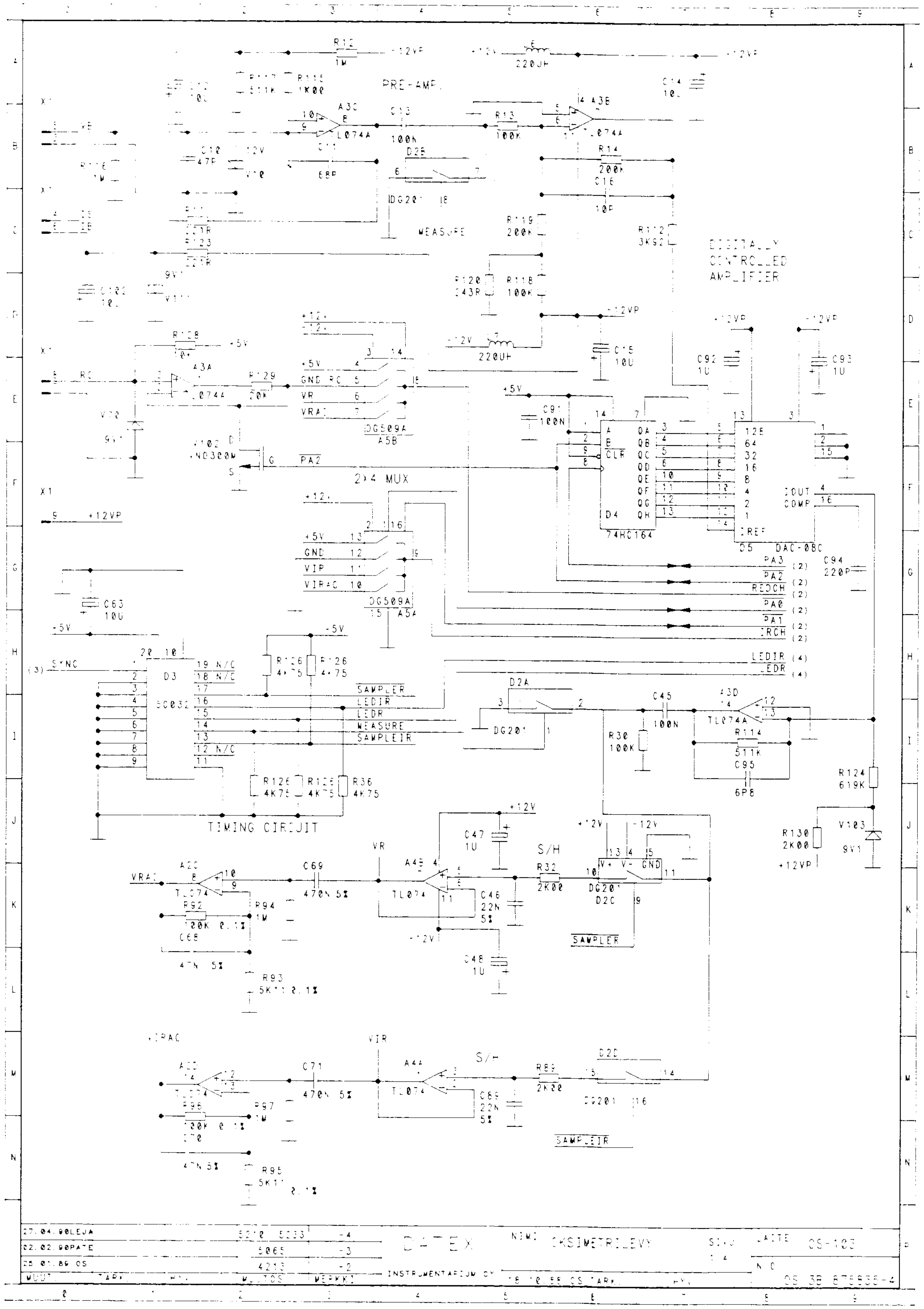


Figure 5.21 SpO_2 measuring board block diagram

Figure 5.22 SpO_2 measuring board parts layout, timing diagram and schematic diagram (part 1)




PRE-AMP.
DIGITALLY CONTROLLED AMPLIFIER
2X4 MUX
TIMING CIRCUIT
74HC164
DAC-08C
DATEX
INSTRUMENTARIUM OY
OKSIMETRILEVY
OS-103

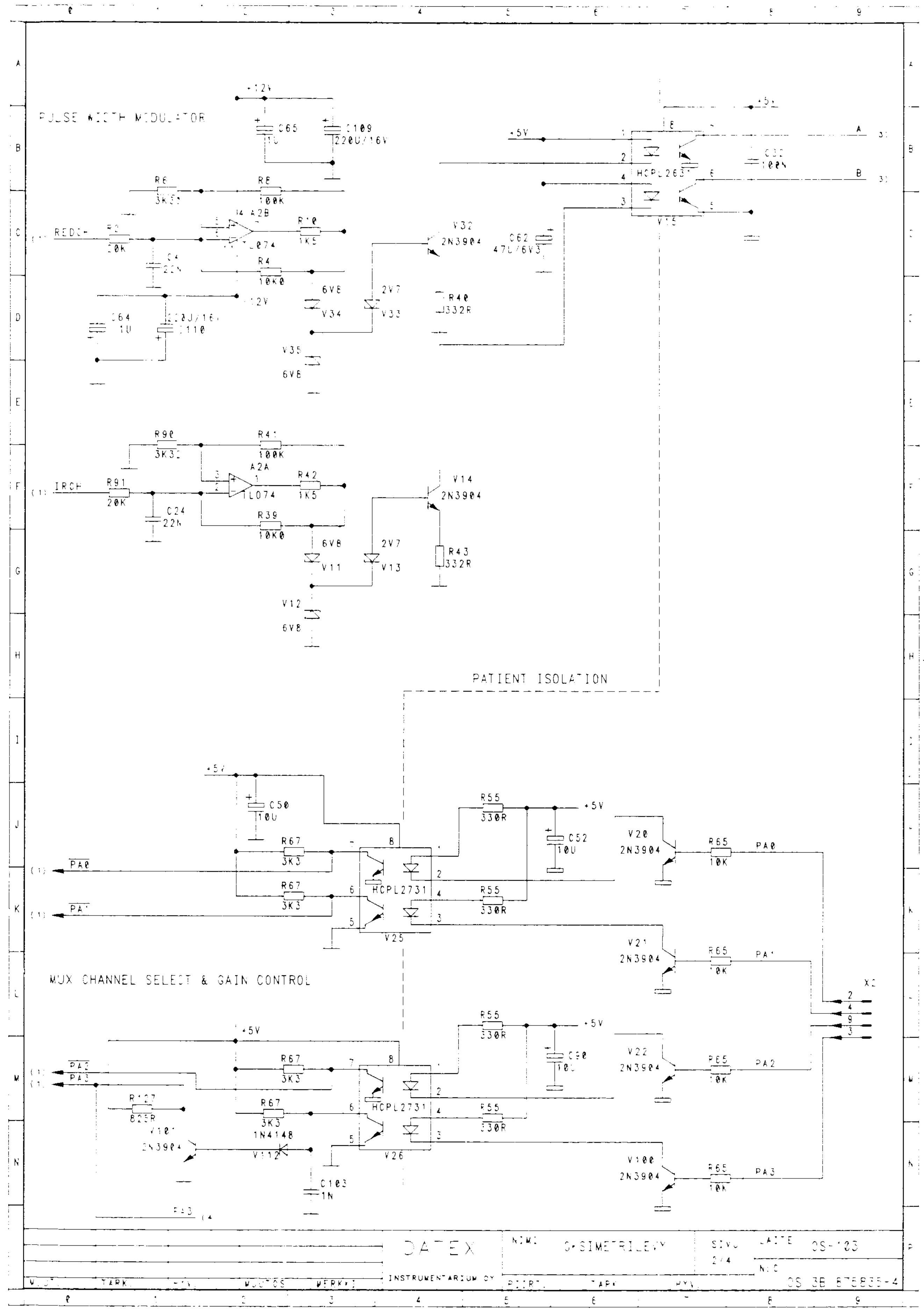
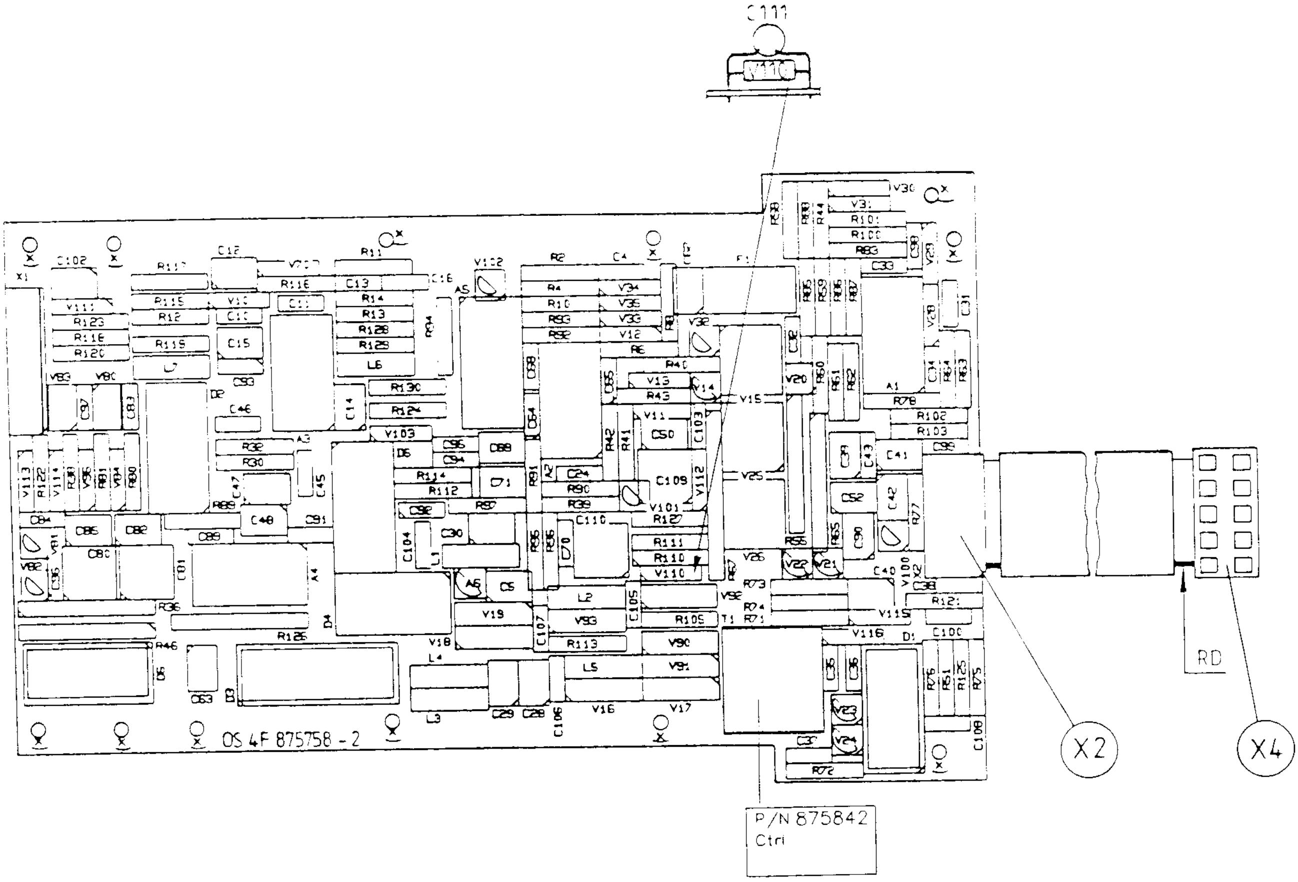
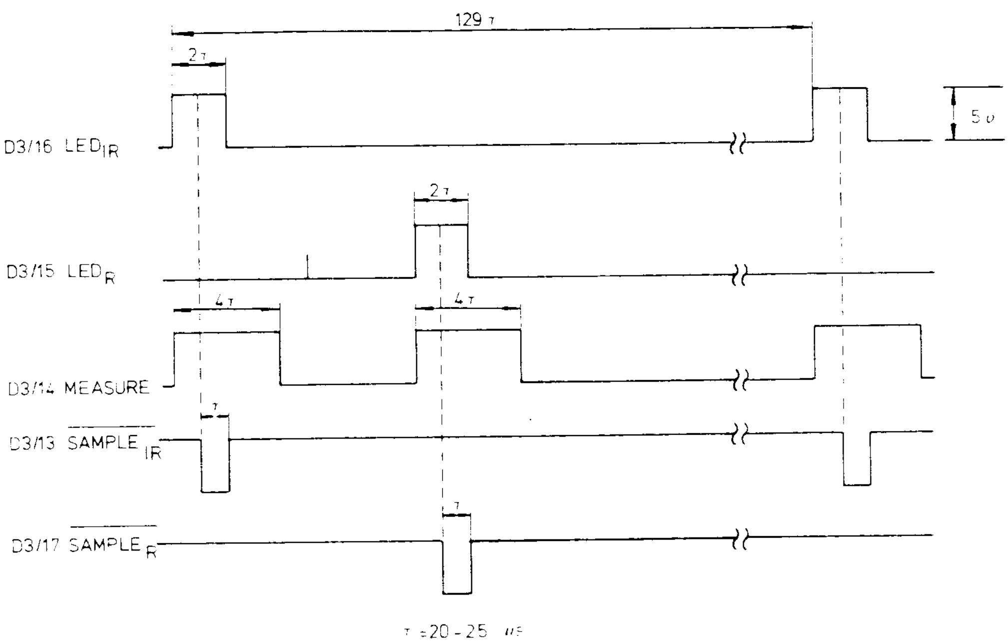
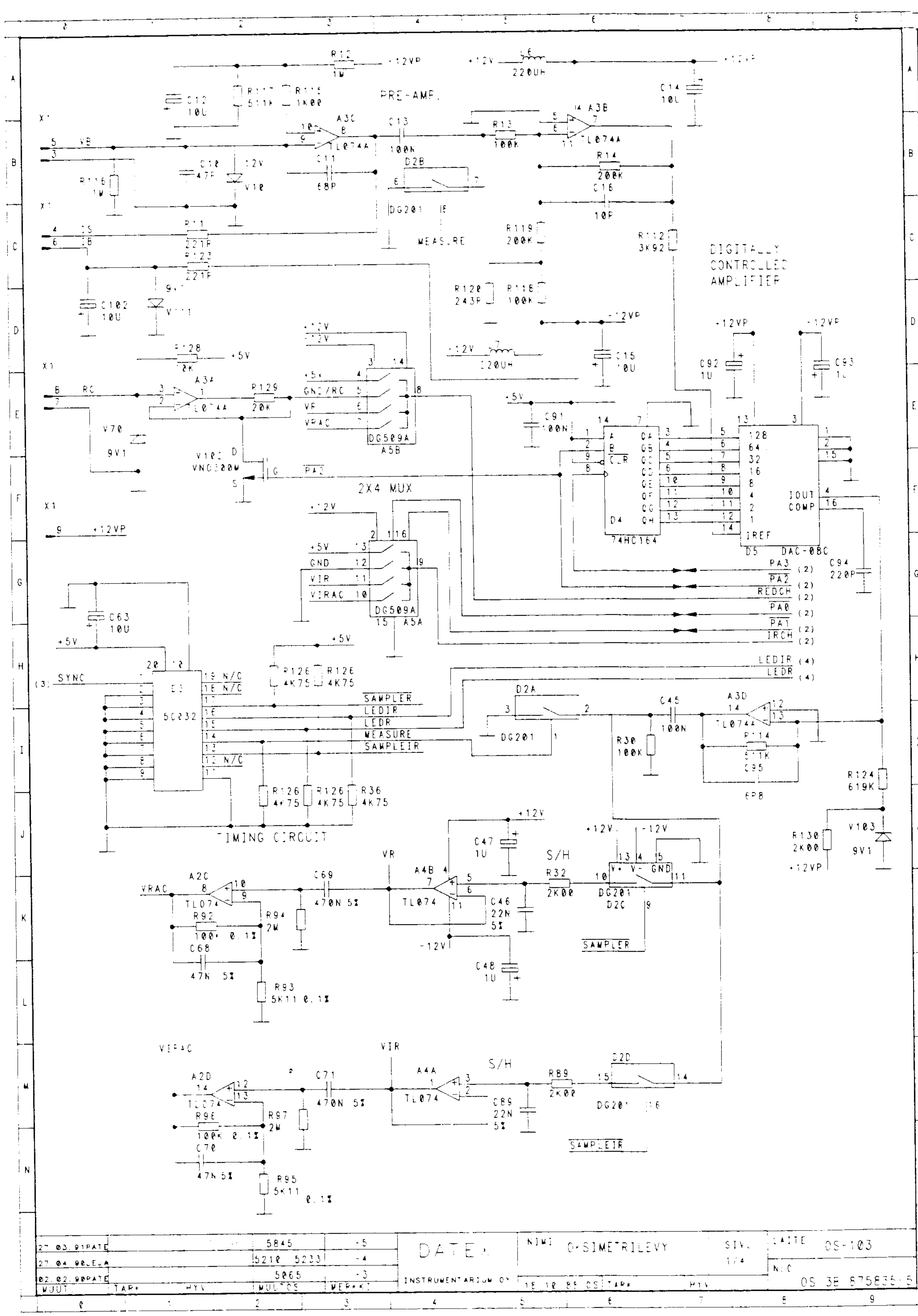

PULSE WIDTH MODULATOR
PATIENT ISOLATION
MUX CHANNEL SELECT & GAIN CONTROL
HCPL2731
DATEX
INSTRUMENTARIUM OY
OKSIMETRILEVY
OS-103

Figure 5.22 SpO_2 measuring board parts layout, timing diagram and schematic diagram (part 1) (board modification level 6 and higher)






PRE-AMP.
DIGITALLY CONTROLLED AMPLIFIER
2X4 MUX
TIMING CIRCUIT
DATEX
INSTRUMENTARIUM OY
OS-103
OS 3E 575835-5

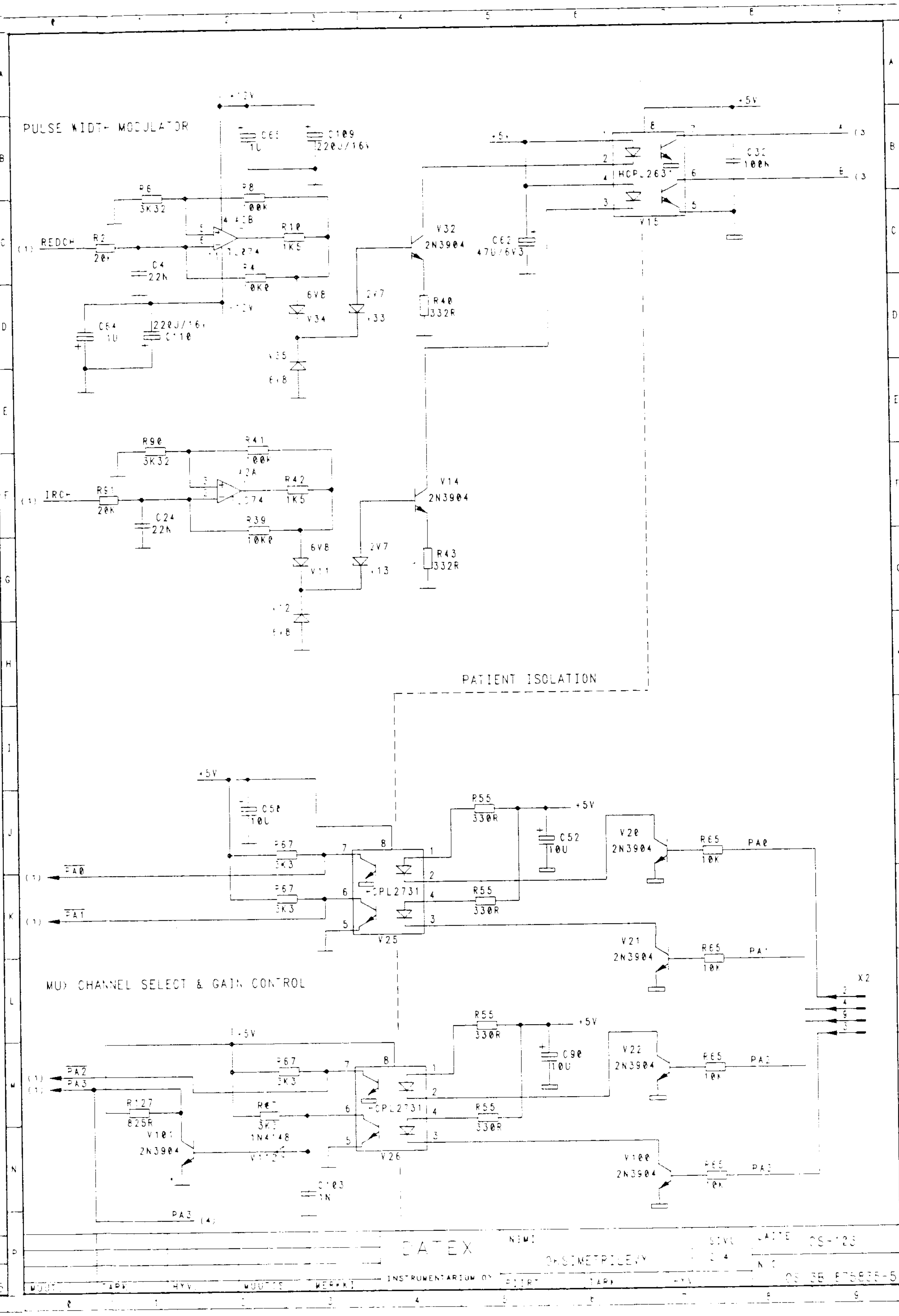
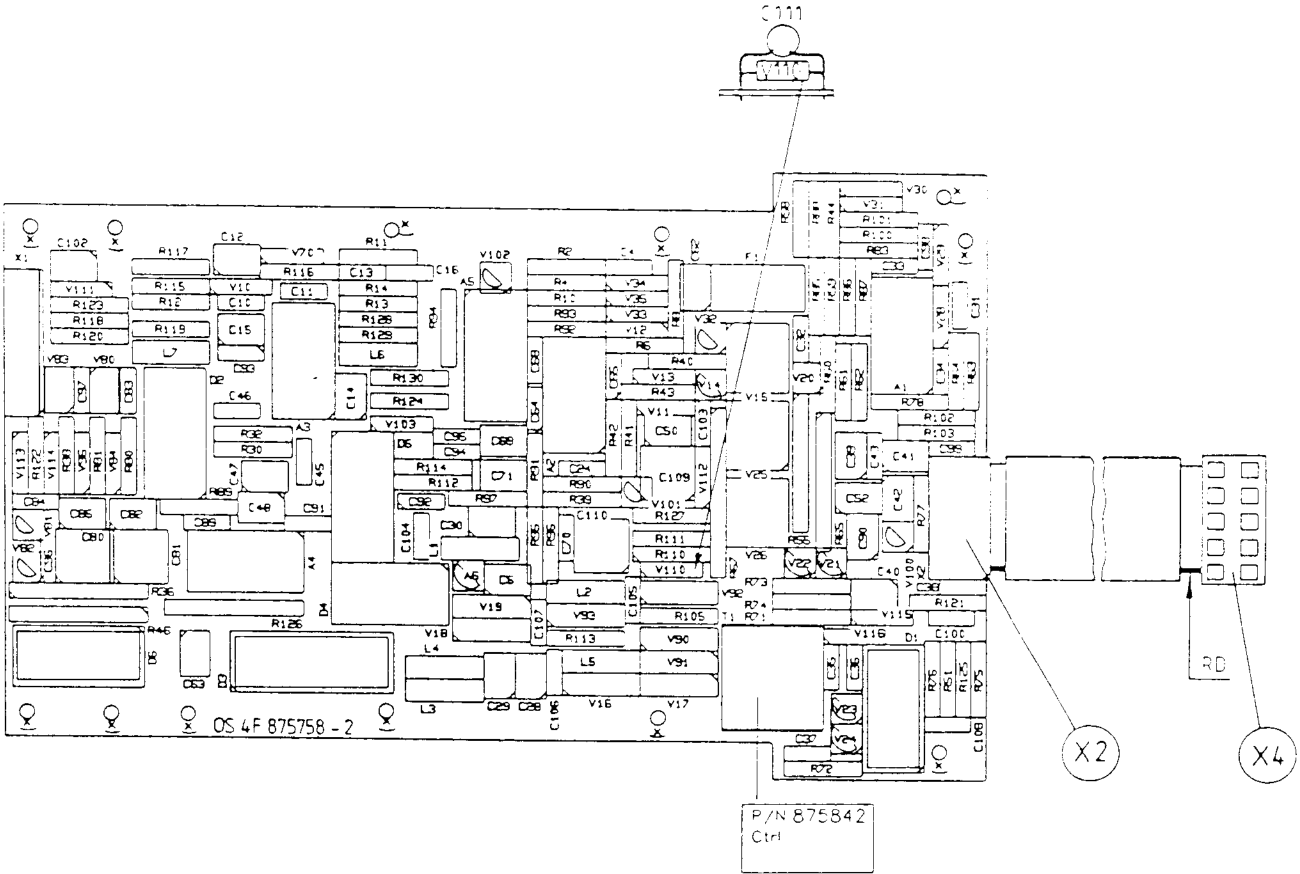
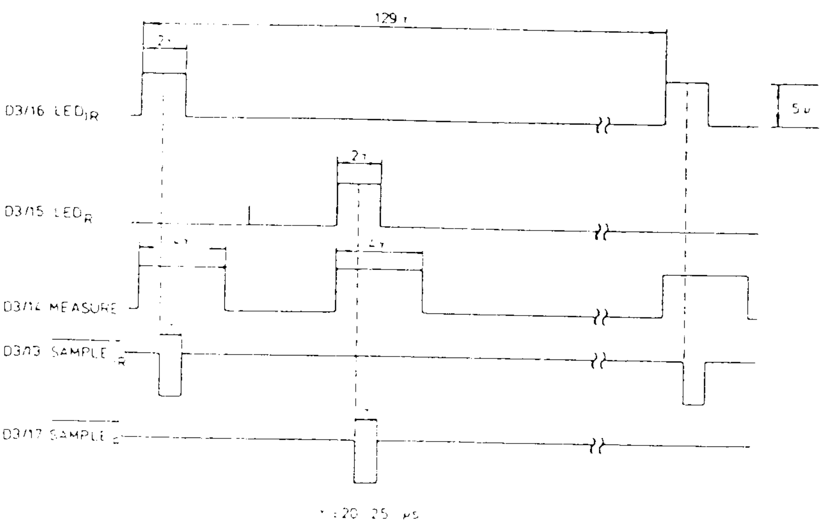

PULSE WIDTH MODULATOR
PATIENT ISOLATION
MUX CHANNEL SELECT & GAIN CONTROL
DATEX
INSTRUMENTARIUM OY
OS-103

Figure 5.22b SpO_2 measuring board parts layout, timing diagram and schematic diagram (part 1) (board modification level 8 and higher)





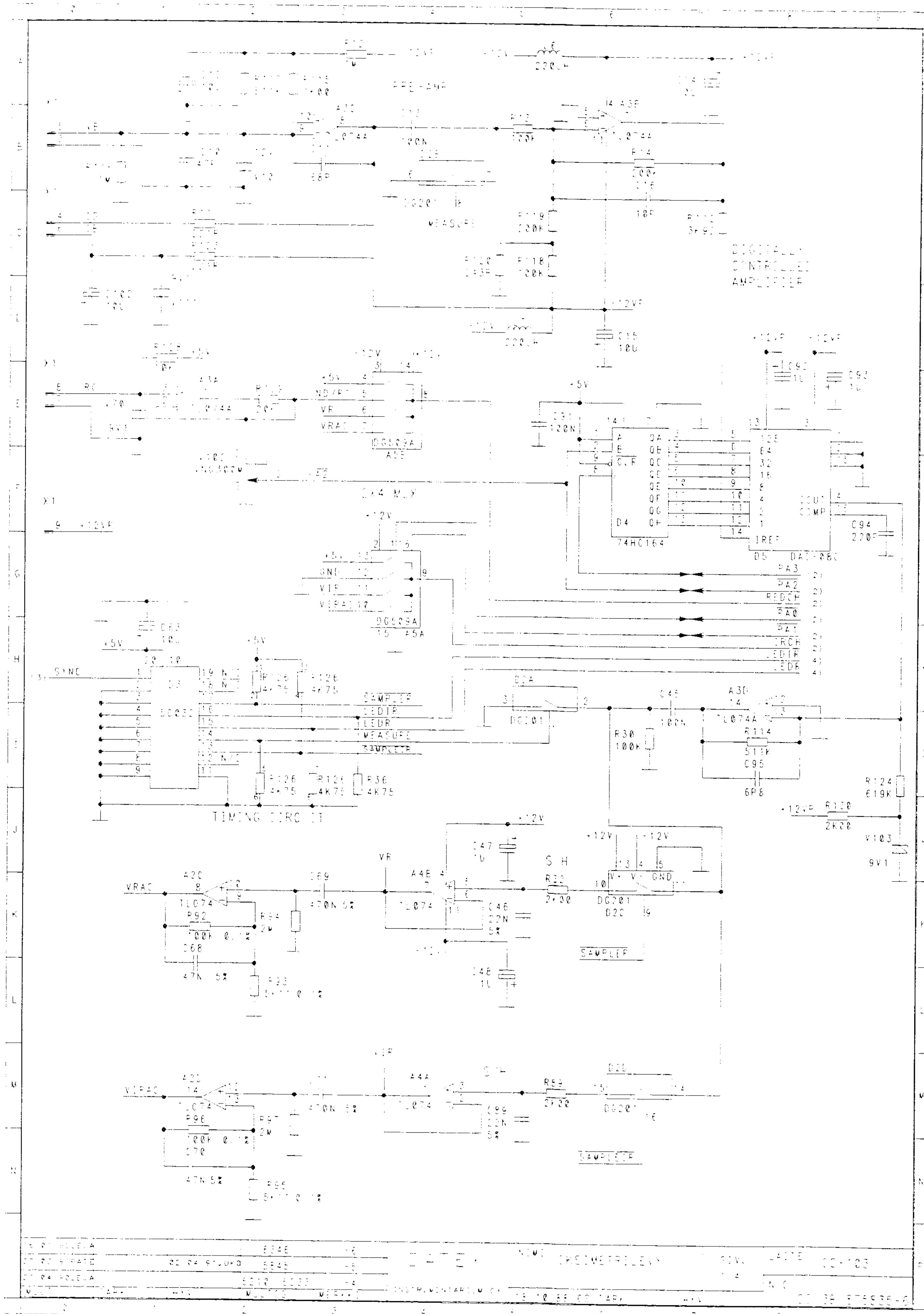
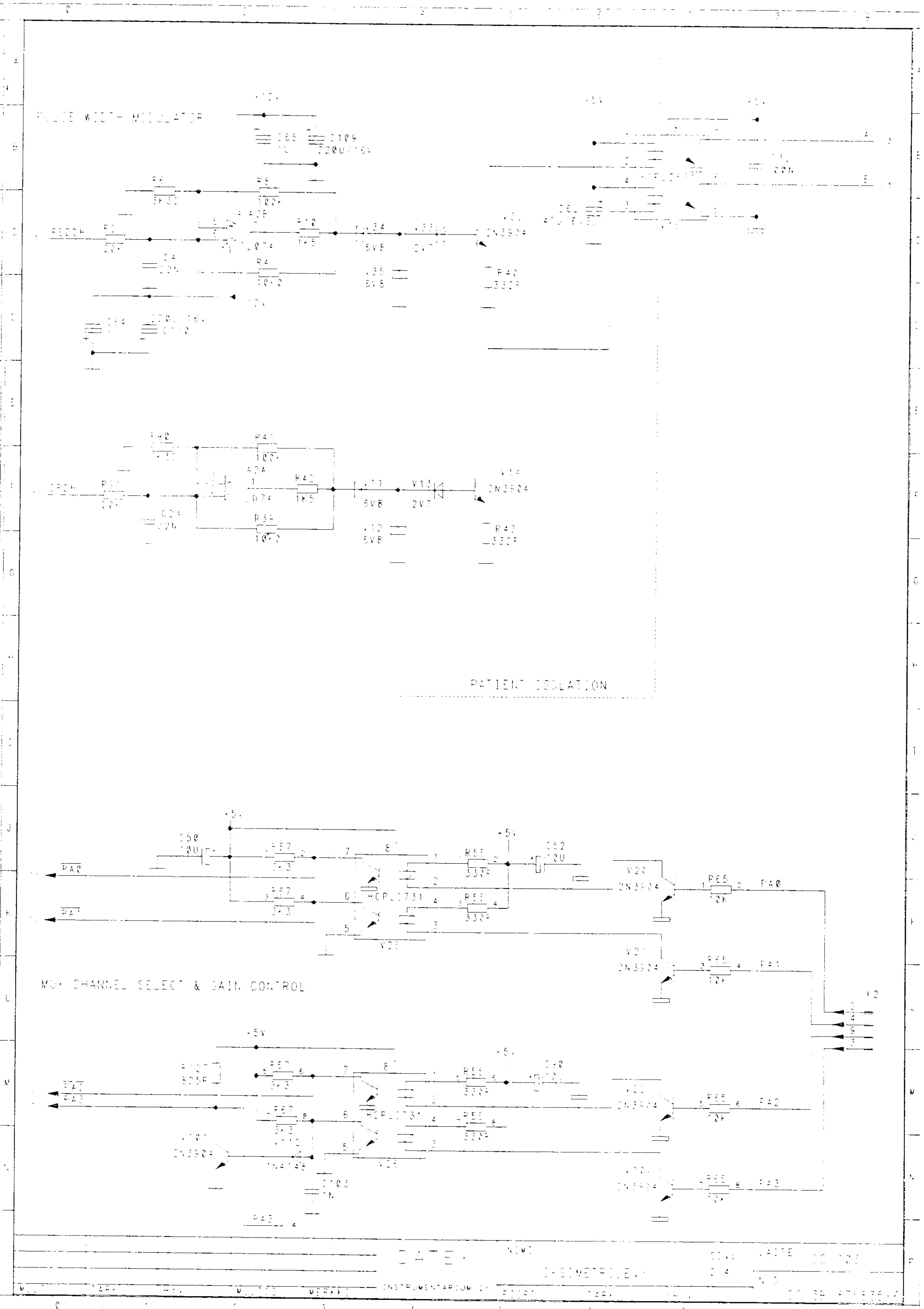
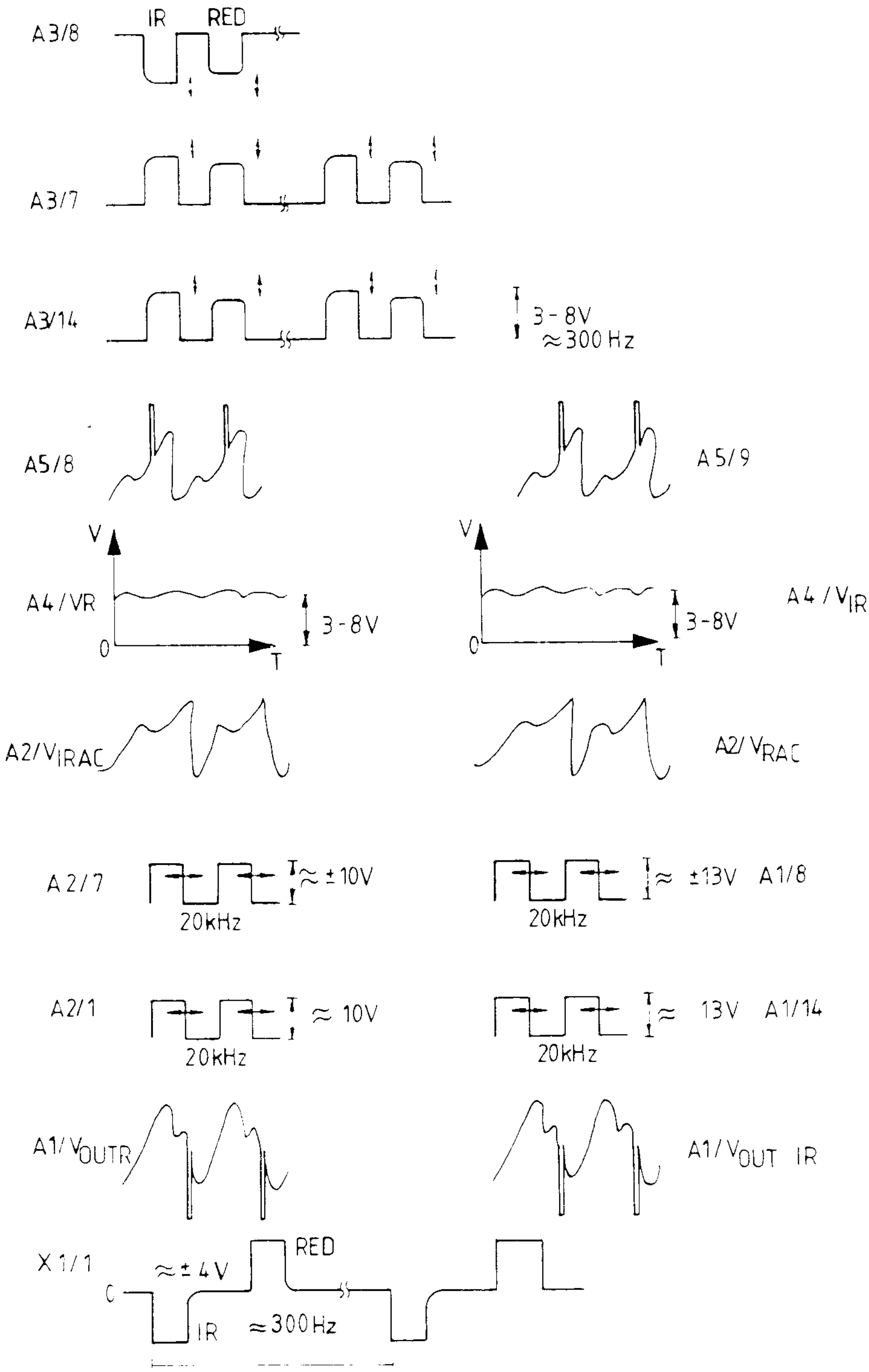
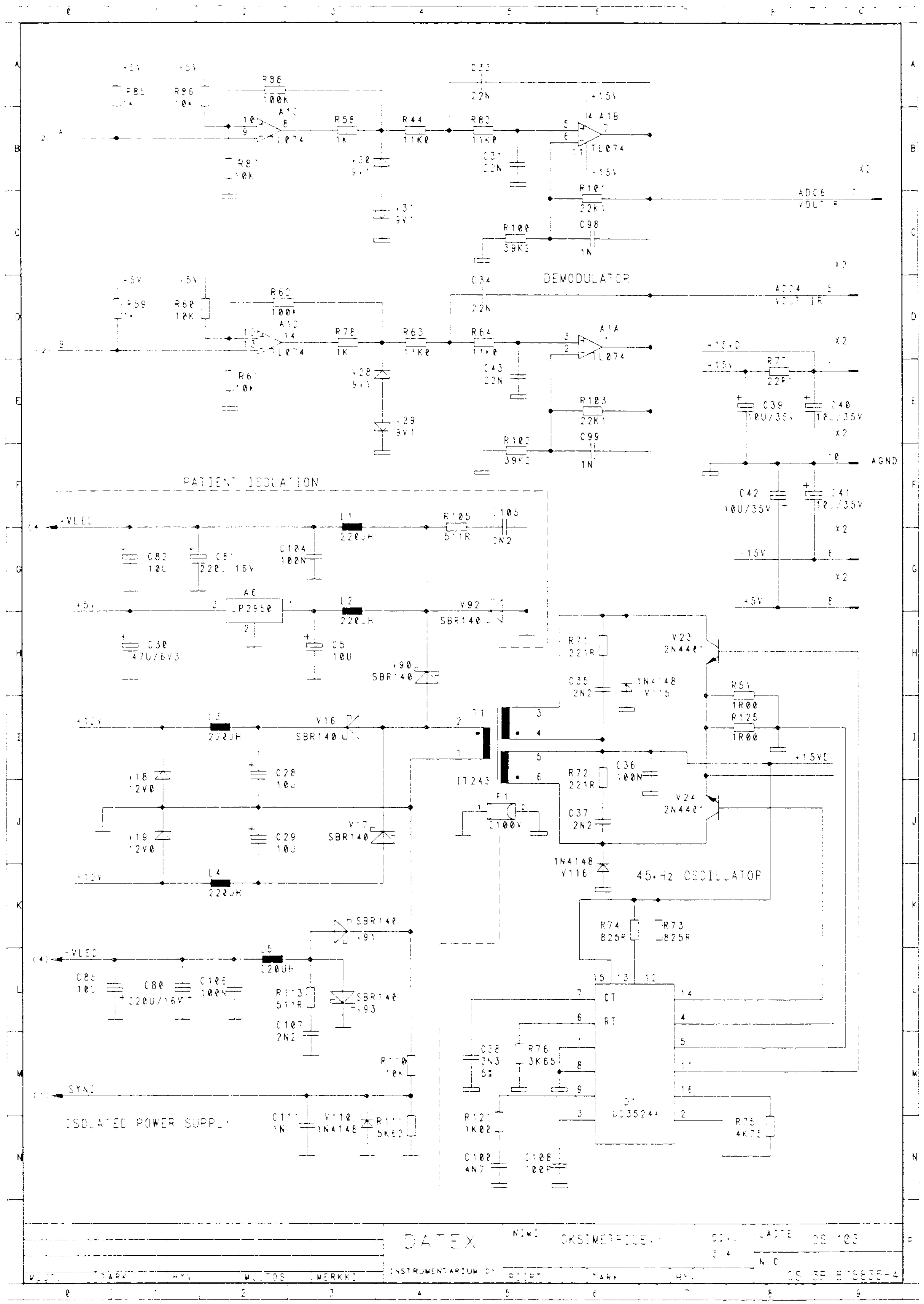
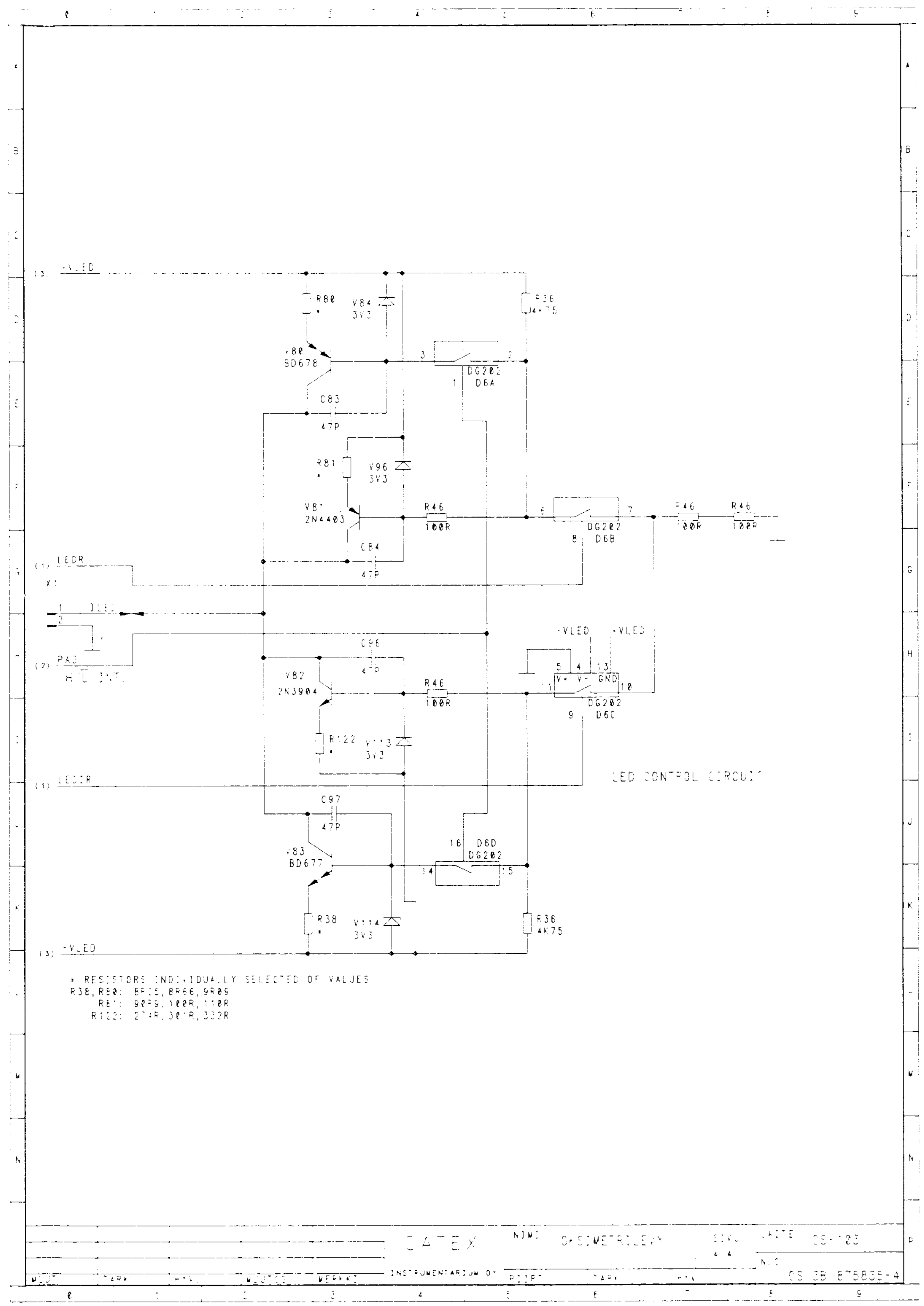

PRE-AMP
DIGITALLY CONTROLLED AMPLIFIER
4x4 MUX
74HC164
TIMING CIRCUIT
SAMPLER
SAMPLER
DG201
TL074
S-H
INSTRUMENTARIUM OY
DATE
NAME

PULSE WIDTH MODULATOR
PATIENT ISOLATION
MUX CHANNEL SELECT & GAIN CONTROL
2N3904
INSTRUMENTARIUM OY
DATE
NAME

Figure 5.23 SpO_2 measuring board signal waveforms and schematic diagram (part 2)



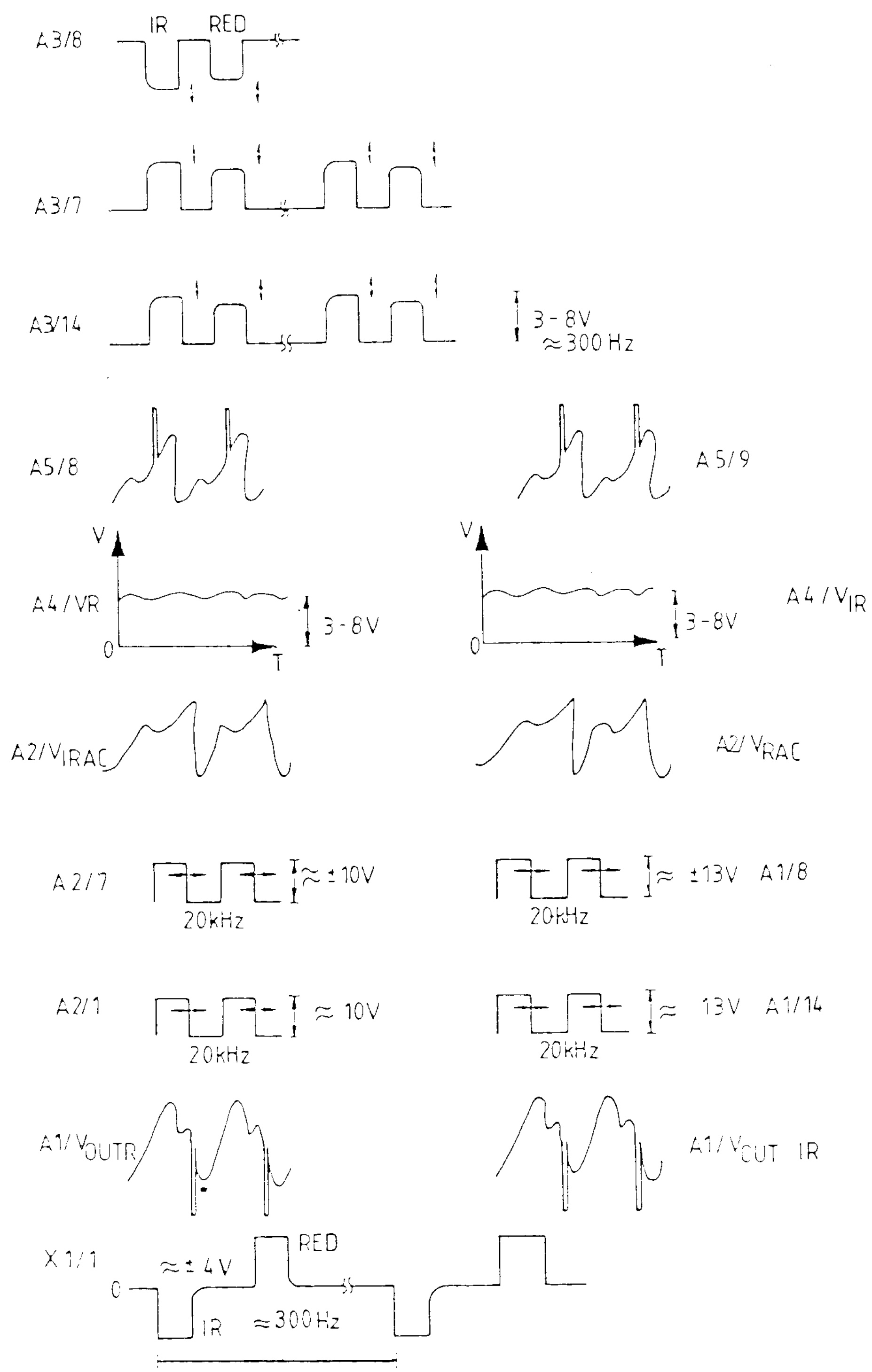


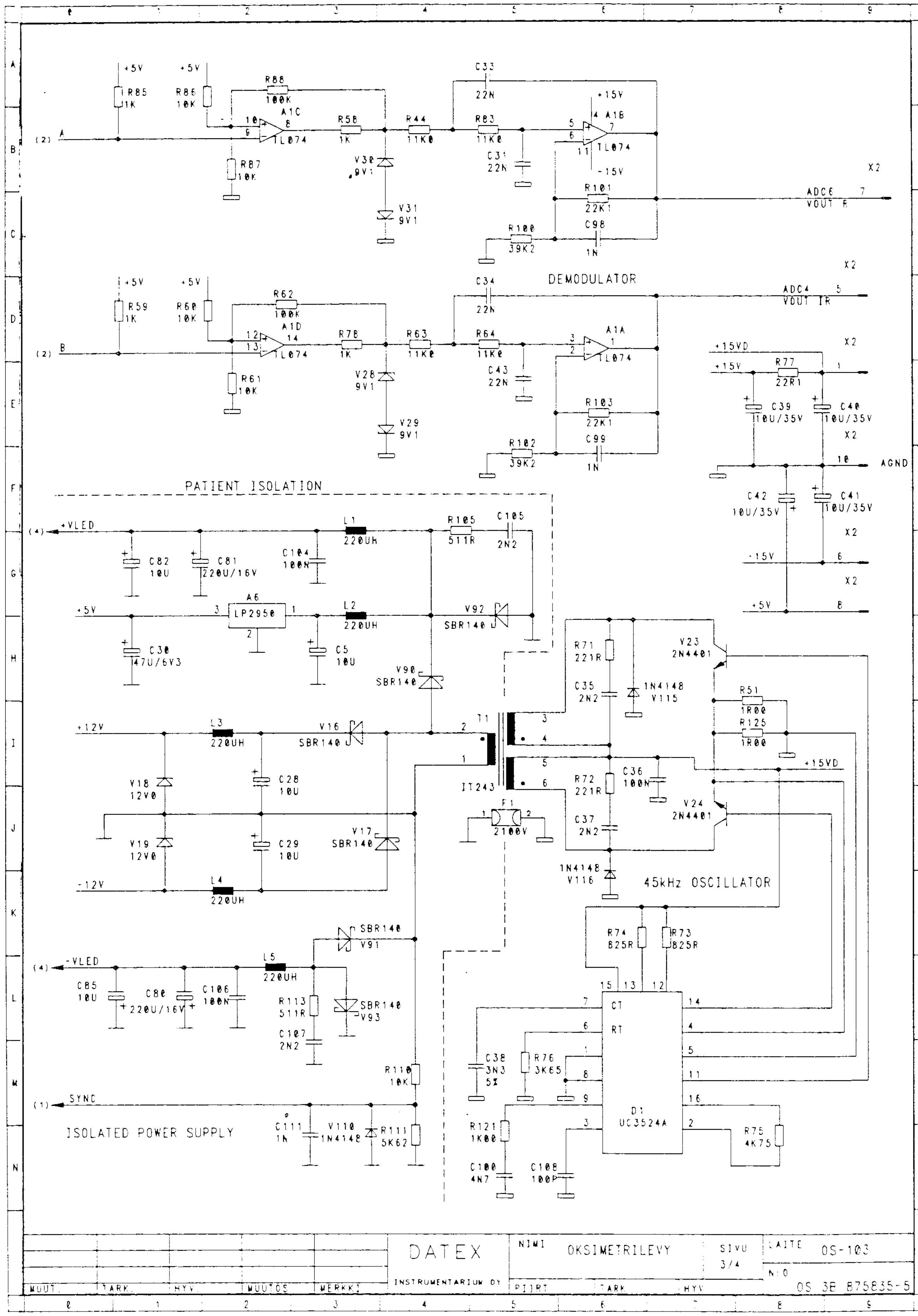
DEMODULATOR
PATIENT ISOLATION
45kHz OSCILLATOR
ISOLATED POWER SUPPLY
DATEX
OKSIMETRILEVY
OS-103



LED CONTROL CIRCUIT
* RESISTORS INDIVIDUALLY SELECTED OF VALUES
DATEX
OKSIMETRILEVY
OS-103

Figure 5.23 SpO_2 measuring board signal waveforms and schematic diagram (part 2) (board modification level 6 and higher)




DEMODULATOR
PATIENT ISOLATION
45kHz OSCILLATOR
ISOLATED POWER SUPPLY
DATEX
INSTRUMENTARIUM OY
NIMI OKSIMETRILEVY
SIVU 3/4
LAITE OS-103
OS 3E 875835-5

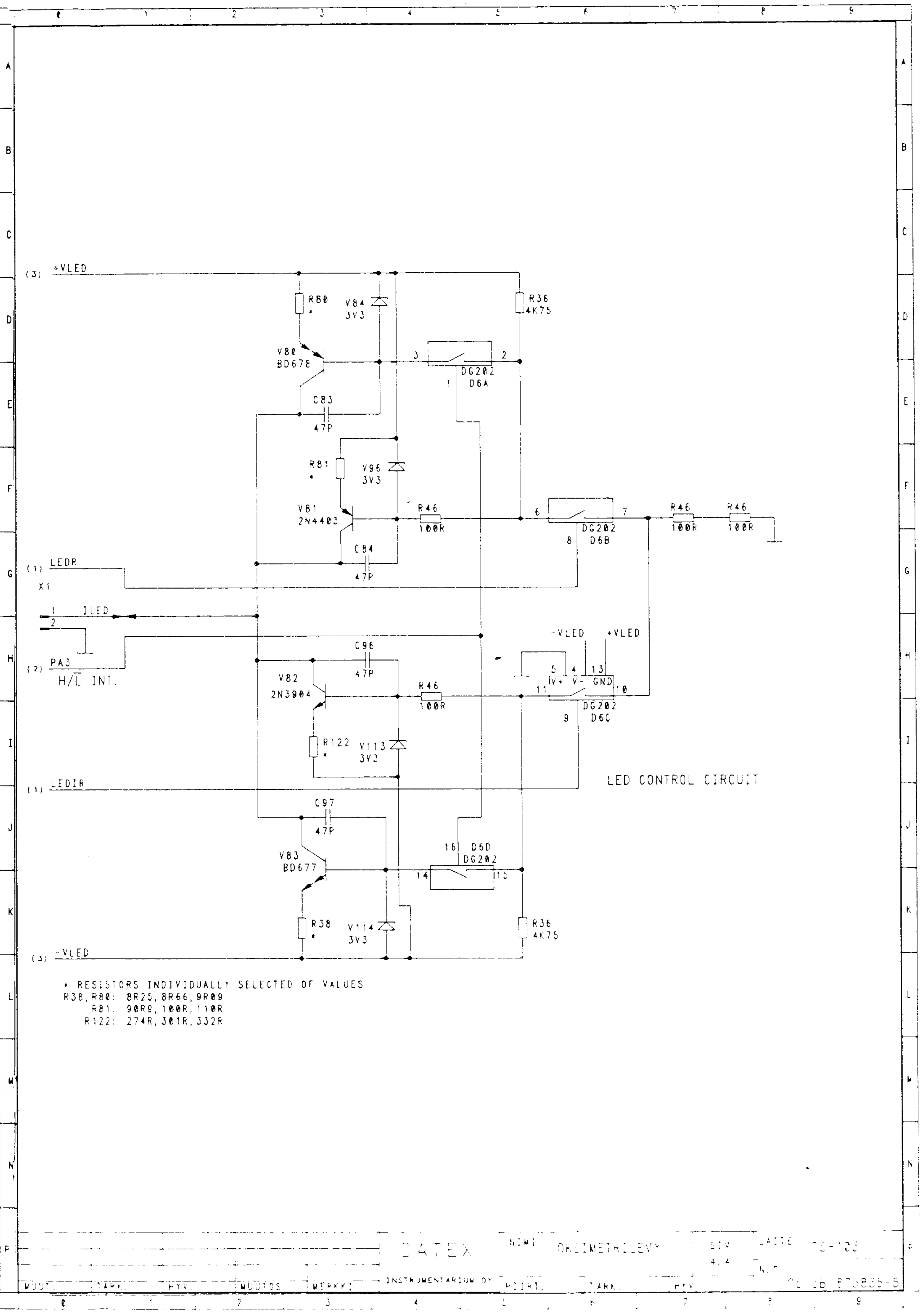
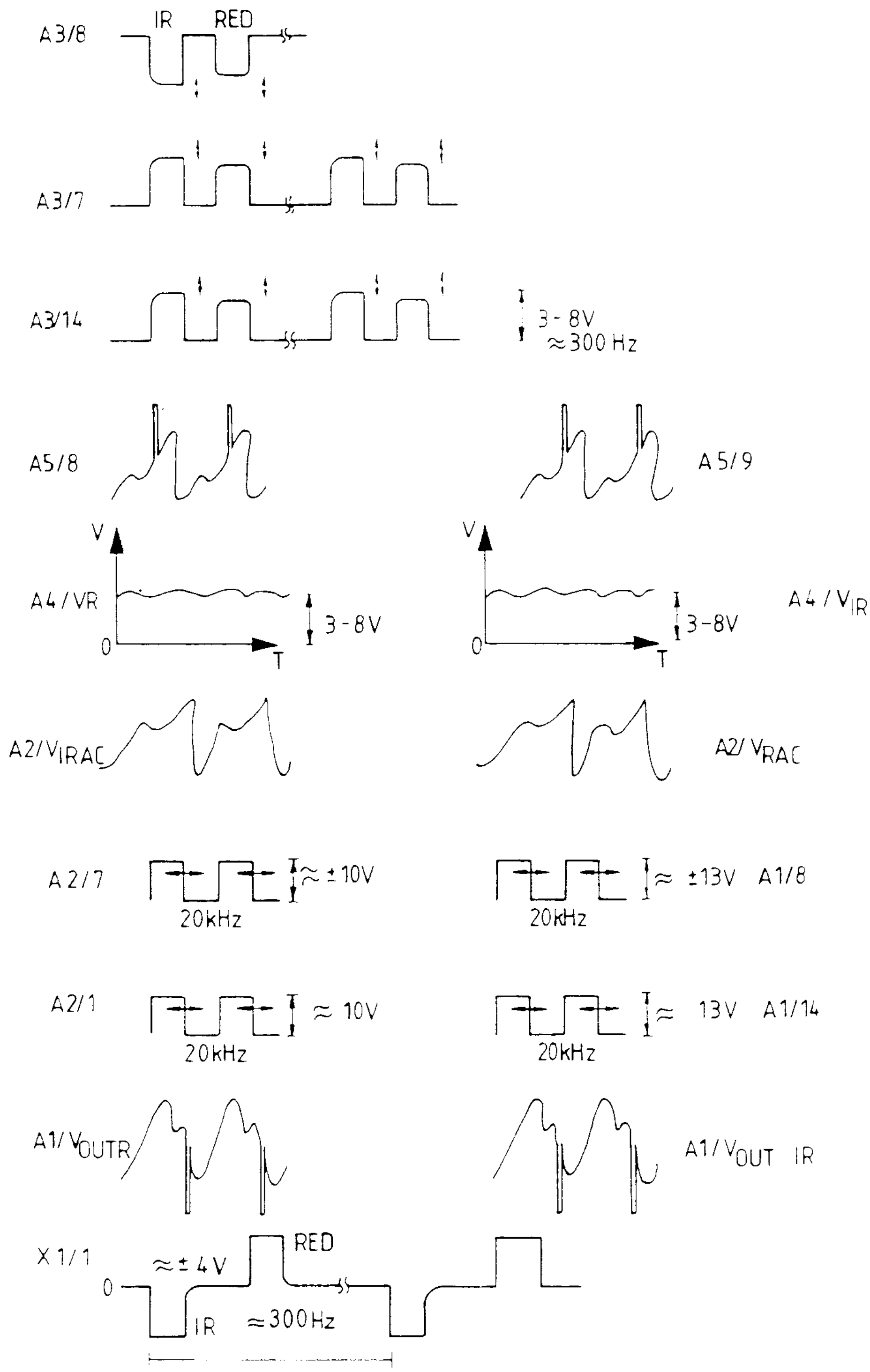
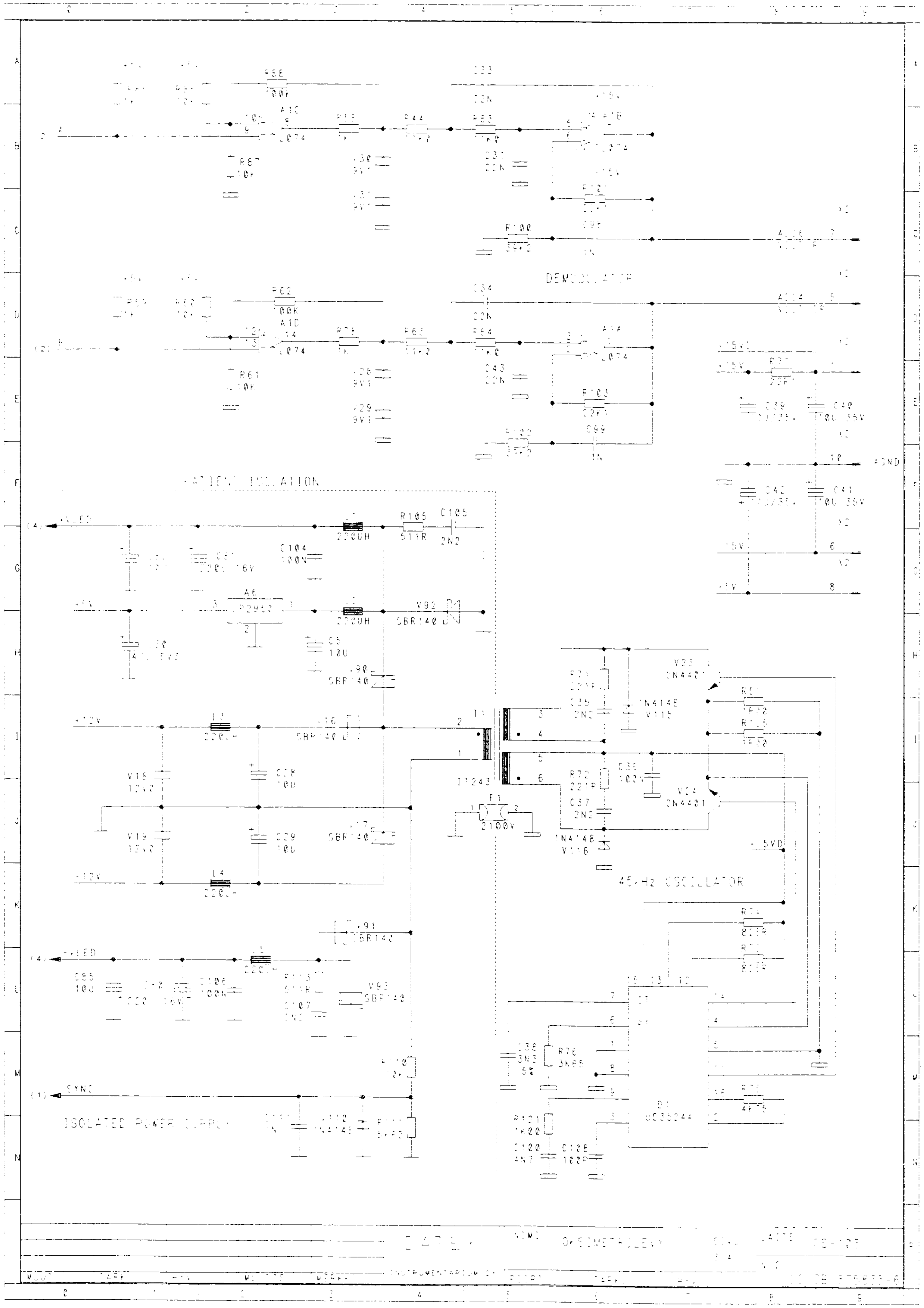
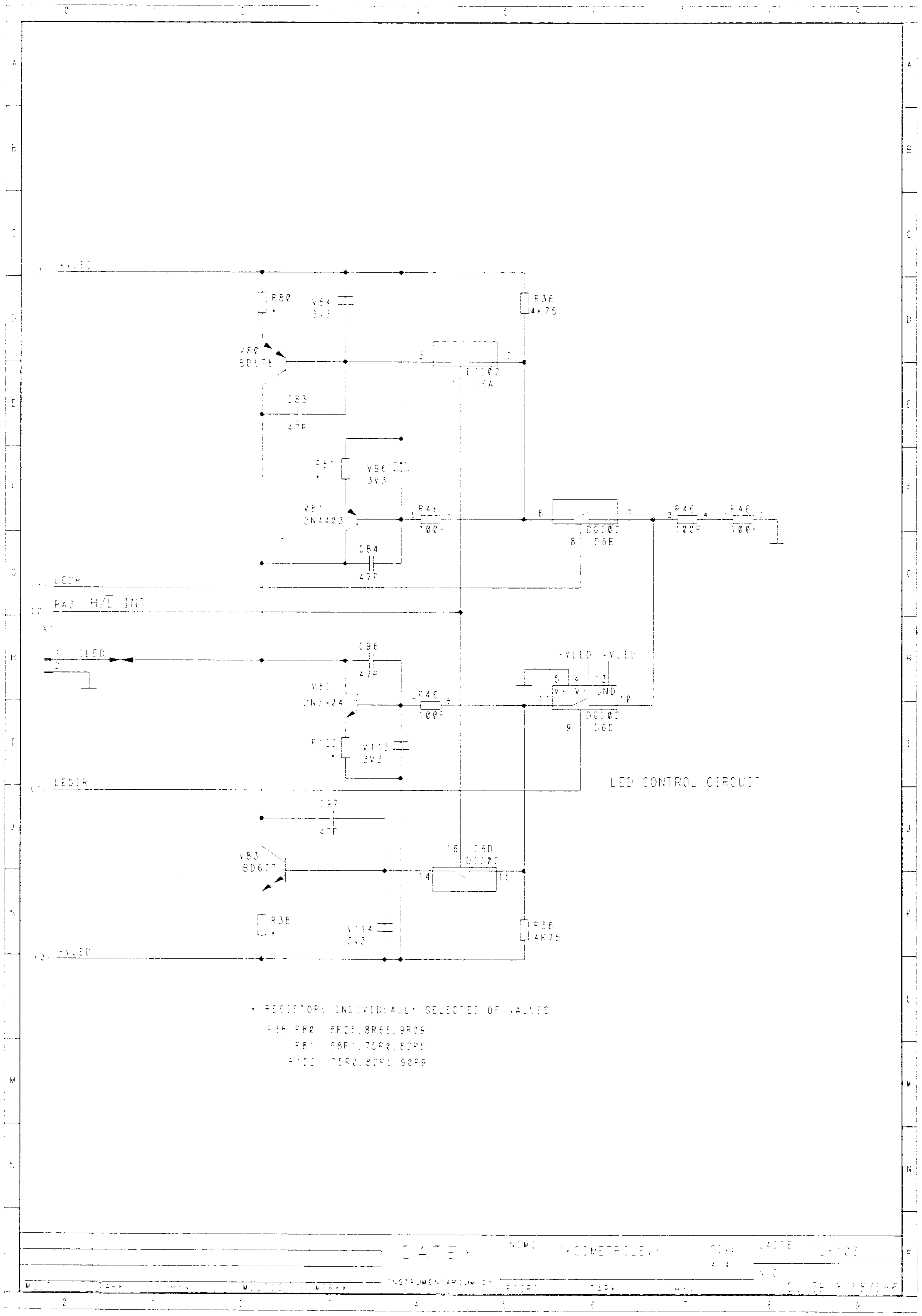

LED CONTROL CIRCUIT
* RESISTORS INDIVIDUALLY SELECTED OF VALUES
R38, R80: 8R25, 8R66, 9R09
R81: 90R9, 100R, 110R
R122: 274R, 301R, 332R
DATEX
INSTRUMENTARIUM OY
NIMI OKSIMETRILEVY
4/4
OS-103

Figure 5.23b SpO_2 measuring board signal waveforms and schematic diagram (part 2) (board modification level 8 and higher)




DEMODULATOR
PATIENT ISOLATION
45kHz OSCILLATOR
ISOLATED POWER SUPPLY
UC3524A
DATEX


LED CONTROL CIRCUIT
DATEX

5.6.2 SpO_2 processor board

The SpO_2 processor board accepts the multiplexed signal from the SpO_2 measuring board, converts the signal to digital data, processes the information and transmits the data and analog PLETH signal (IREDOUT) to the main CPU.

The SpO_2 processor board (see Figure 5.24) contains, the 8031 CPU, EPROM, RAM, the parallel interface circuit, analog multiplexer/demultiplexer, and the analog/digital converter.

The CPU uses the internal bus to access most of the peripheral circuits. CPU port 1 is used to control the analog multiplexer (A3). The serial channel 0 (ASCII computer output) is not used on this board.

The two memory chips are jumper selected for 27256 program EPROM, 8 x 8 kbit low current CMOS RAM 5564 powered by the data retention voltage.

SpO_2 input

The analog signals from the SpO_2 measuring board are sent to an analog MUX, A3 that is used as a demultiplexer. The output goes to a sample/hold circuit and then transmitted to the A/D converter, the output of which is put on to the data bus.

SpO_2 processor board output

Communication between the SpO_2 processor board and the CPU board is established in serial form, using the serial channel (pins 10 and 11) of microprocessor D5 on the SpO_2 processor board. In addition, the measuring board MUX and DAC control signals are sent through the PPI.

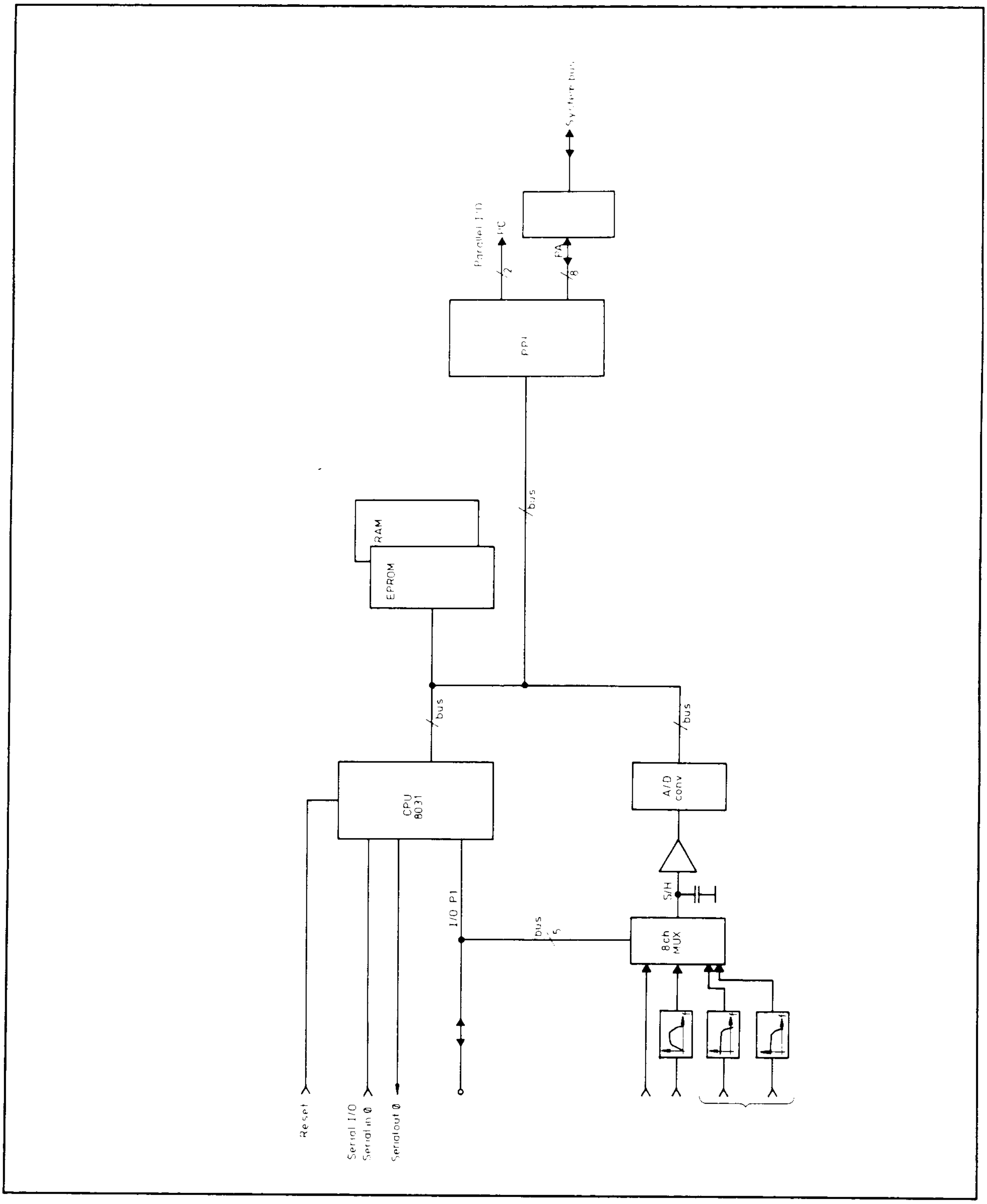
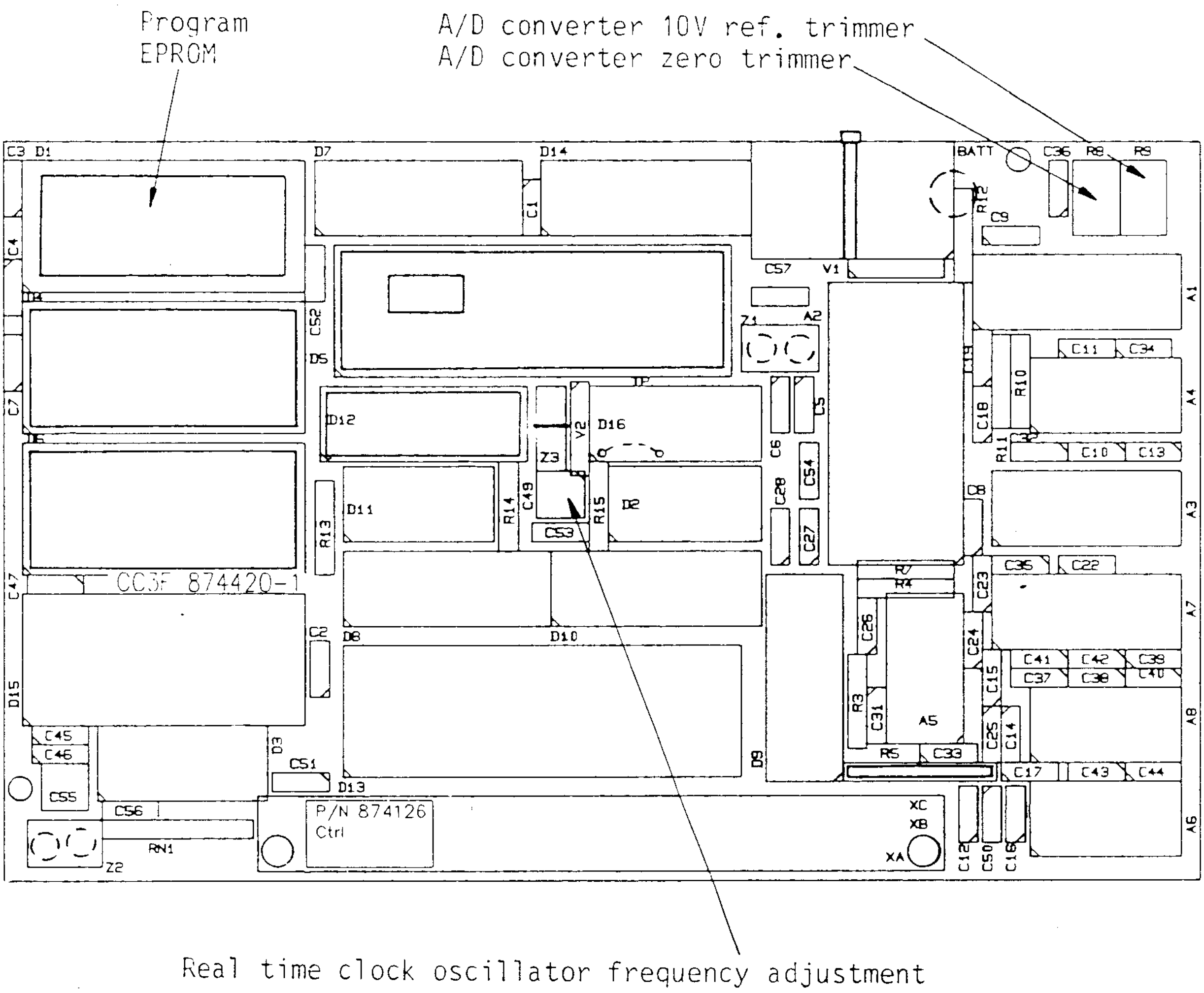
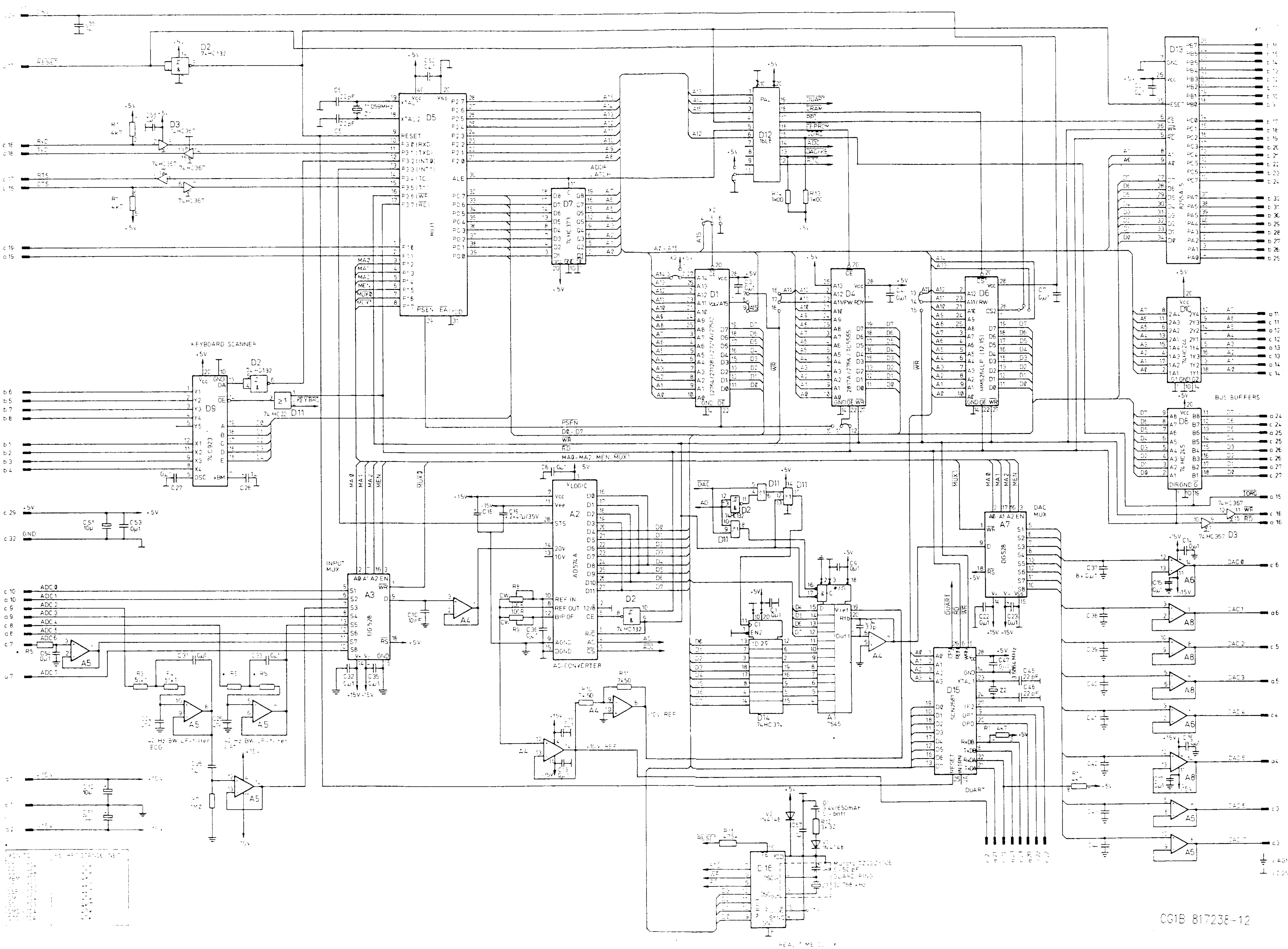


Figure 5.24 SpO_2 processor board block diagram

Figure 5.25 SpO_2 processor board parts layout and schematic diagram




KEYBOARD SCANNER
INPUT MUX
AD-CONVERTER
DAC MUX
BUS BUFFERS
DUART
CG1B 817238-12

5.6.3 SpO_2 connector I/O board

The SpO_2 connector I/O board is located between the SpO_2 measuring board and the SpO_2 processor board.

The board contains a reset circuit for the SpO_2 processor board and +15 V regulator as well as buffers for the serial channels.

Signals from the SpO_2 measuring board pass through the SpO_2 connector I/O board and go to the SpO_2 processor board.

Serial and analog I/O connector outputs from the Power supply board are connected to the SpO_2 connector I/O board with ribbon cable and a pair of D-connectors (see Figure below).

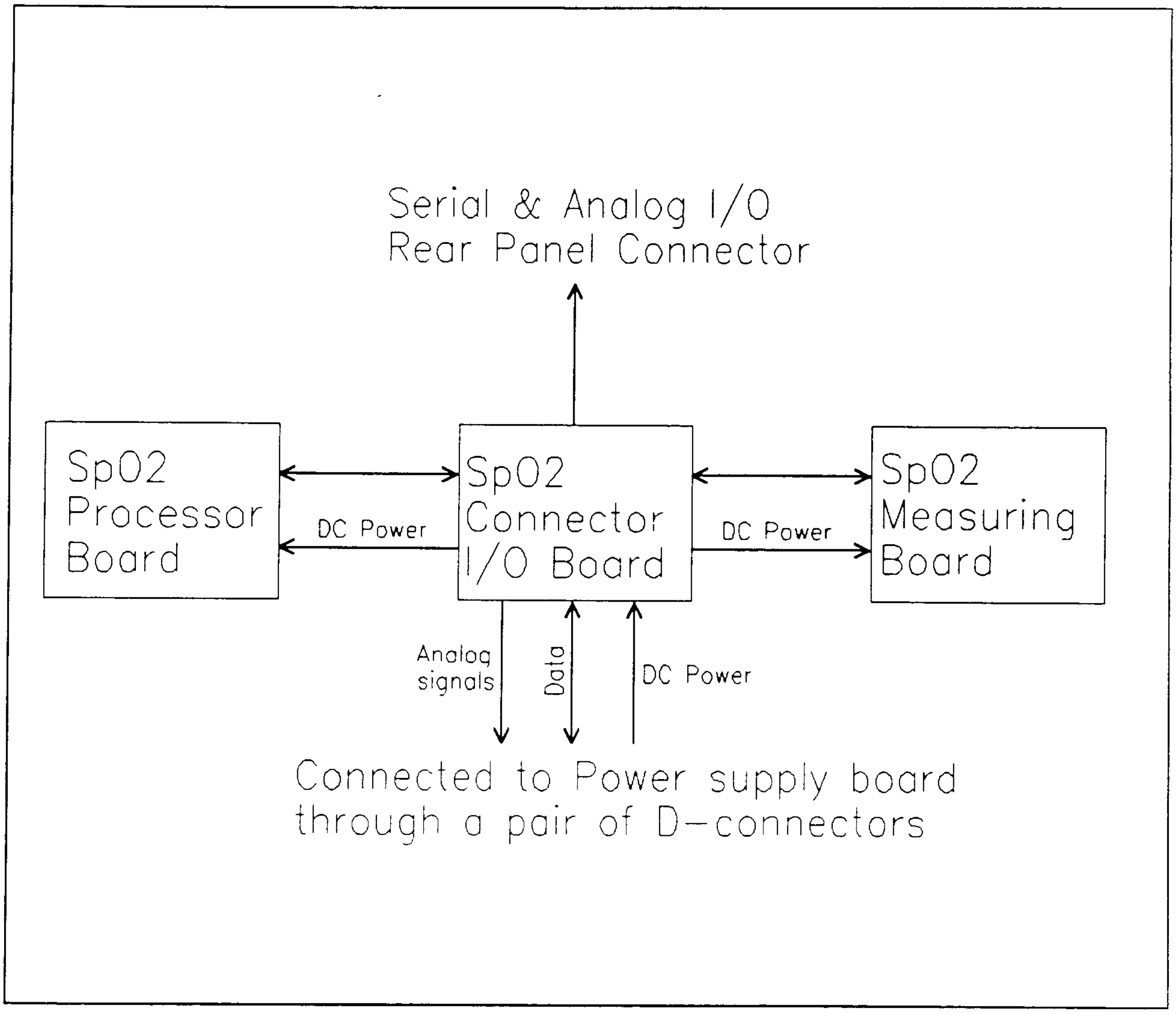
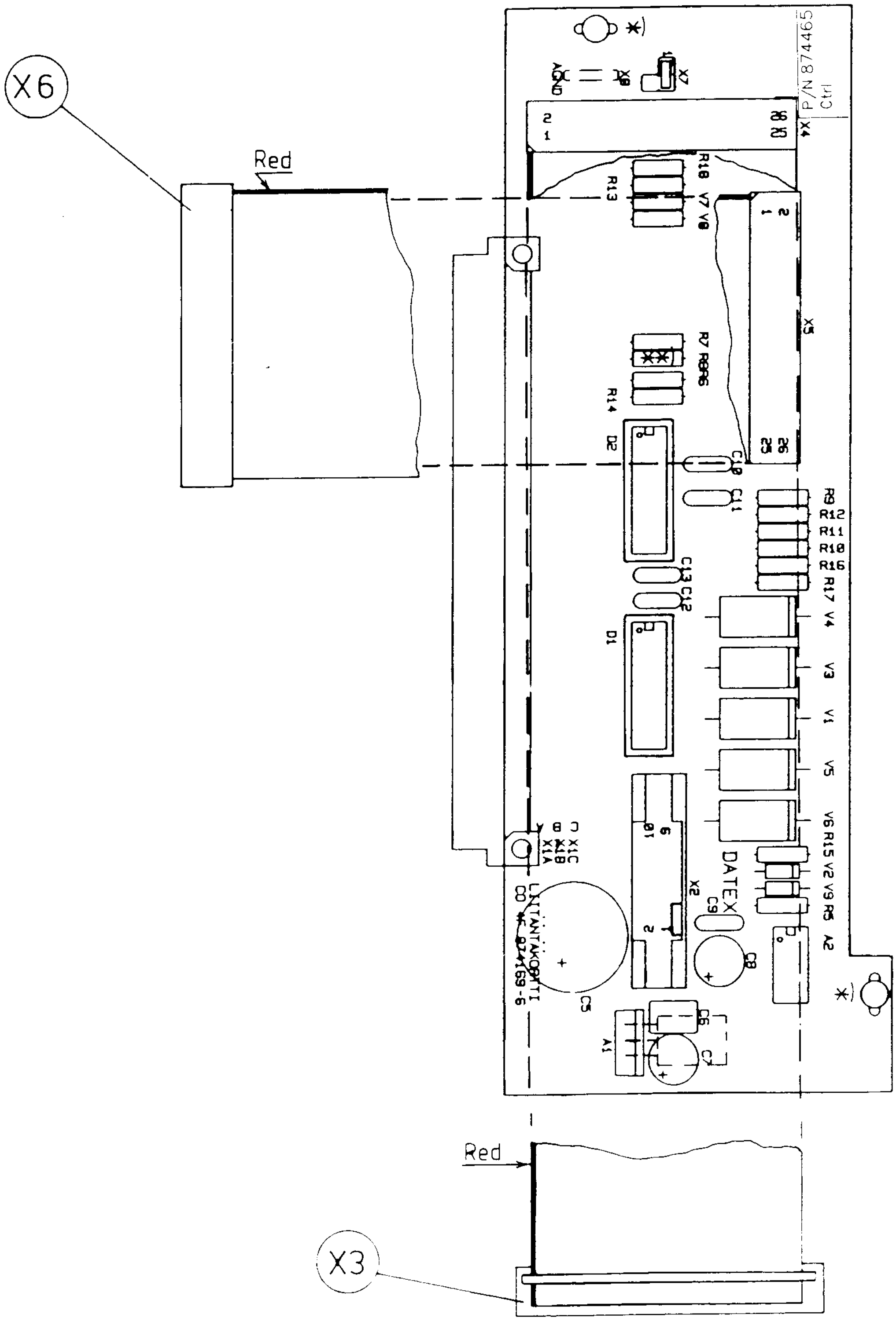
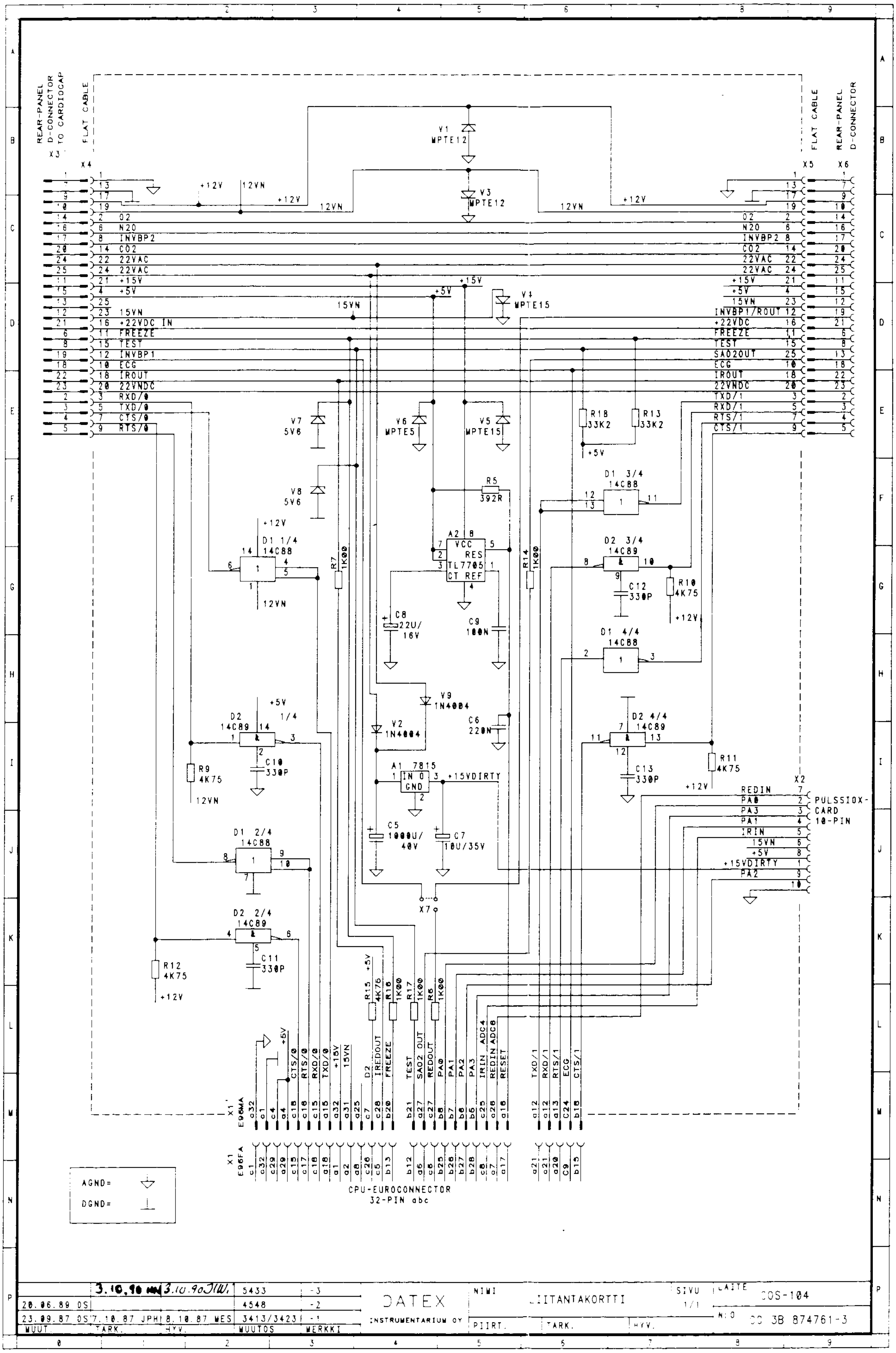


Figure 5.26 SpO_2 boards configuration

Figure 5.27 SpO_2 connector I/O board parts layout and schematic diagram




REAR-PANEL D-CONNECTOR TO CARDIOCAP
FLAT CABLE
X3
X4
X5
X6
REAR-PANEL D-CONNECTOR
PULSSIOX-CARD 10-PIN
X2
CPU-EUROCONNECTOR 32-PIN abc
X1 E96MA
X1 E96FA
AGND=
DGND=
D1 1/4 14C88
D1 2/4 14C88
D1 3/4 14C88
D1 4/4 14C88
D2 1/4 14C89
D2 2/4 14C89
D2 3/4 14C89
D2 4/4 14C89
A2 TL7705
A1 7815
DATEX
INSTRUMENTARIUM OY
NIMI
LIITANTAKORTTI
SIVU 1/1
LAITE
COS-104
N:O
CC 3B 874761-3
PIIRT.
TARK.
HYV.
MUUT
MUUTOS
MERKKI
20.06.89 DS
23.09.87 DS 7.10.87 JPH 8.10.87 MES
5433 -3
4548 -2
3413/3423 -1

5.7 CPU board

The high speed CPU board contains 16 MHz oscillator to replace that of 11,059 MHz. Serial I/O signals that used the CPU's own channel in the previous CPU board are changed and they occupy one channel in QUART.

The board contains, in addition to the 80C32 CPU, the standard EPROM, SRAM, and several analog and digital I/O functions. See the CPU board block diagram.

The CPU (D5, refer to Figure 5.29) uses the CPU board internal bus to access most of the peripheral circuits. Processor port 1 is used to control the analog multiplexers (MUX).

Communication with the NIBP board is established in serial mode through QUART (D15) pins 4 (in) and 3 (out).

The three memory chips are jumper selected for 1M bit program EPROM (D1), 32 x 8 kbit low current CMOS SRAM (D6) powered by the data retention voltage, and battery back-up 8 kbit SRAM (D4) for permanent calibration value memory. See the jumper configuration.

Input signal processing

Analog input signals from the IPT, ECG, CO_2/N_2O measuring boards and O_2 measuring unit are read through the multiplexer (A3) to a sample and hold circuit and to the A/D-converter A2.

Output signal processing

Up to eight analog signals are sent to the output connectors. Digital patient data is sent to a D/A converter A1 and after conversion, sent to the demultiplexer A7. The eight analog signals produced are sent to sample and hold circuits and then transmitted to the power supply board and the connectors in the back of the monitor.

Control signals of MUX are in port 1 on the microprocessor as follows:

P1	pins 3-5	MUX A0-A2 (both)
	pin 6	MUX enable (both)
	pin 7	MUX 0 Write (ADC)
	pin 8	MUX 1 Write (DAC)
	ADC 0	CO_2
	ADC 1	N_2O
	ADC 2	ECG
	ADC 3	O_2
	ADC 4	IPT signal
	ADC 5	GAS PRES
	ADC 6	PB2 signal
	ADC 7	EXT INOP
	DAC 0	CO_2
	DAC 1	O_2
	DAC 2	IPT signal
	DAC 4	ECG TEST
	DAC 5	Loudspeaker volume
	DAC 6	PB2 signal
	DAC 7	Loudspeaker pitch

Ports on the PPI is used for as follows:

PA (output)	PB (input)	PC (low input, high output)
PA0: IPT control	PB0: not used (AUX)	PC0: -ECG INOP
PA1: IPT control	PB1: not used (AUX)	PC1: PB2 INOP
PA2: IPT control	PB2:	PC2: not used
PA3: not used	PB3: CD	PC3: Normocap signal
PA4: not used	PB4: DSR	PC4: Occlusion valve
PA5: not used (AUX)	PB5: CTSB (AUX)	PC5: Pump
PA6: not used (AUX)	PB6: CTSA (AUX)	PC6: Zero valve
PA7: Nurse call (AUX)	PB7:	PC7: not used

When a key is pressed (short-circuit) keyboard scanner (D9) interrupts the microprocessor and this reads from the scanner which key was pressed.

The 16 MHz oscillator clock is first passed through control logic circuit (D2, D16, and D19), which is for wait state control, and fed to the CPU.

Because of slowness of the some internal peripheral circuits, their bus (IODATA) is separated from the high speed bus (DATA) by D18.

Function of real time clock is included in battery back-up SRAM (D4).

Software features are described in the Operator's Manual. Main differences between software revisions are described in Section 3.4.

CAUTION: The SRAM IC (D4) contains a lithium battery. Danger of explosion if the IC is incorrectly replaced. Replace only with same or equivalent type recommended by DATEX. Discard faulty IC:s according to manufacturer's instruction.

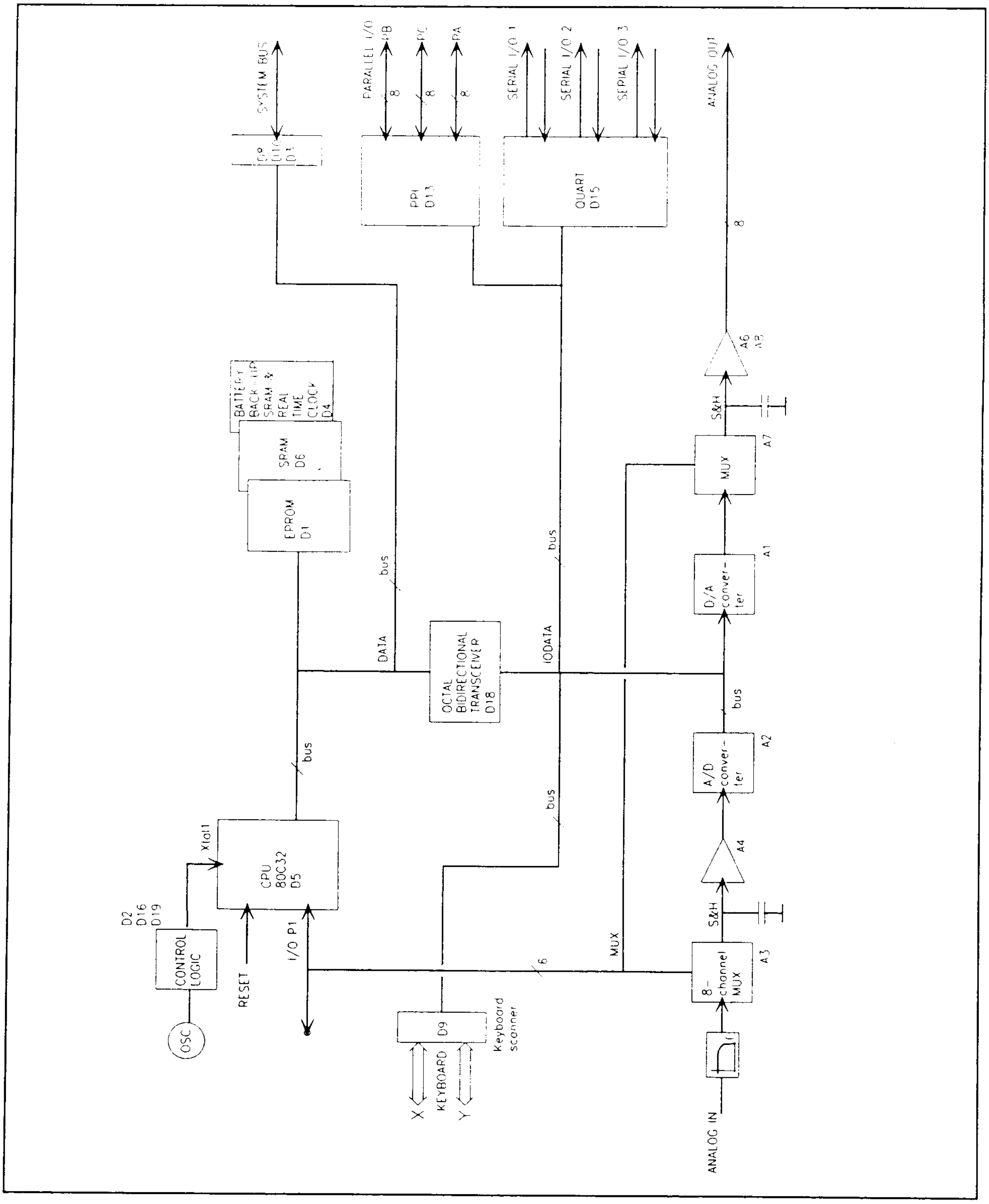
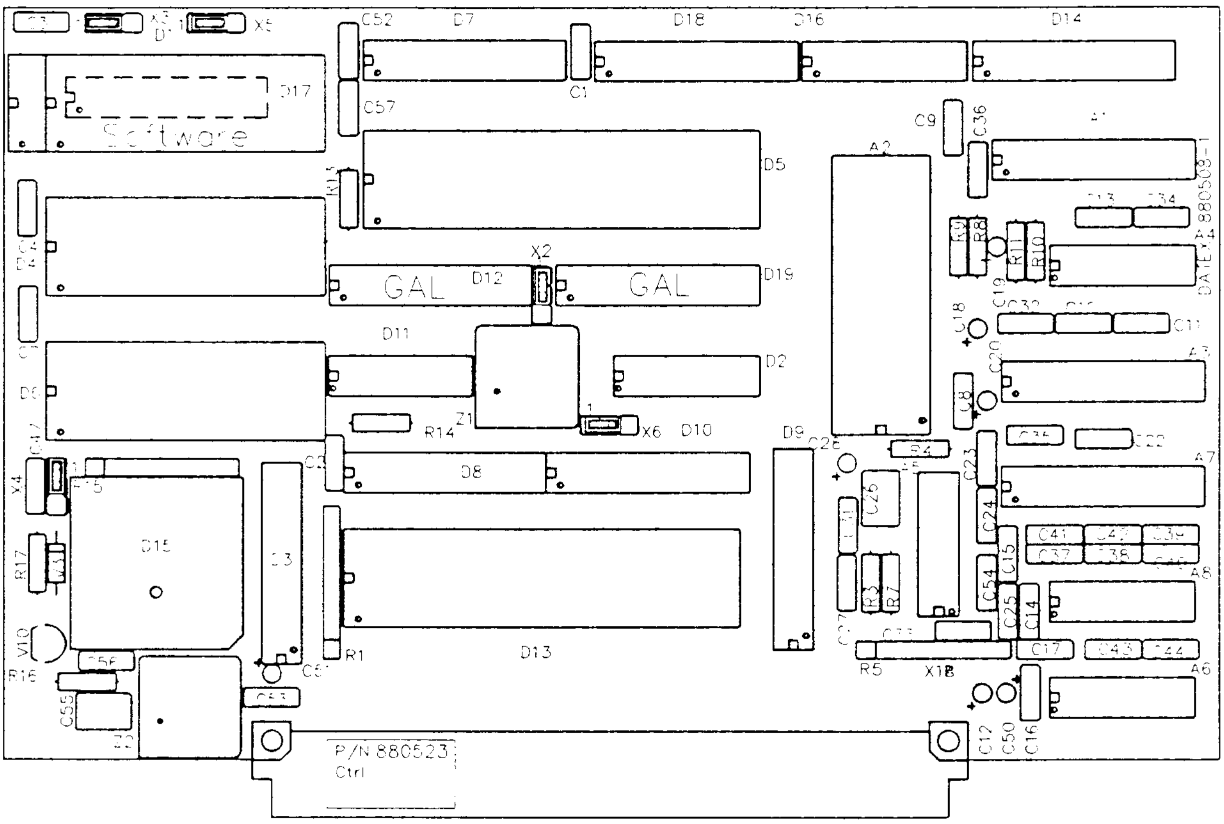
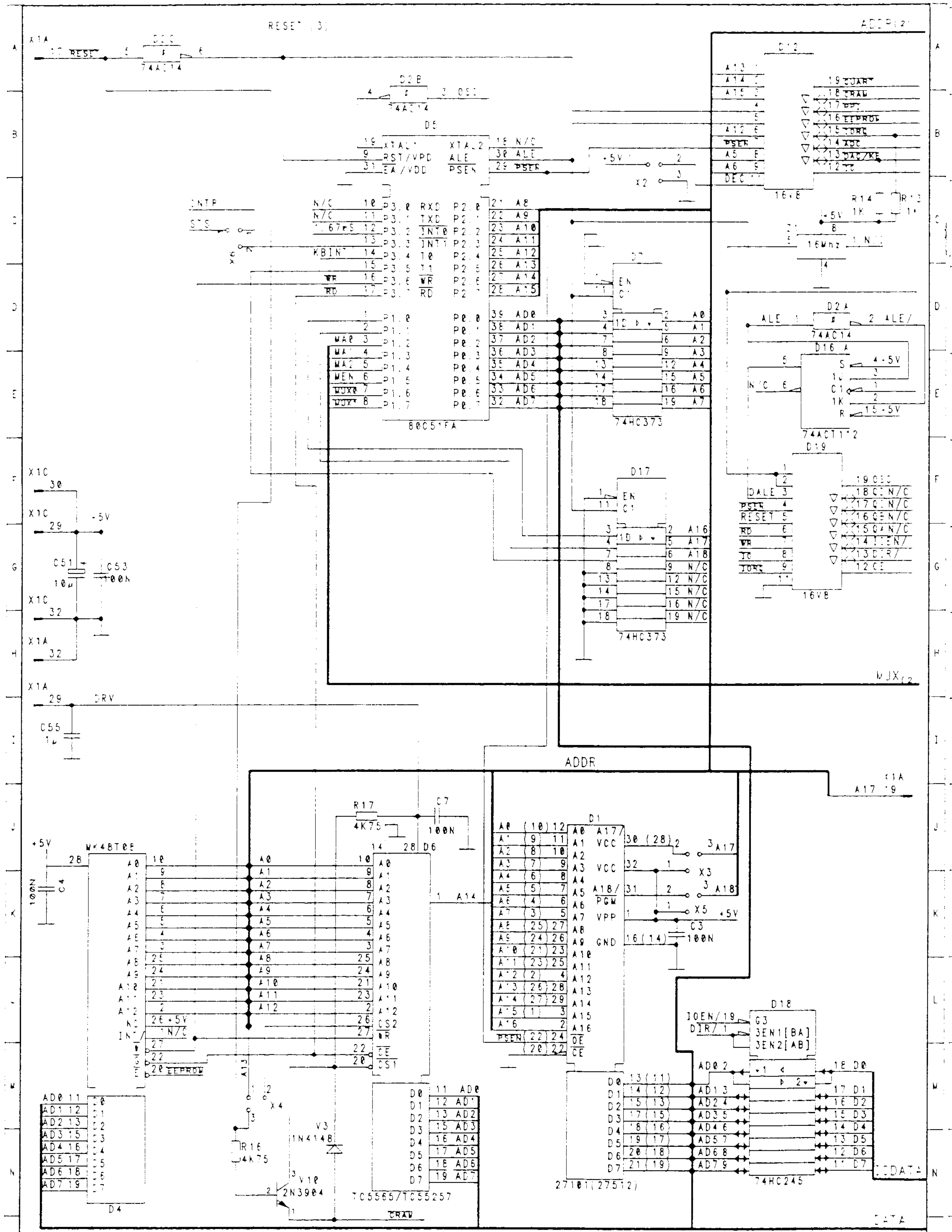


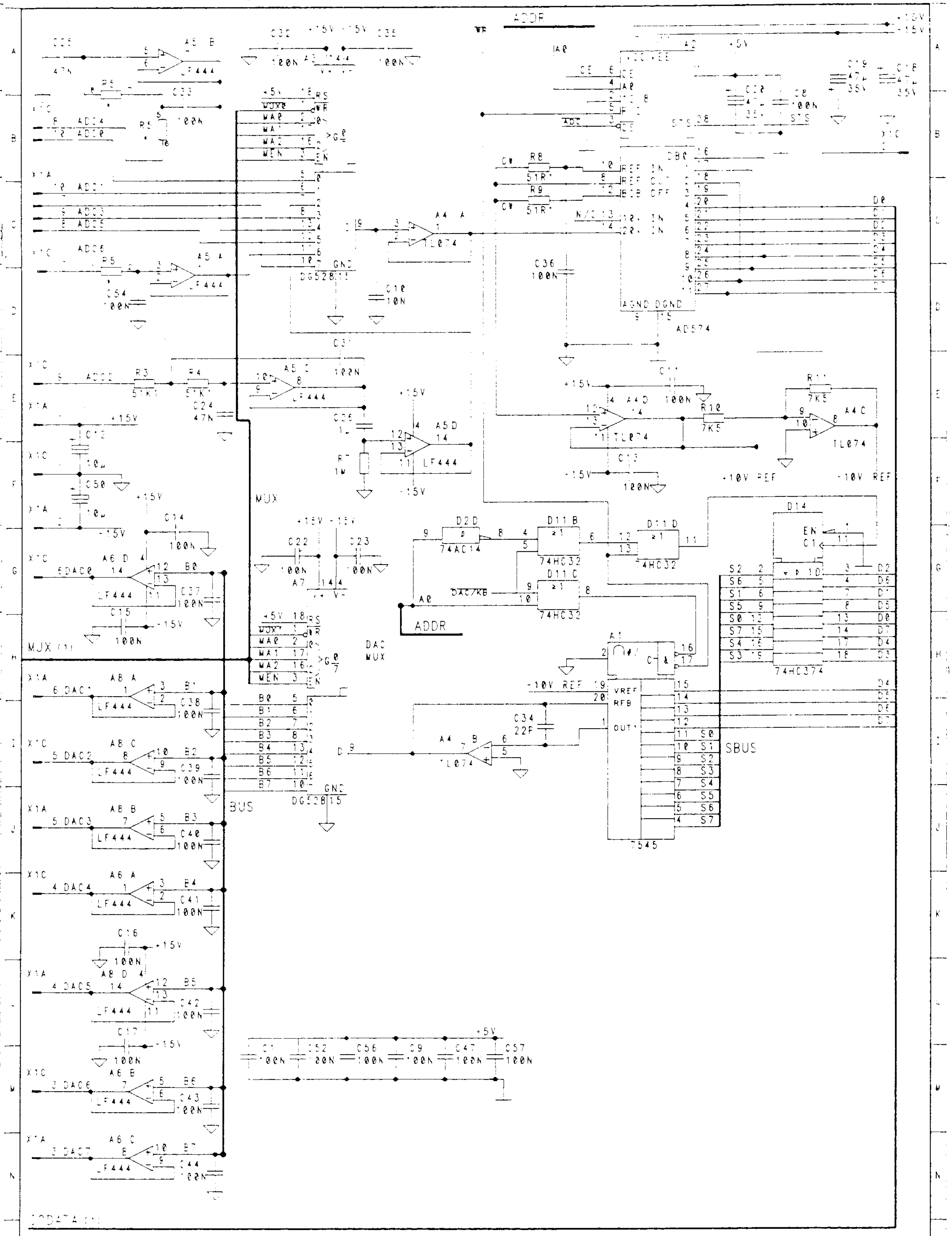
Figure 5.28 CPU board block diagram

Figure 5.29 CPU board parts layout and schematic diagram





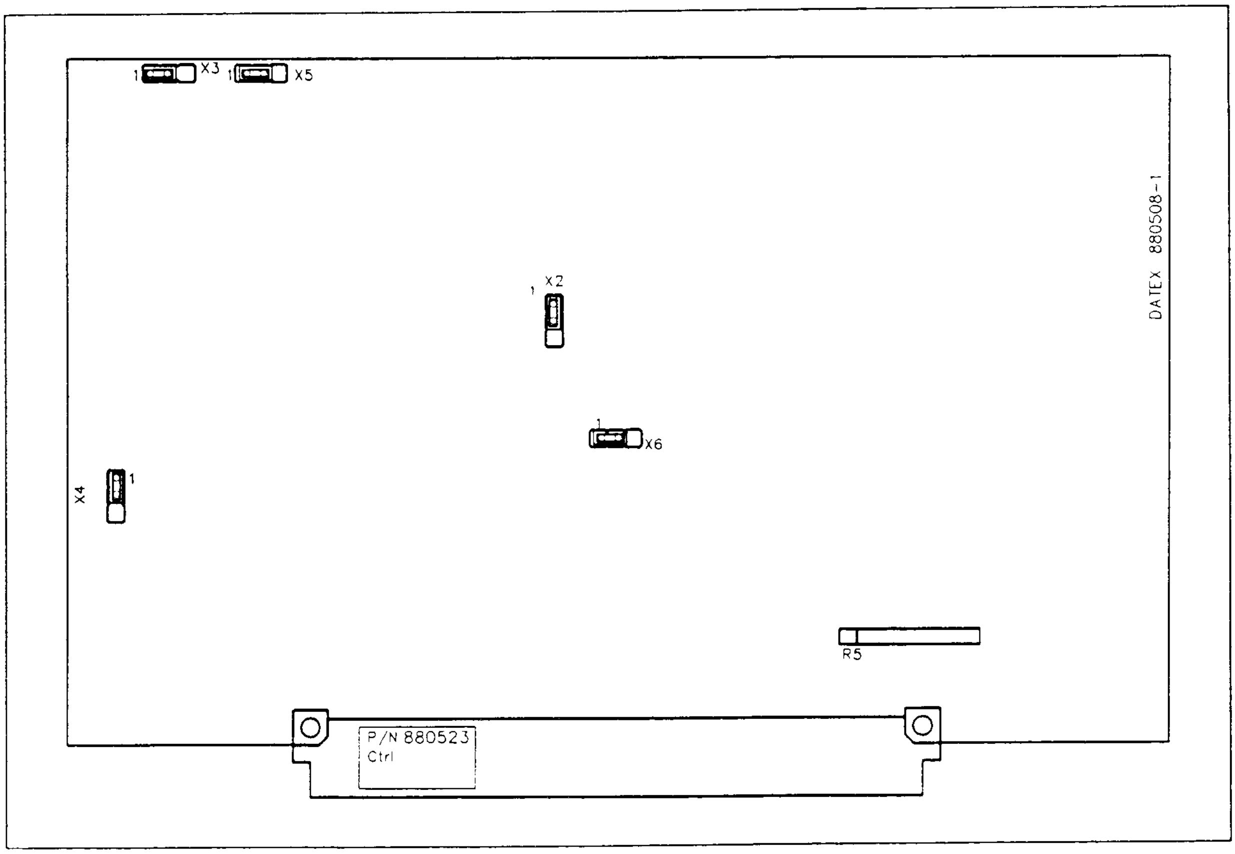
DATEX
INSTRUMENTARIUM OY
NIMI: CPU BOARD
SIVU: 1/3
LAITE: CH-
N:O: CH 3E 880507



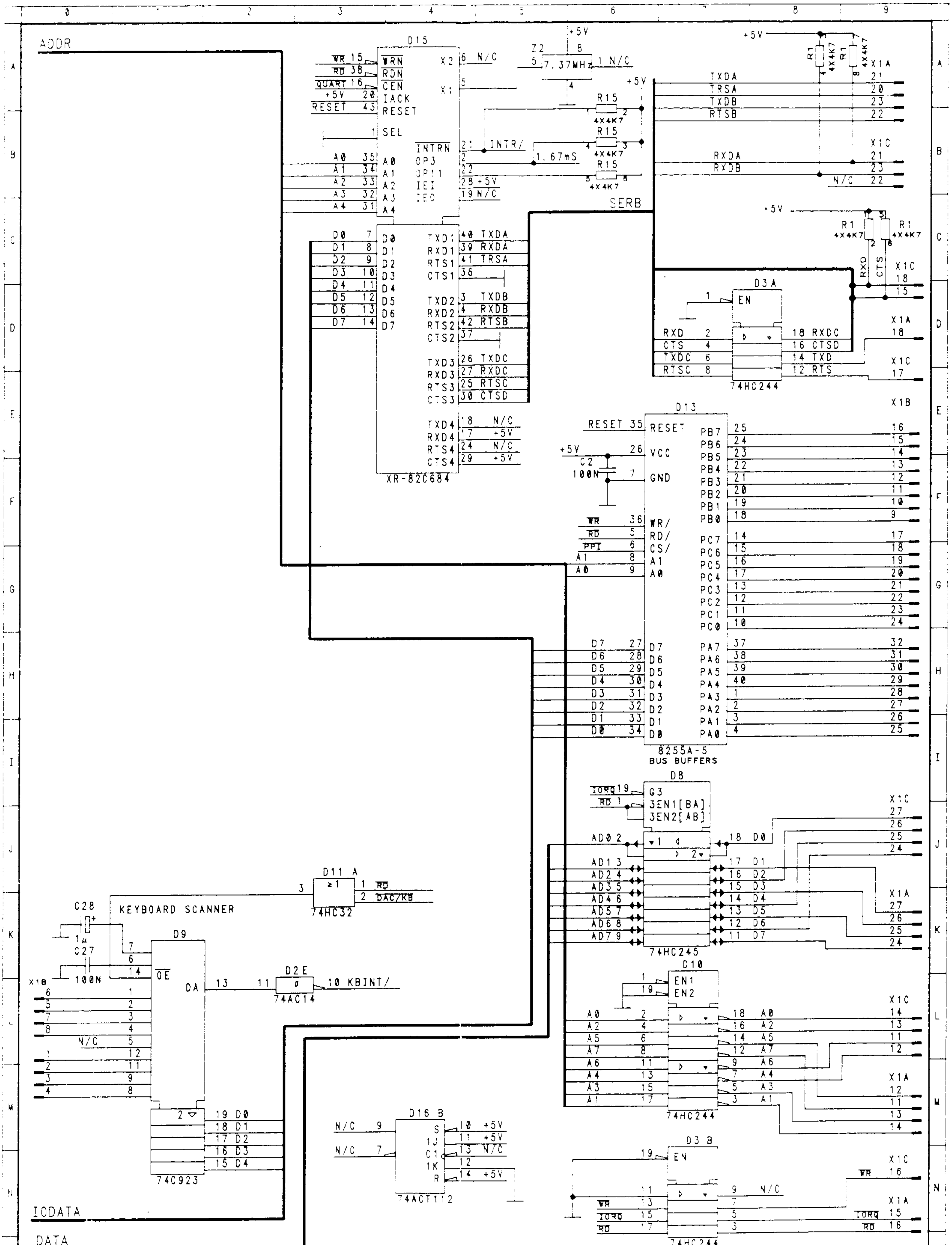
DATEX
INSTRUMENTARIUM OY
NIMI: CPU BOARD
SIVU: 2/3
LAITE: CH-
N:O: CH 3E 880507

Figure 5.30 CPU board jumper configuration

CONNECTOR	JUMPER	MEMORY TYPE
X2 (IO address setting)	1-2	EEPROM (6000H-7FFFH), CRAM (8000H-FFFFH), IORQ (0000H-0FFFH), ADC (1000H-1FFFH), DACKB (2000H-2FFFH), PPI (4000H-4FFFH), QUART (5000H-5FFFH)
	2-3	EEPROM (8000H-9FFFH), CRAM (C000H-DFFFH), IORQ (0000H-1FFFH), ADC (2000H-3FFFH), DACKB (4000H-5FFFH), PPI (A000H-BFFFH), QUART (E000H-FFFFH)
X3 (Code memory)	1-2	D1 : 64k, 128k EPROM
	2-3	D1 : 256k, 512k EPROM
X4 (Static RAM)	1-2	D6 : 32k RAM
	2-3	D6 : 8k RAM
X5 (Code memory)	1-2	D1 : 64k, 128k, 256k EPROM
	2-3	D1 : 512k EPROM
X6 (Interrupt select)	1-2	QUART interrupt
	2-3	ADC interrupt



The value of resistor network R5 is 4 x 47k.



DATEX	NIMI CPU BOARD	SIVU 3/3	LAITE CH-
INSTRUMENTARIUM OY	PIIRT. 31.08.89 OS / TARK. / HYV.		N:O CH 3B 880507

MUUT. | TARK. | HYV. | MUUTOS | MERKKI

5.8 Video control board

The video control board (see the block diagram) is based on an LSI graphics display processor GDP (D4), which accepts commands from the CPU via the system bus and converts them to operations on a bit image in the video RAM memory. The video RAM is then continuously scanned by addressing logic and a video shift register to produce a 24 MHz dot stream that forms the screen image. The display processor adds the synchronization information, which is separated into vertical (50 Hz) and horizontal (15 kHz) components before being sent to the CRT unit. The signals are also combined into a composite video signal, which is output to the rear panel.

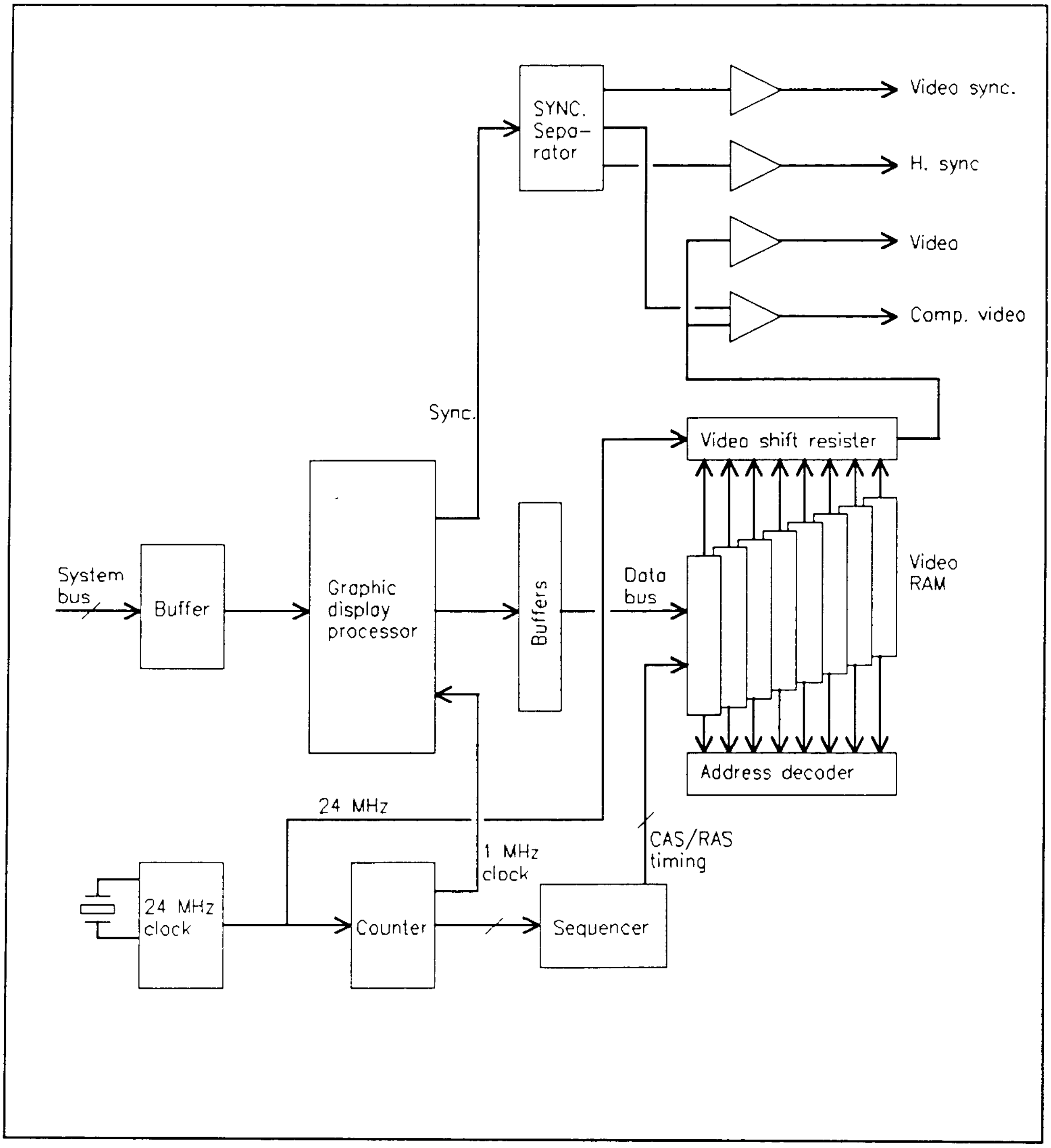
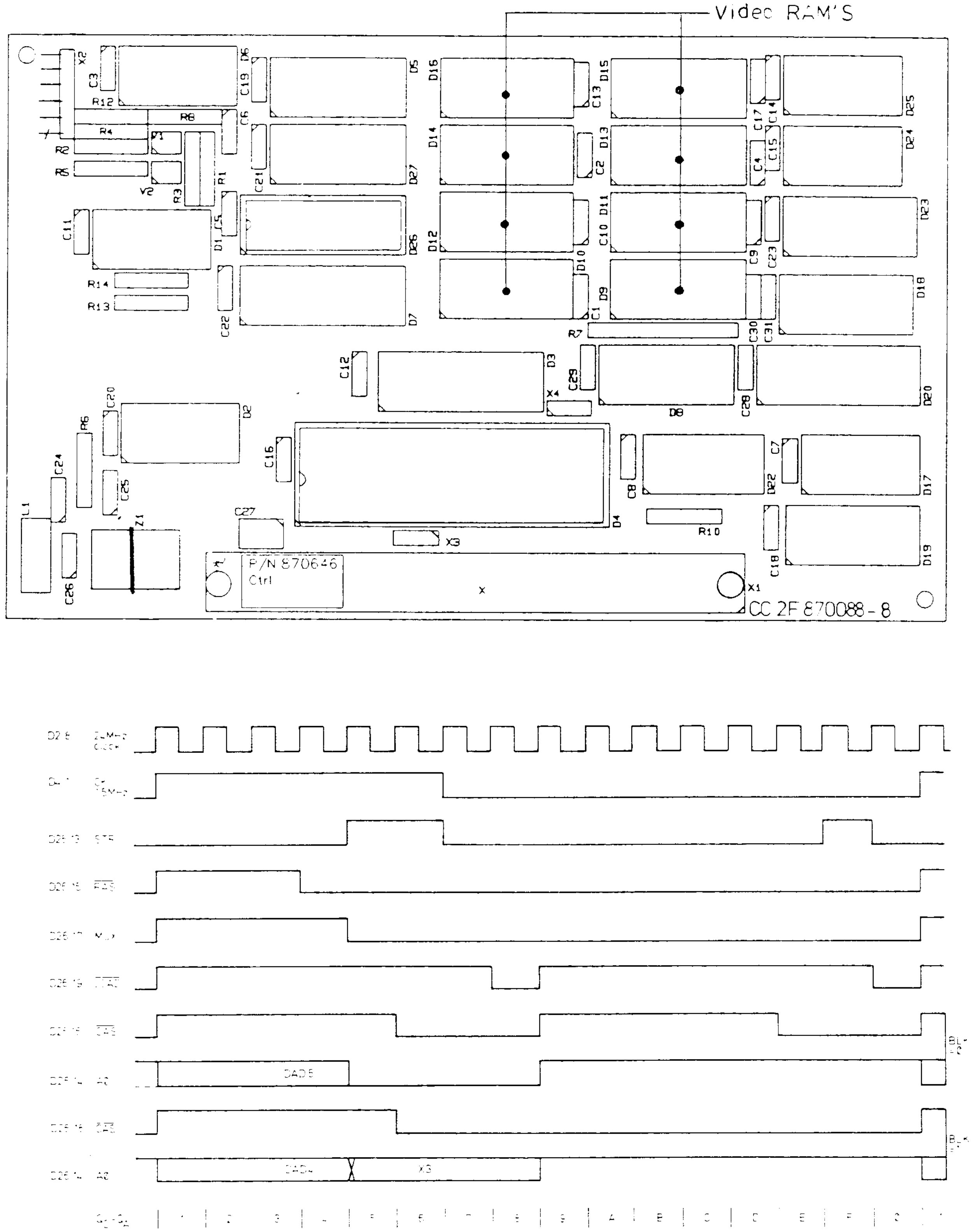
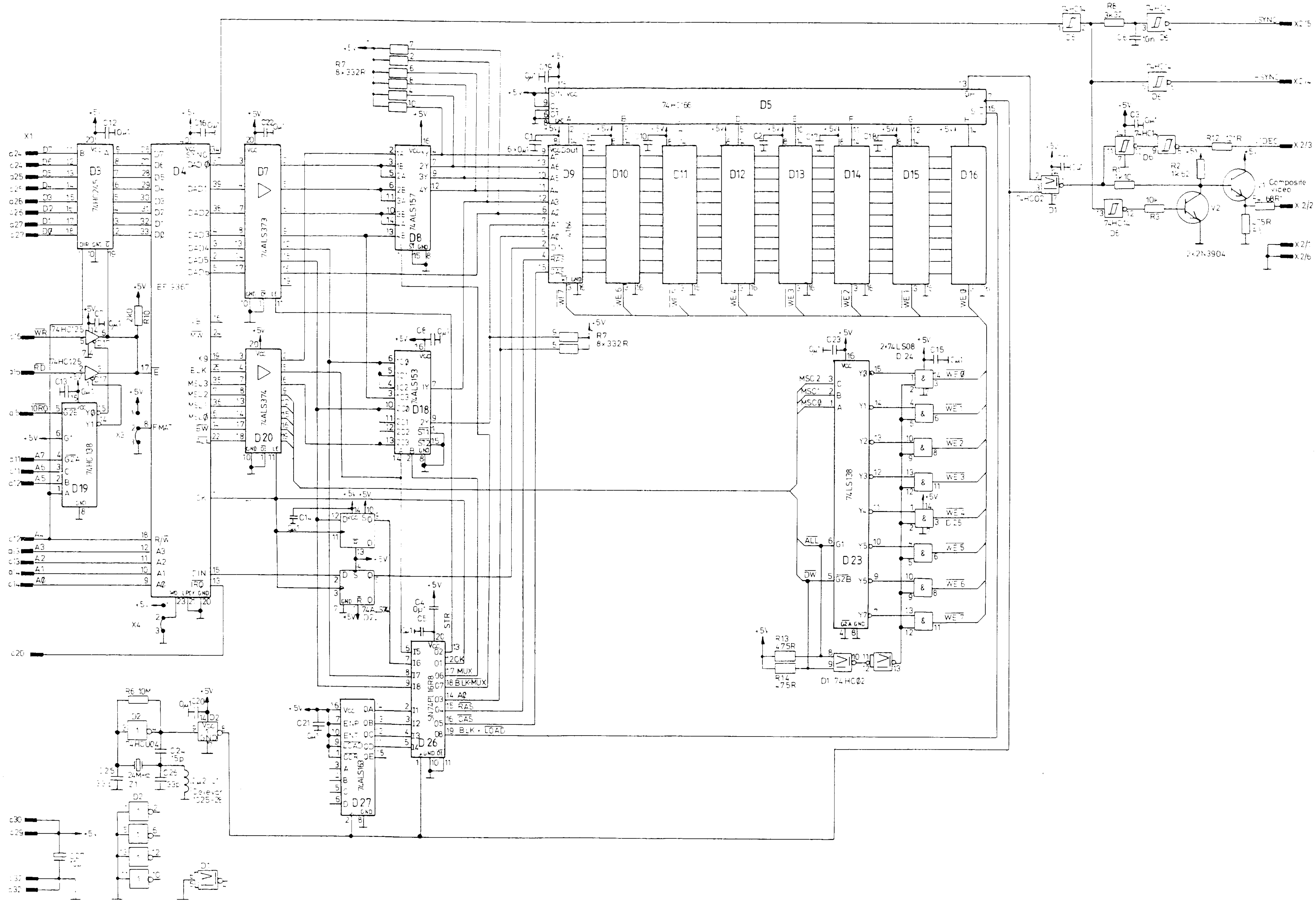


Figure 5.31 Video control board block diagram

Figure 5.32 Video control board parts layout, timing diagram and schematic diagram





5.9 Power supply board

The primary of the power supply is designed to double insulation requirements for added safety. There are two fuses. The primary operating voltage is factory selected by insulating and folding the unused primary leads inside the additional insulation tube.

The mains transformer is magnetically shielded to minimize screen disturbance.

The power supply board contains basically four DC sources:

- +5 V switched, for the digital circuitry
- +15 V switched, for valves, pumps and other components
- +/-15 V regulated for the analog amplifiers

Data retention voltage generation circuit supplies +5 V DRV voltage for memory from switched +15 V supply.

Also, +12 V/1 A for the CRT unit and serial drivers/receivers is derived from the +15 V switched voltage. The -12 V for the serial I/O is derived from -15 V.

In addition to the power supply functions the board contains drivers for two serial channels (including the modem control signals CTS and RTS), a RESET control, which generates a 200 ms reset pulse to the CPU if the +5 V line goes below 4.75 V, and miscellaneous I/O functions like a loudspeaker driver. Some signals from the mother board are passed directly to the rear panel connectors.

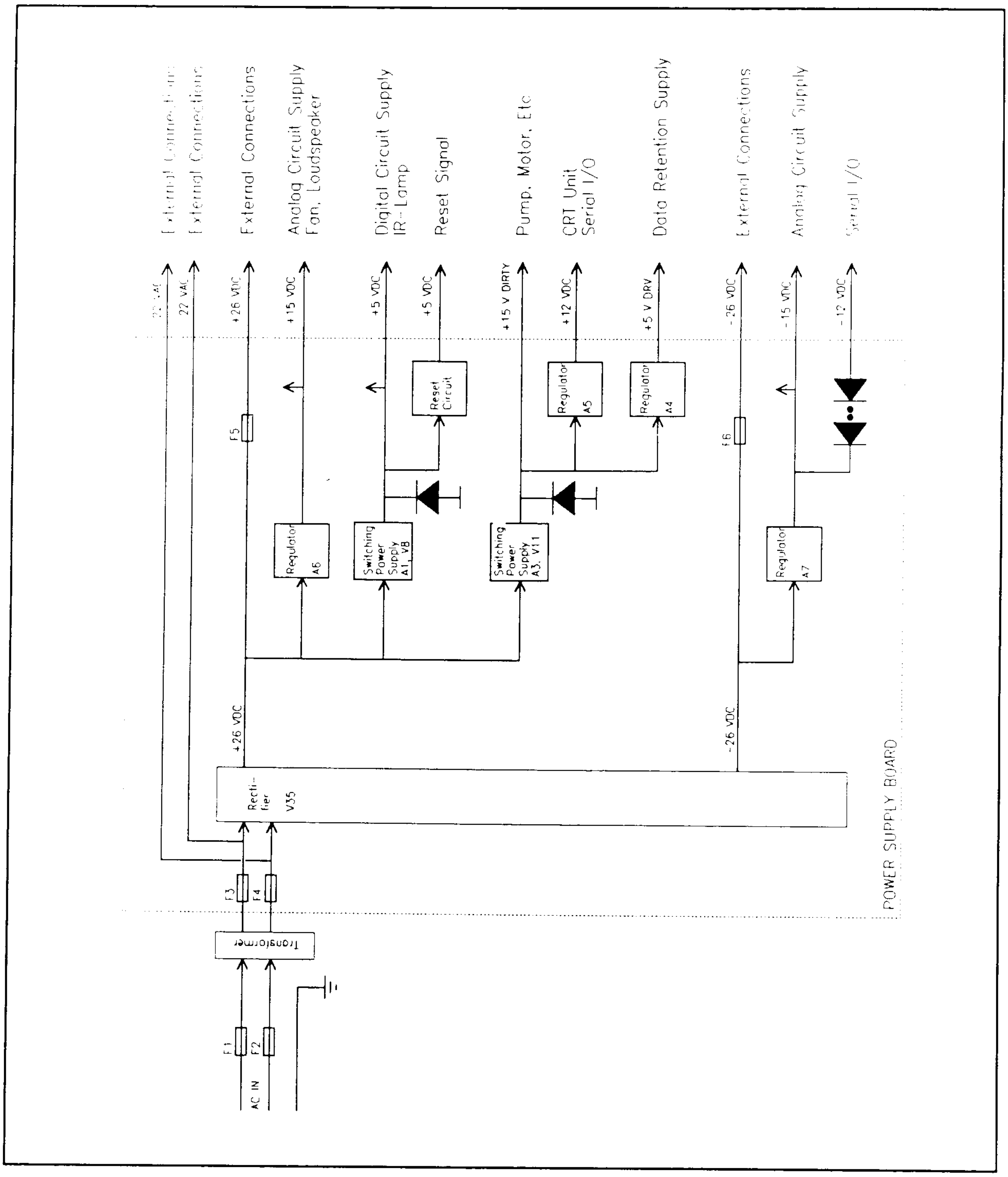
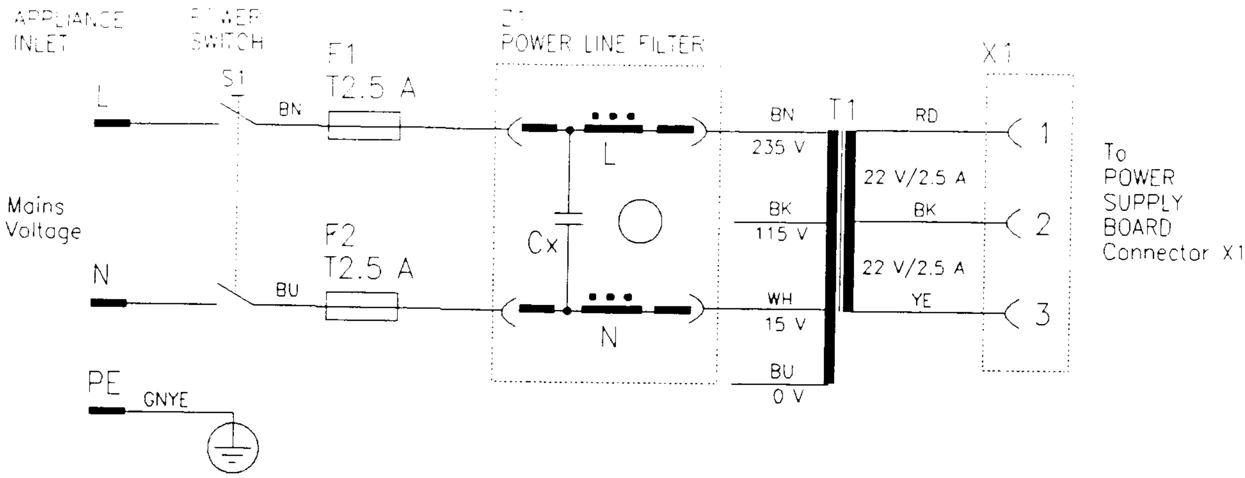
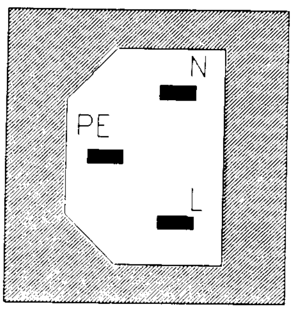


Figure 5.33 Power supply board block diagram

Figure 5.34 Transformer diagram

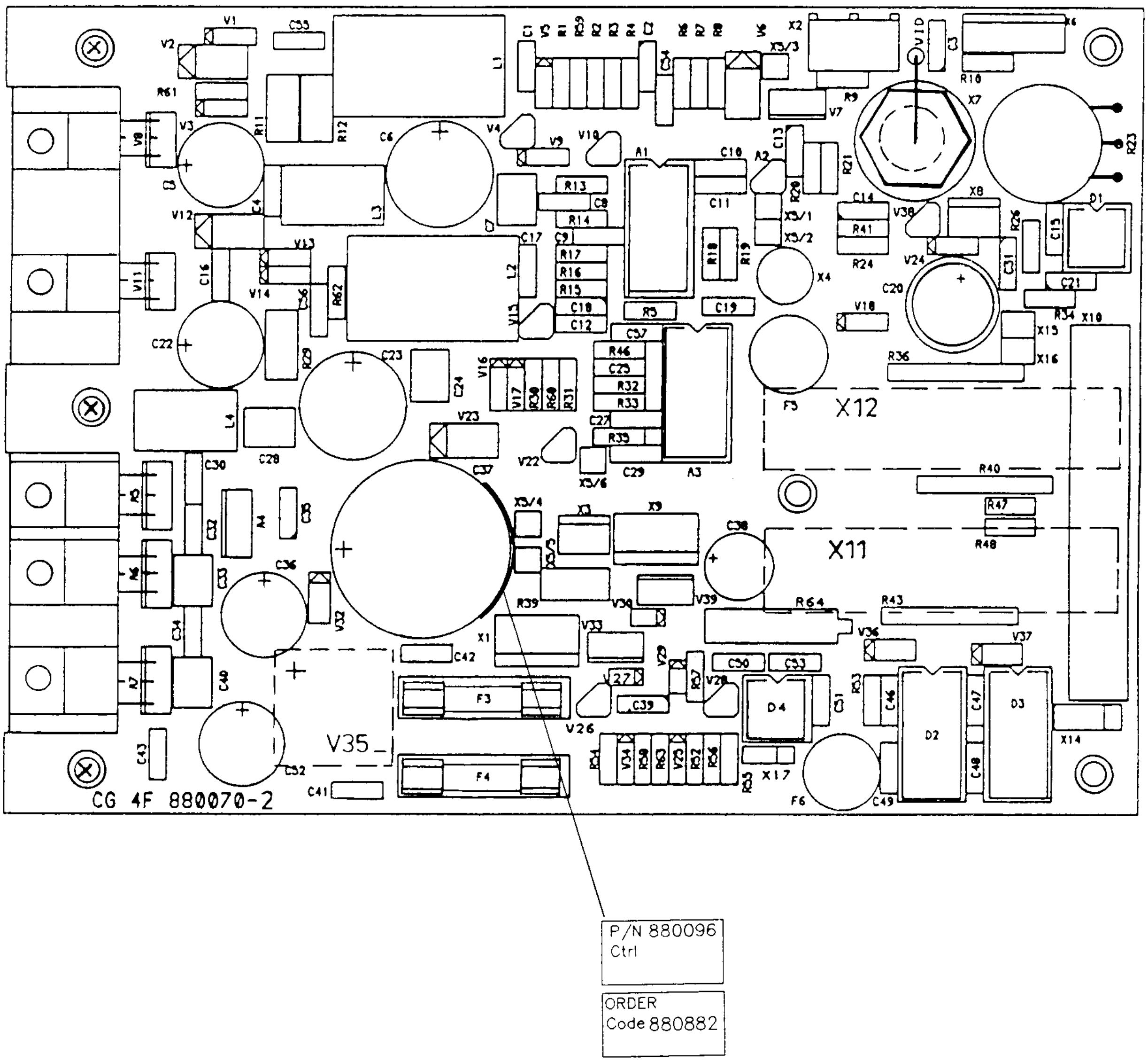


If no polarized mains plug and mains socket outlet system is used, position of line (L) and neutral (N) in the appliance inlet depends on the position of mains plug set into the mains socket outlet.

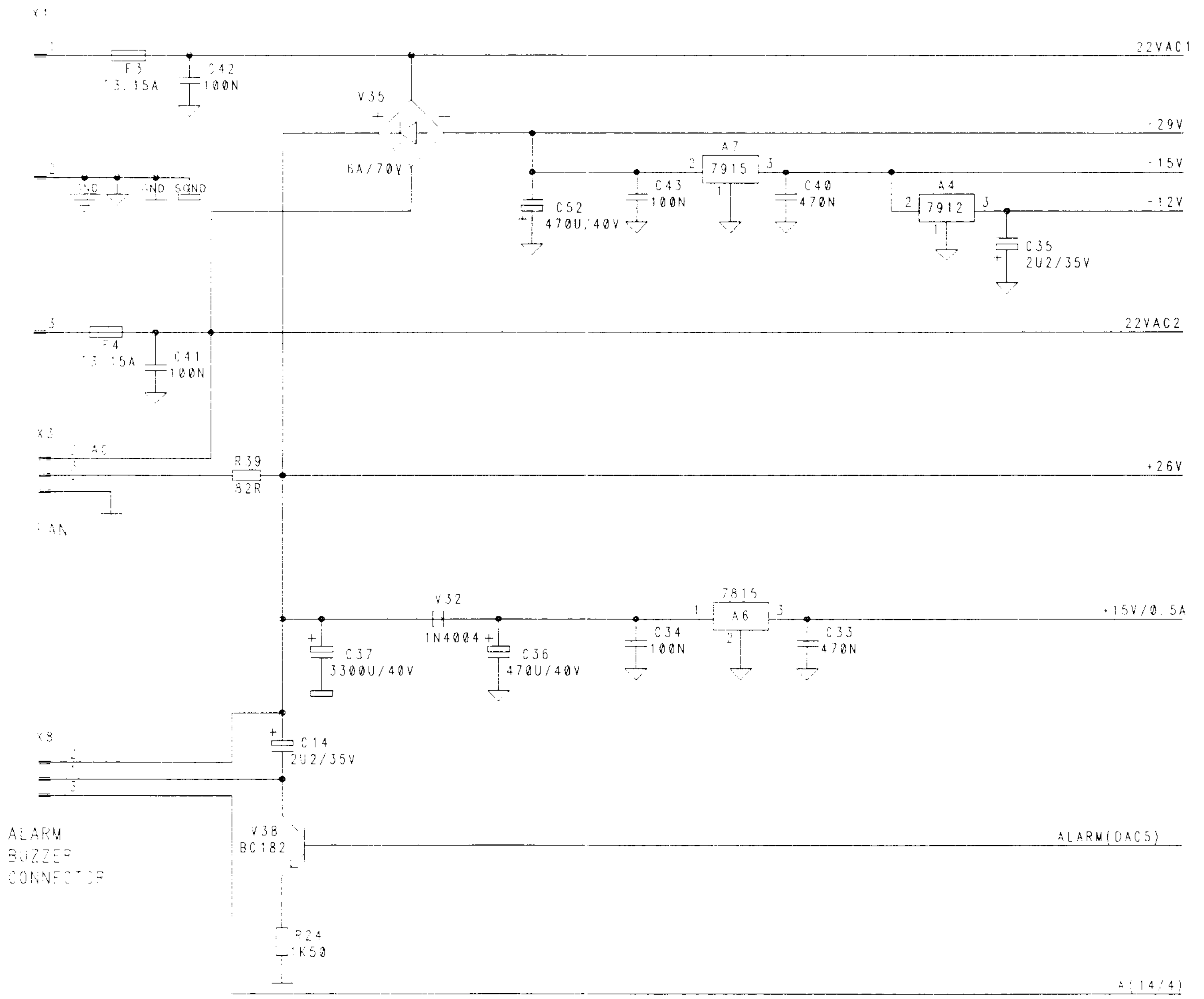


The contact positions of the appliance inlet by looking from outside of the equipment.

Figure 5.35 Power supply board parts layout and schematic diagram (part 1)



Monitor	X11 Serial / Analog I/O							
Pin.No	13	14	16	17	18	19	20	22
CG	Uncal BP.2	O_2	SPO_2	BP.2	ECG	BP.1	CO_2	Input AUX
Pin.No	30	31	37	38	28	33	32	29
	X10 Flatcable							



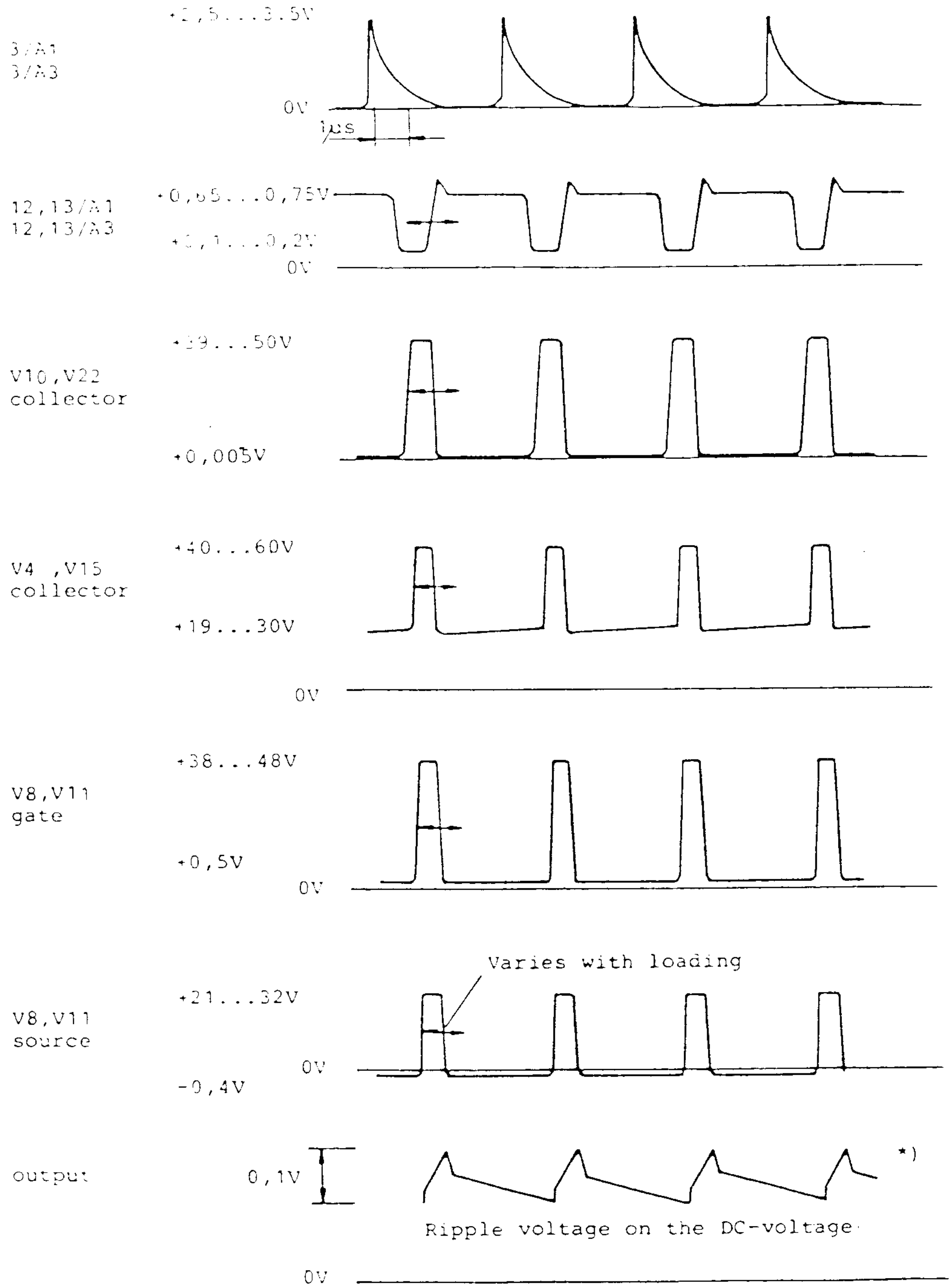
DATEX NIMI POWER BOARD LAITE CH/CG

INSTRUMENTARIUM OY

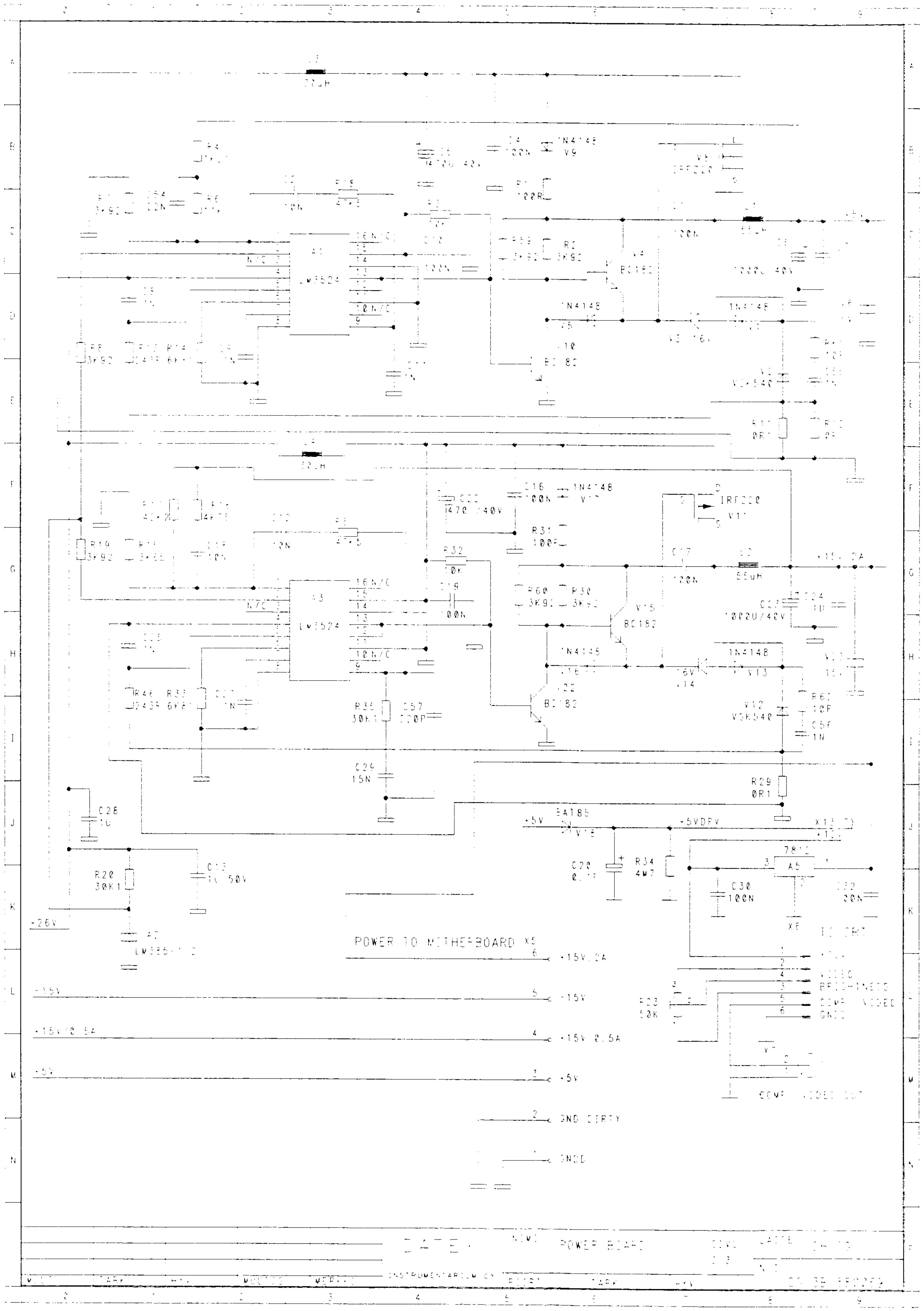
MUUTOS MERKKI

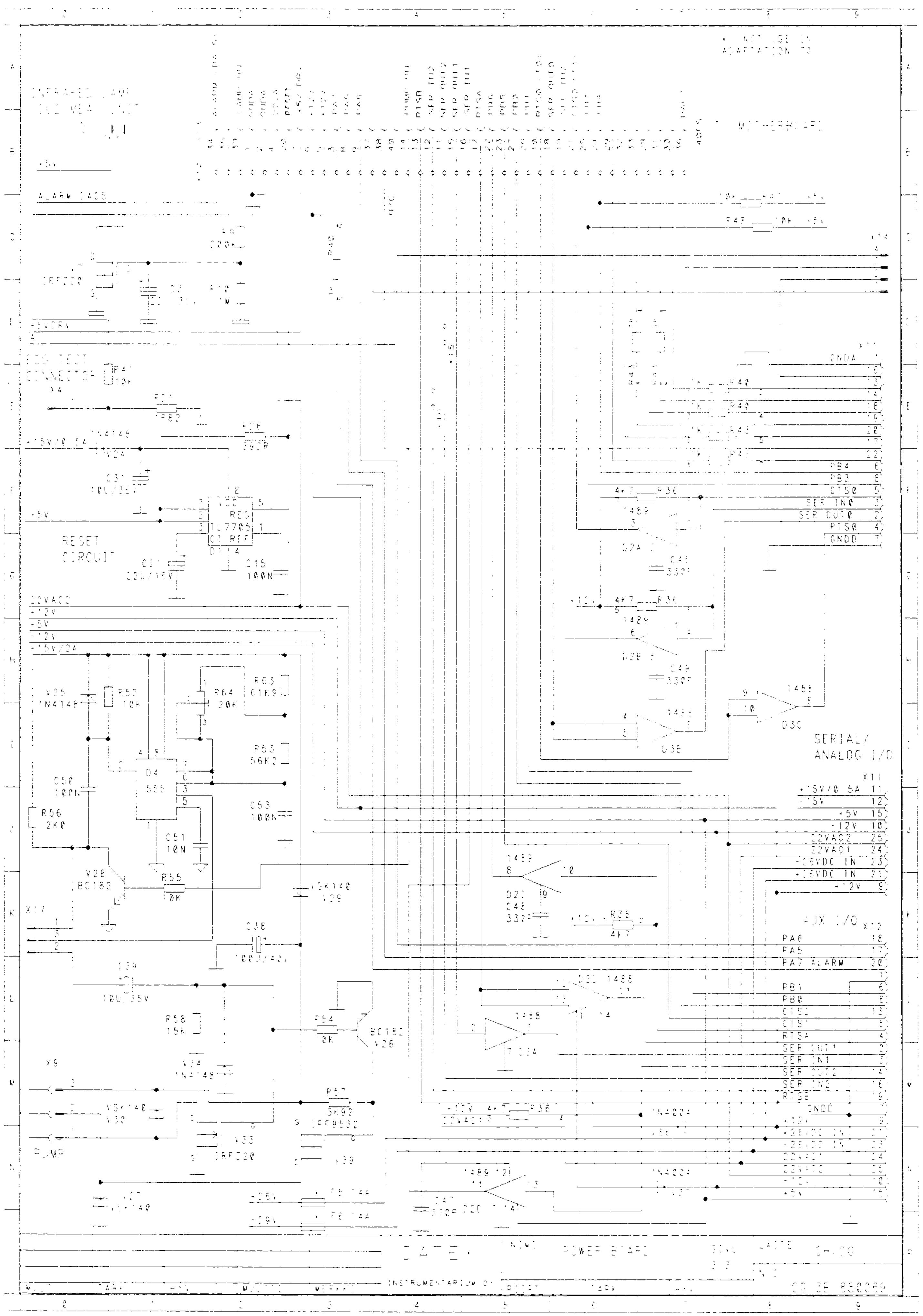
CG 3B 880069

Figure 5.36 Power supply board signal waveforms and schematic diagram (part 2)



*) The ripple on the 12V voltage may be higher because of the uneven loading


POWER TO MOTHERBOARD X5
+15V/2A
+15V
+15V/0.5A
+5V
GND DIRTY
GNDD
LM3524
BC182
IRFD220
DATEX
POWER BOARD
INSTRUMENTARIUM


RESET CIRCUIT
SERIAL/
ANALOG I/O
AUX I/O
555
BC182
BC182
IRFD220
DATEX
POWER BOARD
INSTRUMENTARIUM

5.10 Mother board

The mother board contains the system bus interconnections and connectors. Also on the board are power bypass capacitors and driver transistors for the sampling system magnetic valves (gas zero and pressure valves).

For signals in each bus, see Table 4.7.

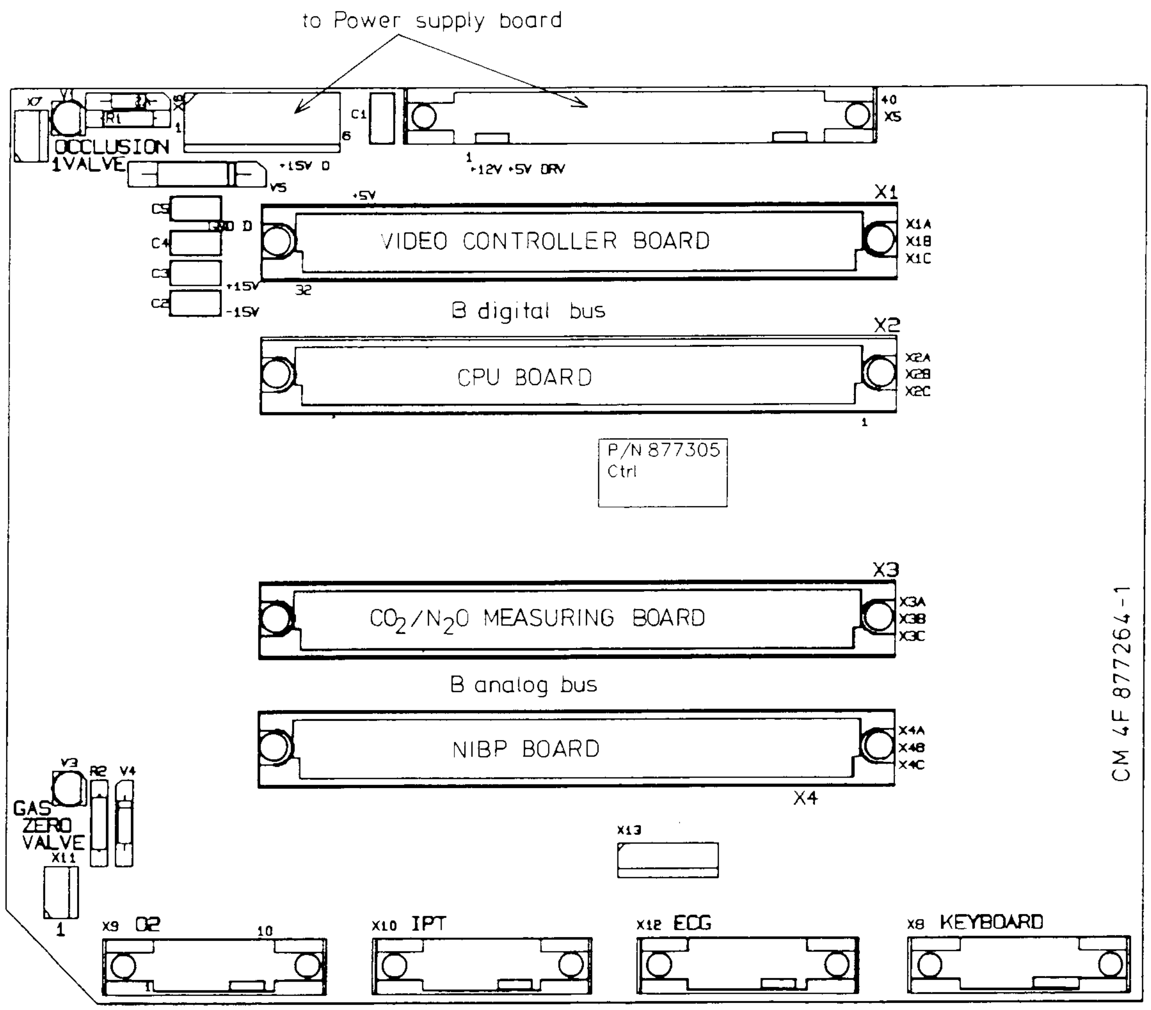
5.11 Keyboard

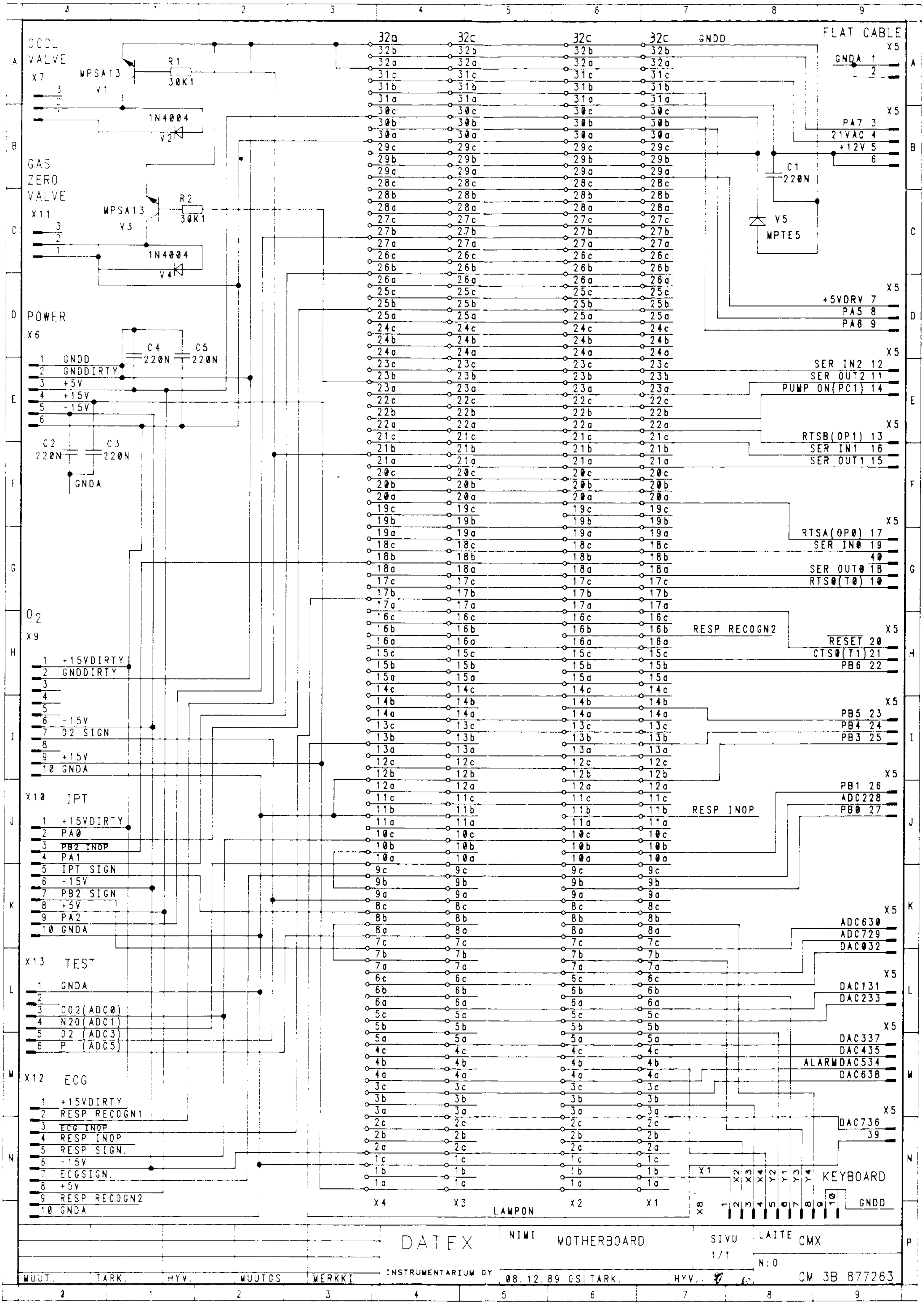
The keypad pcb is a simple 4x4 matrix which is scanned by the keyboard controller on the CPU board.

5.12 Loudspeaker unit

Audible alarms and other tones are generated by a separate loudspeaker unit. It contains an 8 ohm/0.4 W speaker and the associated driving circuitry.

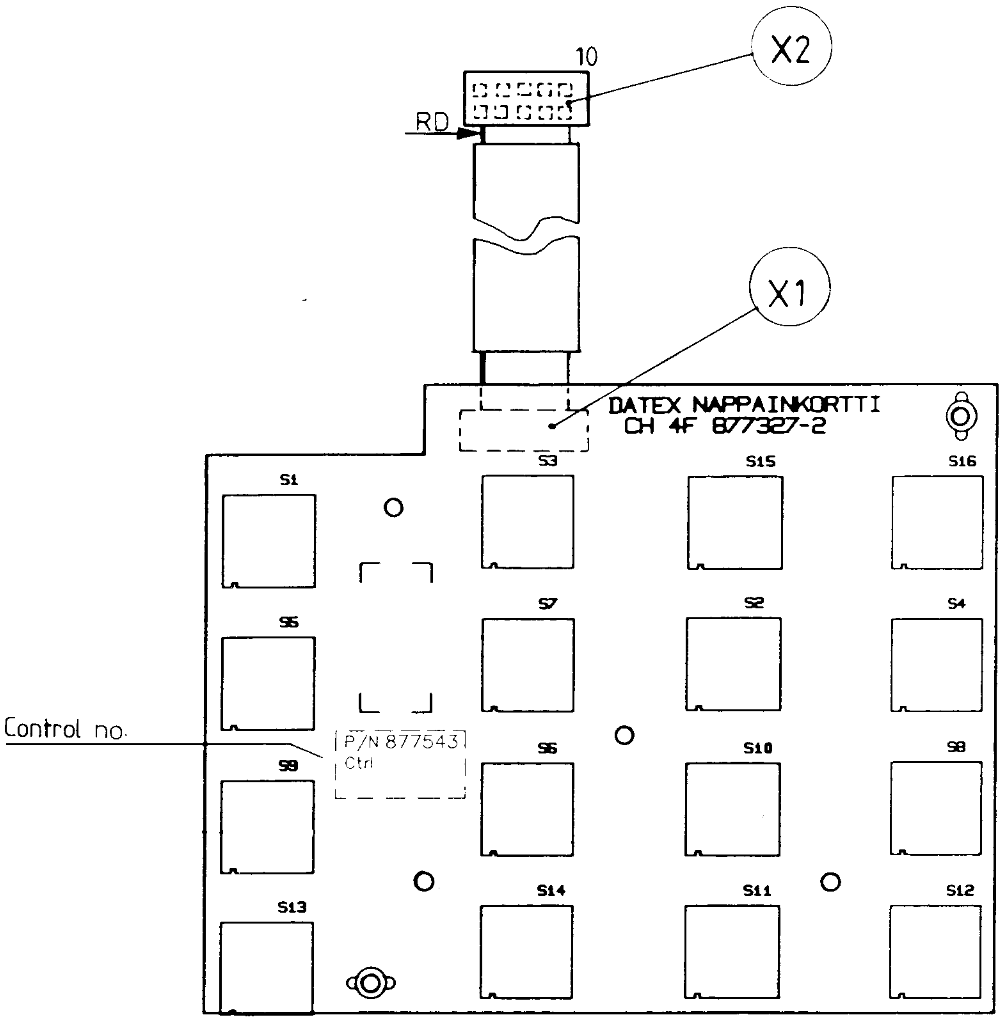
Figure 5.37 Mother board parts layout and schematic diagram





FLAT CABLE
X5
GNDD
CO2 VALVE
X7
MPSA13
V1
R1
30K1
1N4004
V2
GAS ZERO VALVE
X11
MPSA13
V3
R2
30K1
1N4004
V4
C1
220N
V5
MPTE5
GNDA 1
PA7 3
21VAC 4
+12V 5
+5VDRV 7
PA5 8
PA6 9
POWER
X6
GNDD
GNDDIRTY
+5V
+15V
-15V
C4
220N
C5
220N
C2
220N
C3
220N
GNDA
SER IN2 12
SER OUT2 11
PUMP ON(PC1) 14
RTSB(OP1) 13
SER IN1 16
SER OUT1 15
RTSA(OP0) 17
SER IN0 19
SER OUT0 18
RTS0(T0) 10
RESP RECOGN2
RESET 20
CTS0(T1) 21
PB6 22
PB5 23
PB4 24
PB3 25
PB1 26
ADC228
PB0 27
RESP INOP
ADC630
ADC729
DAC032
DAC131
DAC233
DAC337
DAC435
ALARMDAC534
DAC638
DAC736
O2
X9
+15VDIRTY
GNDDIRTY
-15V
O2 SIGN
+15V
GNDA
X10 IPT
+15VDIRTY
PA0
PB2 INOP
PA1
IPT SIGN
-15V
PB2 SIGN
+5V
PA2
GNDA
X13 TEST
GNDA
CO2(ADC0)
N2O(ADC1)
O2 (ADC3)
P (ADC5)
X12 ECG
+15VDIRTY
RESP RECOGN1
ECG INOP
RESP INOP
RESP SIGN.
-15V
ECGSIGN.
+5V
RESP RECOGN2
GNDA
X4
X3
X2
X1
LAMPON
KEYBOARD
X8
GNDD
DATEX
INSTRUMENTARIUM OY
NIMI
MOTHERBOARD
SIVU
1/1
LAITE
CMX
N:O
MUUT.
TARK.
HYV.
MUUTOS
MERKKI
08.12.89 OS
CM 3B 877263

Figure 5.38 Keyboard parts layout and schematic diagram



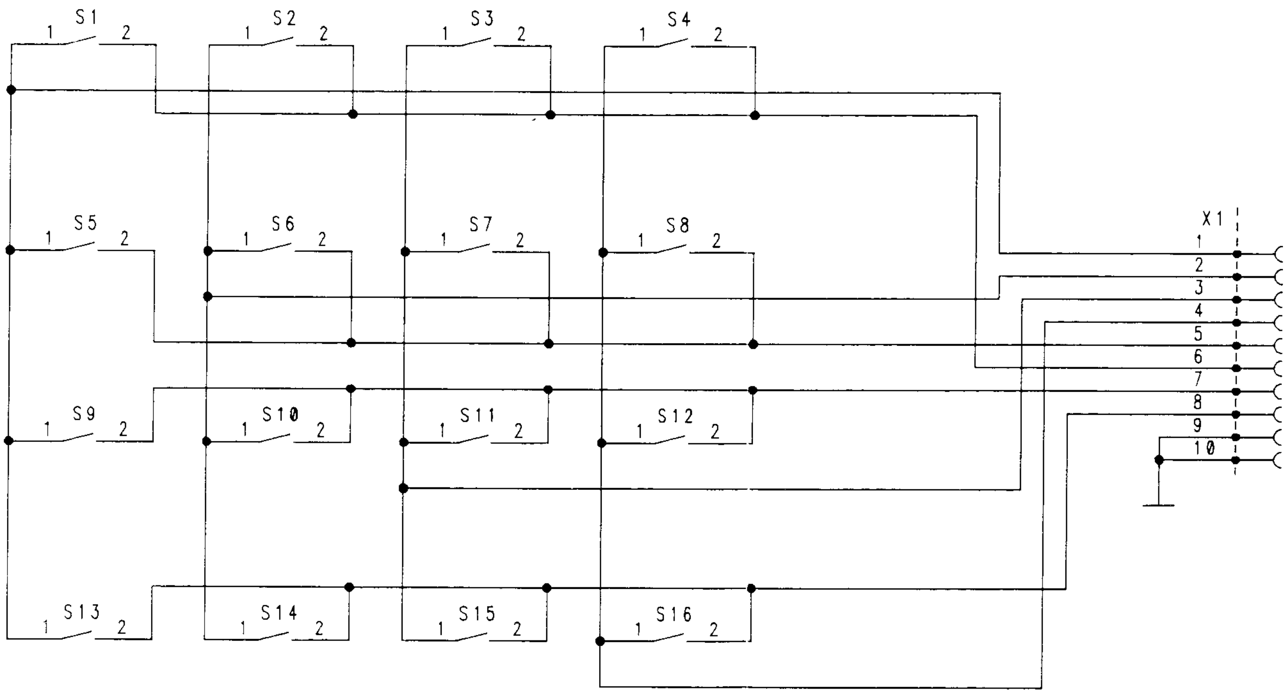
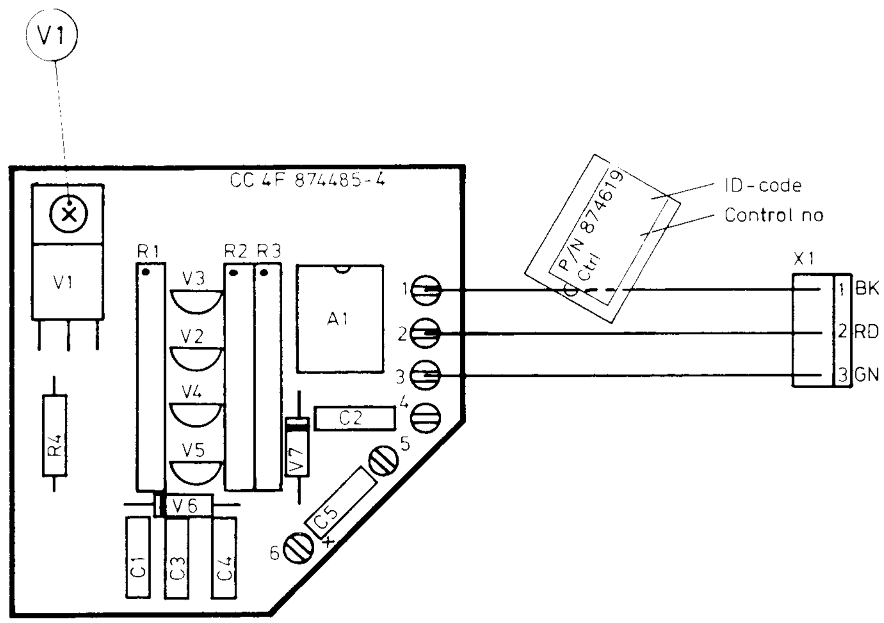
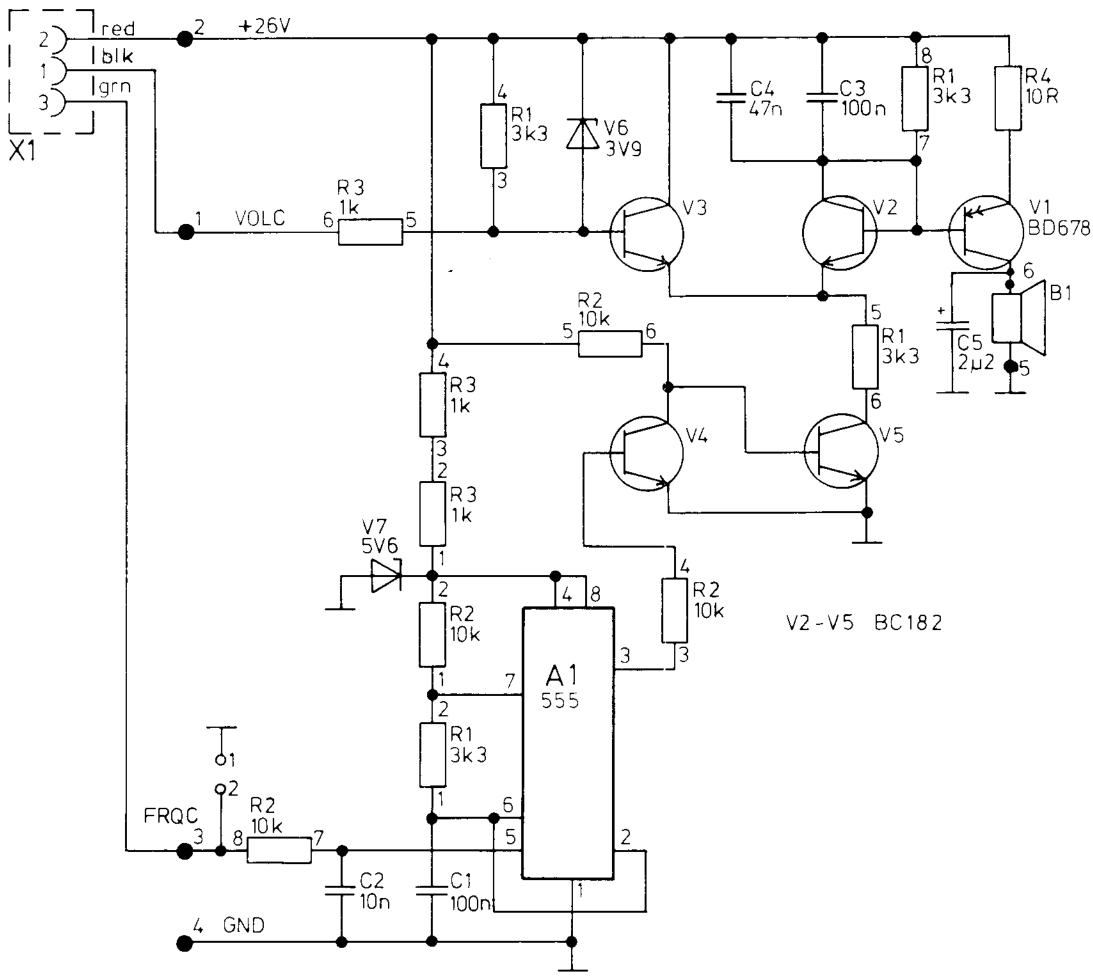

S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
X1
1
2
3
4
5
6
7
8
9
10

Figure 5.39 Loudspeaker unit parts layout and schematic diagram





X1
red
blk
grn
+26V
VOLC
FRQC
GND
R3 1k
R1 3k3
V6 3V9
V3
V2
V1 BD678
C4 47n
C3 100n
R1 3k3
R4 10R
B1
C5 2µ2
R2 10k
R1 3k3
V4
V5
R3 1k
R3 1k
V7 5V6
R2 10k
R1 3k3
R2 10k
A1 555
R2 10k
C2 10n
C1 100n
V2-V5 BC182

5.13 Internal connector configurations

Table 5.3 Video control board (X1) - Mother board (X1)

PIN NO.	a	b	c
1	NC	NC	NC
2	NC	NC	NC
3	NC	NC	NC
4	NC	NC	NC
5	NC	NC	NC
6	NC	NC	NC
7	NC	NC	NC
8	NC	NC	NC
9	NC	NC	NC
10	NC	NC	NC
11	A7	NC	A6
12	A5	NC	A4
13	A3	NC	A2
14	A1	NC	A0
15	/10RQ	NC	NC
16	/RD	NC	NC
17	NC	NC	NC
18	NC	NC	NC
19	NC	NC	NC
20	NC	NC	INT0
21	NC	NC	NC
22	NC	NC	NC
23	NC	NC	NC
24	D7	NC	D6
25	D5	NC	D4
26	D3	NC	D2
27	D1	NC	D0
28	NC	NC	NC
29	NC	NC	+5 V
30	NC	NC	+5 V
31	NC	NC	NC
32	DGND	NC	DGND

NC = not connected
AIN is an AD-converter in and AOUT is a DA-converter out
ADC is an AD-converter and DAC is a DA-converter

Table 5.4 Main CPU board (X1) - Mother board (X2)

PIN NO.	a	b	c
1	+15 V	X1	AGND
2	-15 V	X2	+10 V REF
3	DAC7 ALR ADJ	X3	DAC6 PB2 signal
4	DAC5 ALARM	X4	DAC4 ECG TEST
5	NC	Y2	DAC2 IPT signal
6	DAC1 O_2	Y1	DAC0 CO_2
7	SAL	Y3	ADC6 PB2 signal
8	ADC5 GAS PRES	Y4	ADC4 IPT signal
9	ADC3 O_2	PB0	ADC2 ECG
10	ADC1 N_2O	PB1	ADC0 CO_2
11	A7	NC	A6
12	A5	PB3 CD	A4
13	A3	PB4 DSR	A2
14	A1	PB5	A0
15	/10RQ	PB6	T1 CTS0
16	RDB1	NC	/WR
17	/RESET	PC0 /ECG INOP	TO RTS0
18	SEROUT 0	PC1 PB2 INOP	SERIN0
19	P1.1	PC2	P1.0
20	OP0 RTSA	PC3 Normocap	INT0
21	SEROUT1	PC4 Press. valve	SERIN1
22	OP1 RTSB	PC5 Pump	IP2 TIMERIN0
23	SEROUT2	PC6 Zero valve	SERIN2
24	D7	PC7	D6
25	D5	PA0 IPT	D4
26	D3	PA1 IPT	D2
27	D1	PA2 IPT	D0
28	INT1	PA3	INT3
29	+5 V DRV	PA4	+5 V
30	+15 VDIRTY	PA5	+5 V
31	+12 V	PA6	21 VAC
32	DGND	PA7 ALR CALL	DGND

NC = not connected
AIN is an AD-converter in and AOUT is a DA-converter out
ADC is an AD-converter and DAC is a DA-converter

Table 5.5 CO_2/N_2O measuring board (X1) - Mother board (X3)

PIN NO.	a	b	c
1	+15 V	Motor-	AGND
2	-15 V	Sync	
3	AOUT6	T+	AOUT5
4	AOUT4	T-	AOUT3
5	AOUT2	NC	AOUT1
6	DAC1 O_2	Ref 6.5 V	DAC0 CO_2
7	AIN7 SAL	N_2O zero	ADC6 PB2 signal
8	ADC5 GAS PRES	N_2O zero	ADC4 IPT signal
9	ADC3 O_2	CO_2 zero	ADC2 ECG
10	ADC1 N_2O	CO_2 zero	ADC0 CO_2
11	NC	N_2O calib.	NC
12	NC	CO_2 calib.	NC
13	NC	LAMP	NC
14	NC.	PB5	NC
15	NC	SSYNC	NC
16	RDB2	SMOTOR	NC
17	/RESET	PC0 /ECG INOP	TO RTSO
18	SEROUT 0	PC1 PB2 INOP	SERIN0
19	P1.1	PC2	P1.0
20	OP0 RTSA	PC3 Normocap	INT0
21	SEROUT1	PC4 Press. valve	SERIN1
22	OP1 RTSB	PC5 Pump	IP2 TIMERIN0
23	SEROUT2	PC6 Zero valve	SERIN2
24	NC	PC7	NC
25	NC	PA0 IPT	NC
26	NC	PA1 IPT	NC
27	NC	PA2 IPT	NC
28	INT1	PA3	INT3
29	+5 V DRV	PA4	+5 V
30	+15 VDIRTY	PA5	+5 V
31	+12 V	PA6	21 VAC
32	DGND	PA7 ALR CALL	DGND

NC = not connected
AIN is an AD-converter in and AOUT is a DA-converter out
ADC is an AD-converter and DAC is a DA-converter

Table 5.6 NIBP board (X1) - Mother board (X4)

PIN NO.	a	b	c
1	+15 V	NC	AGND
2	-15 V	NC	NC
3	NC	NC	NC
4	NC	NC	NC
5	NC	NC	NC
6	NC	NC	NC
7	NC	NC	NC
8	NC	NC	NC
9	NC	NC	NC
10	NC	NC	NC
11	NC	NC	NC
12	NC	NC	NC
13	NC	NC	NC
14	NC	NC	NC
15	NC	NC	NC
16	NC	NC	NC
17	/RESET	NC	NC
18	NC	NC	NC
19	NC	NC	NC
20	NC	NC	NC
21	NC	NC	NC
22	NC	NC	NC
23	RXD	NC	SERIN2
24	NC	NC	NC
25	NC	NC	NC
26	NC	NC	NC
27	NC	NC	NC
28	NC	NC	NC
29	NC	NC	+5 V
30	+15 VDIRTY	NC	+5 V
31	NC	ECGSYNC	NC
32	DGND	NC	DGND

NC = not connected

Table 5.7 Power supply board (X10) - Mother board (X5)

PIN NO.	SIGNAL	PIN NO.	SIGNAL
1	AGND	2	AGND
3	PA7 ALR CALL	4	21 VAC
5	+12 V	6	+12 V
7	+5 V DRV	8	PA5
9	PA6	10	T0 RTS0
11	SEROUT2	12	SERIN2
13	OP1 RTSB	14	PC5 Pump
15	SEROUT1	16	SERIN1
17	OP0 RTSA	18	SEROUT0
19	SERIN0	20	/RESET
21	T1 CTS0	22	PB6
23	PB5	24	PB4 DSR
25	PB3 CD	26	PB1
27	PB0	28	DAC1 O_2
29	DAC6 PB2	30	DAC0 CO_2
31	AOUT2	32	AOUT3
33	DAC2 IPT	34	DAC5 ALARM
35	DAC4 ECG TEST	36	DAC7 ALR ADJ
37	AOUT1	38	AOUT5
39	LAMPON	40	NC

NC = not connected
AIN is an AD-converter in and AOUT is a DA-converter out
ADC is an AD-converter and DAC is a DA-converter

Table 5.8 Keyboard (X1) - Mother board (X8)

PIN NO.	SIGNAL	
1	X1	X1 row
2	X2	X2 row
3	X3	X3 row
4	X4	X4 row
5	Y2	Y2 column
6	Y1	Y1 column
7	Y3	Y3 column
8	Y4	Y4 column
9	GND	
10	GND	

Table 5.9 Power supply board - Mother board (X6)

PIN NO.	SIGNAL
1	DGND
2	GND DIRTY
3	+5 V
4	+15 V
5	-15 V
6	+15 VDIRTY

Table 5.10 Mother board test connector (X13)

PIN NO.	SIGNAL
1	AGND
2	ADC4 Pulse&Temp
3	ADC0 CO_2
4	ADC1 N_2O
5	ADC3 O_2
6	ADC5 GASPRESS

Table 5.11 Front panel SpO_2 connector - SpO_2 measuring board (X1)

PIN NO.	SIGNAL
1	Is
2	Ib
3	NC
4	Probe identification
5	Probe identification
6	Ground
7	Iled
8	Vb (-4 ±0.3 V)
9	Ground
10	+12 Vp

Table 5.12 SpO_2 measuring board (X2) - SpO_2 connector I/O board

PIN NO.	SIGNAL
1	+15 VDIRTY
2	PA0
3	PA3
4	PA1
5	ADC 4 VOUT IR
6	-15 V
7	ADC 6 VOUT R
8	+5 V
9	PA2
10	AGND

Table 5.13 SpO_2 processor board (X1) - SpO_2 connector I/O board

PIN NO.	a	b	c
1	+15 V	NC	AGND
2	-15 V	NC	NC
3	NC	NC	NC
4	NC	NC	NC
5	NC	NC	IREDOUT
6	SpO_2 OUT	NC	REDOUT
7	NC	NC	ADC6 R IN
8	NC	NC	ADC4 IR IN
9	NC	NC	ADC2 ECG
10	NC	NC	NC
11	NC	AGND	NC
12	NC	TEST	NC
13	NC	FREEZE	NC
14	NC	NC	NC
15	NC	CTS/1	CTS/0
16	NC	NC	NC
17	/RESET	NC	RTS/0
18	TXD/0	NC	RXD/0
19	NC	NC	NC
20	RTS/1	NC	NC
21	TXD/1	NC	RXD/1
22	NC	NC	NC
23	NC	NC	NC
24	NC	PC7	NC
25	NC	PA0	NC
26	NC	PA1	D2
27	NC	PA2	NC
28	NC	NC	NC
29	+5 V DRV	NC	+5 V
30	NC	NC	NC
31	NC	NC	NC
32	NC	NC	DGND

NC = not connected
AIN is an AD-converter in and AOUT is a DA-converter out
ADC is an AD-converter and DAC is a DA-converter

Table 5.14 ECG board - Mother board (X12)

PIN NO.	SIGNAL
1	+15 VDIRTY
2	NC
3	-ECG INOP
4	NC
5	NC
6	-15 V
7	ECG OUT
8	+5 V
9	NC
10	AGND

Table 5.15 IPT board - Mother board (X10)

PIN NO.	SIGNAL
1	+15 VDIRTY
2	PA0 IPT control
3	NC
4	PA1 IPT control
5	Signal out
6	-15 V
7	InvBP2 out
8	+5 V
9	PA2 IPT control
10	AGND

Table 5.16 Video control board (X2) - Video unit main pc board (X13)

PIN NO.	SIGNAL
1	GND
2	Comp. Video signal
3	Video
4	HSYNC
5	VSYNC
6	GND

Table 5.17 Power supply board (X1) - Line transformer

PIN NO.	SIGNAL	
1	22 VAC	secondary voltage of
2	22 VAC	the line transformer
3	NC	

Table 5.18 Power supply board (X3) - Fan

PIN NO.	SIGNAL	
1	GND	
2	NC	
3	+26 V	supply voltage for fan

Table 5.19 Power supply board (X6) - Video unit main pc board

PIN NO.	SIGNAL
1	+12 V
2	Video brightness control
3	Video brightness control
4	Video brightness control
5	Comp video
6	DGND

Table 5.20 Power supply board (X8) - Loudspeaker

PIN NO.	SIGNAL	
1	DAC5 ALARM	
2	+26 V	power for loudspeaker
3	DAC7	

Table 5.21 NIBP board (X2) - NIBP Pump

PIN NO.	SIGNAL
1	GND
2	NC
3	+15 V supply voltage for pump

Table 5.22 O_2 measuring unit - Mother board (X9)

PIN NO.	SIGNAL
1	+15 VDIRTY
2	GND DIRTY
3	NC
4	NC
5	NC
6	-15 V
7	ADC3 O_2
8	NC
9	+15 V
10	AGND

Table 5.23 Gas zero valve - Mother board (X11)

PIN NO.	SIGNAL
1	+15 VDIRTY
2	ZERO SIGNAL
3	NC

Table 5.24 Pressure valve - Mother board (X7)

PIN NO.	SIGNAL
1	+15 VDIRTY
2	OCCLUS SIGNAL
3	NC

Table 5.25 Power supply board (X2) - IR lamp

PIN NO.	SIGNAL
1	+5 VDC voltage for IR-lamp
2	lamp ON/OFF

6 SERVICE AND TROUBLESHOOTING

6.1 General service information

Usually field service is limited to replacing the faulty circuit boards or mechanical parts. The boards are then returned to DATEX for repair.

DATEX TECHNICAL SERVICE is always available for service advice. Please provide the unit serial number, full type designation, program revision (displayed at monitor startup) and a detailed fault description.

NOTE: After any component replacements see Section 7.1 (Adjustments) and after any service perform the functional field check procedure in Chapter 8.

CAUTION: The tests and repairs outlined in this section should only be attempted by trained personnel with the appropriate equipment. Unauthorized service may void warranty of the unit.

6.2 Disassembly and reassembly

The monitor is disassembled in the following way (see page 3-2 for the parts included in the monitor you are using). See Figure 9.1 for the exploded view of the monitor:

a) Disconnect the power cord.

b) Remove the upper two galvanized screws on the side panels and lift off the top cover.

c) Remove the lower two screws and detach the side panels.

Now the interior of the monitor is exposed. The pneumatic unit for the NIBP measurement and some of the gas sampling system parts are located on the left side and printed circuit boards are located on the right side of the monitor.

d) Video screen frame can be removed. Keyboard pc board with plastic key panel is attached to the front plate. It can be removed by detaching the ECG lead selector knob and disconnecting X8 connector on the mother board. D-FEND™ water trap frame is attached to the key panel with screws.

e) Behind the Keyboard pc board an assembly of pc boards is located. They are (front to rear) ECG board, IPT board, and a plain supporting board. The connector board (no.2) with the pressure and temperature connectors is attached to the IPT board beneath the ECG board. This whole assembly can be detached by removing 6 appropriate screws on the front plate (two on top and one on each side of two connector openings) and disconnecting X10 and X12 connectors from the mother board after the Keyboard pc board is removed. Each board can now be detached from the assembly by removing the screws and spacers.

f) Four boards are attached to the mother board on the right half of the chassis: (moving front to rear) the NIBP processor board, the CO_2/N_2O measuring board, the CPU board, and the Video control board. These boards are removed by pulling upwards.

Beneath the mother board the intermediary bottom plate houses O_2 measuring unit, gas sampling pump, and sampling system parts. In CS and 2CS model monitors the O_2 measuring unit is replaced by three extra constriction cassettes. Remove bottom window plate to get access to those parts.

g) The SpO_2 measuring board, SpO_2 connector I/O board, and SpO_2 processor board are located on the far right of the monitor, attached to a vertically positioned casing. The casing is mounted to the bottom plate with three screws. One of the screws is hidden under the front foot.

h) Power supply board is attached to the rear plate with four screws.

i) Transformer, power cord receptacle block, CO_2/N_2O measuring unit, loudspeaker, fan and dust filter, fuse housing(s), NIBP cuff connector, and ECG test signal connector are all attached to the rear panel.

The rear panel can be tilted back by first detaching the power cord receptacle block and removing the two screws beside the fan which are keeping the rear panel in the upright position and sliding the panel in sideways.

j) The main PC board for the picture tube, NIBP pump and vertically positioned supporting plate, and NIBP safety valve are attached to the bottom plate with screws.

Two magnetic valves, damping chambers II and III, and a choke are screwed to the horizontally positioned plate, which in turn, is screwed to the vertically positioned supporting plate.

CAUTION: When the pneumatic unit is disassembled, make sure that the tubes are reconnected properly.

The picture tube unit is screwed to the front plate.

Most parts can be removed by loosening the appropriate screws.

k) Reassembling is essentially reversing what was described above.

CAUTION: When attaching the top cover, make sure that the tubes and cables are not pinched between the boards and the cover.

6.3 Troubleshooting

6.3.1 Monitor start-up sequence

After the monitor is switched on

- Fan on the rear panel starts to run.
- The selftest text appears on the screen. All the memory in the monitor is checked. Program code and the date of its completion are also displayed.
- Within a half minute, fields for waveforms and numeric values will appear as horizontally running straight lines and dashes on the screen. The real time clock also appears.

  The message 'CALIBRATING GAS FLOW' appears. The zero valve opens to measure the ambient pressure.

  If SpO_2 probe is not connected to the monitor, the message 'NO PROBE' appears. If the probe is connected to the monitor but not to the patient, the message 'PROBE OFF' appears. When the probe is connected to the patient, the message 'PULSE SEARCH' appears and shortly pulse waveform appears on the screen.

  The NIBP software is performing its own selfcheck. If the selfcheck is completed with no error detected, the program code for NIBP appears in the lower left corner of the screen.
- After a moment, the pump starts and the zero valve closes. The monitor measures operation of pump and working pressure.
- The zero valve opens and closes. This is to check the operation of the zero valve.
- Within a minute after switching on, the monitor is ready for use.
- 2 minutes after switching on the reference valve opens to measure pressure gradient between the O_2 measurement flow and the O_2 reference flow. This pressure gradient measurement is repeated normally once an hour.
- After 5 minutes the zero valve opens and the monitor checks the zero levels of each gas. This zeroing is repeated again after 30 minutes.

6.3.2 Error messages

Table 6.1 Error messages

MESSAGE	POSSIBLE CAUSE/REMEDY
xx ZEROING ERROR	Gas zeroing failed. Condensation or residual gases are affecting the zero measurement. Allow monitor to run drawing room air for half an hour and calibrate again. If it does not help, go on to the following troubleshooting sections.
AIR LEAK DETECTED	Air leak in sampling system. Probably water trap or the sampling line is not attached properly. Gas zero valve failure. Pump failure or gas outlet blockage. If Return Gas Kit is used, check the bacteria filter.
O_2 TRANSDUCER ERROR	When attempting zeroing, message is displayed to indicate probable malfunction of the O_2 transducer.
REPLACE WATER TRAP	Flow resistance increased due to residue build-up on water trap membrane. Change the water trap.
OCCLUSION	Sampling line or water trap is occluded. Water trap container is full. If occlusion persists check internal tubing for occlusions.
EXTERNAL RAM ERROR	Check CPU board; RAM read/write problem. (This message possibly appears in startup). Go on to the following electronics troubleshooting sections.
ROM CHECKSUM ERROR	Check CPU board; EPROM read error. (This message possibly appears in startup). Go on to the following electronics troubleshooting sections.
LOW PLETH SIGNAL	The signal quality is poor and the measurement may be inaccurate. Probably no equipment malfunction. (Often occurs in patients with low perfusion).
ARTIFACT	There is a very strong occasional AC component in the measured pleth signal. (Probably because of patient movement or vibration).
NO PROBE	No probe connected to the monitor. Probe faulty. Check probe connections.

MESSAGE	POSSIBLE CAUSE/REMEDY
PROBE OFF though probe properly attached to the patient	Unsuitable site. Try different site. Probe faulty.
CHECK PROBE	An appropriate DC level has not been found in probe signal. (Possibly because of LED in probe failure). Change the probe.
CUFF LOOSE	Check that cuff and hose connectors are tightly connected. Check that cuff is tightly wrapped around the arm. Check internal tubing for loose connections.
NIBP HW ERR x	NIBP HW-error. See more information in Section 6.3.9
BP AIR LEAKAGE	Check cuff and hose connectors for air leakage. Use STASIS mode to pump 80 mmHg pressure. If pressure continuously falls close the tubing at different locations to find the leaking component.
BP ZERO ERROR	Unstable zero pressure due to arm movement or DC-channel zero has been drifted above or under the specified limit. May require another calibration.
NO NONINV. BP	No NIBP installed.
Extra NIBP ARTIFACT	Check for air leakage.
CUFF OCCLUSION	The remaining cuff pressure is more than 20 mmHg over 20 seconds after the last NIBP measurement. Automatic cycling is placed in standby mode. Cuff itself or cuff hose possibly occluded.

6.3.3 Troubleshooting in general

NOTE: Please read "Troubleshooting and Displayed Messages" in the Operator's Manual first. The part of this chart is duplicated from it.

Table 6.2 General troubleshooting chart

SYMPTOM	POSSIBLE CAUSE/REMEDY
No response when power is turned on	Power cord disconnected or not connected properly. Fuse blown. If they get blown repeatedly, go on to the electronics troubleshooting sections.
No picture	Adjust the brightness control. The primary, secondary or video fuse possibly blown. The CPU board or the power supply board faulty. If the keyboard response beep is heard, probably the video control board or CRT unit is faulty.
No response to breathing	Sampling line or water trap blocked or loose, or improperly attached. Water trap container full. If the trouble persists go on to the following troubleshooting sections.
Bad or missing SpO_2 waveform and reading	Faulty SpO_2 probe. If not, faulty SpO_2 measuring or processor board.
Constant leads off message, noise, bad trace or no pacemaker detection.	Lead selector in V-position, ECG board connector loose, faulty ECG board.
Bad or missing plethysmogram.	Faulty transducer, faulty IPT board.
Bad or missing pressure trace.	Faulty pressure transducer or IPT board.
Erroneous or missing temperature (38°C).	Erroneous software zero set (TEMP CAL in engineering menu), bad IPT board.
Nonlinear temperature or errors at temperatures other than 38°C (Temp test button).	Bad calibration of temp trimmer cal., bad IPT board.
NIBP does not start	NIBP is not selected.

6.3.4 Gas sampling system troubleshooting

The faults which can occur in the sampling system are: leaks or occlusions in the tubing, failure of the sampling pump or the magnetic valves, or reduced flow rates due to pump aging or dirt accumulating in the internal tubing. The troubleshooting chart of the sampling system is shown in Figure 6.1.

When testing or servicing the sampling system, check all flow rates and make any adjustments as required.

The sampling system details are illustrated in Figure 5.2 and described in Tables 5.1 and 5.2.

> **NOTE:** DATEX D-FEND™ water trap should be changed once every two months or if the occlusion alarm comes on during the monitor start-up sequence in normal use.

Connect power cord and sampling line. Turn the power on and wait until the monitor is ready for use.

1. SAMPLING SYSTEM LEAK TEST

Connect a tube to the sample gas out connector on the rear panel and drop its other end into a glass of water.

Block the sample inlet, the reference flow to the oxygen measuring unit, and the open port of the gas zero valve. Wait for one minute.

There should be less than 1 bubble per 10 seconds coming out of the tube. Bubble should not move upwards more than 11 mm per 30 seconds inside the tube. If it does, there is a leak between the pump and the sample gas out connector.

> **CAUTION:** Do not turn the pump off while performing the leak test. Negative pressure in the sampling system will draw the water from the glass into the monitor.

2. WATER SEPARATION

The water trap and the internal flow rates can indirectly be checked by testing the water separation efficiency. To do this, place a few drops of distilled water on a clean surface and draw them into the monitor one at a time.

The occlusion text should appear to indicate that the pressure detection system functions.

If the occlusion text does not appear, check all internal tubing, especially the side flow of the water trap, for blocked or kinked tubes.

3. RESPONSE TIME

To check the response time, connect the analog output (CO_2) to a fast recorder. Let the monitor sample test gas, then very quickly remove the sampling line from the gas flow. From the recorder chart paper measure the fall time from 90 % of reading to 10 %. This should be within specifications (<= 270 ms).

Connect the recorder to the O_2 analog output. Repeat the test using oxygen; the fall time should be less than 430 ms. If an analog recorder is not available, the screen display can be used. One time step on the waveform is 20 ms. The trace can also be selected to show the O_2 waveform in GAS SETUP function.

If both responses are too slow, the cause may be a wrong size sampling line, contaminated water trap, the side flow is too high or deteriorated sampling pump. If only the oxygen fall time is too long, the fault is most likely inside the O_2 measuring unit, which must be replaced.

4. GAS PUMP TEST

To perform gas pump test, press down the GAS key during the monitor start-up. The message "Ready To Test Pump" appears. Block the sampling line with your finger and press the RETURN TO MONITOR key. The pump starts and negative pressure inside the sampling system is displayed on the screen. The test is terminated automatically. If the test result is not satisfactory, the message "Weak Flow Result Rejected" appears. In this case check the sampling system for fault and if the system is OK, change the sampling pump.

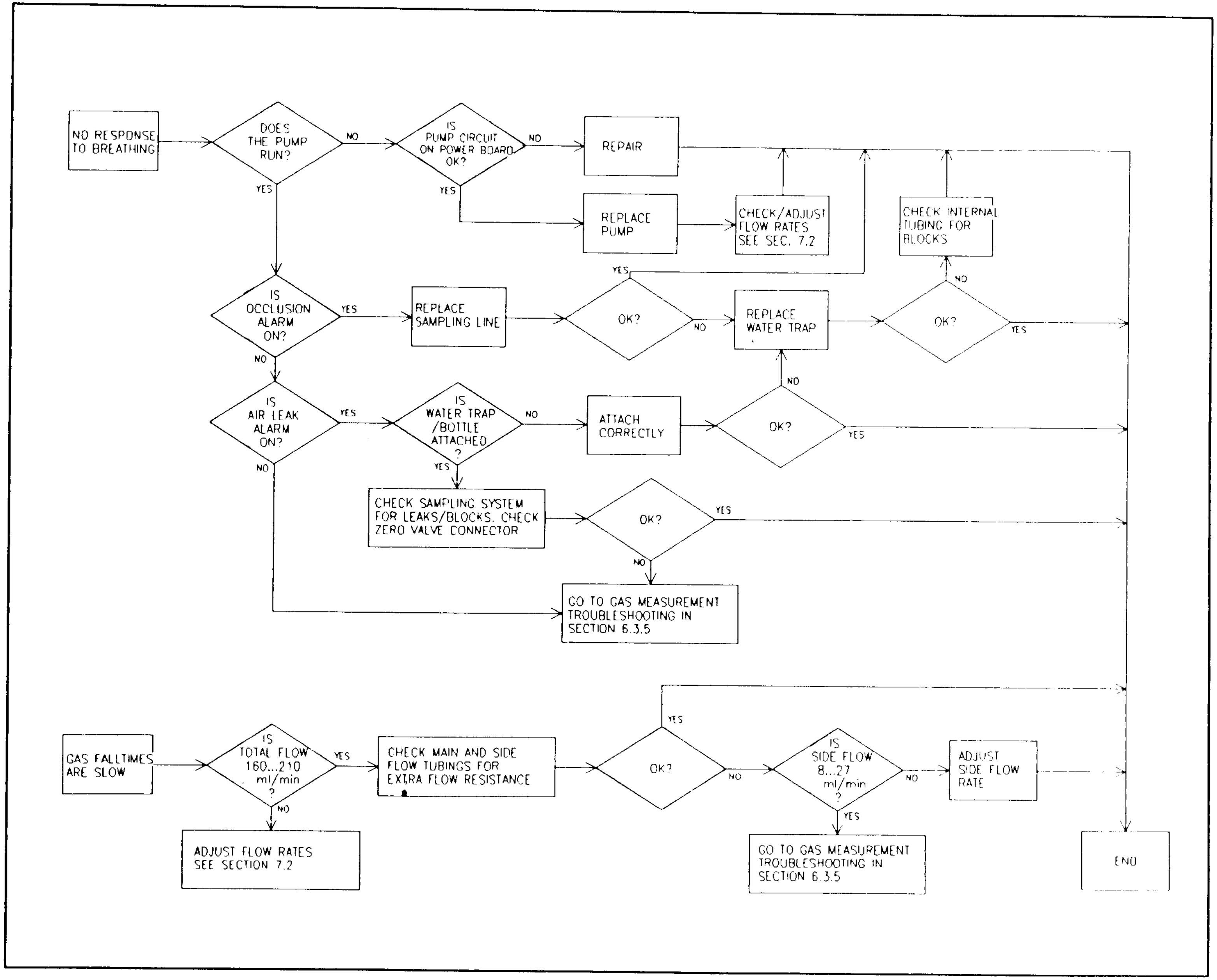


Figure 6.1 Gas sampling system troubleshooting chart

6.3.5 Gas measurement troubleshooting

> NOTE: D-FEND™ water trap prevents any liquids from entering the monitor. In rare cases where contamination is observed in the measuring chamber, remove the unit from the monitor and clean it as described at the end of this chapter.

> NOTE: If fault is found inside the CO_2/N_2O measuring unit (photometer) we recommend that you replace the whole measuring unit.

Table 6.3 Gas measurement troubleshooting chart

SYMPTOM	POSSIBLE CAUSE/REMEDY
No response to any gas	Sampling line or water trap blocked. Internal tubing (constriction cassettes) blocked or loose. Water container loose. Pressure valve malfunction. Pump failure. Supply voltage missing (power supply board failure) A/D converter faulty.
No response to neither CO_2 nor N_2O	Chopper motor not running. IR lamp failure. Check the IR lamp resistance (approximately 3.5 ohm) and the lamp voltage (4 VDC min). If there is no voltage, check the LAMP ON signal from the CO_2/N_2O measuring board (connector X1 pin b13). If the line is high the mosfet V7 on power supply board is faulty, if low, the chopper motor is probably stalled. Check for timing pulses from the preamplifier board. AGC amplifier (A4) faulty. Coarsely erroneous or missing reference voltage. Timing pulses missing.
Either CO_2 or N_2O response missing	Analog switch faulty or control pulses missing. Other components fault in the measuring electronics. Check by following the signal with an oscilloscope along the amplifier chain.
No O_2 response	O_2 measuring unit tubes loose or blocked. O_2 measuring unit connecting cable loose or faulty. O_2 measuring unit internal tubings blocked by water. Disconnect O_2 measuring unit tubings and try to remove water by pumping air into the connector "OUT". O_2 measuring unit faulty. Replace. Analog multiplexer faulty.

SYMPTOM	POSSIBLE CAUSE/REMEDY
Zeroing of CO_2 and/or N_2O fails	Measuring chamber contamination. CO_2/N_2O measuring board faulty. Adjust analog zero or replace the board.
Strong drift in all gases	Leak in sampling line or internal tubing (especially in conjunction with too low readings). AGC malfunction. Check analog switches and control pulses.
Strong drift of CO_2 and N_2O	Fluid or dust in measuring chamber. Electrical connections to IR lamp faulty. Loose screws in measuring unit. AGC circuit faulty (CO_2/N_2O measuring board).
Strong drift of O_2	Blocked O_2 reference flow. Uneven sample pump function. Replace pump.
Sudden increase in gas display	Measuring chamber contamination. +/-15 V missing (fault in the power supply).
The above occurs frequently	Water trap malfunction. Check all internal tubing and the interior of the water trap for occlusions or leaks. Replace water trap. Check flow rates.
CO_2/N_2O software calibration fails	Analog gains out of range. Check the general functioning of the measuring electronics.
O_2 software calibration failure	Adjust the gain trimmer of O_2 measuring unit. If not possible, replace the measuring unit.
'CALIBRATING GAS FLOW' - message remains on the screen	CO_2/N_2O gas analog voltages out of range (over about 9 V).
Impossible to adjust gain	AGC malfunction. Check analog switches and A4. False reference voltage. Faulty temperature compensation circuit.

SYMPTOM	POSSIBLE CAUSE/REMEDY
Too low response in both CO_2 and N_2O (and possibly O_2)	Leak in water trap, or tubing between the trap and the measuring units; the sample is diluted with air.
Abnormally high response to all gases (or abnormally low) or sudden occlusion warning	Pressure transducer failure (check Pout voltage).
Random output (resembling noise)	Timing pulses out of sync. Check timing pulses from photometer, pulse shaping circuit, and logic circuitry on the measuring board. Chopper motor not running Motor faulty or connection loose. Driver transistor C-E open circuit or current limiter short circuit.

Measuring chamber cleaning

> **NOTE:** D-FEND™ water trap prevents any liquids from entering the monitor. In rare cases where contamination is observed in the measuring chamber, you may remove the unit from the monitor and clean it as described below.

Most often 'contamination' results from water which will evaporate and cause no permanent damage if the monitor is left running to dry the chamber. In rare cases where contamination persists, first try rinsing the measuring chamber with distilled water. If unsuccessful, then the measuring chamber may be cleaned using DATEX Measuring Chamber Cleaning Fluid (P/N 85909).

> **CAUTION:** Using alkaline detergents may cause permanent damage to the internal parts of the measuring unit.

a) Turn off the monitor and unplug the power cord.

b) Detach the measuring assembly by removing two screws on the rear panel and disconnecting sampling tubes and wires for the IR lamp.

c) Inject distilled water or cleaning fluid into the chamber with a syringe using the larger connector.

d) Leave the fluid in place for 15 minutes. If the cleaning procedure does not succeed, repeat step c but leave the cleaning fluid for increasingly longer period (up to overnight).

e) Blow the fluid out completely with the syringe filled with air.

NOTE: If you have used DATEX Measuring Chamber Cleaning Fluid, then repeat the next steps f and g at least ten times.

f) Inject distilled water into the chamber with the syringe until the chamber is completely filled.

g) Slowly blow out the water as done in step e.

h) Dry the chamber by filling the syringe with air and blowing the air into the chamber.

i) Connect the tubes and attach the measuring chamber back to the rear panel. Connect the wires.

j) Switch the monitor on and let it run sampling room air until all the values stabilize at zero.

k) Check the gas calibration of the monitor.

6.3.6 O_2 measurement troubleshooting

Because of the complex and very sensitive construction of the oxygen measuring unit no repairs should be attempted inside the unit. Instead, if the fault has been found in the measuring unit itself, it should be replaced and the faulty unit be sent to DATEX for repair.

If there is no response to O_2 or strong drift, check the tubing for loose connections, occlusions, and leaks.

Check the measurement and reference flows. They should be within the specifications described in Chapter 7.2.

CAUTION: Never apply an overpressure to the O_2 measuring unit as the pressure transducer may be permanently damaged.

If O_2 zero error message is displayed check the O_2 measuring unit output voltage at pin 13 of connector X13 on the mother board (see Section 7.3.1).

If the adjustment range of the (software) calibration is insufficient check the O_2 measuring unit output voltage and adjust the gain if necessary (see Section 7.3.2).

If there are problems with O_2 response time check the O_2 measurement flow rate and adjust it if necessary (see Section 7.2).

If the O_2 signal is noisy, check the measurement unit suspension springs.

6.3.7 ECG board troubleshooting

In troubleshooting the ECG board it is important to note that the isolated ground has no connection to the system electronics ground. Also, when the problem is excessive high frequency noise, it may be that altering the normal grounding by connecting an oscilloscope ground to the isolated ground may cancels the noise.

When checking ECG board problems, first confirm that the isolated power (±12 V) is available and stable. The waveform at the secondary of T1 should be 100 kHz square wave, 50 % duty cycle and 25 - 30 Vpp.

Table 6.4 ECG board troubleshooting chart

SYMPTOM	POSSIBLE CAUSE/REMEDY
No ECG signal, 'LEADS OFF'	ECG amplifier connector loose, input amplifier or diodes blown, intermediate amplifier or pulse width modulator blown.
No ECG signal, no 'LEADS OFF'	No isolated power.
50/60 Hz noise	Notch trim error (R48)

6.3.8 IPT board troubleshooting

Table 6.5 IPT board troubleshooting chart

SYMPTOM	POSSIBLE CAUSE/REMEDY
No transducers recognized, no temperature display when temp test button is depressed.	IPT board connector loose, faulty board, no isolated power mux blown, common channel blown, mux address select optoisolator blown, CPU board PPI output blown.
One transducer error.	Specific preamplifier blown, transducer blown.

6.3.9 NIBP board troubleshooting

The NIBP board has its own diagnostics software that tests the NIBP hardware every time the monitor is switched on. Should there be any trouble with the NIBP, the monitor should be switched off and on again and a possible NIBP error message be observed. If the NIBP unit is ok it displays the NIBP VER X.X. message.

Table 6.6 NIBP board troubleshooting chart

SYMPTOM	POSSIBLE CAUSE/REMEDY
NIBP text is not shown at power up	NIBP CPU has not started or serial interface is not working, replace the NIBP board.
NIBP HW ERR 1	External RAM error. Check that D3 is properly in place. Replace D3. Check the operation of the decoder circuit D5. Check for short circuits in the internal bus.
NIBP HW ERR 2	ROM checksum error. Replace program EPROM D2. Check for short circuits in the internal bus.
NIBP HW ERR 3	Power switch error. Check the +15 VD power switch (V1, V3). Check that +15 VD power is on (TP X7/4).
NIBP HW ERR 4	A/D converter error. Check that converter clock is running (U1/19, TP X6/2). Check that a waveform is seen on the input pin U1/6. Voltage levels should be between 0 and +5 V. Check that a waveform is shown on pin U1/5, if not CPU is not reading the converter or the converter is faulty. Check that the analog circuitry is operating properly and all voltages are present.
NIBP HW ERR 5	Analog zero point ERROR. Check that all voltages are present. Check circuits A4, A3, A2, A1 and U1.

SYMPTOM	POSSIBLE CAUSE/REMEDY
NIBP HW ERR 6 NIBP HW ERR 7	Pressure DC-channel zero is above or under the specified limit. Check that the pressure transducer B1 is operating. Check that all voltages are present. Check analog circuitry. Go to calibration mode and adjust trimmers R6 and R11 (see Section 7.7). **NOTE:** If the pressure transducer has drifted more than 20 mmHg the transducer is probably faulty and should be replaced.
NIBP HW ERR 8	NIBP HW-timer check. Too short time. Check watchdog circuit.
NIBP HW ERR 9	NIBP HW-timer check. Too long time. Check watchdog circuit
Pressure does not rise to 270 mmHg.	Check that safety valve is not operating at pressures lower than 270 mmHg.

6.3.10 SpO_2 measuring electronics troubleshooting

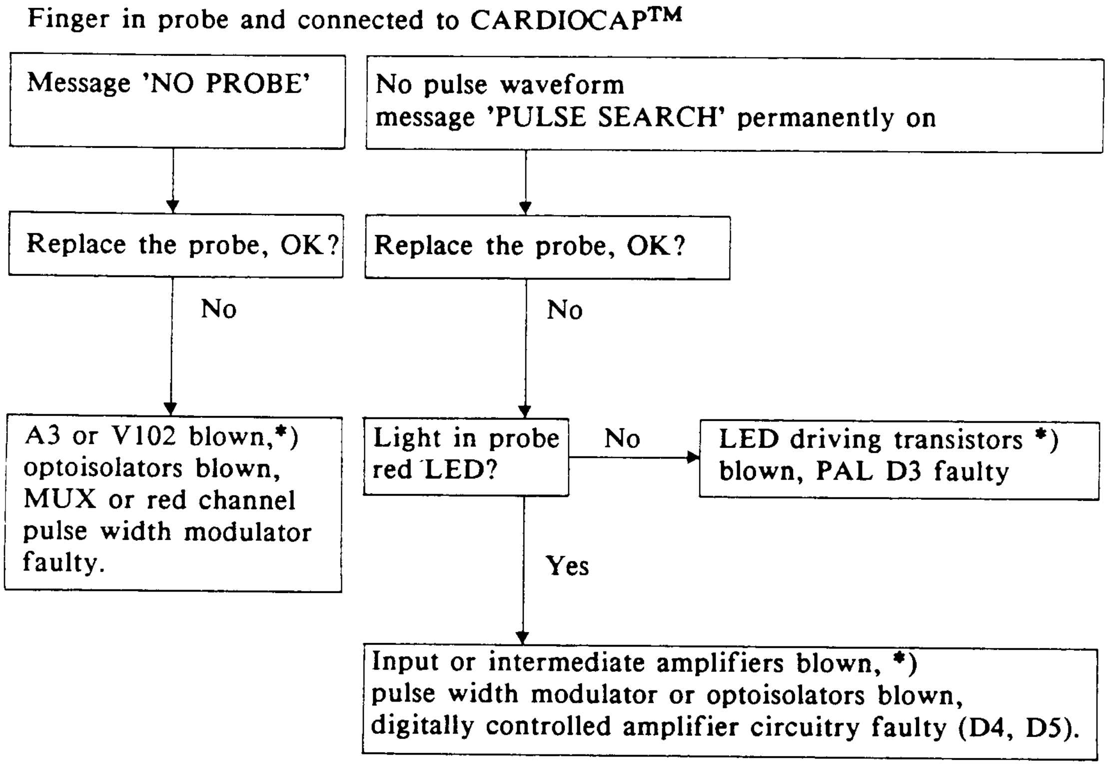
In troubleshooting the measuring board it is important to note that the isolated ground has no connection to the system electronics ground. Also, when the problem is excessive high frequency noise, it may be that altering the normal grounding by connecting an oscilloscope ground to the isolated ground may cancels the noise.

When checking measuring board problems, first confirm that the isolated DC power (+12 V, -12 V, and +5 V) are present and are stable. The waveform at the secondary of T1 (e.g. anode of V16) should be 45 kHz square wave, 50 % duty cycle and 21 - 30 V_{pp}.

The troubleshooting chart of the measuring electronics is shown in Table 6.6.

For the parts layout and schematic diagram of the SpO_2 measuring board see Section 5.

Table 6.7 SpO_2 measuring electronics troubleshooting chart



*) see Figure 5.23 for signal waveforms.

NOTE: When doing any work on the measuring board care has to be taken that the patient isolation is not violated.

NOTE: When reassembling the measuring board see Figure 9.1 for the proper placement of the shields.

6.3.11 SpO_2 processor board troubleshooting

Due to the complexity of the LSI circuitry there are few faults in the CPU digital electronics that can be located without special equipment. The following checks may, however, be performed:

a) All integrated circuits are properly inserted into the sockets.

b) The 11.059 MHz clock signal at the CPU pins 18 and 19 (use a high impedance probe to check).

c) PSEN (CPU pin 29) shows that instructions are being fetched. If this line is static, the processor is not running.

d) RESET (CPU pin 9) is normally low but pulled up to +5 V for a moment after power up. If RESET is constantly high, check the +5 V supply line for spikes or too low level.

The analog part is somewhat easier to debug. The input analog voltages are easily tracked to the MUX input. After the MUX, the voltages are multiplexed so that the resulting waveform frequency is at 200 - 600 Hz.

6.3.12 CPU board troubleshooting

Due to the complexity of the LSI circuitry there are few faults in the CPU digital electronics that can be located without special equipment. The following checks may be performed:

a) The RAM, EPROM, CPU, and other socketed integrated circuits are properly installed and the memory configuration jumpers are correct (see Figure 5.30).

b) The 16 MHz (revision 02 and up) or 11.059 MHz clock signal at the CPU pins 18 and 19 (use a high impedance probe to check).

c) PSEN (CPU pin 29) shows that instructions are being fetched. If this line is static, the processor is not running.

d) RESET (CPU pin 9) is normally low, but pulled to +5 V for a moment after power up. If RESET is constantly high, check the +5 V supply line for spikes or low voltage.

The analog sections are easier to troubleshoot. The input analog voltages are easily tracked to the MUX input. After the MUX, the voltages are multiplexed so that the resulting waveform frequency is at 200 - 600 Hz.

IR analog output is updated every 10 ms. All other analog output channels are updated every 40 ms. Thus the D/A conversion interval is 5 ms.

6.3.12.1 Instructions after replacing the software or CPU board

After replacing the software or CPU board:

- Perform factory reset in the engineering menu (see the Operator's Manual Section 2).

- re-establish previously used settings or inform the monitor user that all other settings are default values.

6.3.13 Video control board troubleshooting

Before proceeding with the video control board troubleshooting, check the composite video output with an external video monitor (24 MHz bandwidth required) to differentiate between faults in the control board and faults in the video display module; if the composite output gives a good picture, the control board is probably ok and the trouble lies in the cables or in the video display module. For troubleshooting of the video display module please refer to the Panasonic Model M-K9101NB Service Manual (available from DATEX).

Due to the complexity of this board, there is very little that can be done without extensive special equipment. The following checks, however, can be performed:

a) Visual inspection

b) Check the 24 MHz clock oscillator (8/D2) and the 1.5 MHz clock (1/D4).

c) Check the horizontal and vertical sync as well as the output video signal to point the fault to the GDP or video shift register/RAM part.

d) Check that a continuous pulse stream is shown at pin 17/D4. If this pin is high the CPU does not write data to the video controller. Check that the CPU is running. If the CPU is ok check the bus signals and data buffers to D4.

e) If the picture has vertical stripes one of the video RAM's (D9 - D16) is faulty. The faulty RAM can be identified as follows:

Faulty column from left edge (n = 0,1,2...)	**Faulty RAM**
1 + 8n	D16
2 + 8n	D15
3 + 8n	D14
4 + 8n	D13
5 + 8n	D12
6 + 8n	D11
7 + 8n	D10
8 + 8n	D9

f) Check transistors V1 and V2.

6.3.14 Power supply board troubleshooting

The following troubleshooting chart will help in pinpointing a malfunctioning component. The only part that requires good understanding of operating principles are the switching supplies. Consult the IC data sheet for more information on the LM 3524 switcher controller.

Table 6.8 Power supply board troubleshooting chart

SYMPTOM	POSSIBLE CAUSE/REMEDY
No voltages.	Secondary fuses F3 and F4 blown. NOTE: They usually get blown at the same time.
Both switcher voltages missing.	Voltage reference (A2) blown, L3 blown.
One switcher voltage missing.	Faulty switcher IC (A1 or A3), power FET, bipolar trans. NOTE: If the FET is shorted it usually shorts the Transzorb zener (V6, V23) and blows the secondary fuses.

6.3.15 Mother board/Keyboard troubleshooting

Fault finding on the mother board/keyboard is reduced to:

- visual inspection of board surface and connectors
- continuity and short circuit testing with an ohmmeter
- measuring of power supply voltages.

6.3.16 Loudspeaker troubleshooting

Loudspeaker can be evaluated by checking its supply voltage (red wire), volume (black), and pitch (green) signals. The measurement can be performed easily by detaching the loudspeaker from the rear panel.

6.4 Service mode

The service mode is designed originally for factory use. However some simple checks can be done in the service mode to ensure the proper operation of the monitor without having to disassemble it.

Enter the service mode as follows:

a) Turn on the monitor and allow it to go into normal monitoring mode.

b) Press the soft keys 1, 2, 3, and 4 in that order and then immediately press and hold down the RETURN TO MONITOR key.

The character 'S' blinks and the text 'SERVICE MODE ON' appears to indicate that you have entered the service mode.

c) Press soft key 4. The service mode menu will appear.

The menu is:
STAND BY
GAS SERVICE
SERVICE OFF

Press the soft key 1 to move box from selection to another. Press the RETURN TO MONITOR key to enter the menu.

In STAND BY, normal monitoring can be continued even though you are in the service mode.

In GAS SERVICE, the following items are displayed:

P amb (ambient pressure)
P int (internal=working pressure compared to P amb. Normally 700 mmHg)
P drift (pressure drift after filtered with software)
P al-lim (air leak pressure limit compared to P amb)
P occl (occlusion pressure limit compared to P amb)
P max (maximum occlusion pressure limit compared to P amb)
P OMplim (pressure limit that triggers the next OMref measurement compared to P amb)
P OMin-ref (pressure difference between O_2 measurement flow and O_2 reference flow. Normally about 8 mmHg)

OMmeasTMR (time in minutes before the next OMref measurement)

Pumpindex (indicates pump power in number. Default value is 0)

CO2, N2O, O2 sample [V] (outputs of measuring units received by AD converter in CPU board)

Tf [ms] (fall times of each gas measurements)

> **NOTE:** Pressure limits of occlusion, maximum occlusion, and air leak are determined by Pumpindex.

d) In GAS SERVICE, press soft key 1. Now the pump, the zero valve, and pressure valve can be operated manually with the soft keys 2, 3, and 4. Exit this mode by pressing the RETURN TO MONITOR key.

e) In GAS SERVICE, press soft key 2. "MEASURE OMin-OMref PRESSURE" appears. Then press the soft key 1 to perform the measurement. Shortly a beep will be heard and the measurement is done.

f) Exit the GAS SERVICE by pressing soft key 4 to have the service mode menu displayed. Then choose the service off with the soft key 1 and press the RETURN TO MONITOR key.

7 ADJUSTMENTS

7.1 Adjustments after component replacements

COMPONENT REPLACED	ADJUSTMENTS
SAMPLING SYSTEM	After any work on the sampling system check the flow rates and adjust if necessary (see Section 7.2).
CO_2 AND N_2O MEASUREMENT	
Integrated circuits, diodes, transistors or passive components	Zero (see Section 7.3.1) and gain (see Section 7.3.2).
Reference diode (V2 on CO_2/N_2O measuring board)	Reference voltage adjustment (see Section 7.3.3).
Photodetector, measuring chamber, IR lamp, filter wheel or whole photometer	Zero (see Section 7.3.1), and gain (see Section 7.3.2).
Chopper motor	No adjustment needed.
Preamplifier board	Temperature compensation (see Section 7.3.4).
CO_2/N_2O measuring board	Zero (see Section 7.3.1) and gain (see Section 7.3.2).
Pressure transducer (on CO_2/N_2O measuring board)	Change also the offset and temperature compensation resistors. Adjust offset and gain (see Section 7.3.5).
O_2 MEASUREMENT	
O_2 measuring unit	If the output is noisy perform frequency adjustment (see Section 7.4.4).
CPU BOARD	
Any component in real time clock circuit	Adjust real time clock frequency (see Section 7.9).
HIGH SPEED CPU BOARD	No adjustment necessary.

7.2 Gas sampling system adjustment

Flow rates should be measured and possibly adjusted under the following conditions:

- After any part within the sampling system has been replaced
- If the gas response is slow

> NOTE: Before testing or adjusting the flows, replace the D-FEND™ water trap and attach a sampling line to the water trap.

To perform the flow rate measurements, a flowmeter with a low flow resistance and capability to measure low flow rates is required. When making flow rate measurements, the sampling line has to be connected to the monitor as it has a considerable effect on the flow.

The flow rates are adjusted by changing the flow resistance cassettes (constriction cassettes) in the sampling system. See Table 5.2 for the alternative cassettes.

The adjustments and the respective constrictions to be adjusted are shown in Figure 7.1.

Flow rate

Total flow rate is measured by attaching the flowmeter to the sampling line. The rate should be between 160 and 210 ml/min. The flow rate is adjusted by changing the constriction cassette which is located behind the pump (no. 19).

Rate of the side flow is checked by blocking the side flow tubing behind the water trap and measuring the flow rate as above. The rate should decrease by 8 to 27 ml/min. The side flow rate can be adjusted with the cassette no. 21.

Measurement flow and reference flow of the oxygen measuring unit are checked as follows:

a) Connect flowmeter behind the constriction cassette (no. 22) and ahead of the oxygen measuring unit REF inlet. The flowmeter should show between 25 and 42 ml/min. The flow rate is adjusted by changing the cassette.

b) Connect flowmeter between the oxygen measuring unit IN inlet and the tube which is connected to it. The flow rate should be between 18 and 25 ml/min **larger** than the REF flow. This is adjusted by changing the constriction cassette (no. 20) which is located between the IN and OUT inlets.

CAUTION: When changing cassettes make sure that there are no kinks or splits in the tubes and that the tubes are reconnected properly. See Figure 5.2.

Flow to be adjusted	**Cassette No. (see Figure 7.1)**	**Nominal value (tolerance) ml/min**
total flow	19	180 (160 to 210)
side flow	21	8 to 27
O_2 measurement in	20	43 to 67
O_2 reference in	22	25 to 42

NOTE: Changing any of the cassettes will have some effect on the other flow rates. Check all flow rates after making any adjustments.

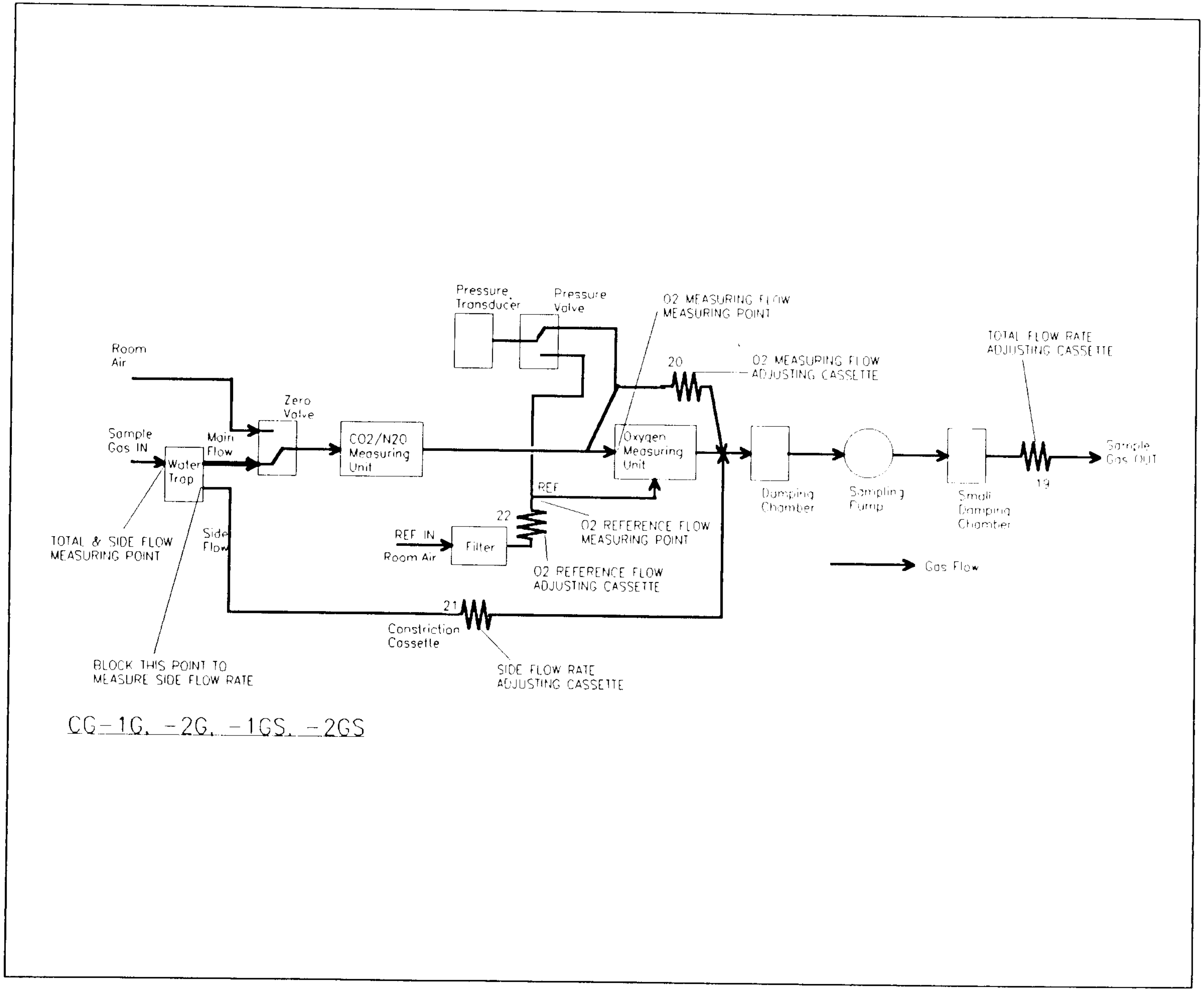


Figure 7.1 Gas sampling system adjustment chart

O_2 measurement flow pressure measurement

Gradual decrease of main flow rate due to the water trap filter becoming clogged can be checked by measuring pressure difference between the O_2 measurement flow and the O_2 reference flow. Remember that the sampling line should be attached to the water trap during the test.

The pressure difference can be displayed on the screen in GAS SERVICE in the service mode under the text "P OMin-ref".

The pressure difference should be between +5 to +10 mmHg (factory adjusted).

If the pressure difference is too large, decrease the measurement flow rate by changing the cassette no. 20.

The pressure difference is automatically checked once every one hour during normal operation and once in every 15 minutes when the pressure difference is between 0 and -5 mmHg.

When the pressure difference reaches -5 mmHg, then during normal monitoring the message "REPLACE WATER TRAP" appears and the audible alarm sounds to indicate that the water trap should be replaced.

7.3 CO_2 and N_2O measurement adjustments

Section 7.1 gives the guidelines to what adjustments are necessary after component replacement. Otherwise, the only adjustment that may be needed is the analog zero adjustment to compensate for gradual contamination within the measuring chambers.

> NOTE: The CO_2/N_2O measuring chamber should be cleaned before performing an electrical zero. Zeroing should not be done to compensate for contamination, unless it cannot be removed by washing.

See Figure 7.2 for the location of the adjustment trimmers.

7.3.1 Zero adjustments

The software accepts zero signals between -2.5 V and +2.5 V. When servicing a monitor, zero adjustment should be carried out if the voltages are greater than +1.5 V or less than -1.5 V after cleaning and drying the measuring chamber.

a) Connect a CO_2 absorber to the sample input. For N_2O no absorber is necessary, but care must be taken not to have any sources of N_2O contamination in the room where the zeroing is performed.

b) Run the monitor at least 10 minutes to eliminate errors caused by initial warm-up.

c) Monitor the CO_2 and N_2O outputs by using a digital voltmeter (mother board test connector X13, pin 3 (CO_2) and pin 4 (N_2O)).

d) Adjust the outputs to 0 V $\pm$0.1 V with the trim resistors R23 and R24. If CO_2 or N_2O zeroing is not possible with resistors R23 or R24 try changing the series resistance by adjusting dip switches S1.

e) Perform software zeroing and calibration (refer to the Operator's Manual).

7.3.2 Gain adjustments

Calibration gases are needed for the gain adjustment. The CO_2 concentration should be between 5 and 10 %, and should be known to within +5 % or better (the absolute accuracy of the concentration is not critical as the final calibration is done from the keyboard). For N_2O adjustment the common 100 % N_2O gas used in hospitals may be used.

If the gain has drifted out of specification, calibration of the monitor will become impossible and it will be necessary to adjust the gain. When servicing a monitor, gain adjustment should be carried out if the voltages are not within +0.3 V.

a) Let the monitor run at least one hour.

b) Adjust the zero as previously described.

c) Sample the standard gas and adjust the output at pin 10c of the measuring board connector with the trim resistor R16 to a voltage corresponding to the CO_2 content in the sample. The voltage is found in Table 7.1.

d) Sample N_2O and adjust the output at pin 10a of the measuring board connector to 7.5 V with R17. If other than 100 % N_2O is used, the voltage is found in Table 7.2.

e) Check and if necessary repeat steps b to d.

f) Perform software zeroing and calibration (refer to Operator's Manual).

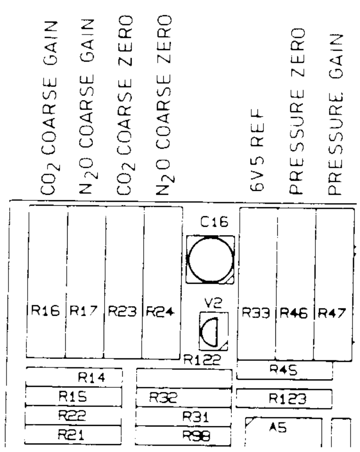


Figure 7.2 Adjustment Trimmers Location

Table 7.1 CO_2 Linearization

%CO2	OUT/V	%CO2	OUT/V	%CO2	OUT/V
0.00	0.00	2.30	3.00	6.67	6.00
0.03	0.05	2.35	3.05	6.76	6.05
0.05	0.10	2.40	3.10	6.86	6.10
0.08	0.15	2.46	3.15	6.96	6.15
0.11	0.20	2.51	3.20	7.06	6.20
0.14	0.25	2.57	3.25	7.16	6.25
0.17	0.30	2.63	3.30	7.26	6.30
0.20	0.35	2.68	3.35	7.36	6.35
0.23	0.40	2.74	3.40	7.46	6.40
0.26	0.45	2.80	3.45	7.56	6.45
0.29	0.50	2.86	3.50	7.67	6.50
0.32	0.55	2.92	3.55	7.77	6.55
0.35	0.60	2.98	3.60	7.88	6.60
0.38	0.65	3.04	3.65	7.99	6.65
0.41	0.70	3.10	3.70	8.10	6.70
0.44	0.75	3.16	3.75	8.21	6.75
0.47	0.80	3.22	3.80	8.32	6.80
0.50	0.85	3.29	3.85	8.43	6.85
0.53	0.90	3.35	3.90	8.54	6.90
0.57	0.95	3.42	3.95	8.66	6.95
0.60	1.00	3.48	4.00	8.77	7.00
0.63	1.05	3.55	4.05	8.89	7.05
0.67	1.10	3.61	4.10	9.01	7.10
0.70	1.15	3.68	4.15	9.13	7.15
0.73	1.20	3.75	4.20	9.25	7.20
0.77	1.25	3.82	4.25	9.37	7.25
0.80	1.30	3.89	4.30	9.49	7.30
0.84	1.35	3.96	4.35	9.62	7.35
0.88	1.40	4.03	4.40	9.74	7.40
0.91	1.45	4.10	4.45	9.87	7.45
0.95	1.50	4.17	4.50	10.00	7.50
0.99	1.55	4.24	4.55	10.13	7.55
1.02	1.60	4.31	4.60	10.26	7.60
1.06	1.65	4.39	4.65	10.39	7.65
1.10	1.70	4.46	4.70	10.53	7.70
1.14	1.75	4.54	4.75	10.66	7.75
1.18	1.80	4.61	4.80	10.80	7.80
1.22	1.85	4.69	4.85	10.94	7.85
1.26	1.90	4.77	4.90	11.08	7.90
1.30	1.95	4.85	4.95	11.22	7.95
1.35	2.00	4.93	5.00	11.36	8.00
1.39	2.05	5.01	5.05	11.51	8.05
1.43	2.10	5.09	5.10	11.66	8.10
1.47	2.15	5.17	5.15	11.81	8.15
1.52	2.20	5.25	5.20	11.96	8.20
1.56	2.25	5.33	5.25	12.11	8.25
1.61	2.30	5.41	5.30	12.26	8.30
1.65	2.35	5.50	5.35	12.42	8.35
1.70	2.40	5.58	5.40	12.58	8.40
1.75	2.45	5.67	5.45	12.74	8.45
1.79	2.50	5.76	5.50	12.90	8.50
1.84	2.55	5.84	5.55	13.06	8.55
1.89	2.60	5.93	5.60	13.23	8.60
1.94	2.65	6.02	5.65	13.39	8.65
1.99	2.70	6.11	5.70	13.56	8.70
2.04	2.75	6.20	5.75	13.74	8.75
2.09	2.80	6.29	5.80	13.91	8.80
2.14	2.85	6.38	5.85	14.09	8.85
2.19	2.90	6.48	5.90	14.26	8.90
2.24	2.95	6.57	5.95	14.45	8.95
2.30	3.00	6.67	6.00	14.63	9.00

Table 7.2 N_2O Linearization

%N2O	OUT/V	%N2O	OUT/V	%N2O	OUT/V
-0.01	0.00	37.19	3.00	76.87	6.00
0.56	0.05	37.84	3.05	77.57	6.05
1.14	0.10	38.50	3.10	78.26	6.10
1.71	0.15	39.15	3.15	78.96	6.15
2.29	0.20	39.81	3.20	79.67	6.20
2.87	0.25	40.46	3.25	80.37	6.25
3.45	0.30	41.12	3.30	81.09	6.30
4.03	0.35	41.77	3.35	81.80	6.35
4.61	0.40	42.43	3.40	82.52	6.40
5.20	0.45	43.09	3.45	83.25	6.45
5.78	0.50	43.74	3.50	83.98	6.50
6.37	0.55	44.40	3.55	84.71	6.55
6.96	0.60	45.05	3.60	85.45	6.60
7.56	0.65	45.71	3.65	86.20	6.65
8.15	0.70	46.37	3.70	86.95	6.70
8.75	0.75	47.02	3.75	87.70	6.75
9.35	0.80	47.68	3.80	88.47	6.80
9.95	0.85	48.33	3.85	89.24	6.85
10.55	0.90	48.99	3.90	90.02	6.90
11.15	0.95	49.65	3.95	90.80	6.95
11.76	1.00	50.30	4.00	91.59	7.00
12.37	1.05	50.96	4.05	92.39	7.05
12.98	1.10	51.61	4.10	93.20	7.10
13.59	1.15	52.27	4.15	94.01	7.15
14.20	1.20	52.93	4.20	94.84	7.20
14.82	1.25	53.58	4.25	95.67	7.25
15.43	1.30	54.24	4.30	96.51	7.30
16.05	1.35	54.89	4.35	97.37	7.35
16.67	1.40	55.55	4.40	98.23	7.40
17.30	1.45	56.20	4.45	99.10	7.45
17.92	1.50	56.86	4.50	99.99	7.50
18.54	1.55	57.52	4.55	100.88	7.55
19.17	1.60	58.17	4.60	101.79	7.60
19.80	1.65	58.83	4.65	102.70	7.65
20.43	1.70	59.49	4.70	103.64	7.70
21.06	1.75	60.14	4.75	104.58	7.75
21.69	1.80	60.80	4.80	105.54	7.80
22.33	1.85	61.46	4.85	106.51	7.85
22.96	1.90	62.12	4.90	107.49	7.90
23.60	1.95	62.77	4.95	108.49	7.95
24.24	2.00	63.43	5.00	109.50	8.00
24.88	2.05	64.09	5.05	110.53	8.05
25.52	2.10	64.75	5.10	111.58	8.10
26.16	2.15	65.41	5.15	112.64	8.15
26.80	2.20	66.08	5.20	113.72	8.20
27.44	2.25	66.74	5.25	114.82	8.25
28.09	2.30	67.40	5.30	115.93	8.30
28.73	2.35	68.07	5.35	117.06	8.35
29.38	2.40	68.74	5.40	118.22	8.40
30.03	2.45	69.40	5.45	119.39	8.45
30.67	2.50	70.07	5.50	120.58	8.50
31.32	2.55	70.74	5.55	121.79	8.55
31.97	2.60	71.42	5.60	123.02	8.60
32.62	2.65	72.09	5.65	124.28	8.65
33.27	2.70	72.77	5.70	125.55	8.70
33.92	2.75	73.44	5.75	126.86	8.75
34.58	2.80	74.12	5.80	128.18	8.80
35.23	2.85	74.81	5.85	129.53	8.85
35.88	2.90	75.49	5.90	130.90	8.90
36.54	2.95	76.18	5.95	132.30	8.95
37.19	3.00	76.87	6.00	133.72	9.00

7.3.3 Reference voltage adjustments

Make this adjustment if the voltage differs more than 0.3 V of the value specified below.

a) Connect a digital voltmeter between measuring board connector X1 pin 6b and ground.

b) Using CO_2/N_2O measuring board trimmer R33 adjust the DVM to read 6.50 V.

7.3.4 Temperature compensation adjustments

For adjusting the temperature compensation the following gas mixtures are needed.

- 5 to 9 % CO_2 in air
- 70 to 100 % N_2O

The exact percentage of gases is not critical, but the same gases must be used throughout the procedure.

The compensation may be performed using room temperature and the heat produced by the monitor, but more accurate result is achieved if a temperature controlled room is available.

Atmospheric pressure should remain constant within ± 5 mbar during the procedure.

a) Before the compensation let the monitor cool down with power off at room temperature at least 4 hours.

b) Connect a digital voltmeter between test points T+ and T- (pins 1 and 3 at the pre-amplifier board flat cable connectors).

c) Switch power on and let the monitor run approximately 10 minutes. Adjust R16 on the CO_2/N_2O preamplifier board until the DVM reads zero.

d) Adjust the zero points of CO_2 and N_2O as described in Section 7.3.1.

e) Sample the CO_2 standard gas and make a note of the reading obtained. Repeat the same for N_2O.

f) Let the monitor run at least three hours with covers closed. Best result is obtained if the room temperature is simultaneously raised by some 10 degrees.

g) After the warm-up adjust the zero (Section 7.3.1) and sample the CO_2 standard gas. Adjust the output with the pre-amplifier board trimmer R7 to the same reading as was obtained in step e). Repeat for N_2O using R6.

> NOTE: If either CO_2 or N_2O zero has drifted from the cool phase by more than 5 % of full scale, do not attempt the compensation, but try to locate the source of the drift and correct it. Excessive zero drift is always an indication of a fault.

h) Switch power off and let the monitor cool down for approximately 4 hours lowering, if possible, the room temperature simultaneously.

i) Switch the monitor on and let it run 10 minutes. Adjust zero (Section 7.3.1) and check the gain readings. If they deviate from those measured when the monitor was warm by more than 2 % f.s., repeat the whole procedure.

j) Perform software zero and calibration (refer to the Operator's Manual).

7.3.5 Pressure measurement offset and gain adjustments

These two adjustments must be made simultaneously since they have a strong mutual influence.

The complete adjustment procedure is as follows. Some method of producing a pressure differing from the ambient, e.g., a vacuum pump is needed along with an instrument for measuring the pressure.

a) Disconnect the pressure transducer from the monitor tubing system and attach the pressure source and manometer to the transducer

b) Attach a digital voltmeter to pin 6 (GASPRESS) of the mother board test connector X13.

c) Apply sub-atmospheric pressure (P_1) to the transducer and turn the offset trim potentiometer R46 until the output is at the voltage determined by the formula:

$V_1 = (P_1 \text{ (mmHg)}/1023)\ 20\ V - 10\ V$

d) Now apply atmospheric pressure to the transducer and adjust the output with the gain trimmer R47 to the voltage determined by the formula:

$V_2 = (P_2 \text{ (mmHg)}/1023)\ 20\ V - 10\ V$

e) Repeat steps c and d until the readings remain stable. A number of adjusting cycles are usually necessary to obtain a stable reading.

The adjustment may be done using atmospheric pressure as P_1 and above atmospheric pressure as P_2.

CAUTION: To avoid permanent damage to the pressure transducer it must never be exposed to pressures higher than 2 bar absolute pressure.

7.4 Oxygen measurement adjustments

The only field service procedures for the O_2 measuring unit are the offset(zero), gain, and frequency adjustments. In case of any other trouble, the measuring unit should be replaced and the faulty one sent to DATEX for repair.

7.4.1 Offset(zero) adjustment

Because the oxygen measuring unit is a differential sensor, which actually measures the difference between the O_2 concentrations in the sample and reference gases, its output must be adjusted to equal zero when atmospheric air is present at both inputs.

a) Connect a digital voltmeter to the output of the O_2 measuring unit at pin 5 of connector X13 on the mother board.

b) Let the monitor draw in room air and adjust the voltage to zero with the O_2 measuring unit trim resistor designated 'ZERO' (see Figure 7.3) in the O_2 module pcb. The potentiometers are located at the same side of the measuring unit as the tubing connectors.

c) Perform software calibration (refer to the Operator's Manual).

7.4.2 Gain adjustment

a) Adjust the O_2 measuring unit offset as described in the previous section.

b) Sample 100 % oxygen and adjust the measuring unit output to between 7.7 V and 8.3 V with the trim resistor designated 'G' (see Figure 7.3).

c) Check and if necessary readjust the offset and gain until the readings remain stable.

d) Perform software calibration (refer to the Operator's Manual).

7.4.3 Temperature compensation adjustment

Factory calibration only.

7.4.4 Frequency adjustment

The switching frequency of the electromagnet of the O_2 measuring unit has been selected to be 165 Hz to avoid interference from harmonics of both 50 Hz and 60 Hz power frequency.

Fine adjustment is seldom necessary. However if you wish to reduce the effects of mechanical resonance peaks of the cabinet which appears as high noise level of the O_2 measuring unit analog output (above 20 mV peak to peak) it is worth of trying the fine frequency adjustment. One turn of trimmer "F" will change the frequency by 1.5 Hz. Try to find minimum noise but do not deviate more than ±5 Hz.

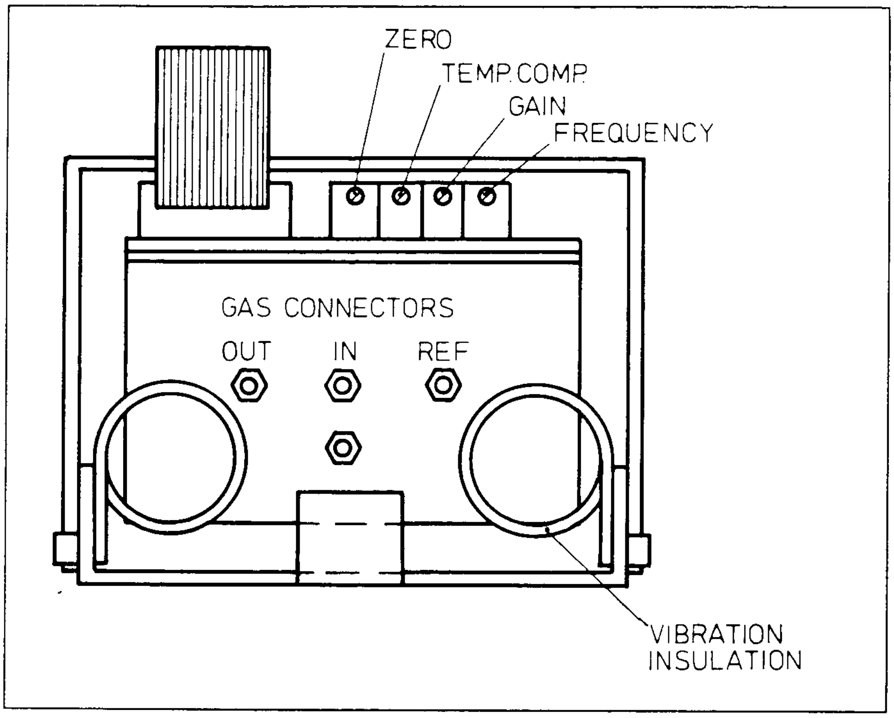


Figure 7.3 O_2 measuring unit adjustments

7.5 ECG board adjustment

The only adjustment on the ECG board is the 50/60 Hz notch. This is also the only difference between 50/60 Hz CARDIOCAPs.

To adjust the notch, feed a 1 - 10 mV 50/60 Hz signal into the ECG input, e.g. between LA and RA in LEAD I configuration, via a resistive divider from system bus pin 31c (22 VAC) or from a signal generator. Adjust R48 (accessible from top of the ECG board) to minimize the displayed amplitude (fast speed).

WARNING: When doing any work on the ECG and IPT boards, care has to be taken that the patient isolation is not violated.

7.6 IPT board adjustment

The only adjustments on the IPT board are the temperature gain set trimmers, which are adjusted as follows:

a) Set the 38°C TEMP CAL via the engineering menu. To enter the engineering menu keep the MARK RESET key depressed during power up until the menu appears. With temperature measuring jack disconnected choose CALIBRATE and TEMP CAL, depress the TEMP TEST button and adjust the reading to 38.0°C.

b) Insert a plug with a precision resistor listed below into the jack receptacle and adjust R11 and R12 to show the correct temperature. The trimmers are accessible from above without removing the ECG-IPT board assembly.

YSI 400 series temperature-resistance table:

°C	ohms
15	3539
20	2814
25	2253
30	1815
35	1471
38	1301
40	1200
44	1024

NOTE: For temperature gain calibration use a precision resistor between 3539 and 2000 ohms.

WARNING: When doing any work on the IPT board, care has to be taken that the patient isolation is not violated.

7.7 NIBP board adjustment

The NIBP board performs automatically all adjustments except pressure calibration, which must be done manually. Pressure zero is automatically maintained by the processor. If the zero point drifts too much NIBP transmits an error message. Normally zero point trimmer R6 should not be touched.

CALIBRATION

NIBP calibration can be performed as follows:

a) Enter engineering menu by pressing MARK RESET key during power up. Keep the key down until the "STARTING" sequence has been completed.

b) Press soft key 2 to enter calibration mode.

c) Press soft key 2 again to enter NIBP calibration.

d) In the calibration mode the automatic zero adjustment is not operating to allow the adjustment of the pressure channel zero trimmer R6 (upper trimmer on the NIBP board). Adjust R6 until the mean pressure value M is zero. Make sure that the upper pneumatic connector is not connected to a pressure source to allow proper zeroing.

e) Remove the female connector from an adult cuff and connect it to the male connector in the twin hose. Connect an external pump and mercury manometer to it and pump the pressure up to 200 mmHg and adjust the calibration trimmer R11 (lower trimmer on the NIBP board) until the mean value M shows 200.

f) Repeat steps 4 and 5 until zero and 200 mmHg readings are both correct.

g) Check the linearity of the pressure transducer at the pressure of 100 mmHg.

h) Press "RETURN TO MONITOR" to enter normal operating mode.

NOTE: In the normal operating mode the zero pressure drift is compensated by software and this drift does not affect the accuracy of the device. If zero drift is more than ±20 mmHg NIBP issues an error message, see troubleshooting chart.

7.8 SpO_2 processor board adjustment

There are only two adjustments on the SpO_2 processor board:

1 A/D-converter zero (R9).

2 A/D-converter 10 V reference (R8).

The A/D-converter adjustments are performed only at the factory.

7.9 CPU board adjustment

There is one adjustable capacitor on the CPU board for real time clock oscillator frequency. It is factory adjusted, but may need to be readjusted if some components are replaced.

Real time clock oscillator frequency

The real time clock oscillator frequency is set by connecting a counter to pin 15 of D16 and adjusting C49 to read 256.00 Hz corresponding to a cycle time of 3906.25 us.

NOTE: The high speed CPU board does not require any adjustments.

8 FUNCTIONAL FIELD CHECK PROCEDURE

8.1 Preoperative check list

Perform the following tests daily to assure proper operation of the monitor.

> WARNING: If the monitor fails to respond as described, stop using the monitor, troubleshoot, and correct the situation.

Power up

Confirm that the water trap bottle is empty and inserted completely, and the water trap is properly attached to the monitor.

Connect the gas sampling line to the connector on the water trap.

> NOTE: Occlusion pressure limit is set during start-up. Attach sampling line before turning monitor on.

Turn the power on. The monitor performs a start-up and self test procedure.

Confirm that no error messages appear.

Gas Check

a) Confirm that the inspiratory O_2 reading is about 21 %, and that no other gas is detected.

b) Breath five times into the sampling line and verify that a capnogram and the end tidal value are displayed.

If the end tidal values are not in the expected range, calibrate the monitor. See the operator's manual.

c) Stop breathing into the sampling line. After 20 seconds the monitor will give the first audible and visible alarm indicators.

ECG Check

a) Plug an ECG cable into the ECG connector receptacle on the front panel.

b) Connect the ECG lead wires to the clip-on pins on the monitor's rear panel according to the letter codes.

c) Turn the lead selector to position I.

The ECG waveform should display a train of 1 mV pulses with a frequency of 60 ± 1 bpm.

Confirm that the QRS indicator '*' is flashing to the left and above the ECG channel.

d) Remove the ECG leads from the test pins. Ensure that the message 'LEADS OFF' appears in the upper right corner of the screen.

NIBP Check

a) Assemble the blood pressure cuff with the cuff hose and connect it to the NIBP connector on the rear panel.

b) Attach the cuff to your arm.

c) Take a blood pressure measurement by pressing the START key. Confirm that the pump inflates the cuff. Confirm that the cuff pressure is displayed during measurement and that final systolic, diastolic, and mean values are displayed.

SpO_2 Check

a) Connect the pulse oximeter probe to the monitor. The message 'NO PROBE' is replaced by 'PROBE OFF'.

b) Confirm that the red light is seen from the probe, and that the probe surface is undamaged.

c) Attach the pulse oximeter probe to your finger.

Wait for the pulse search to be completed and readings to stabilize. Verify that the SpO_2 readings are in the expected range and that the plethysmographic pulse waveform is regular.

8.2 Checks after component replacements

The following test should be performed after any service to ensure proper operation of the monitor.

a) Check visually that tubes, valves, sampling system parts, and pumps are properly connected. Tubes are not pinched, clogged, or jammed. Tubes are not touching the pump or oxygen measuring unit. Confirm that there are no sharp bends or splits at connectors or joints.

b) Connect power cord and sampling line. Switch the monitor on and wait until the initialization is over.

c) Check that no error messages are shown.

d) Check the operation of the real time clock:
- Verify the date (use engineering menu).
- Verify time.
- Check that the clock is running. Set the time correct in SETUP menu.

e) Connect the ECG cable to the rear panel test connectors. Verify that the test signal is shown on the display. Heart rate display should read 60 ±1.

f) Connect the invasive blood pressure transducer(s) to the front panel connector(s) PRESSURE 1 (and 2). Zero the sensor(s) by pressing PRESSURE key and soft key 1 (and 2). Verify proper operation by connecting a manometer and hand pump in series with the transducer(s). Check calibration at 200 mmHg pressure.

g) Connect the NIBP cuff. Perform one measurement with yourself. Verify operation. Perform venous stasis (see the Operator's Manual Section 7) and check for leaks. Check NIBP calibration (see Section 7.7).

h) Check temperature channel by pressing the TEMP TEST switch. Reading should be 38.0 ±0.1°C (100.4 ±0.2°F).

i) Connect the SpO_2 probe and observe the message 'PULSE SEARCH' followed by 'PROBE OFF'. Put the probe on your finger and keep the hand still.

- First the message 'PULSE SEARCH' should appear.

- After a while a numeric value should appear in the SpO_2 field (normally between 94 and 98 in non-anesthetized people).

- The plethysmographic pulse waveform from SpO_2 probe should be shown on the screen.

j) Keep the SpO_2 probe on your finger for several minutes. Press the TRENDS key and check that the measurement results are enough to draw trend waveform.

k) Check that 5 minutes after power up the automatic zeroing takes place. This is indicated by the 'ZEROING GASES, PLEASE WAIT' message. After zeroing the gas displays should read:

CO_2	0.0 % or 00 mmHg
O_2	21 %
N_2O	0 %

l) Perform gas calibration (see the operator's manual). When all the gas are calibrated, recheck the calibrated values once again. Perform the calibration again if necessary.

m) Create an occlusion by blocking the sampling line. Check that the occlusion alarm comes on. Check both audible and visual alarms.

n) Perform Gas sampling system leak test, Water separation test, and Response time test (see Section 6.3.4 Gas sampling system troubleshooting).

o) Detach the water trap. Confirm that the text 'AIR LEAK DETECTED' appears on the screen. Attach the trap again. The text should be replaced by 'APNEA'.

p) Choose service mode and then GAS SERVICE. The working pressure value on the screen (P amb - P int) will be about 700 mmHg (depending on atmospheric pressure). Block the sample gas out connector and the P int value should rise about 60 mmHg. Check that "pump index" shown in gas service is nonzero. Otherwise see Section 6.3.4.4 to perform pump test.

q) Check the operation of the loudspeaker by creating an alarm situation.

r) Connect serial printer to serial & analog I/O connector on the rear panel of the monitor. Turn the power on and check that the printer prints data correctly.

s) Reset the monitor by pressing the MARK RESET key for about five seconds.

t) Check the leakage current of the unit. Check the condition of all cables and connectors.

u) Disconnect power cord for 10 seconds. Then connect it back and turn the monitor on. When the initialization is over, make trend displayed on the screen. The trend which had been measured before the power cut-off should be displayed.

v) Check that there are no dirt stains in the monitor. Top cover, side panels, and bottom plate are properly attached with screws.

8.3 Preventive maintenance check list

We recommend that you perform these checks at least once every six months to keep the monitor in good working condition.

1. VISUAL INSPECTIONS		OK
a)	Remove the top cover and check sampling system for proper connections.	☐
b)	Internal tubing system for sharp bends and dirt (especially the special tube).	☐
c)	Rear panel dust filter (clean at least once a month).	☐
d)	Screen for distortion (adjust if necessary).	☐
e)	Software version numbers (update if necessary).	☐

2. MAIN FUNCTIONAL CHECKS		OK
f)	Check ECG functions (see Section 8.2 step e).	☐
g)	Check invasive blood pressure measurement (see Section 8.2 step f).	☐
h)	Check NIBP operation (see Section 8.2 step g).	☐
i)	Check temperature (see Section 8.2 step h).	☐
j)	Check Pulse oximeter and plethysmograph signal functions (see Section 8.2 step i).	☐
k)	Perform SAMPLING SYSTEM LEAK TEST (see Section 6.3.4).	☐
l)	Perform WATER SEPARATION TEST (see Section 6.3.4).	☐
m)	Check GAS RESPONSE TIME (see Section 6.3.4).	☐
n)	Perform FLOW RATE TEST (see Section 7.2).	☐

o) Check D-FEND™ water trap. ☐

Visual test: remove water container and check that the membrane filter is clean. Service menu test: In O_2 measurement flow pressure measurement (see Section 7.2), pressure value should not drop more than 20 mmHg compared to the value gained with a new water trap.

p) Check pressure and zero valves functions. ☐

Auditory test: Operate pressure and zero valves in the service mode manually (see Section 6.4). You will hear the clicking sounds when the valve opens/closes.

Visual test: Block the sampling line and make sure that the pressure value (P int) changes when you open and close the pressure valve or zero valve manually in the service mode (see Section 6.4).

q) Check date in the engineering menu. ☐

r) Check real time in SETUP menu. ☐

s) Check the function of the loudspeaker in SETUP menu. ☐

9 SPARE PARTS

9.1 Spare parts

For the locations of the main parts see Figure 9.1.

Item	Item description	Order No.
24,29	Lithium battery 3.4 V, 650 mAh	17503*
16	Fuse 4A, slow miniature (for 880882)	51060*
2	Fuse 2.5 A, slow	51118*
2	Fuse 2.5 A, slow UL/CSA approved	511181*
17	Fuse 3.15 A, slow (for 880882)	51119*
7	Loud-speaker	874619
53	Switch cable	52118
19	Power cord receptacle block	52124
12	Mains cable (USA)	86236*
12	Mains cable (EUR)	54563*
	Mains filter	26906
49	Video display unit, complete	875244
	Chopper motor	872454
	Magnetic valve, without port plug	58534*
	Port plug for 58534	58535*
33	Foot front	65160
14	Foot rear	65161
	Preamplifier board	872290
	Sync board assembly (incl.motor)	86323
	NTC resistor AA, CO_2/N_2O	48220
	Measuring chamber	86542
	IR-detector block	86543
	Chopper wheel, CO_2, N_2O	86622
8	Fan	870641
4	Dust filter	871558**
4	Dust filter (rev 02 and up)	880832**
1	Dust filter holder	871559
1	Dust filter holder (02 and up)	871559
	Bar for filter holder	873085
	Bar for filter holder (02 and up)	877337
	Holder plate for fan (02 and up)	879253
5	Wire net	871684
61	Connector cover	877665
	ECG knob	880084
48	Keyboard	877543
42	Mother board	877305
21	Video control board	870646*

Item	Item description	Order No.
22	CPU board, without software	878822*
23	Software (1G, 1GS) (English) (rev 00)	877921
23	Software (1G, 1GS) (German) (00)	877923
23	Software (1G, 1GS) (French) (00)	877922
23	Software (1G, 1GS) (Germany) (00)	877924
23	Software (2G, 2GS) (English) (00)	877666
23	Software (2G, 2GS) (German) (00)	877717
23	Software (2G, 2GS) (French) (00)	877716
23	Software (2G, 2GS) (Germany) (00)	877718
23	Software (CS, 2CS) (English) (00)	878115
23	Software (CS, 2CS) (German) (00)	878116
23	Software (CS, 2CS) (French) (00)	878117
23	Software (CS, 2CS) (Germany) (00)	878118
23	Software (1G, 1GS) (English) (rev 01)	879433
23	Software (1G, 1GS) (German) (01)	879434
23	Software (1G, 1GS) (French) (01)	879435
23	Software (1G, 1GS) (Germany) (01)	879436
23	Software (2G, 2GS) (English) (01)	879437
23	Software (2G, 2GS) (German) (01)	879438
23	Software (2G, 2GS) (French) (01)	879439
23	Software (2G, 2GS) (Germany) (01)	879440
23	Software (CS, 2CS) (English) (01)	879441
23	Software (CS, 2CS) (German) (01)	879442
23	Software (CS, 2CS) (French) (01)	879443
23	Software (CS, 2CS) (Germany) (01)	879444
22	High speed CPU board, without software	880523*
23	Software (1G, 1GS) (English) (rev 02)	880776
23	Software (1G, 1GS) (German) (02)	880777
23	Software (1G, 1GS) (French) (02)	880778
23	Software (1G, 1GS) (Germany) (02)	880779
23	Software (2G, 2GS) (English) (02)	880772
23	Software (2G, 2GS) (German) (02)	880773
23	Software (2G, 2GS) (French) (02)	880774
23	Software (2G, 2GS) (Germany) (02)	880775
23	Software (CS, 2CS) (English) (02)	880780
23	Software (CS, 2CS) (German) (02)	880781
23	Software (CS, 2CS) (French) (02)	880782
23	Software (CS, 2CS) (Germany) (02)	880783
	Internal sample tubing, complete	877632
	Constriction cassettes*	see Table 5.2
	Special internal sample tube A	876432*
56	D-FEND Water trap panel unit	877565
20	Sample pump	878250*
3	Sample out connector	871981
41	O_2 measuring unit, complete	872898*
	CO_2 absorber box	870724

Item	Item description	Order No.
28	CO_2/N_2O measuring board	871487*
25	CO_2/N_2O meas. board press transducer	873022
60	CO_2/N_2O measuring unit, complete	871488*
	CO_2/N_2O meas unit (incl.meas.board)	876045*
	IR-lamp unit	871497
15	Power supply board	880882*
39	Pump unit for NIBP, complete	877607*
40	Pneumatic unit	879537
	Pneumatic tubing	879536
	Shunt valves (I and II)	876964
	Damping chamber II	879535
	Damping chamber II (02 and up)	880798
46	IPT board (2-press. 1-temp)	877545*
46	IPT board (2-press. 1-temp) (Fin)	879702*
46	IPT board (1-press. 2-temp)	877544*
46	IPT board (1-press. 2-temp) (Fin)	879703*
46	IPT board (0-press. 1-temp)	877605*
46	IPT board (0-press. 1-temp) (Fin)	879701*
51	Pleth/pressure cable connector	874785
47	ECG amplifier board	880509*
47	ECG amplifier board (Fin)	880511*
34	NIBP safety valve	877109
44	NIBP board, without software	876963*
44	NIBP board, without software (Ger)	878513*
26	NIBP software (rev 00)	877039
26	NIBP software (Germany) (00)	877040
26	NIBP software (01 and up)	879808
26	NIBP software (Germany) (01 and up)	879809
43	NIBP pressure transducer	16533*
18	NIBP magnetic valve unit	877038
6	Cuff connector	64654
10	Mains transformer, 100 V	878451
10	Mains transformer, 115 V	878452
10	Mains transformer, 220 V	878453
10	Mains transformer, 220 V (France)	878454
10	Mains transformer, 240 V	878455
58	Front plate (large)	877464
59	Front panel plate (small)	877500
	Front panel (1G) (English)	877595
57	Front panel (1G) (German)	877673
57	Front panel (1G) (French)	878368

Item	Item description	Order No.
57	Front panel (2G) (English)	877593
57	Front panel (2G) (German)	878416
57	Front panel (2G) (French)	878420
57	Front panel (1GS) (English)	877594
57	Front panel (1GS) (USA)	877649
57	Front panel (1GS) (German)	878132
57	Front panel (1GS) (French)	878330
57	Front panel (2GS) (English)	877592
57	Front panel (2GS) (USA)	877651
57	Front panel (2GS) (German)	877672
58	Front panel (2GS) (French)	877670
9	Rear panel (English)	877387
9	Rear panel (German)	877389
9	Rear panel (French)	877391
32	Top cover	877432
38	Enclosure bottom	877533
50	Video frame	877591
13	Side cover	872893
11	Side panel screw	61655
55	Hole covering pad (1-press. 2-temp)	877771
55	Hole covering pad (2-press. 1-temp)	877762
55	Hole covering pad (0-press. 1-temp)	877770
35	Instruction sheet 1 (Eng) (CS, 2CS) (rev 00)	878650
35	Instruction sheet 1 (Eng) (CS, 2CS) (01 and up)	879741
35	Instr sheet 1 (Eng) (1G,2G,1GS,2GS) (00)	878094
35	Instr sheet 1 (Eng) (1G,2G,1GS,2GS) (01 and up)	879727
36	Instruction sheet 2 (Eng) (CS)	878093
36	Instr sheet 2 (Eng) (2CS, 1GS, 2GS)	878088
36	Instruction sheet 2 (Eng) (1G, 2G)	878092
37	Instruction sheet 3 (Eng) (00)	878089
37	Instruction sheet 3 (Eng) (01 and up)	879543
35	Instruction sheet 1 (Ger) (CS, 2CS) (00)	878651
35	Instruction sheet 1 (Ger) (CS, 2CS) (01 and up)	879742
35	Instruction sheet 1 (Ger) (1G,2G,1GS,2GS) (00)	878438
35	Instruction sheet 1 (Ger) (1G,2G,1GS,2GS) (01 and up)	879728
36	Instruction sheet 2 (Ger) (CS)	878437
36	Instr sheet 2 (Ger) (2CS,1GS,2GS)	878432
36	Instruction sheet 2 (Ger) (1G,2G)	878436
37	Instruction sheet 3 (Ger) (00)	878433
37	Instruction sheet 3 (Ger) (01 and up)	879544

Item	Item description	Order No.
35	Instruction sheet 1 (Fre) (CS, 2CS) (00)	878652
35	Instruction sheet 1 (Fre) (CS, 2CS) (01 and up)	879743
35	Instr sheet 1 (Fre) (1G,2G,1GS,2GS) (00)	878502
35	Instr sheet 1 (Fre) (1G,2G,1GS,2GS) (01 and up)	879729
36	Instruction sheet 2 (Fre) (CS)	878501
36	Instr sheet 2 (Fre) (2CS,1GS,2GS)	878496
36	Instruction sheet 2 (Fre) (1G, 2G)	878500
37	Instruction sheet s.3 (Fre) (00)	878497
37	Instruction sheet s.3 (Fre) (01 and up)	879545
45	SpO_2 measuring board	875842*
45	SpO_2 measuring board (Fin)	879348*
30	SpO_2 processor board	874126*
31	SpO_2 software (rev 00)	874630
31	SpO_2 software (01 and up)	878106
27	SpO_2 connector I/O board	874465
52	SpO_2 panel connector with int. cable	874166
	SpO_2 Cliplite finger probe	878579**
	Spring for D-FEND™	875598

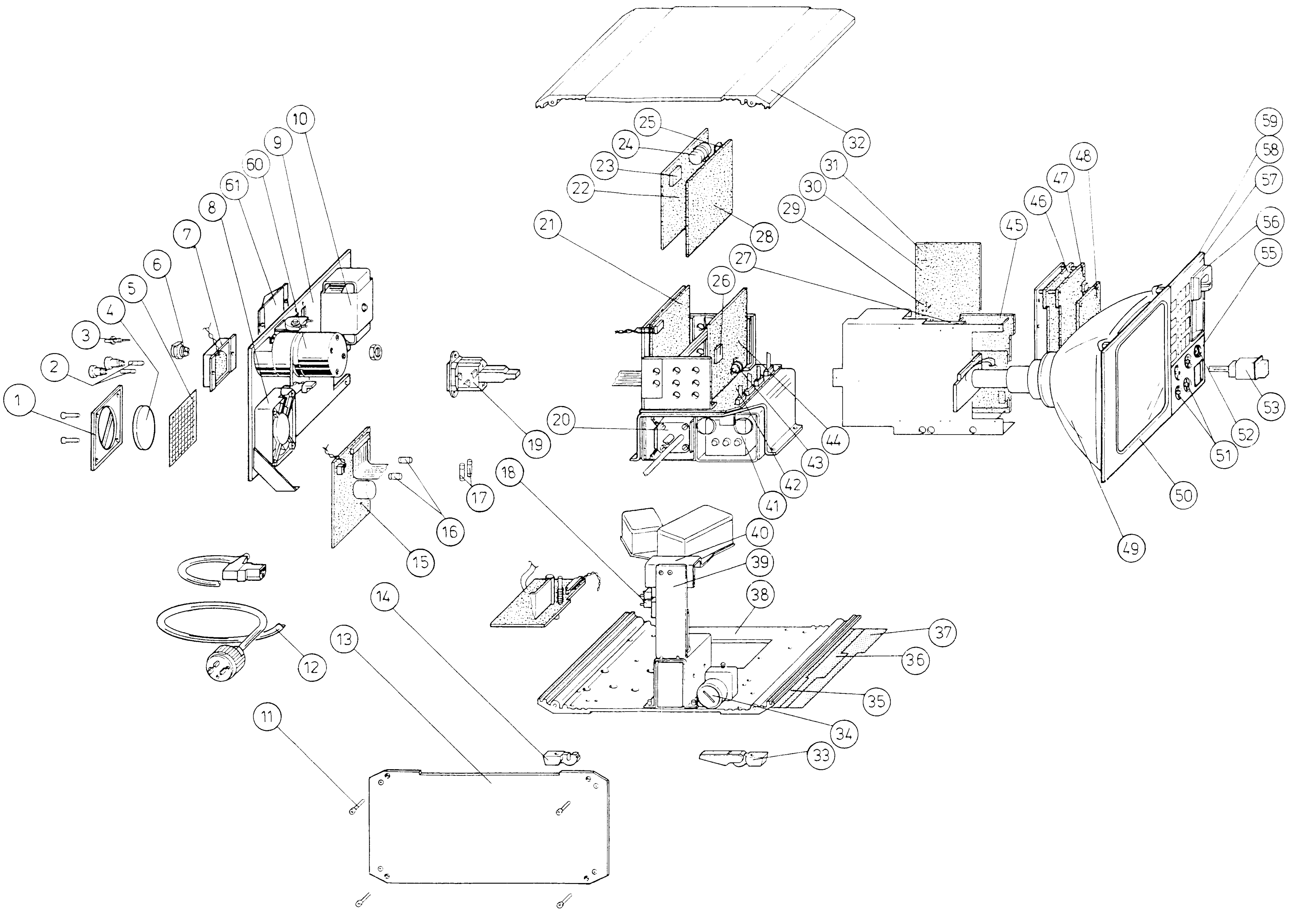
When ordering front or rear panels, please specify the serial number and the full monitor code as found in the type shield on the rear panel.

* = The part is recommended for stock.
** = The part is sold as an accessory.

9.2 Service accessories

Item description	Order No.
Extension board (lifts the board above the stack of boards to allow measurements)	872930
Cardiocap simulator (for a quick check of the monitor functions)	874027
Temperature calibration test plug set	874876
Flow meter	874521

Figure 9.1 Exploded pictures of the monitor


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
55
56
57
58
59
60
61

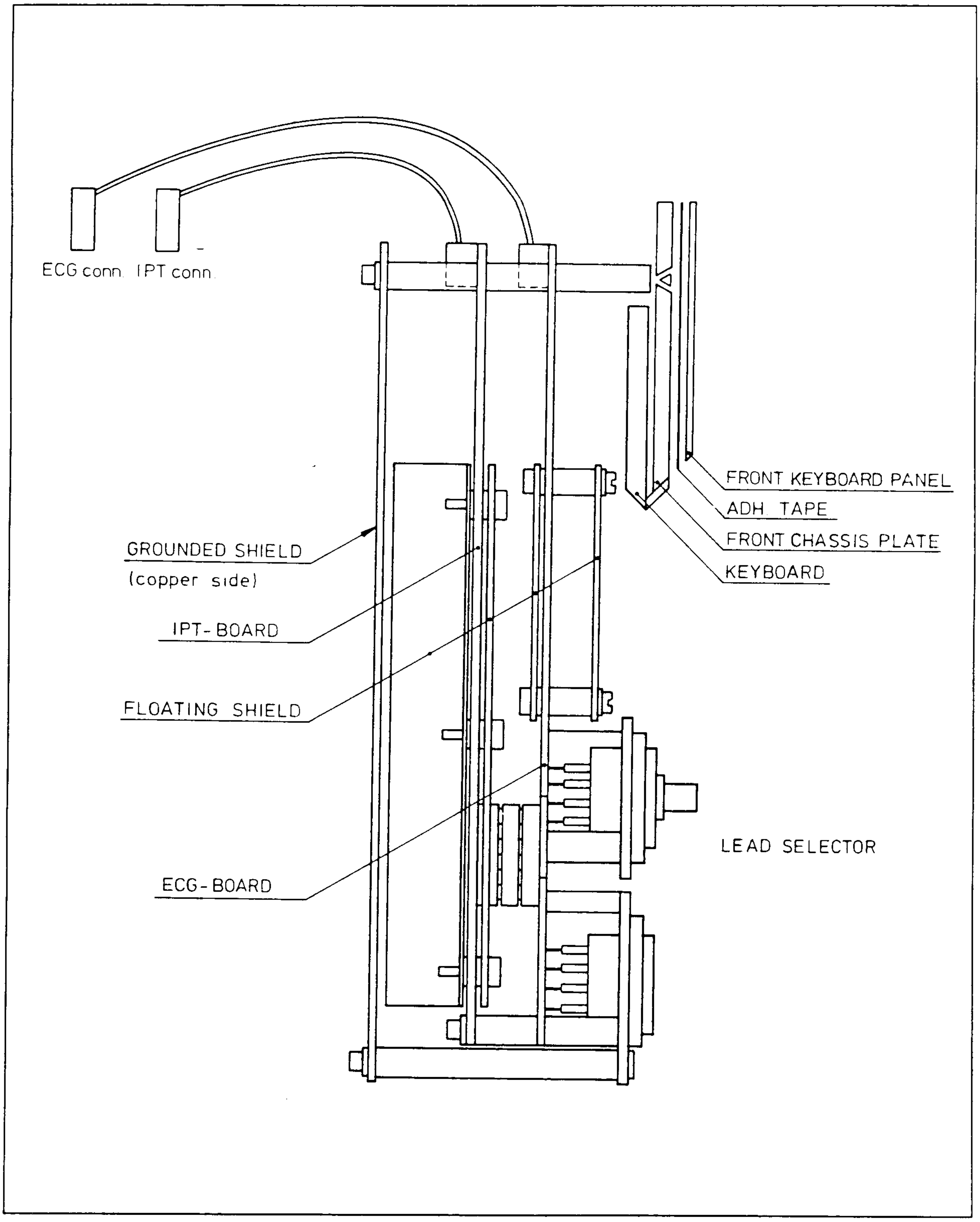


Figure 9.2 ECG and IPT boards assembly

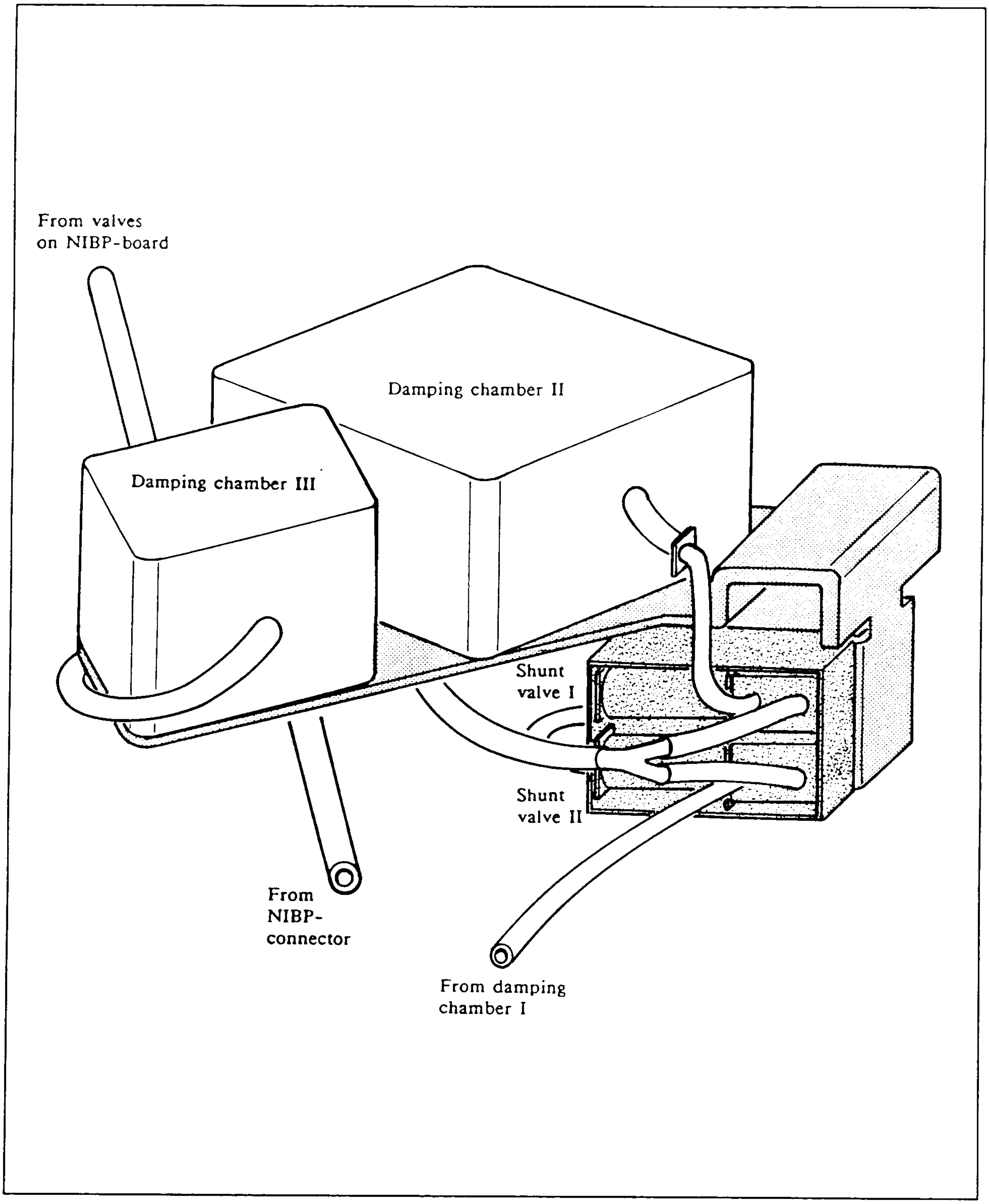
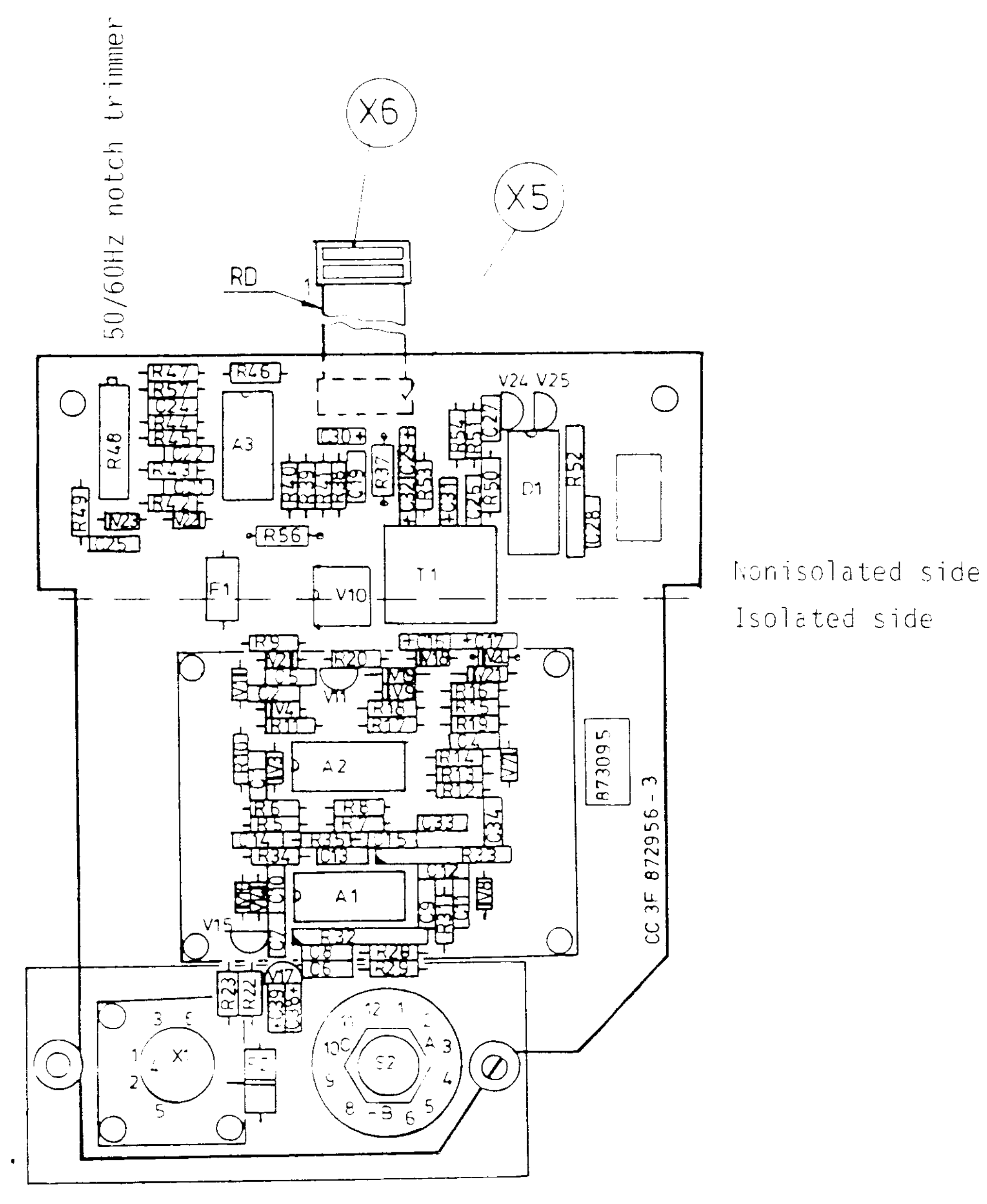
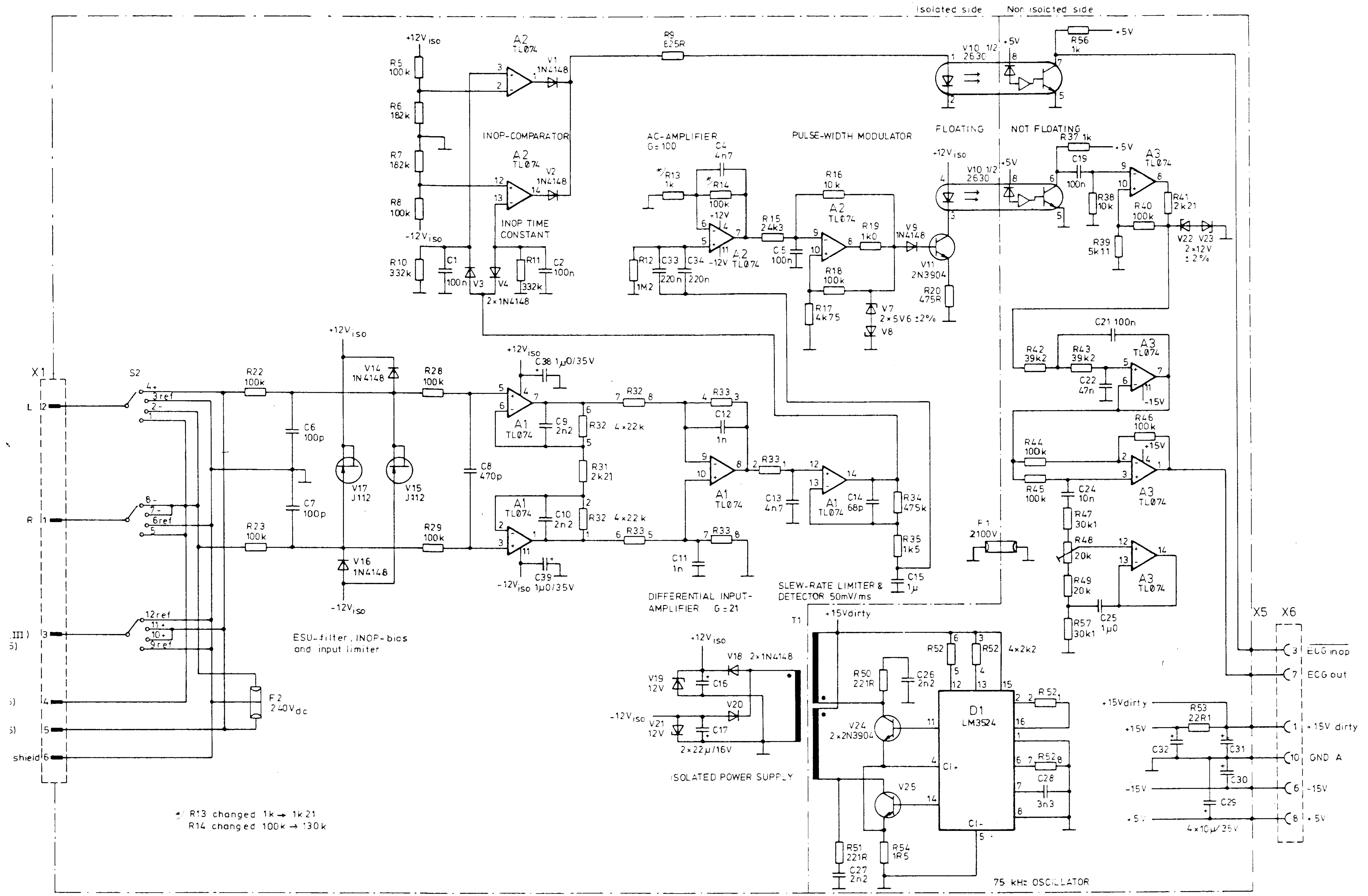


Figure 9.3 Pneumatic unit parts layout

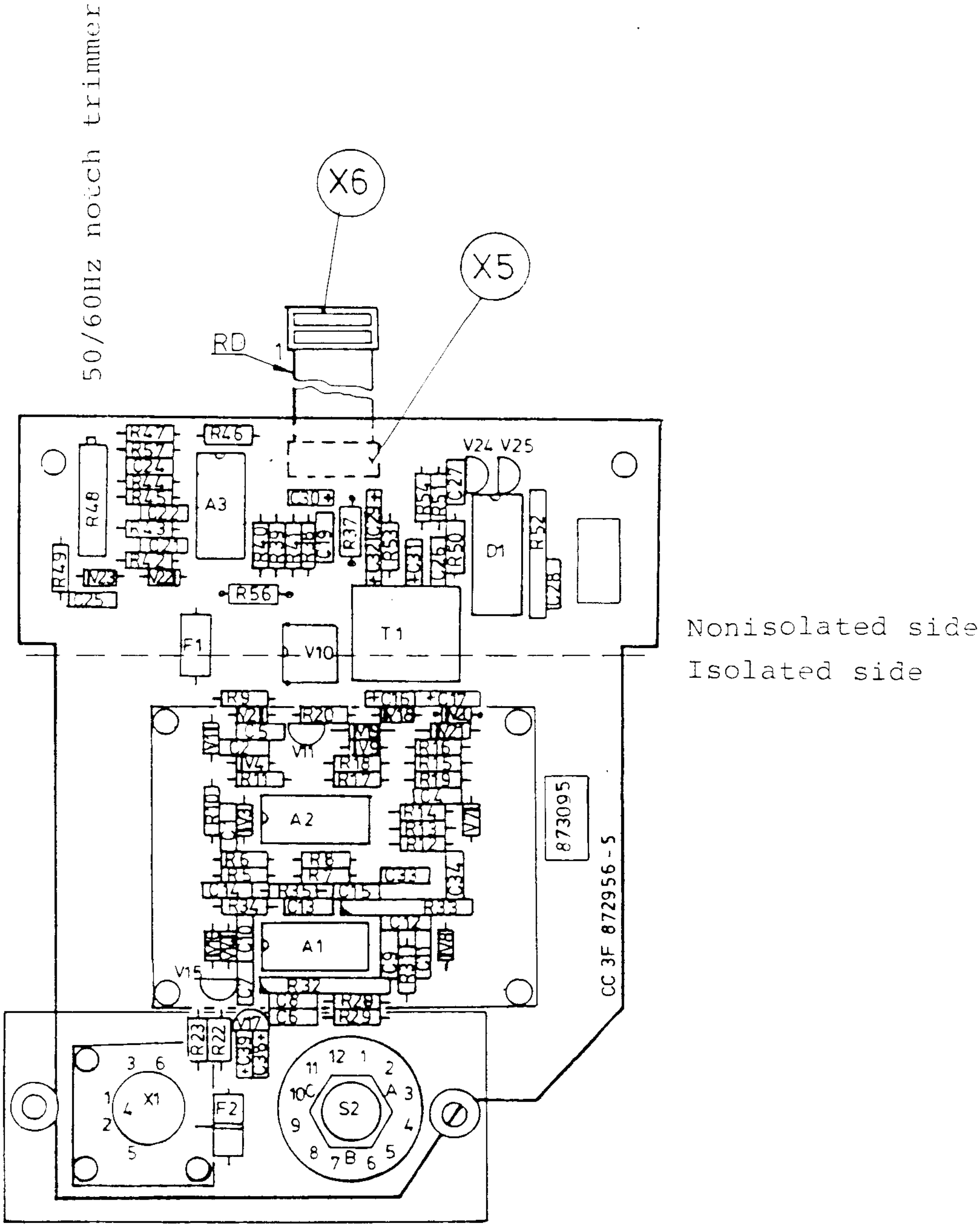
Figure 5.11 ECG board parts layout and schematic diagram

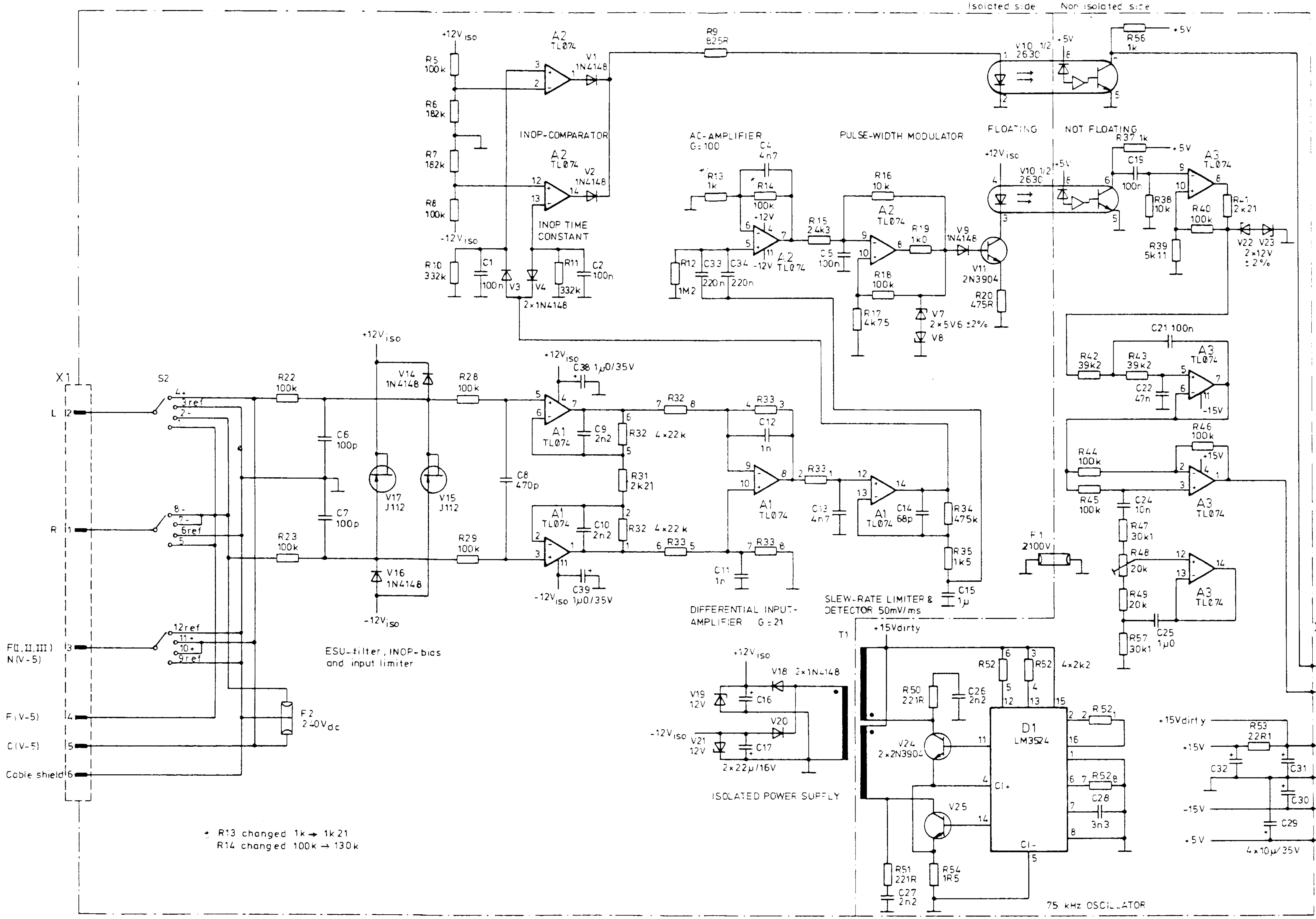




Isolated side
Non isolated side
INOP-COMPARATOR
INOP TIME CONSTANT
AC-AMPLIFIER G=100
PULSE-WIDTH MODULATOR
FLOATING
NOT FLOATING
ESU-filter, INOP-bias and input limiter
DIFFERENTIAL INPUT-AMPLIFIER G=21
SLEW-RATE LIMITER & DETECTOR 50mV/ms
ISOLATED POWER SUPPLY
75 kHz OSCILLATOR
ECG inop
ECG out
+15V dirty
GND A
-15V
+5V
shield
*) R13 changed 1k → 1k21
R14 changed 100k → 130k

Figure 5.11a ECG board parts layout and schematic diagram
(board modification level 10 and higher)





Isolated side
Non isolated side
INOP-COMPARATOR
INOP TIME CONSTANT
AC-AMPLIFIER G=100
PULSE-WIDTH MODULATOR
FLOATING
NOT FLOATING
ESU-filter, INOP-bias and input limiter
DIFFERENTIAL INPUT-AMPLIFIER G=21
SLEW-RATE LIMITER & DETECTOR 50mV/ms
ISOLATED POWER SUPPLY
75 kHz OSCILLATOR
* R13 changed 1k → 1k21
R14 changed 100k → 130k

5.7 CPU board

The CPU board contains, in addition to the 8051FA CPU and the standard EPROM, RAM and EEPROM, several analog and digital I/O functions. See the CPU board block diagram.

The CPU (D5, refer to Figure 5.29) uses the CPU board internal bus to access most of the peripheral circuits. Processor port 1 is used to control the analog multiplexers (MUX).

Communication with the NIBP board is established in serial mode through DUART (D15) pins 7 (in) and 8 (out).

The three memory chips are jumper selected for 1M bit program EPROM (D1), 32 x 8 kbit low current CMOS RAM (D6) powered by the data retention voltage, and EEPROM (D4) for permanent calibration value memory. See the jumper configuration.

Input signal processing

Analog input signals from the IPT, ECG, CO_2/N_2O measuring boards and O_2 measuring unit are read through the multiplexer (A3) to a sample and hold circuit and to the A/D-converter A2.

Output signal processing

Up to eight analog signals are sent to the output connectors. Digital patient data is sent to a D/A converter A1 and after conversion, sent to the demultiplexer A7. The eight analog signals produced are sent to sample and hold circuits and then transmitted to the power supply board and the connectors in the back of the monitor.

Control signals of MUX are in port 1 on the microprocessor as follows:

P1	pins 3-5	MUX A0-A2 (both)
	pin 6	MUX enable (both)
	pin 7	MUX 0 Write (ADC)
	pin 8	MUX 1 Write (DAC)
	ADC 0	CO_2
	ADC 1	N_2O
	ADC 2	ECG
	ADC 3	O_2
	ADC 4	IPT signal
	ADC 5	GAS PRES
	ADC 6	PB2 signal
	ADC 7	EXT INOP
	DAC 0	CO_2
	DAC 1	O_2
	DAC 2	IPT signal
	DAC 4	ECG TEST
	DAC 5	Loudspeaker volume
	DAC 6	PB2 signal
	DAC 7	Loudspeaker pitch

Ports on the PPI is used for as follows:

PA (output)	PB (input)	PC (low input, high output)
PA0: IPT control	PB0: not used (AUX)	PC0: -ECG INOP
PA1: IPT control	PB1: not used (AUX)	PC1: PB2 INOP
PA2: IPT control	PB2:	PC2: not used
PA3: not used	PB3: CD	PC3: Normocap signal
PA4: not used	PB4: DSR	PC4: Occlusion valve
PA5: not used (AUX)	PB5: CTSB (AUX)	PC5: Pump
PA6: not used (AUX)	PB6: CTSA (AUX)	PC6: Zero valve
PA7: Nurse call (AUX)	PB7:	PC7: not used

When a key is pressed (short-circuit) keyboard scanner (D9) interrupts the microprocessor and this reads from the scanner which key was pressed.

Real time clock (D16) is powered by a 3.4 V lithium battery G1. Oscillator frequency of the clock is adjusted with trimmer capacitor C49.

Software features are described in the Operator's Manual. Main differences between software revisions are described in Section 3.4.

CAUTION: The board contains a lithium battery. Danger of explosion if the battery is incorrectly replaced. Replace only with same or equivalent type recommended by DATEX. Discard used batteries according to manufacturer's instruction.

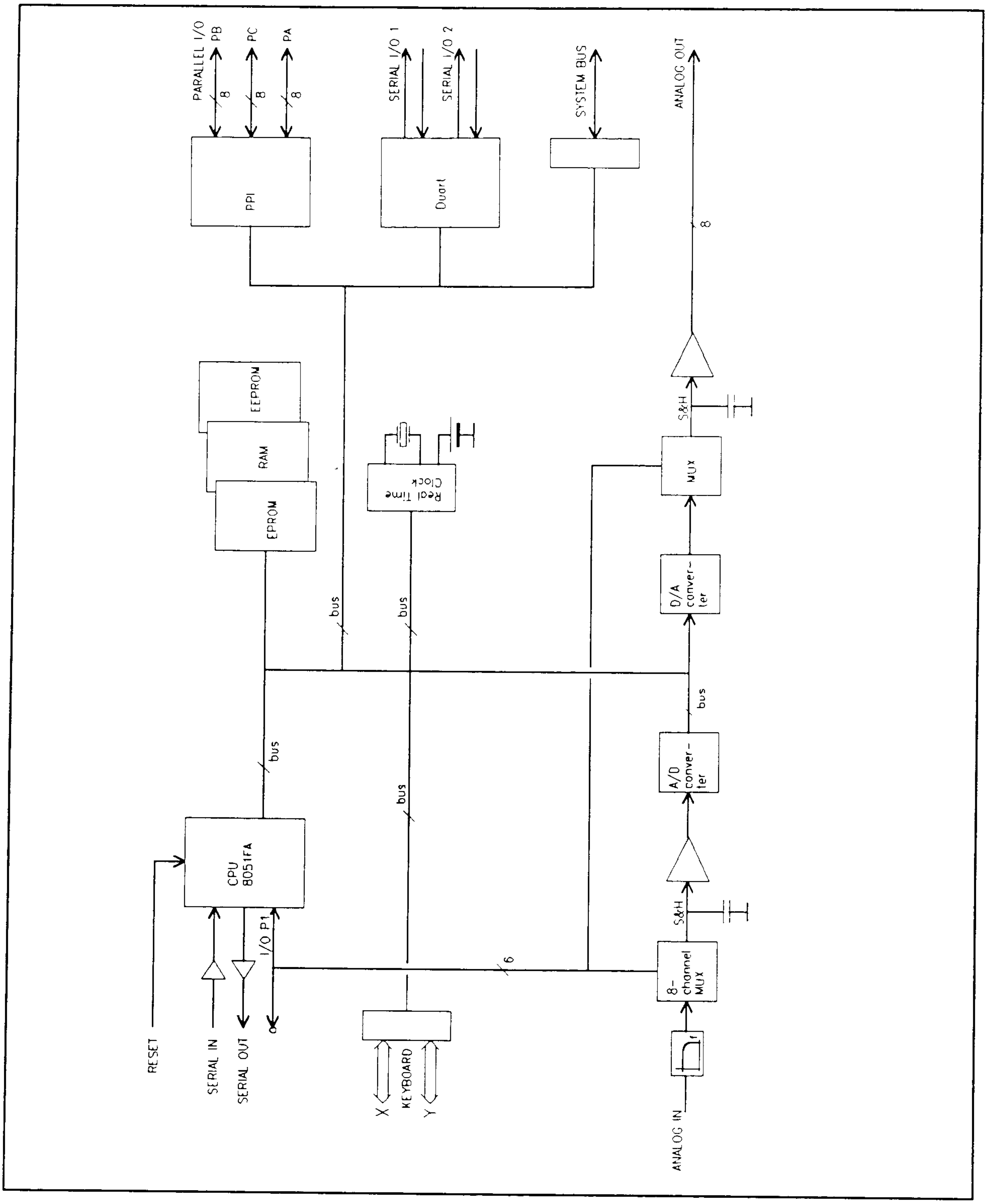
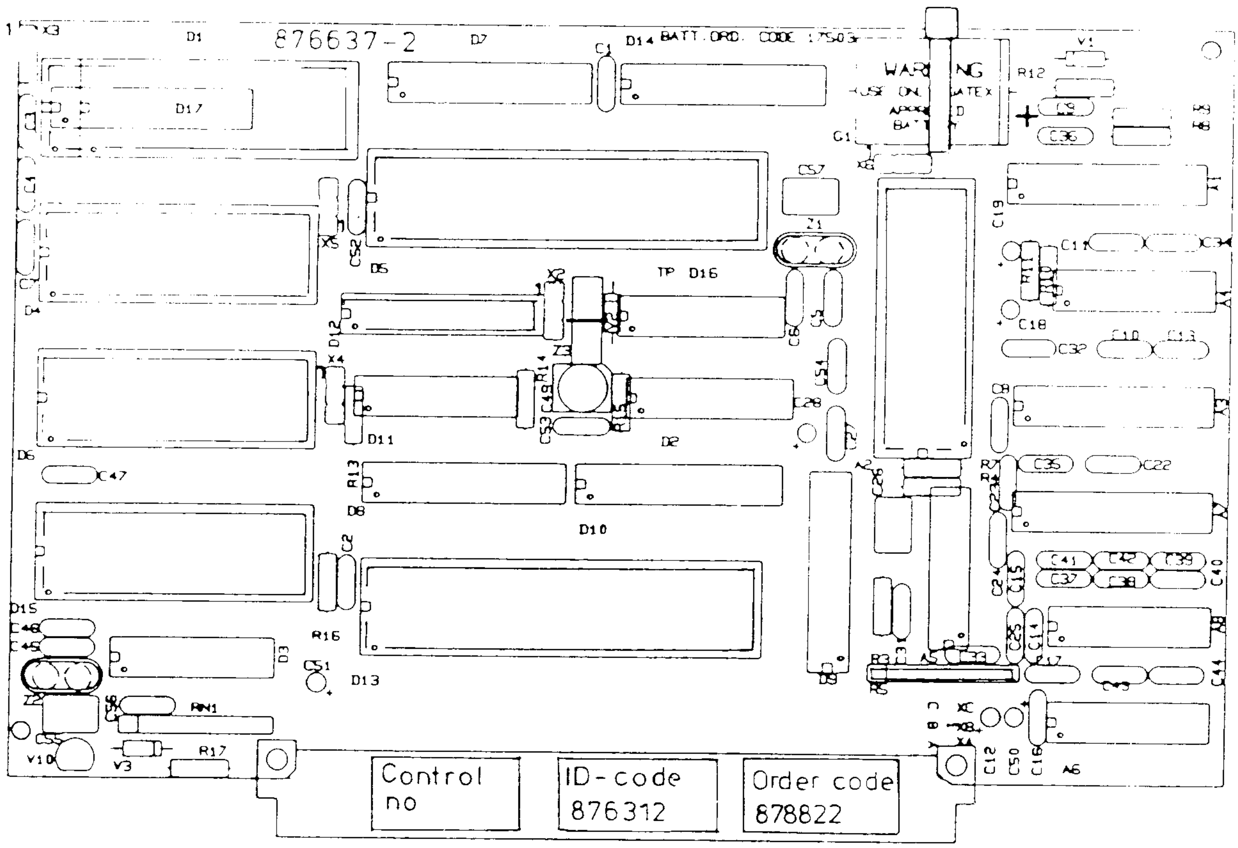
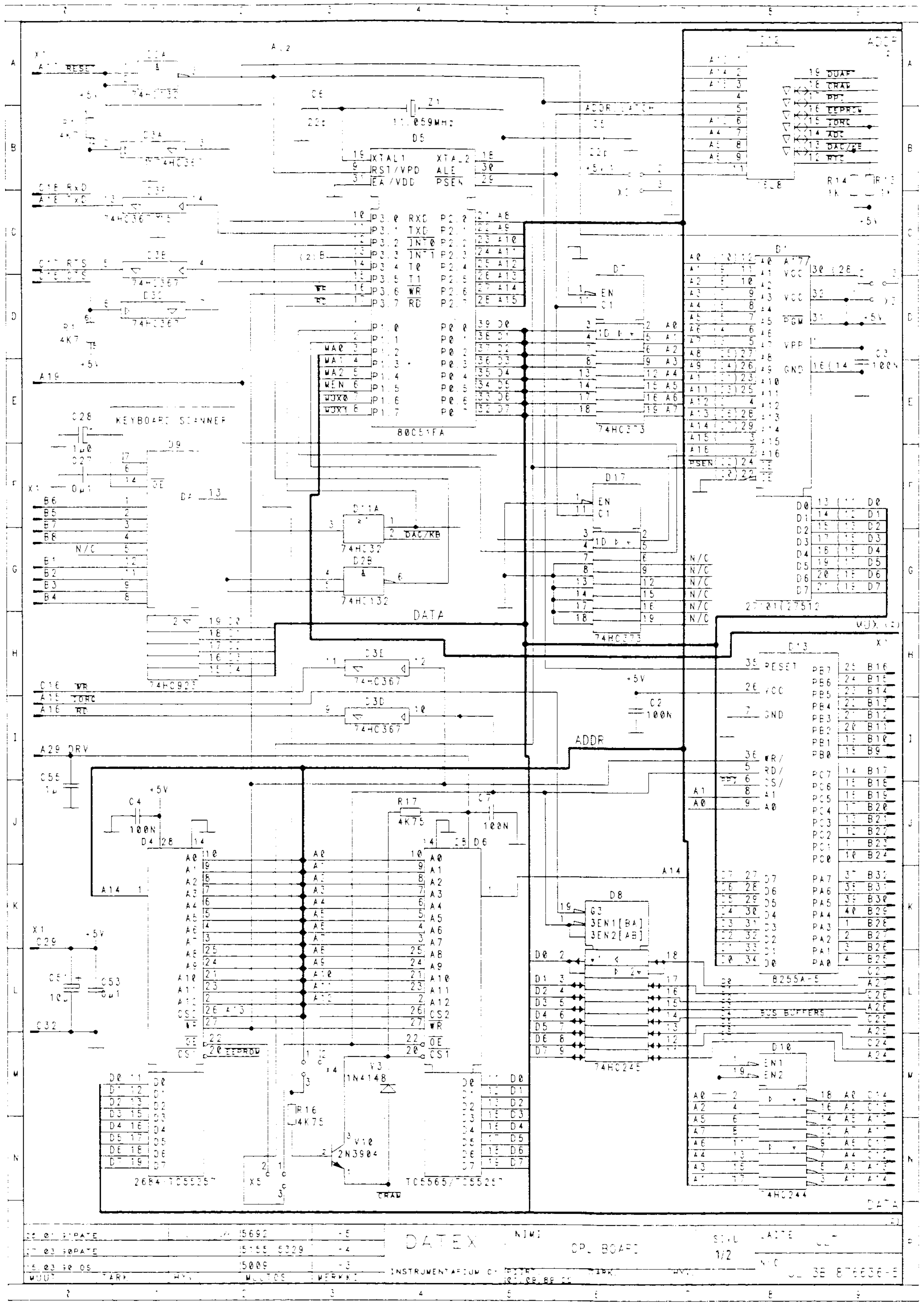


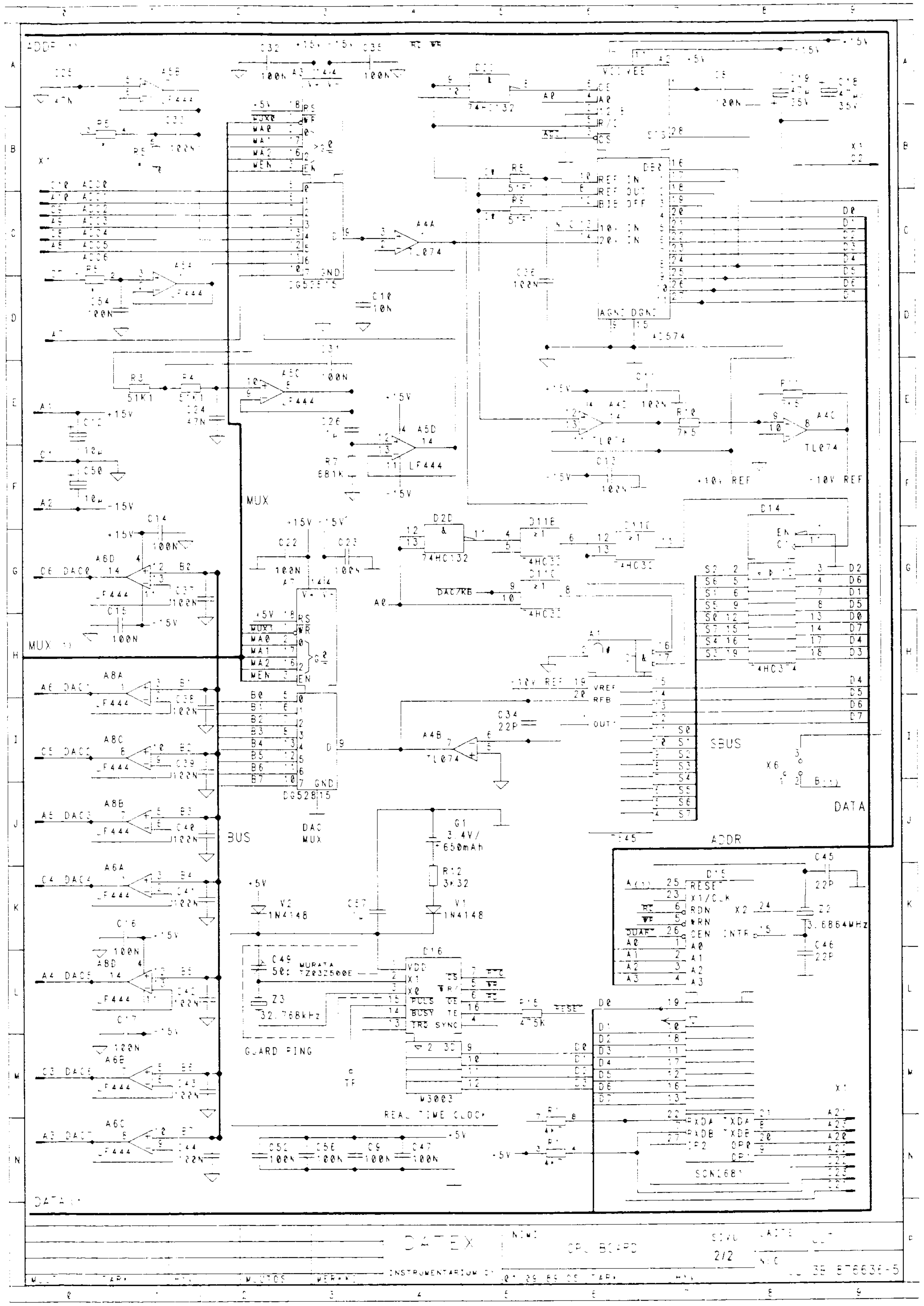
Figure 5.28 CPU board block diagram

Figure 5.29 CPU board parts layout and schematic diagram





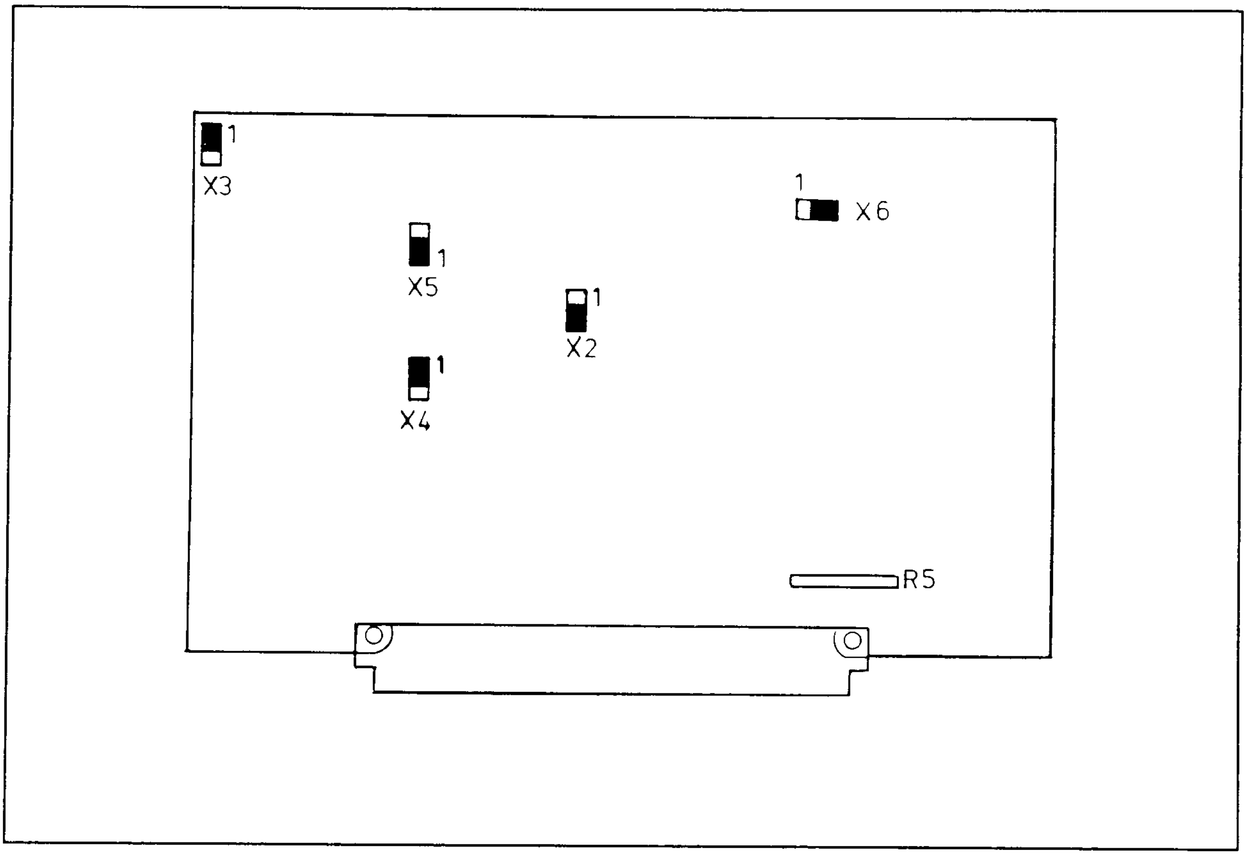
80C51FA
KEYBOARD SCANNER
74HC132
74HC367
74HC273
74HC245
74HC244
8255A-5
BUS BUFFERS
DATA
ADDR
DATEX
INSTRUMENTARIUM OY
CPU BOARD
1/2



TL074
LF444
74HC132
MUX
BUS
DAC
SBUS
DATA
ADDR
REAL TIME CLOCK
GUARD RING
32.768kHz
3.6864MHz
DATEX
INSTRUMENTARIUM OY
CPU BOARD
2/2

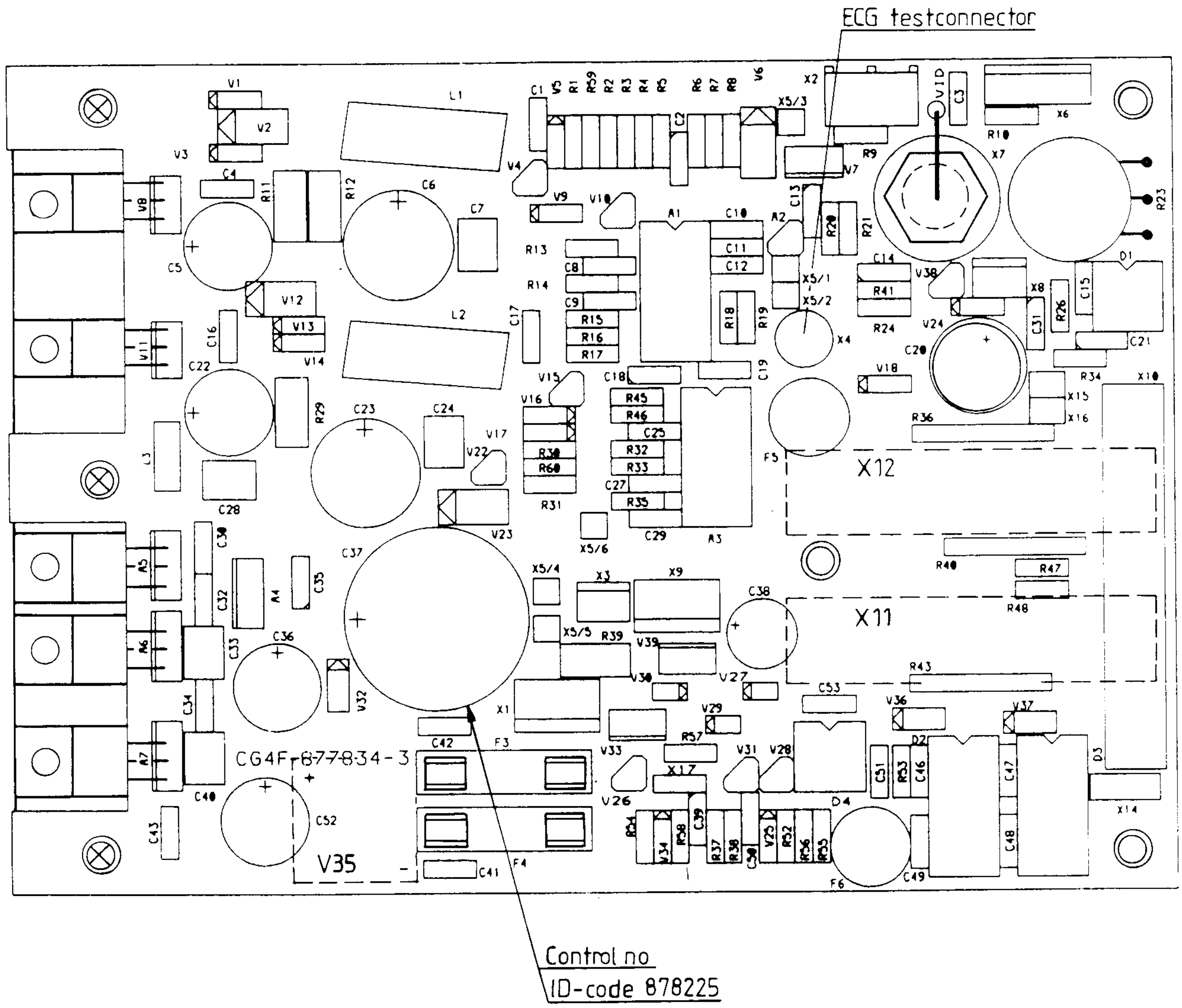
Figure 5.30 CPU board jumper configuration

CONNECTOR	JUMPER	MEMORY TYPE
X2	1-2	RAM area 32k (FFFF-8000) (rev 01)
	2-3	RAM area 8k (FFFF-C000) (rev 00)
X3	1-2	D1 : 512k, 1M EPROM
	2-3	D1 : 2M, 4M EPROM
X4	1-2	D6 : 32k x 8 RAM
	2-3	D6 : 8k x 8 RAM
X5	1-2	D4 : E2PROM, RAM
	2-3	D4 : EPROM
X6	1-2	Norm
	2-3	Test

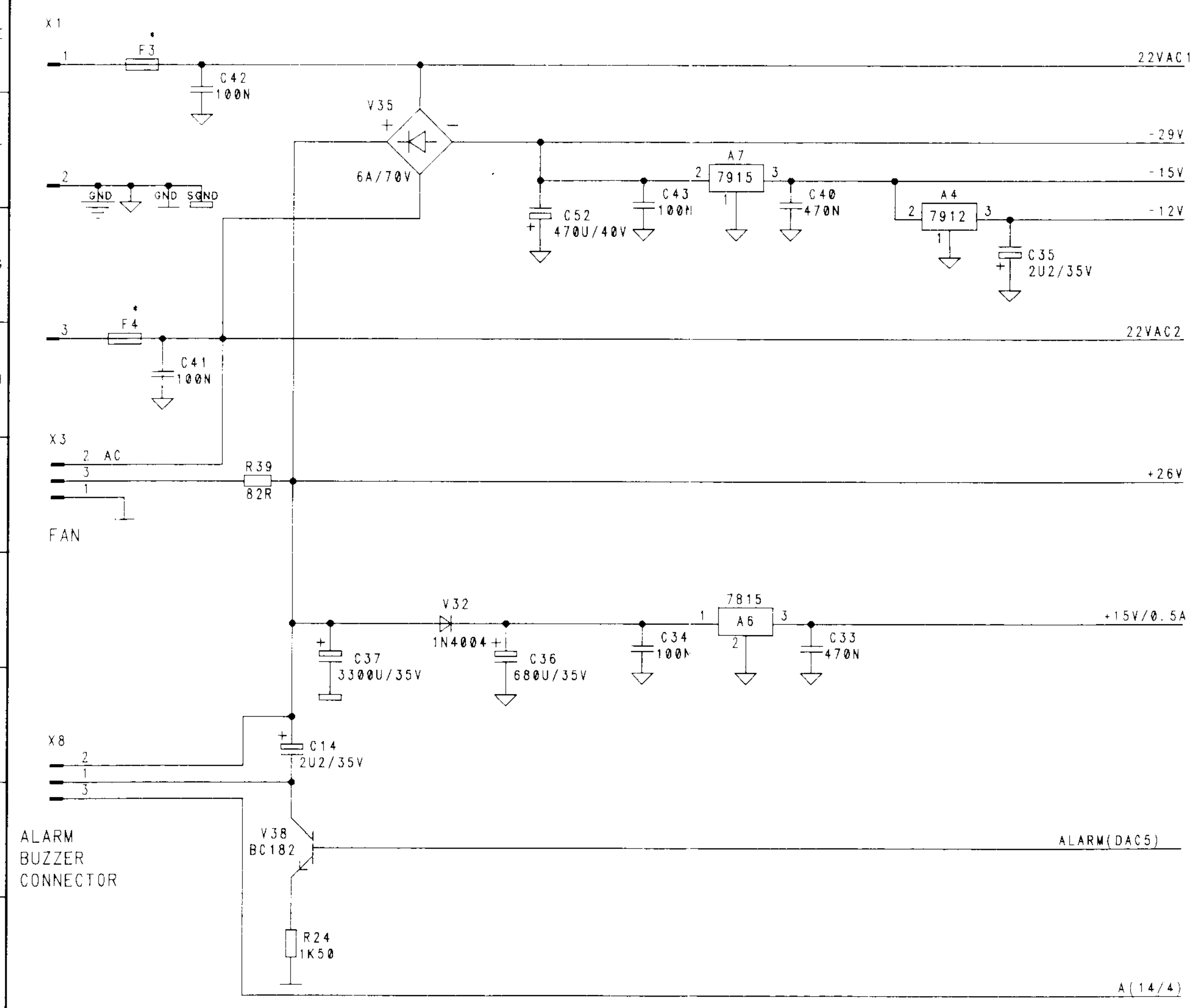


The value of resistor network R5 is 4 x 47k

Figure 5.35 Power supply board parts layout and schematic diagram (part 1)



Monitor	X'1 Serial / Analog I/O							
Pin.No	13	14	16	17	18	19	20	22
CG	Uncal BP.2	O_2	-	BP.2	ECG	SPO_2/ BP.1	CO_2	Input AUX
Pin.No	30	31	37	38	28	33	32	29
	X10 Flatcable							



08.11.90 OS			5594	-2	
24.08.90 OS			5449	-1	
MUUT.	TARK.	HYV.	MUUTOS	MERKKI	

DATEX — INSTRUMENTARIUM OY

NIMI HAKKURIPOWERI

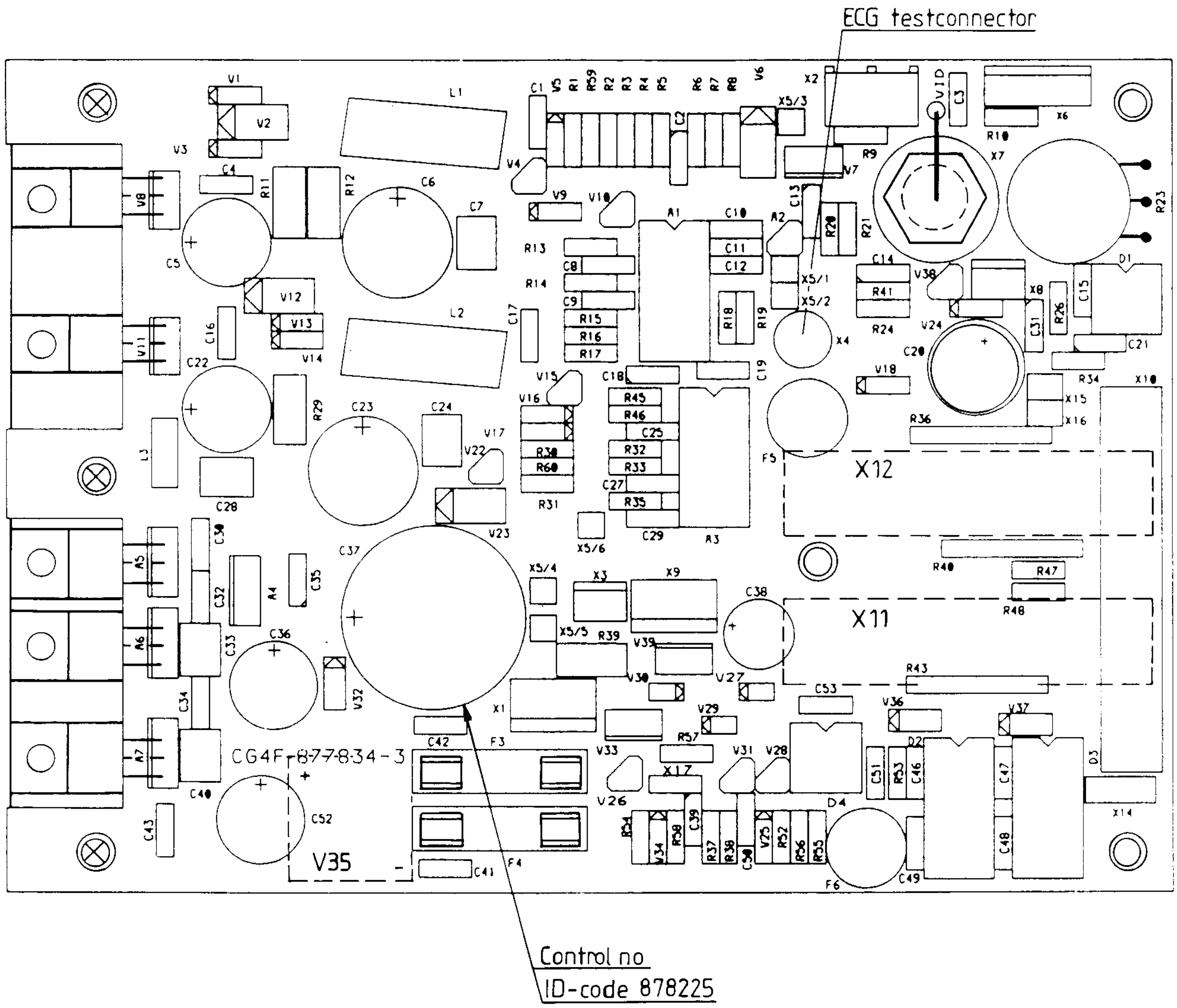
SIVU 3

LAITE CH/CG

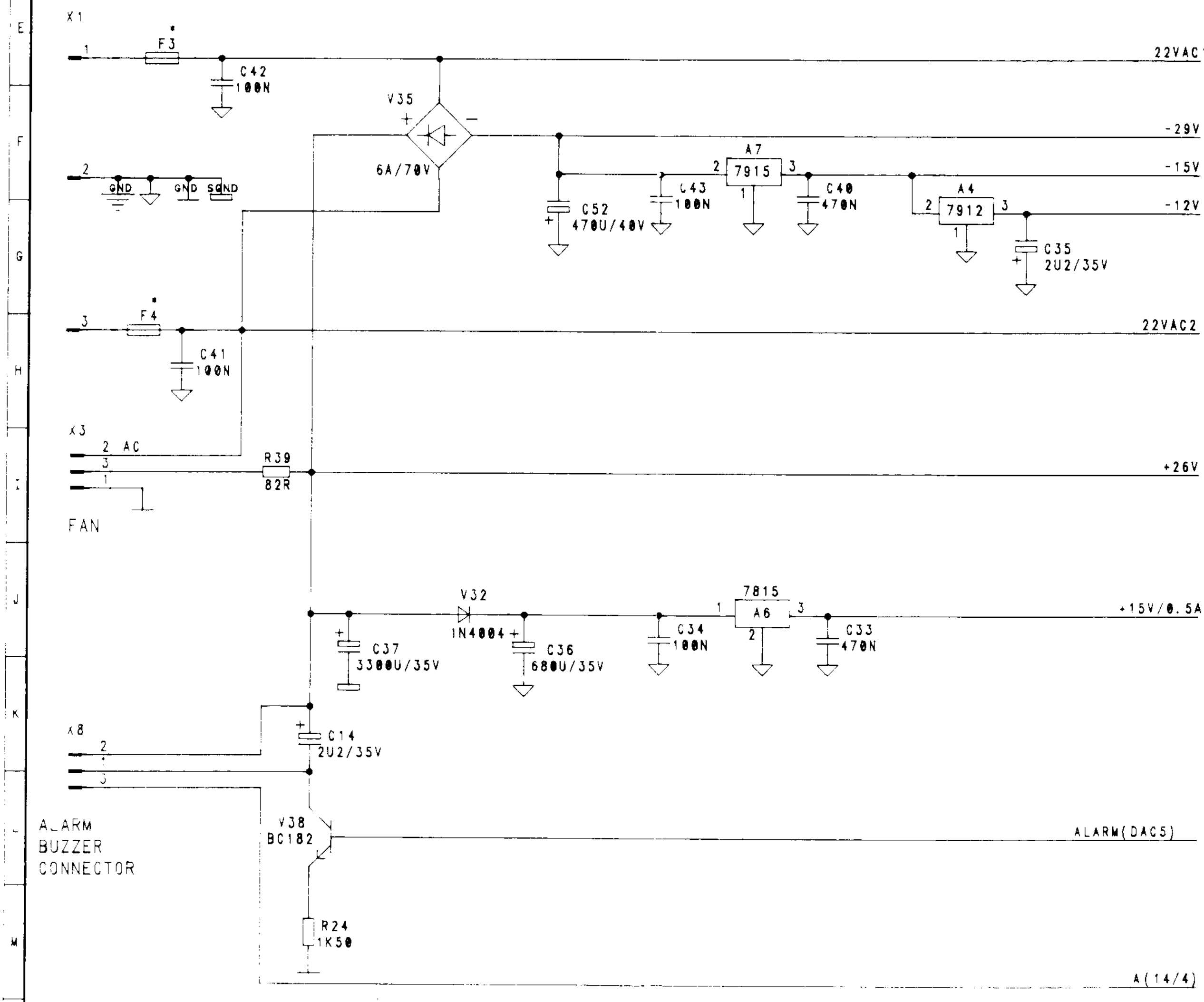
27.07.90 OS TARK. HYV.

N:O CG 3B 877839-2

Figure 5.35a Power supply board parts layout and schematic diagram (part 1) (board modification level 2 and higher)

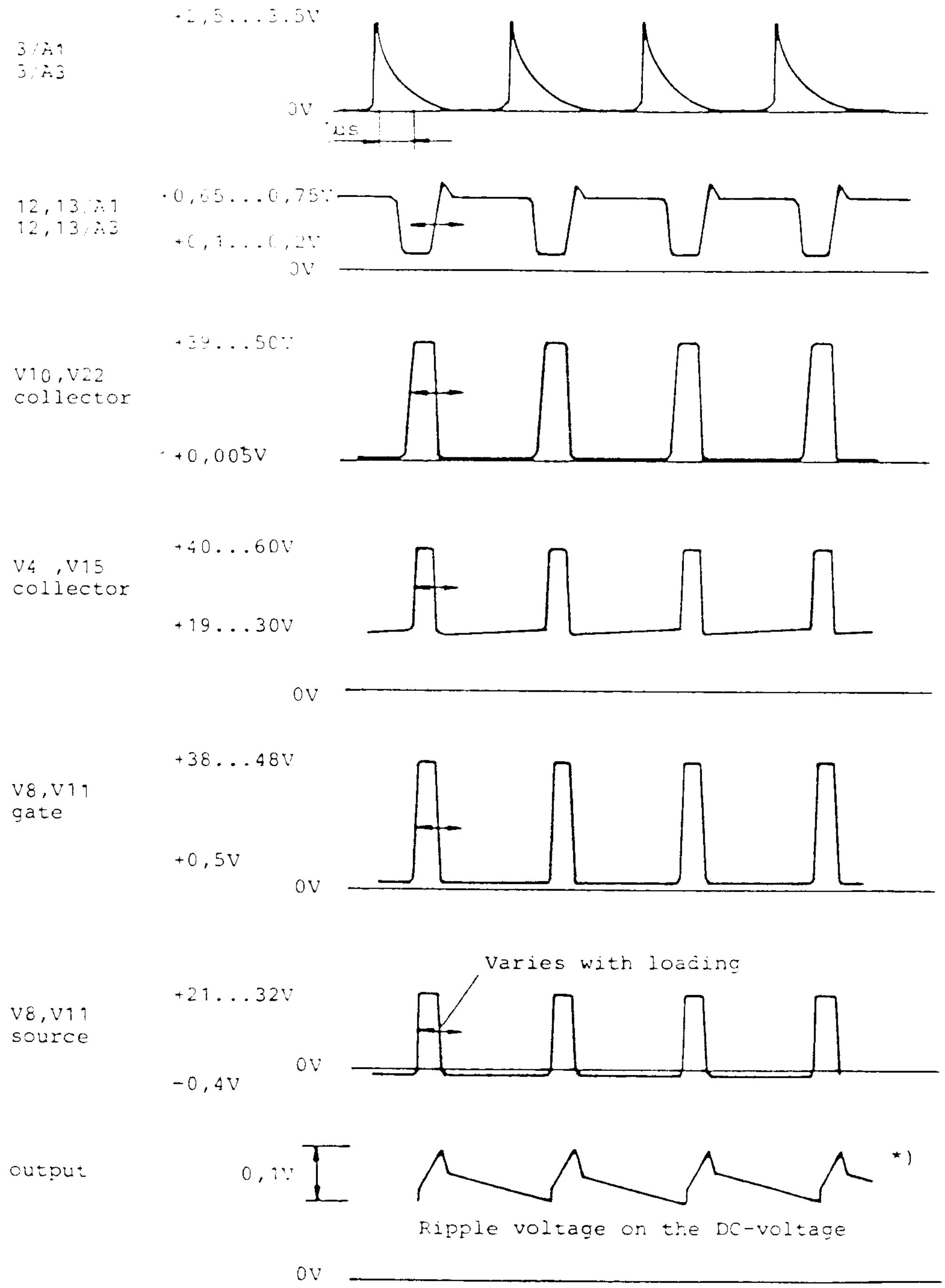


Monitor	X11 Serial / Analog I/O							
Pin.No	13	14	16	17	18	19	20	22
CG	Uncal BP.2	O_2	-	BP.2	ECG	SPO_2/ BP.1	CO_2	Input AUX
Pin.No	30	31	37	38	28	33	32	29
	X10 Flatcable							

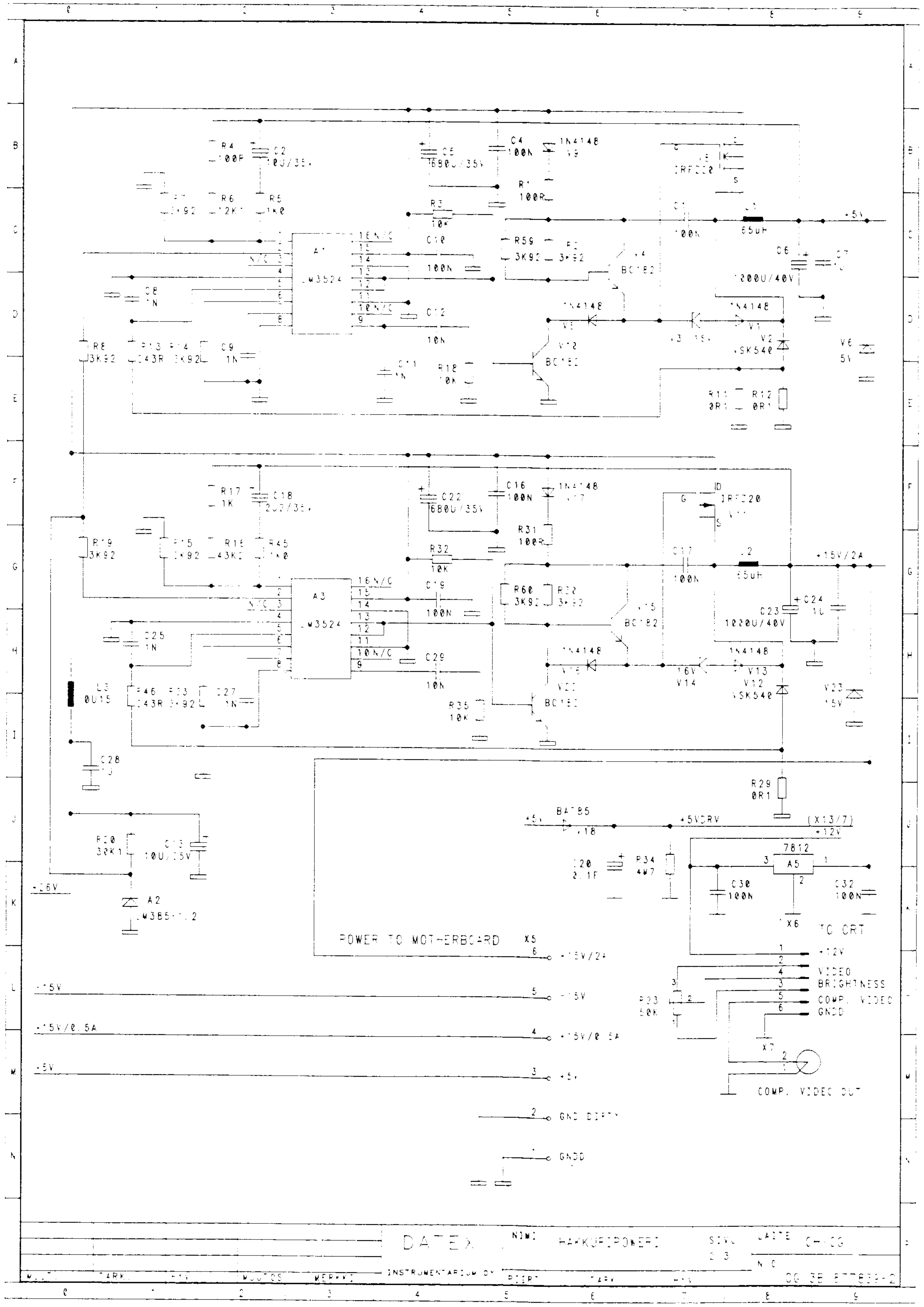


11.02.91 EN	[illegible]	5787	-3	DATEX	NIMI HAKKURIPOWERI
08.11.90 OS		5594	-2		SIVU 1/3 LAITE [illegible] CG
24.08.90 OS	28.08.90 JOKQ	5449	-1	INSTRUMENTARIUM OY	27.07.90 OS TARK. HYV. N:O
MUUT. TARK.	HYV.	MUUTOS	MERKKI		CG 35 877839-3

Figure 5.36 Power supply board signal waveforms and schematic diagram (part 2)



*) The ripple on the 12V voltage may be higher because of the uneven loading


LM3524
POWER TO MOTHERBOARD
TO CRT
VIDEO
BRIGHTNESS
COMP. VIDEO
COMP. VIDEO OUT
DATEX
HAKKURIPOWERI
INSTRUMENTARIUM OY

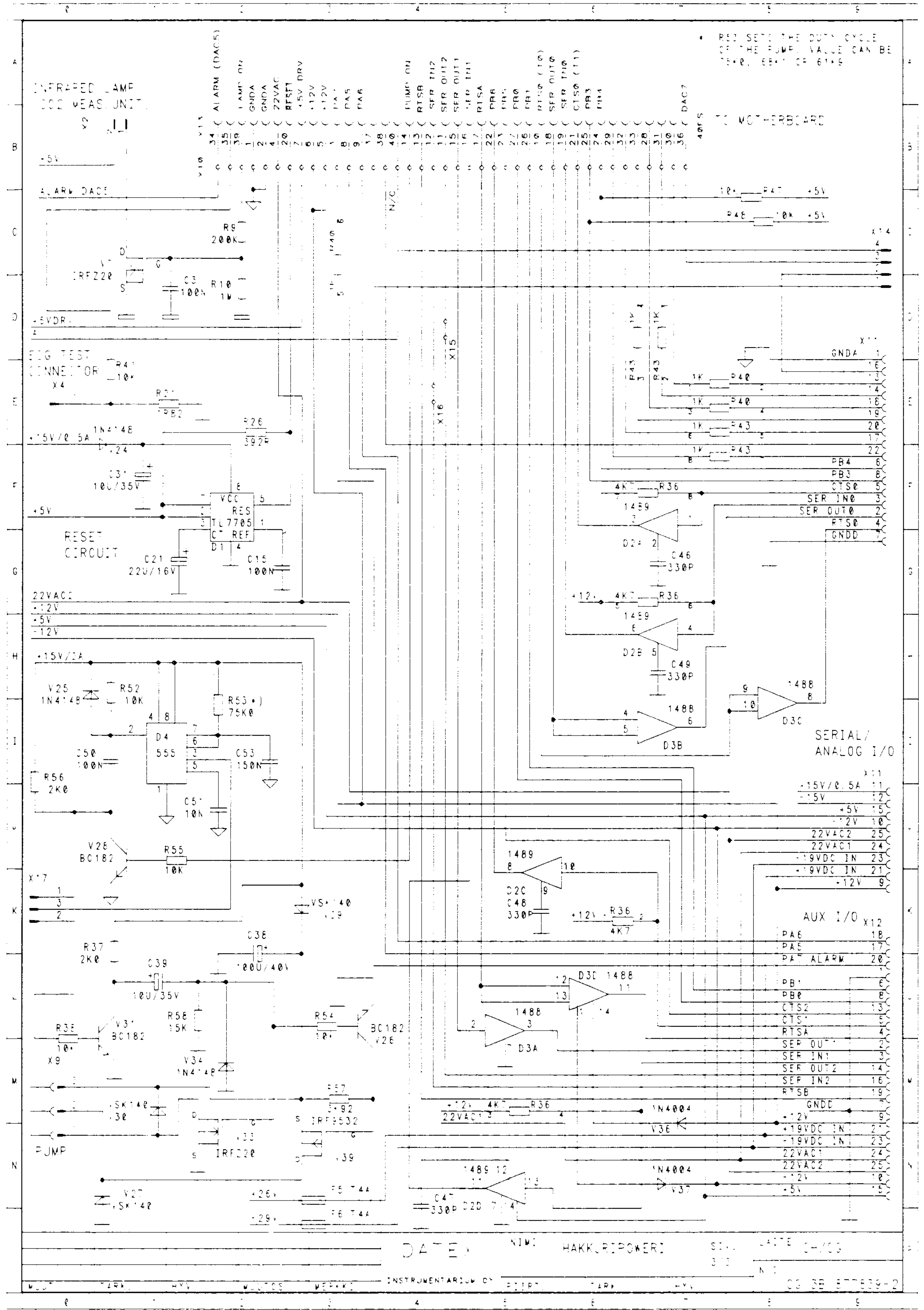
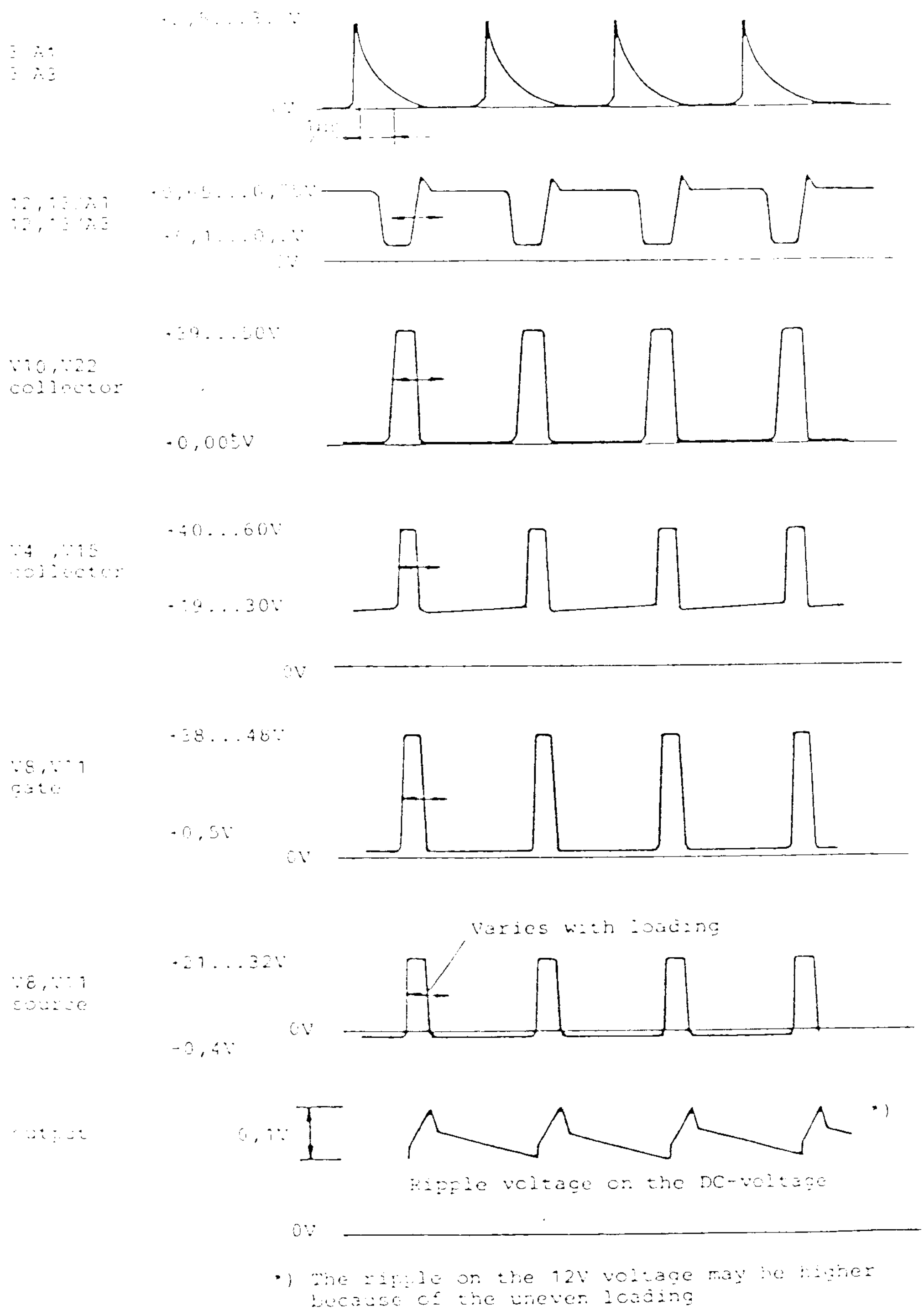

INFRARED LAMP
TO MOTHERBOARD
EEG TEST CONNECTOR
RESET CIRCUIT
SERIAL/ ANALOG I/O
AUX I/O
PUMP
DATEX
HAKKURIPOWERI
INSTRUMENTARIUM OY

Figure 5.36a Power supply board signal waveforms and schematic diagram (part 2)
(board modification level 2 and higher)



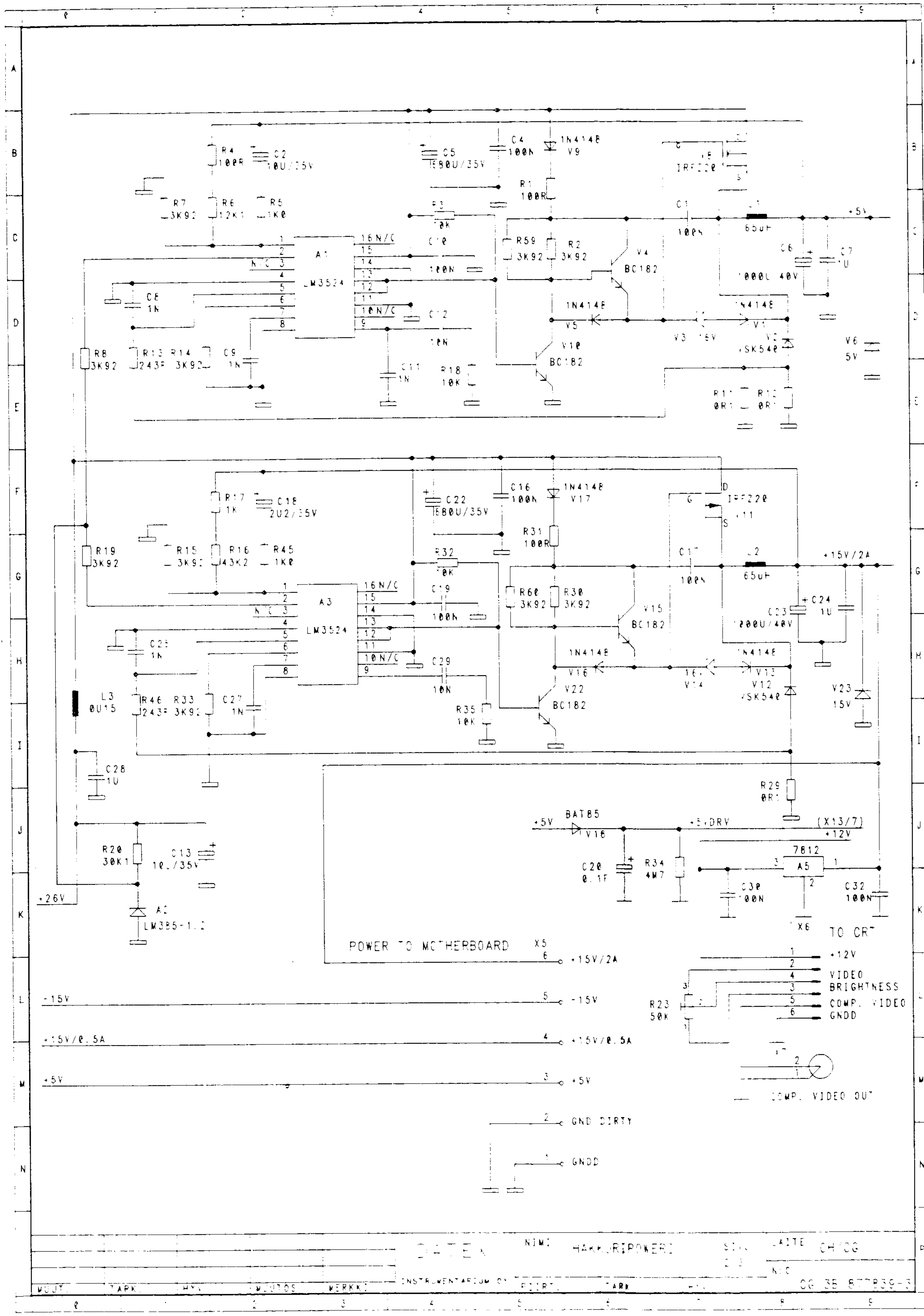
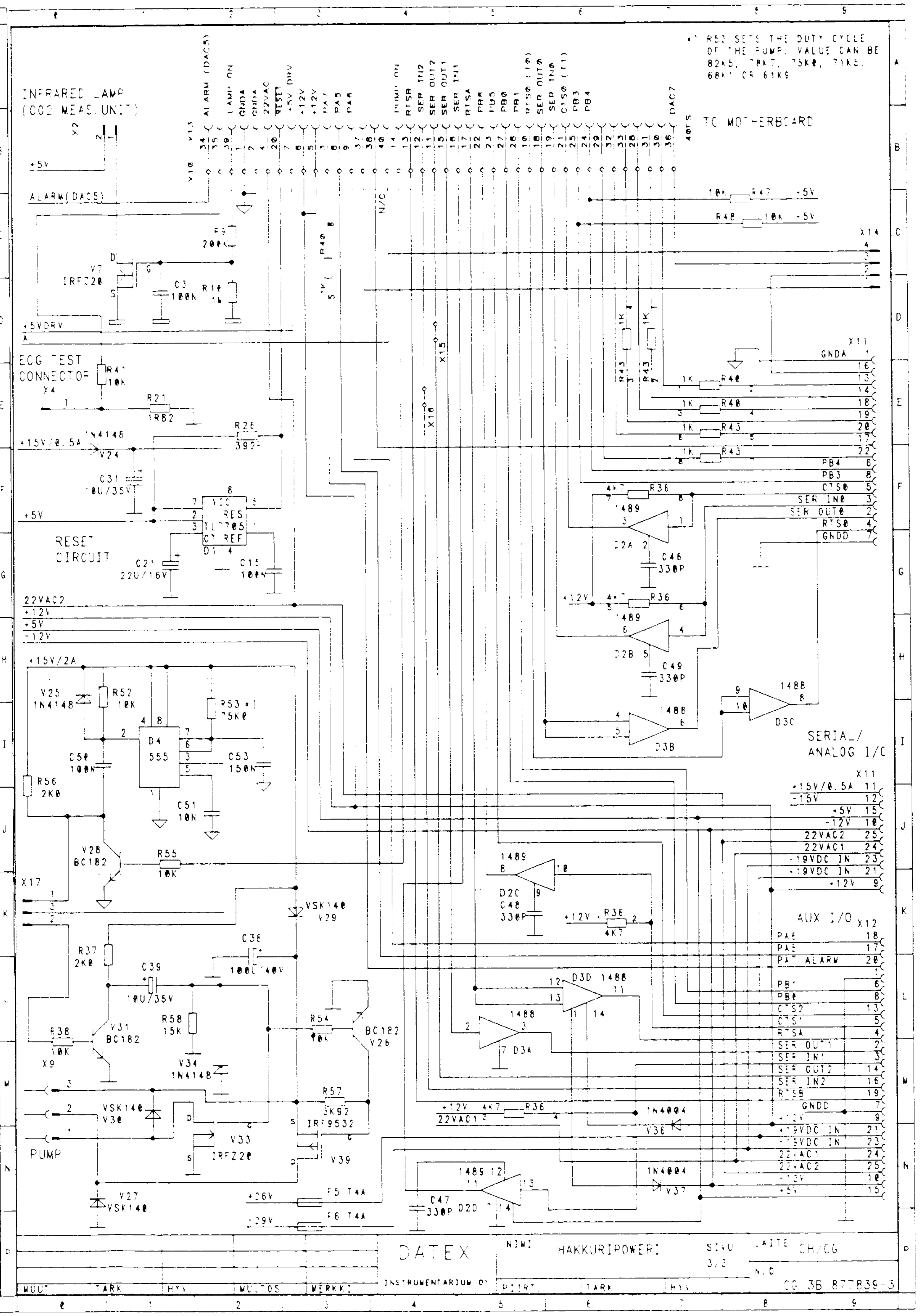
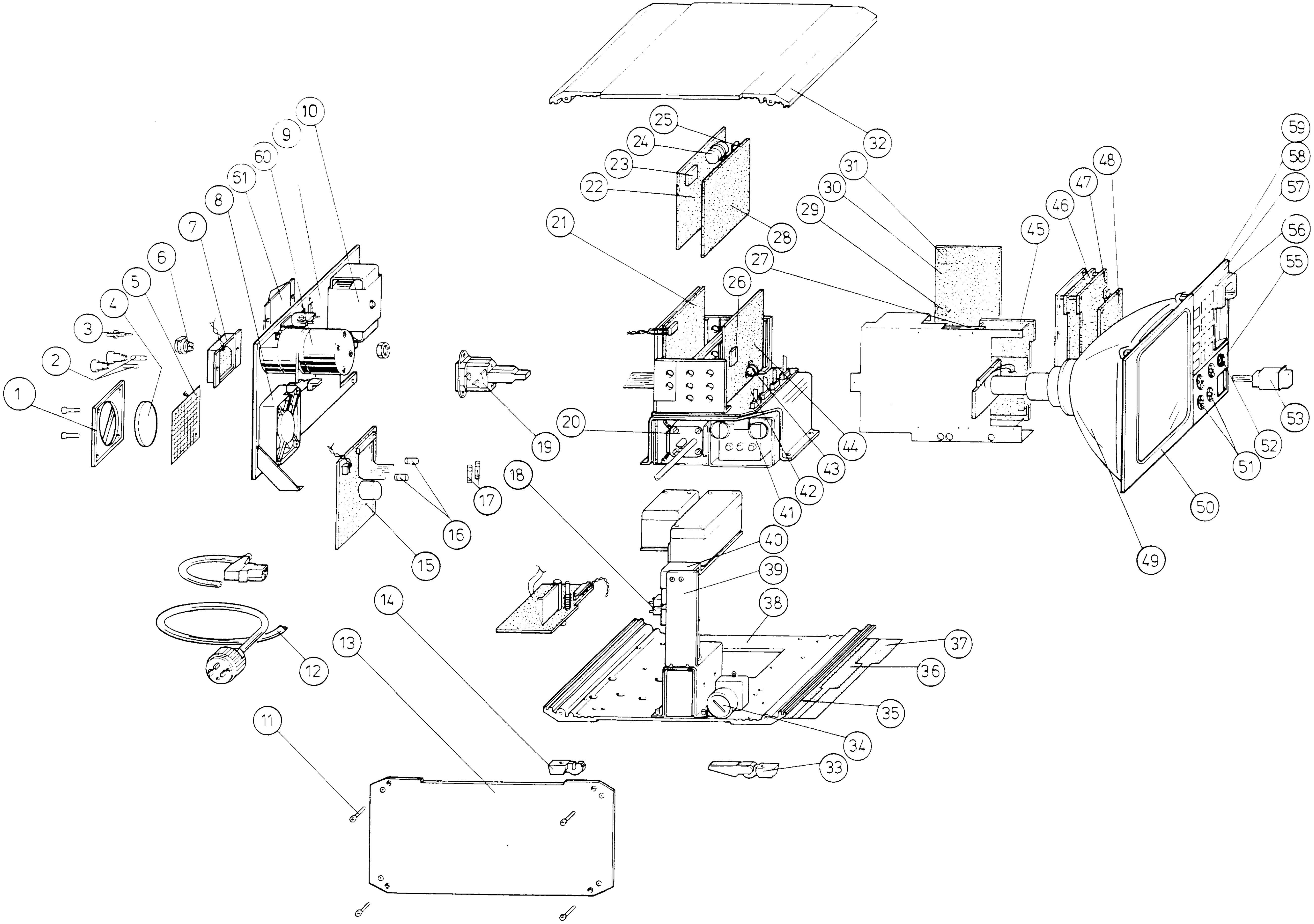

LM3524
POWER TO MOTHERBOARD
TO CRT
COMP. VIDEO OUT
+12V
VIDEO
BRIGHTNESS
COMP. VIDEO
GNDD
GND DIRTY
+15V/2A
+15V/0.5A
+5V
-15V
+26V
DATEX
NIMI HAKKURIPOWERI
LAITE CH/CG
INSTRUMENTARIUM OY
CG 3B 877839-3

R53 SETS THE DUTY CYCLE OF THE PUMP. VALUE CAN BE 82K5, 78K7, 75K0, 71K5, 68K1 OR 61K9
INFRARED LAMP (CO2 MEAS. UNIT)
TO MOTHERBOARD
ECG TEST CONNECTOR
RESET CIRCUIT
SERIAL/ ANALOG I/O
AUX I/O
PUMP
DATEX
NIMI HAKKURIPOWERI
SIVU 3/3
LAITE CH/CG
INSTRUMENTARIUM OY
CG 3B 877839-3

Figure 9.1 Exploded pictures of the monitor



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
55
56
57
58
59
60
61

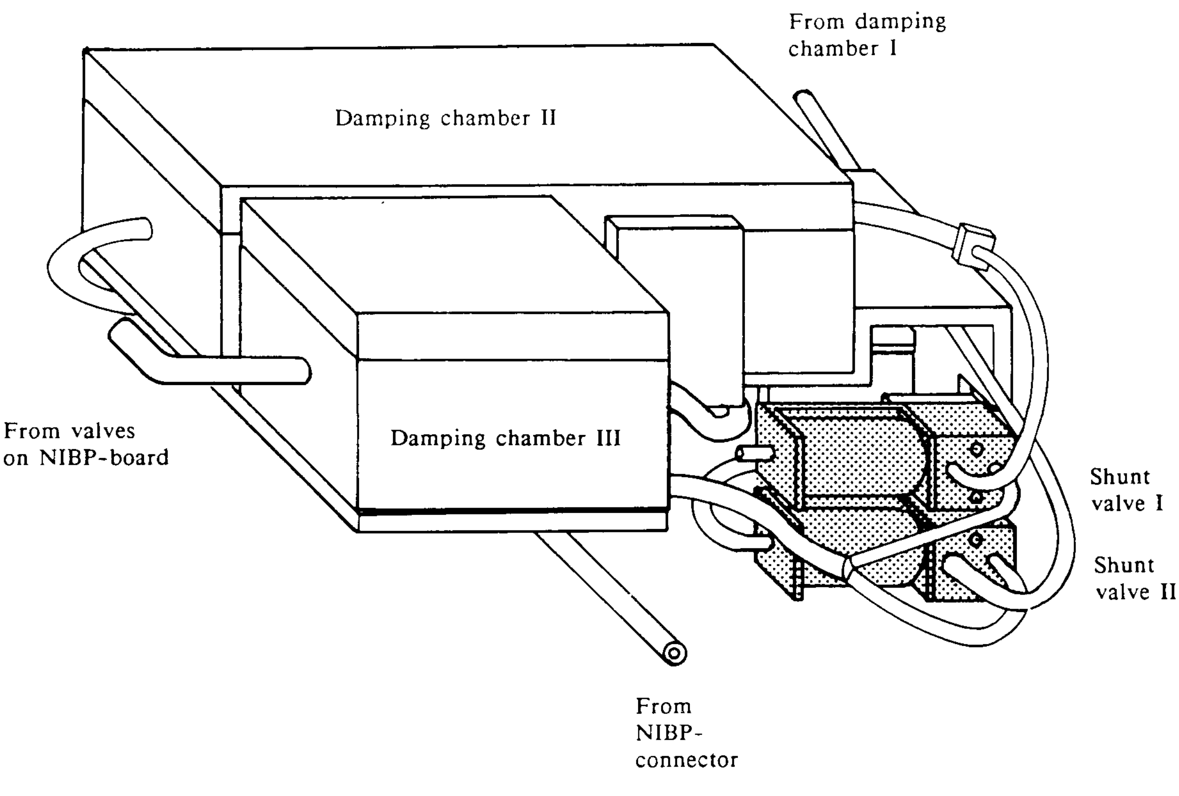


Figure 9.3 Pneumatic unit parts layout

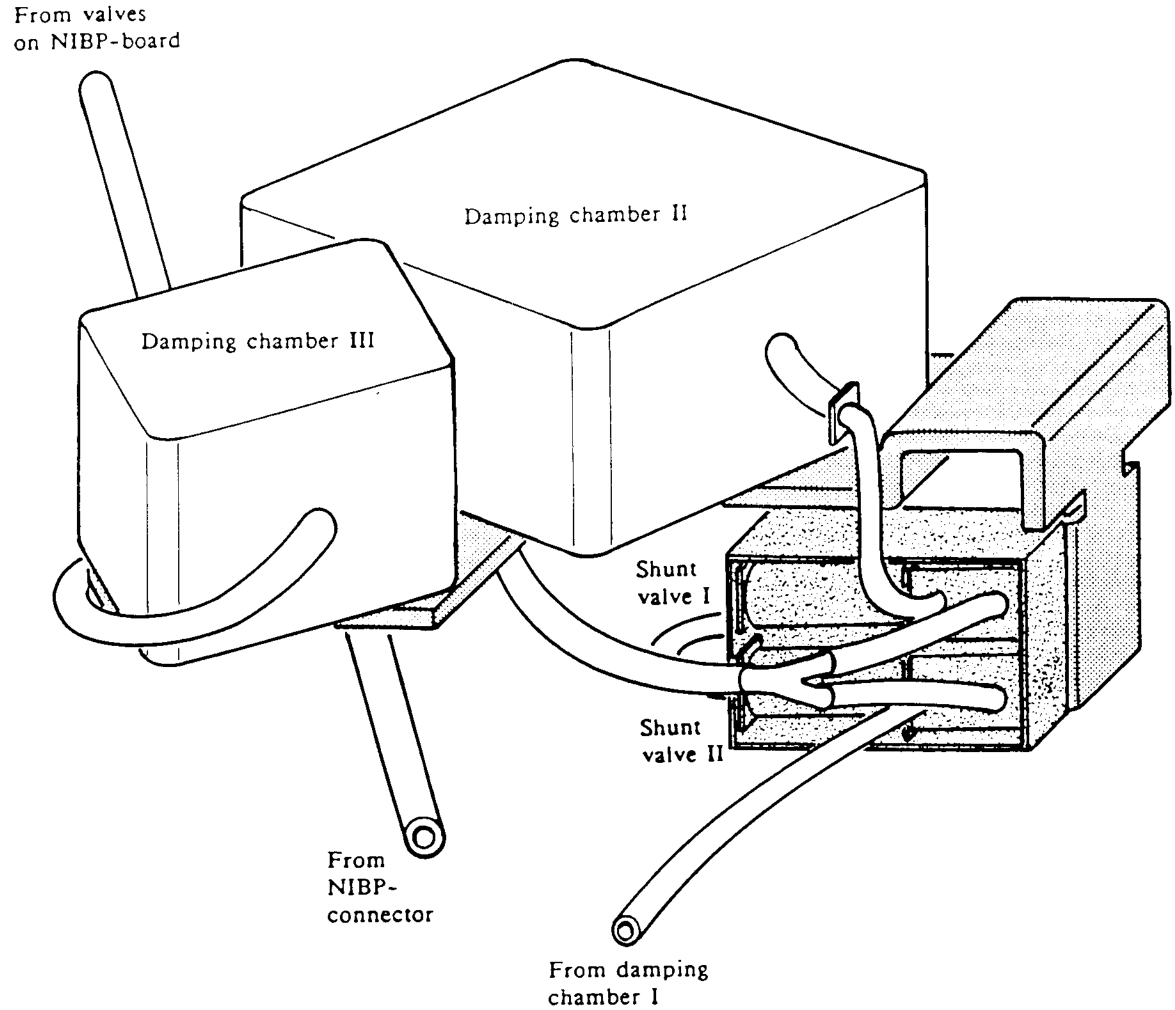


Figure 9.3 Pneumatic unit parts layout

12 APPENDICES

A COMPUTER OUTPUT (Serial & Analog I/O Connector)

CG-1G, CG-1GS
Transmission rate 1200 Baud. 8 data bits, no parity. 1 start bit and 1 stop bit. Each parameter has 3 digits. Parameters are separated by commas.

Output string format: →| |←10 sec–

NIBP string (when obtained)
Status
Systolic
Mean
Diastolic
(000)
(pzero)
(000)

```
C01,000,129,099,084,000,019,000
```

SpO2 string
Reserved
Reserved
Reserved
Pulse rate (1/min)
SpO2 %
Iredmod
Redmod
Gain
*)

Basic string	
Marker number	
Hours	
Minutes	
$ETCO_2$	% x 10
$FICO_2$	% x 10
FIO_2	(0-100 %)
ETO_2	(0-100 %)
FIN_2O	(0-100 %)
ETN_2O	(0-100 %)
Respiration rate (1/min)	
Heart rate (1/min)	
P1 syst	
P1 mean	
P1 diast	
Temp1	(x 10)
Temp2	(x 10)
Status	

```
C00,001,013,020,046,005,021,016,000,000,018,071,089,069,053,376,000,300
C04,000,000,,063,095,036,022,027,620
C00,001,013,020,055,000,021,015,000,000,013,071,090,070,053,376,000,422
C04,000,000,,082,096,037,022,027,700
C00,001,013,020,056,001,021,015,000,000,013,071,090,070,053,376,000,510
C04,000,000,,085,097,035,021,027,700
C00,001,013,021,059,002,021,015,000,000,015,071,089,069,052,376,000,600
```

*) Alternately status code and 6xx
(xx = amplitude factor of pleth)

SpO_2 string if available.

CG-2GS, CG-2G, CG-2GS
Transmission rate 1200 Baud. 8 data bits, no parity. 1 start bit and 1 stop bit. Each parameter has 3 digits. Parameters are separated by commas.

Output string format:

NIBP string (when obtained)		SpO$_2$ string	Basic string	
Status		Reserved	Marker number	
Systolic		Reserved	Hours	
Mean		Reserved	Minutes	
Diastolic		Pulse rate (l/min)	ETCO$_2$	% x 10
(000)		SpO$_2$ %	FICO$_2$	% x 10
(pzero)		Iredmod	FIO$_2$	(0-100 %)
(000)		Redmod	ETO$_2$	(0-100 %)
		Gain	FIN$_2$O	(0-100 %)
		*)	ETN$_2$O	(0-100 %)
			Respiration rate (1/min)	
			Heart rate (1/min)	
			P1 syst	
			P1 mean	
			P1 diast	
			Temp	(x 10)
			P2 syst	
			P2 mean	
			P2 diast	
			Status	

NIBP string:

```
C01,000,129,099,084,000,019,000
```

SpO$_2$ string and Basic string (alternating, 10 sec):

```
C04,000,000,000, AA,066,096,019,011,005,605
C02,000,014,049,052,001,021,015,001,001,009,066,144,111,082,375,017,013,010,300
C04,000,000,   ,065,095,035,022,005,700
C02,000,014,053,048,001,021,016,001,001,016,065,144,111,081,375,017,013,009,600
C04,000,000,C02,067,000,035,024,005,605
C02,000,014,053,048,001,021,016,001,001,016,067,143,112,082,375,017,013,010,513
C04,000,000,   ,064,095,027,018,005,700
C02,000,014,052,049,002,021,016,001,001,015,064,144,110,080,375,017,013,009,422
C04,000,000,C02,068,096,053,032,005,605
C02,000,014,052,047,002,021,016,001,001,018,068,143,111,082,375,016,013,010,300
```

*) Alternately status code and 6xx
(xx = amplitude factor of pleth)

SpO$_2$ string if available.

The Status Characters of the Standard String

1st chr	2nd chr	3rd chr	Explanation
0	undefined	undefined	
1	<occl> <O_2 inop> <zero valve error> <air leak>	<CO_2 error> <O_2 zero error> <N_2O zero error>	Gas status bits
2	<apn> <rebr> <CO_2 high> <CO_2 low>	<O_2 high> <O_2 low> <SpO_2 high> <SpO_2 low>	Resp alarm bits
3	<asy> <ECG leads off> <hr high> <hr low>	<pl/NIBP high> <pl/NIBP low> <p2 high> <p2 low>	Circulatory alarm bits
4	ECG size number N = 99 (0.2 mV/cm) down to N = 5 (4 mV/cm) with 19 = mV/cm (Size = 1/(0.051 (N-5) + 0.25) in mV/cm)		
5	(BP1) 0 = no PB1 1 = 100 mmHg ref 2 = 50 mmHg ref 3 = 25 mmHg ref 4 = zero error 5 = 150 mmHg ref	(BP2) 0 = no PB2 1 = 100 mmHg ref 2 = 50 mmHg ref 3 = 25 mmHg ref 4 = zero error 5 = 150 mmHg ref 6 = 12.5 mmHg ref	Invasive blood pressure scale (= REF scales)
6	Pleth size 1 - 99 with 16 = default = min		
7	<no probe> <no finger> <no pulse> <poor signal quality>	<high SpO_2> <low SpO_2> <high PR> <low PR>	pleth/SpO_2 status and alarm

The bits in the last two characters are coded as follows:

30H +	0 0 0 0	< > < > < > < >	= 30H to 3FH
hex base = '0'	zero bits	status bits from above	

Alarm Activation/Deactivation String

Alarm activation string appears immediately when an alarm is given.

C99,	<=====	CARDIOCAP™ alarm activation string identification
P2,	<=====	Alarm parameter
024,	<=====	Alarm activation value
	<=====	< or > depending on whether low or high limit
,020	<=====	Limit

The alarm parameter can be one of the following:

HR (heart rate) P1 (P1/NIBP systolic), P2 (P2 systolic), ASY (Asystole), ELO (ECG leads off), SAO (oxygen saturation)

C98,	<=====	CARDIOCAP™ alarm deactivation string identification
P2	<=====	Alarm parameter

Command/Info String

C97,	<=====	CARDIOCAP™ command/ info string identification
RES	<=====	RES for reset, POW for power-up
	<=====	Program code

B CCP-104 GRAPHICS PRINTER

The CCP-104 is an HP ThinkJet graphics printer. Earlier printers (CCP-104-xx-00, see the type plate on the bottom of the unit) require an isolated connecting cable (P/N 873152) to satisfy medical electronics safety requirements. Printers currently in production (CCP-104-xx-01) are IEC 601-1 class II devices and do not require an isolated cable. The non-isolated connecting cable's part number is 875370. Due to mechanical changes the isolated connecting cable can not be connected to the current printers.

For troubleshooting the printer please refer to the HP ThinkJet service manual.

See below for the correct DIP switch settings in the printer.

C CCK-104 KEYBOARD

1 GENERAL DESCRIPTION

1.1 Specifications

Character set	256 character ASCII
Communications interface	RS 232C compatible
Baud rate	1200 Bd
Power requirements	+5 V 300 mA, ±12 V 40 mA (supplied by the host monitor)
Dimensions (WxDxH)	380 x 180 x 45 mm
Weight	1.4 kg approximately

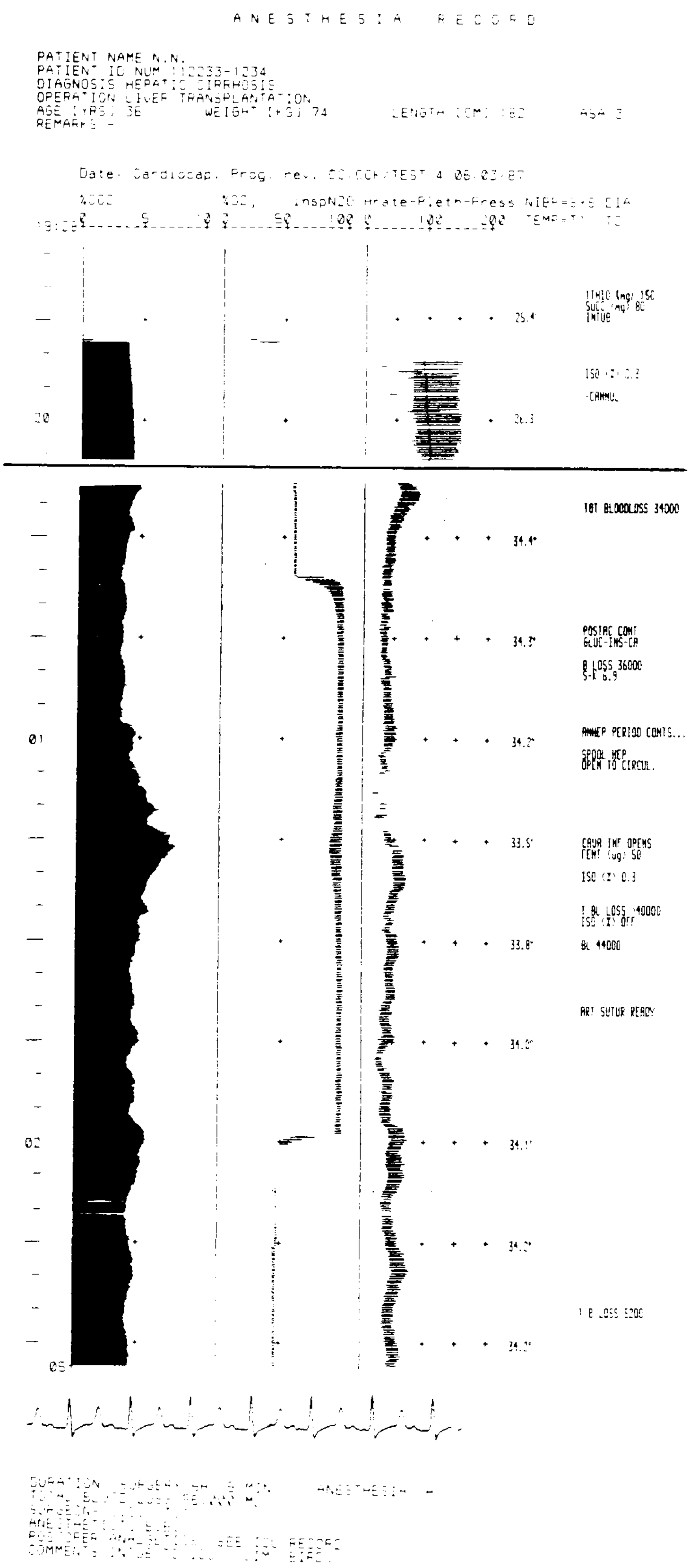
1.2 Principle of operation

The keyboard allows the anesthesia personnel to key in details of an operation to produce a complete anesthesia record using the CCP-104 graphics printer (see Figure C.1 for an example of anesthesia record).

When the information is keyed in, it can be observed on the screen. The keyboard has preprogrammed and programmable function keys to facilitate operation.

NOTE: LED's are only for production testing.

Figure C.1 Example of anesthesia record produced with CCK-104 keyboard and CCP-104 printer



1.3 General block diagram

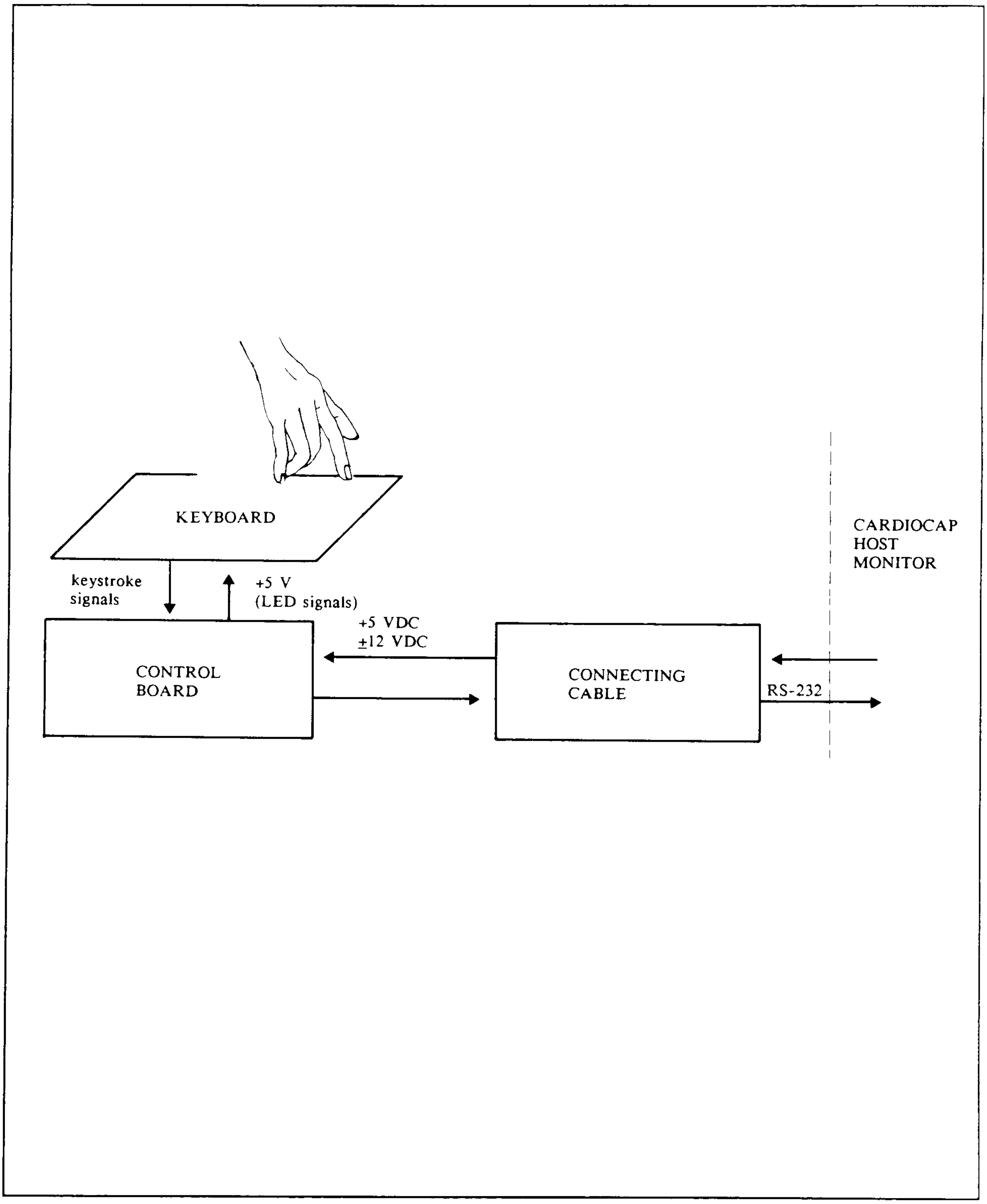
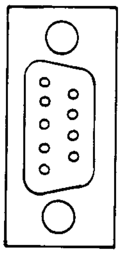


Figure C.2 CCK-104 block diagram

1.4 Connector configurations

Keyboard connecting cable connector



PIN NO.	SIGNAL	
1	-12 V	
2	NC	not connected
3	TXD	serial output
4	+5 V	
5	+5 V	
6	+12 V	
7	GND	
8	GND	
9	GND	

For connecting cable pin configuration see Figure C.8.

2 DETAILED DESCRIPTION OF MODULES

2.1 Keyboard

The keyboard contains 79 keys for entering data and LED's for informing the user of selected operations.

2.2 Control board

The control board block diagram is shown in figure C.3. The board is intended to perform the following tasks:

- provide the +5 V for the keyboard
- provide the $\pm$12 V for the RS-232 line drivers
- read the keyboard strokes, convert them to ASCII code and transmit the serial data to the host monitor
- control the keyboard LED's
- control the keyboard loud-speaker

The keyboard scan drivers, the loud-speaker and the led drivers are selected with address bits A8 and A3.

All the drivers are darlington transistor arrays.

The RS 232 transmitter consists of an op-amp and two smith triggers and receiver with one smith trigger.

The loud-speaker oscillator is based on RC-oscillator with the frequency of approximately 800 Hz.

The processor controls the keyboard scanning, the ASCII conversion of pressed keys and the serial communication to the host monitor.

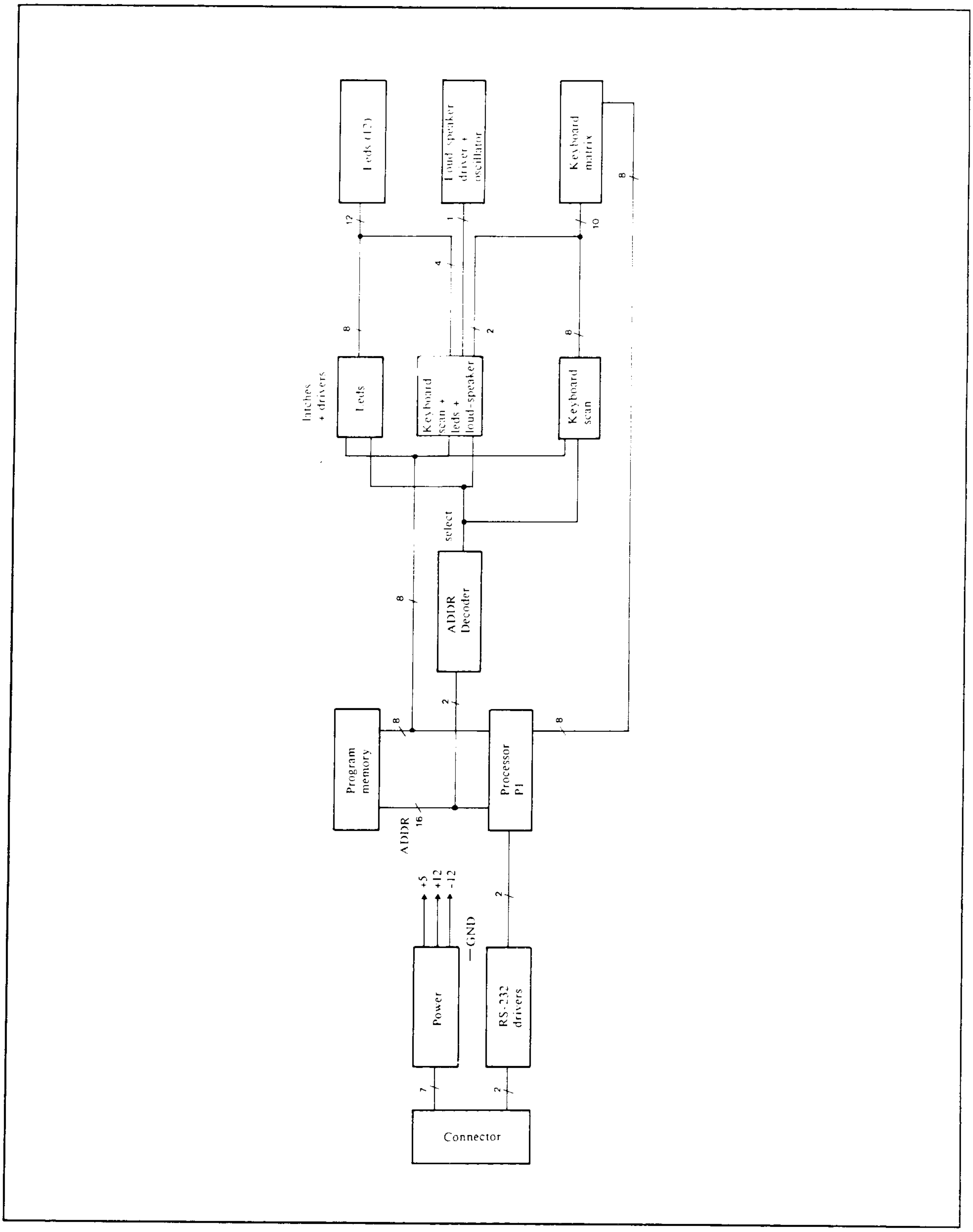


Figure C.3 Control board block diagram

3 SERVICE AND TROUBLESHOOTING

3.1 Disassembly and reassembly

See the exploded view in Figure C.9 for the mechanical construction of CCK-104.

3.2 General troubleshooting

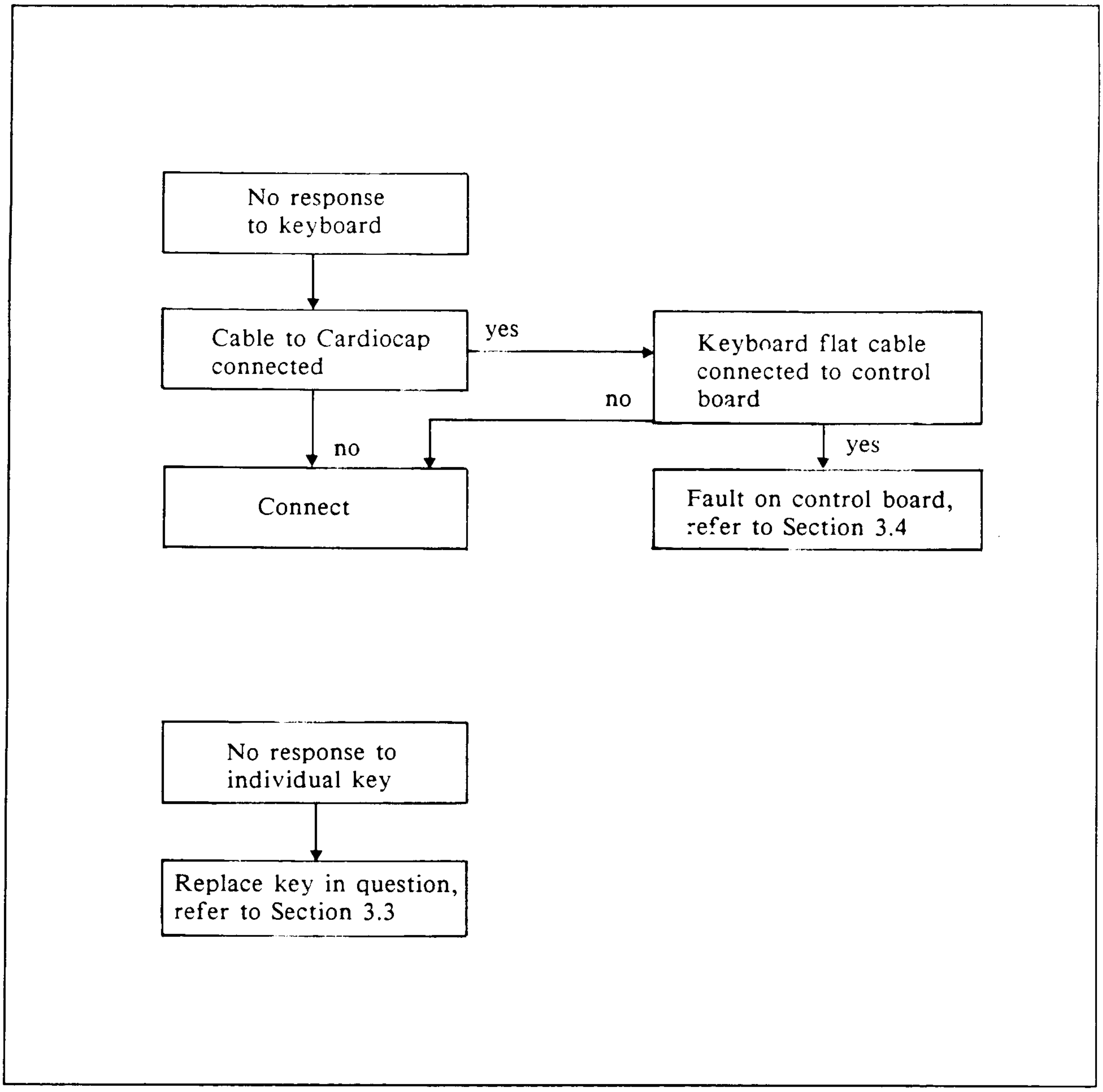


Figure C.4 General troubleshooting chart

3.3 Keyboard troubleshooting

See Figure C.5 for keyboard parts layout and schematic diagram.

3.3.1 Keyboard test mode

Keyboard test mode is started by pressing the CTRL-key and simultaneously typing the code 874733. While in the test mode the serial interface is switched off so the keyboard does not send any characters to the monitor.

The test procedure checks all the keys in the keyboard rows one by one. All the LEDs in the keys S1 through S12 are switched on at the beginning of the test. A blinking LED indicates the row under test (see the table below):

S1 blinking=test S1 - S12-keys(default when entering the test mode)
S2 blinking=test F1 - F12-keys
S4 blinking=test number row (1, 2, 3...)
S6 blinking=test upper character row (ESC, Q, W...)
S8 blinking=test middle character row (CTRL, A, S...)
S10 blinking=test lower character row (SHIFT, Z, X...)
S12 blinking=test SPACEBAR

Every LED indicates one key in a row to be tested. The LEDs S1 to S12 indicate the keys from left to right (or the key itself in case of the keys S1 through S12). Test the keys in a row by pressing them one by one. When a key passes the test, the corresponding LED is switched off (the blinking LED is not switched off). When all the keys in a row are tested the test immediately moves to the next row. After the last row (the SPACEBAR) is tested the software automatically returns to normal mode. CTRL- and SHIFT-keys are tested by pressing two keys simultaneously:

Test CTRL-key	: press CTRL and 'A'-key.
Test left SHIFT-key	: press SHIFT and 'Z'-key.
Test right SHIFT-key	: press SHIFT and '?'-key.

The test does not move automatically to the next row unless all the keys in the row pass the test. You can select the row you wish to test by pressing simultaneously the CTRL-key and the green S-key corresponding to the row you wish to test (according to the list on top). Keyboard is turned to normal mode by pressing simultaneously CTRL and 'C'-keys.

3.4 Control board troubleshooting

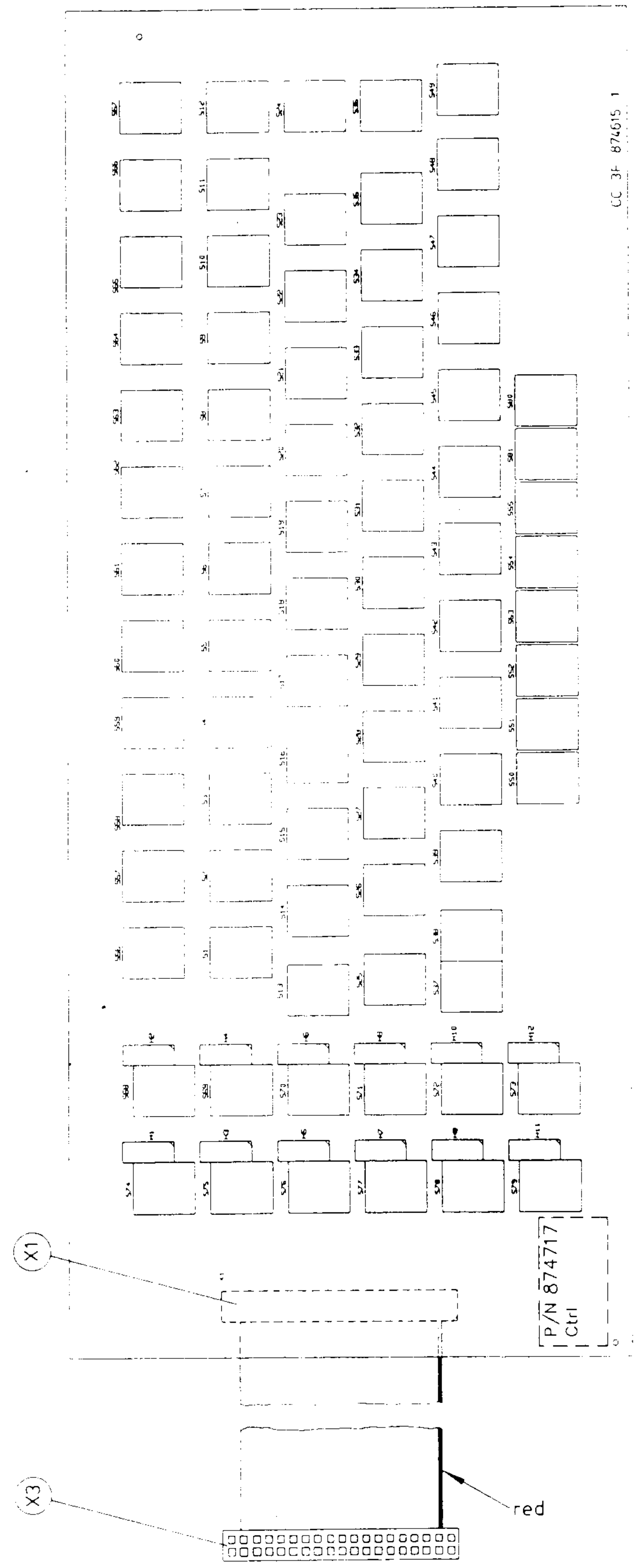
See Figure C.6 for control board troubleshooting. The parts layout and schematic diagram are given in Figure C.7.

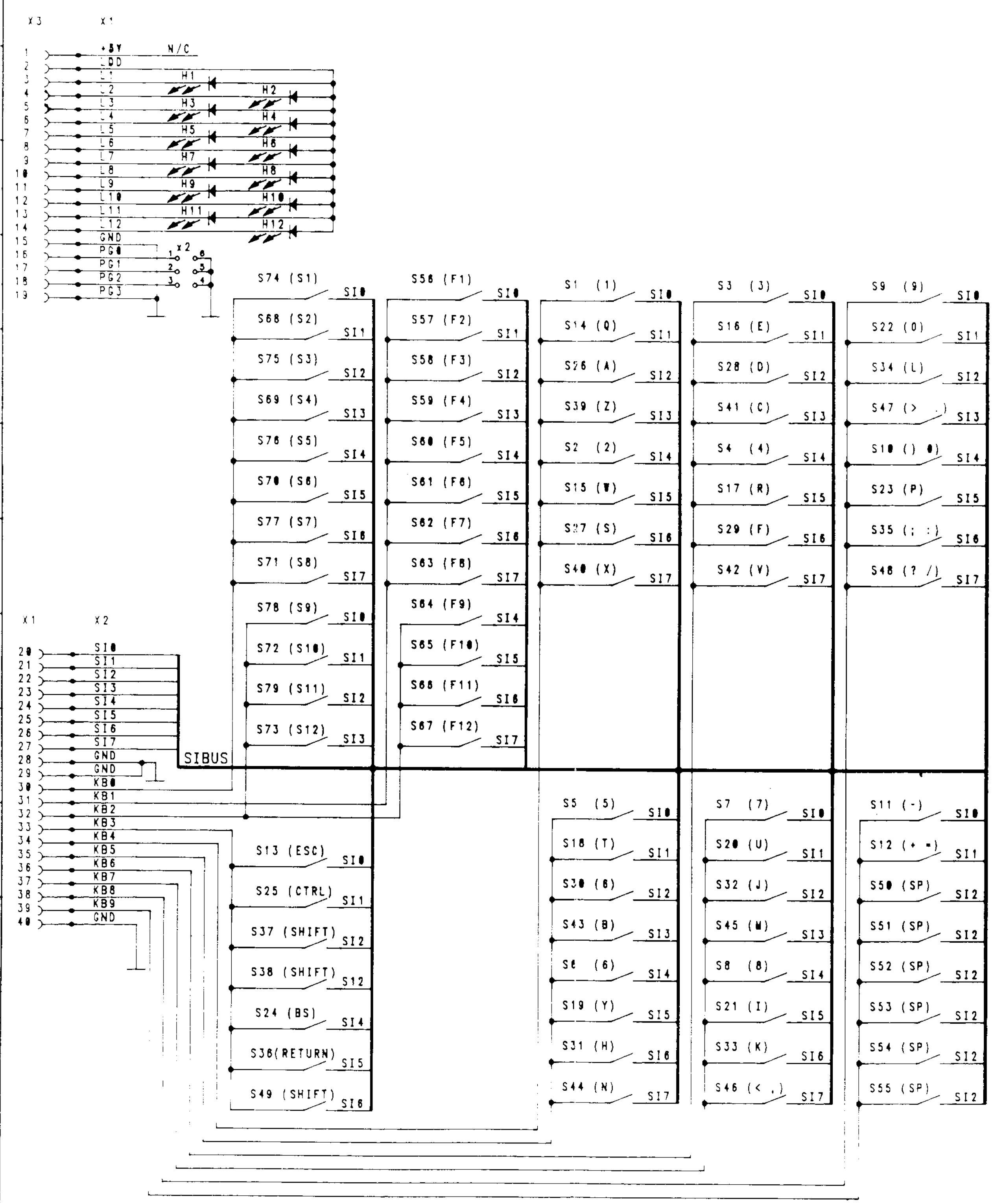
NOTE: First check supply voltages of all the circuits.

3.5 Connecting cable troubleshooting

See Figure C.8 for connecting cable schematic diagram.

Figure C.5 Keyboard parts layout and schematic diagram





9.3.89 SAHE		4284	-2	DATEX INSTRUMENTARIUM OY	NIMI: KEYBOARD
MUUT.	TARK.	HYV.	MUUTOS	MERKKI	PIIRT. / TARK. / HYV.
SIVU 1/1	LAITE CCK-104	N:O CC 3B 874659-2			

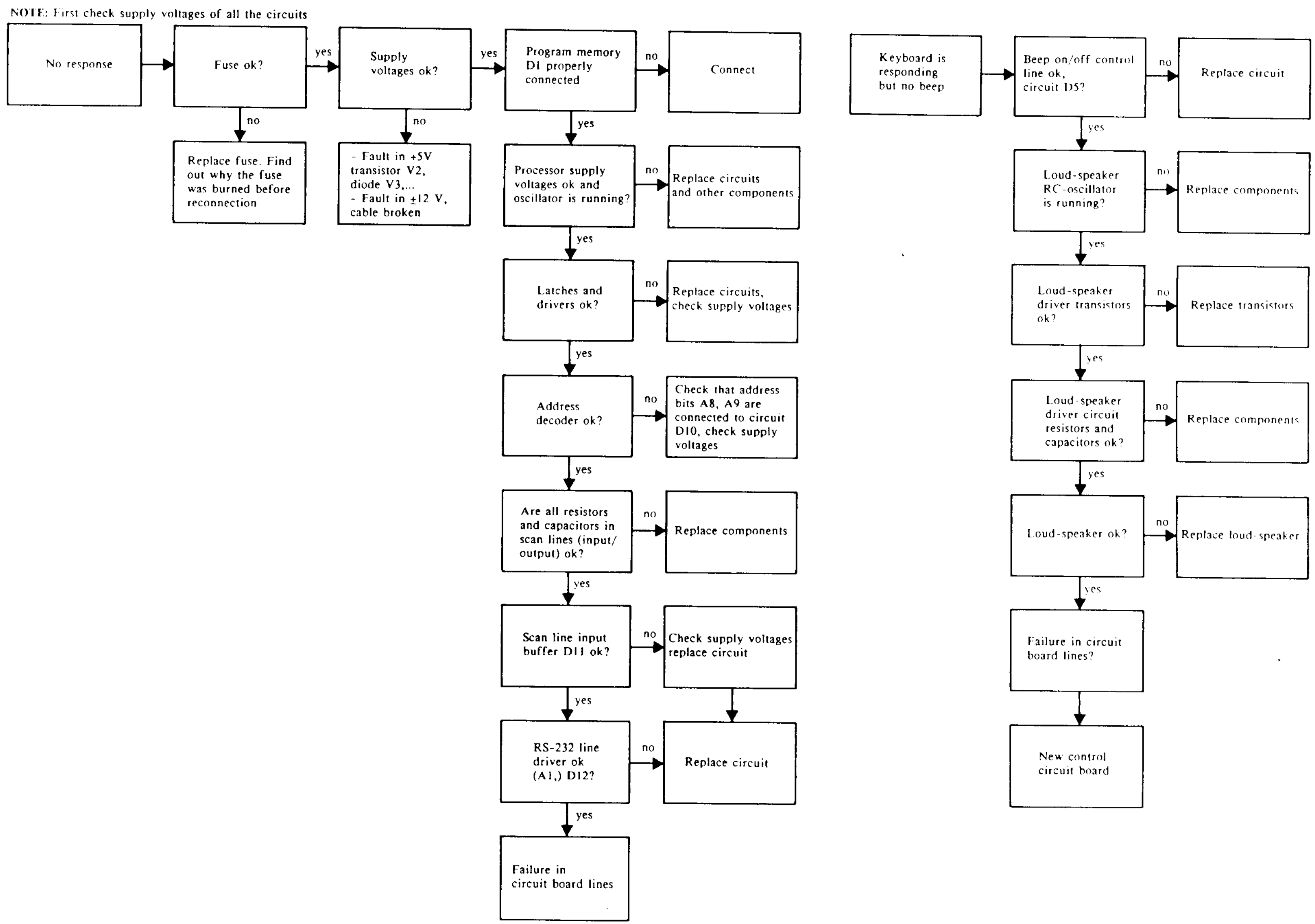
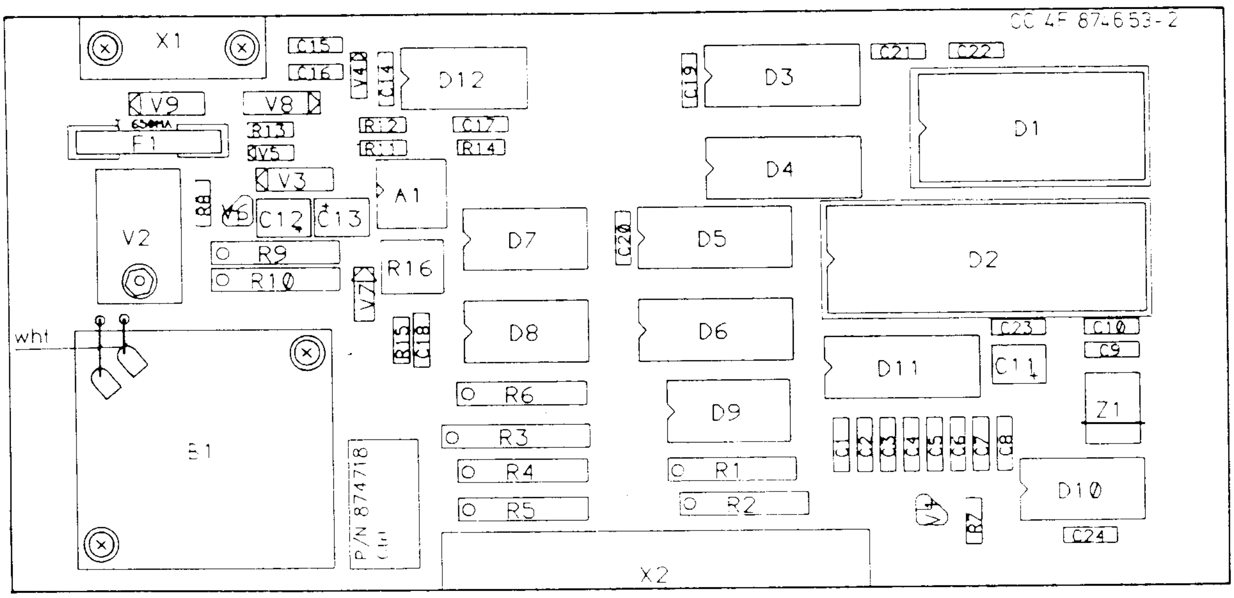
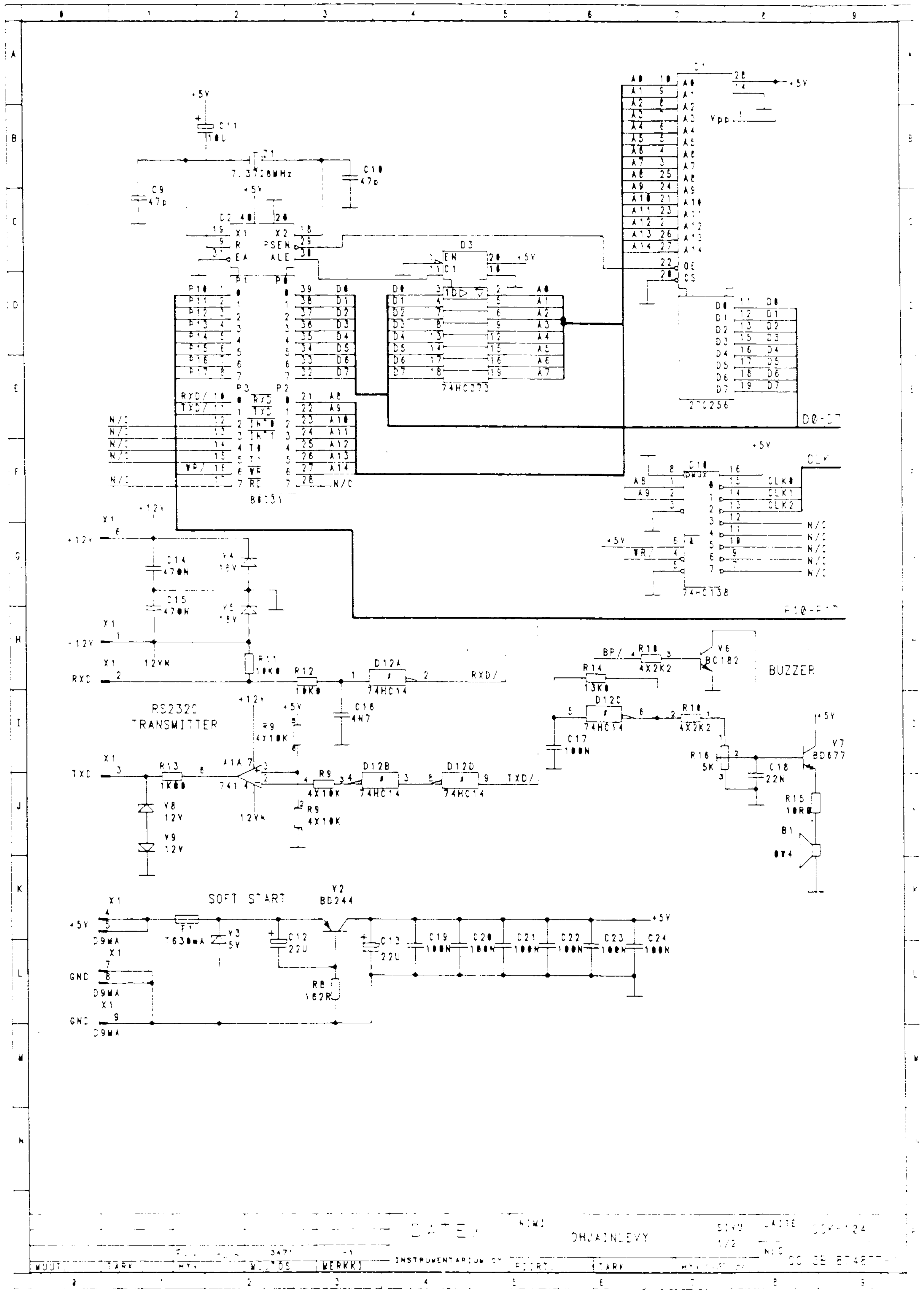


Figure C.6 Control board troubleshooting chart

Figure C.7 Control board parts layout and schematic diagram




80C31
74HC373
27C256
74HC138
74HC14
RS232C
TRANSMITTER
SOFT START
BUZZER
DATEX
OHJAINLEVY
CCK-104
INSTRUMENTARIUM OY

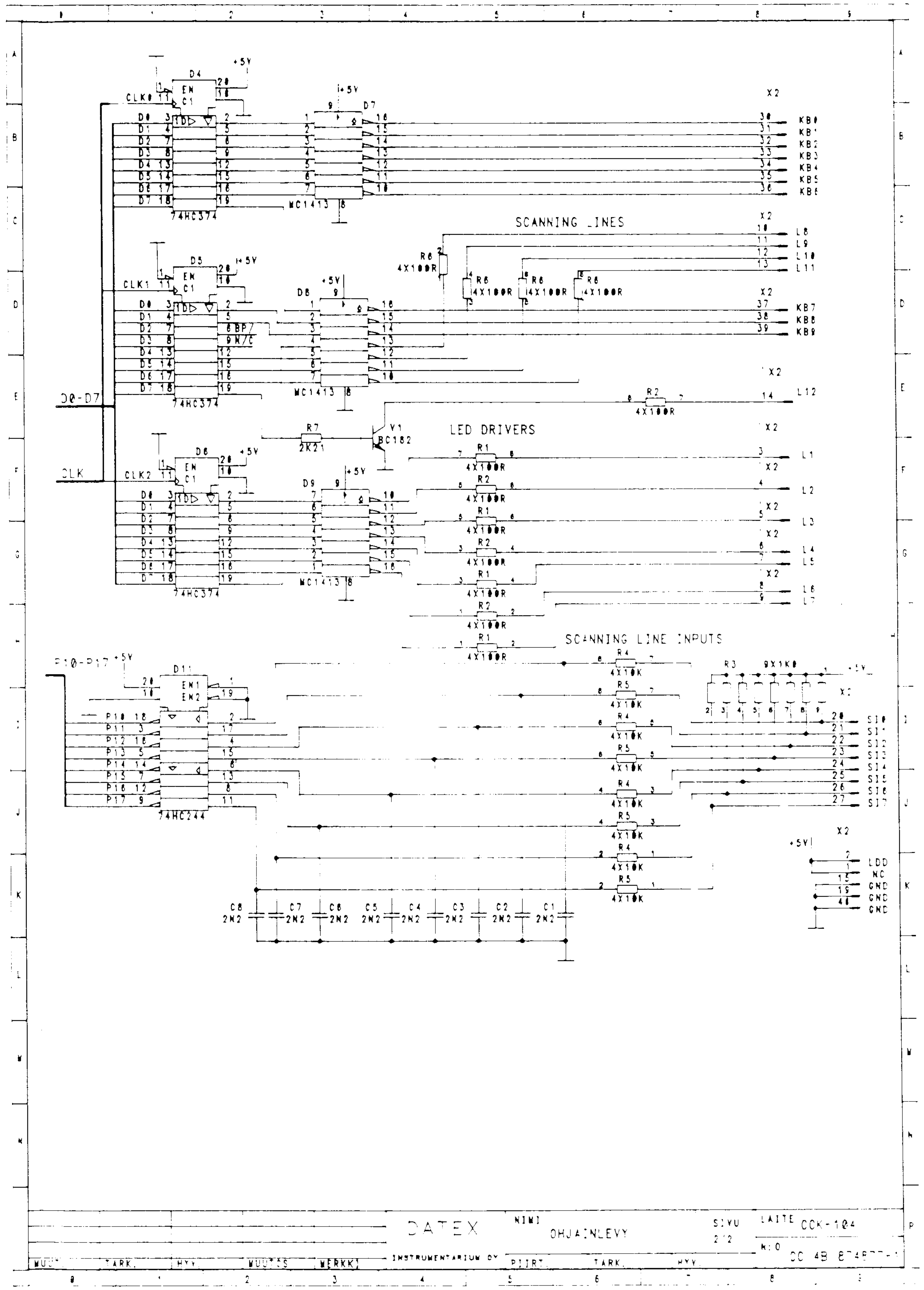
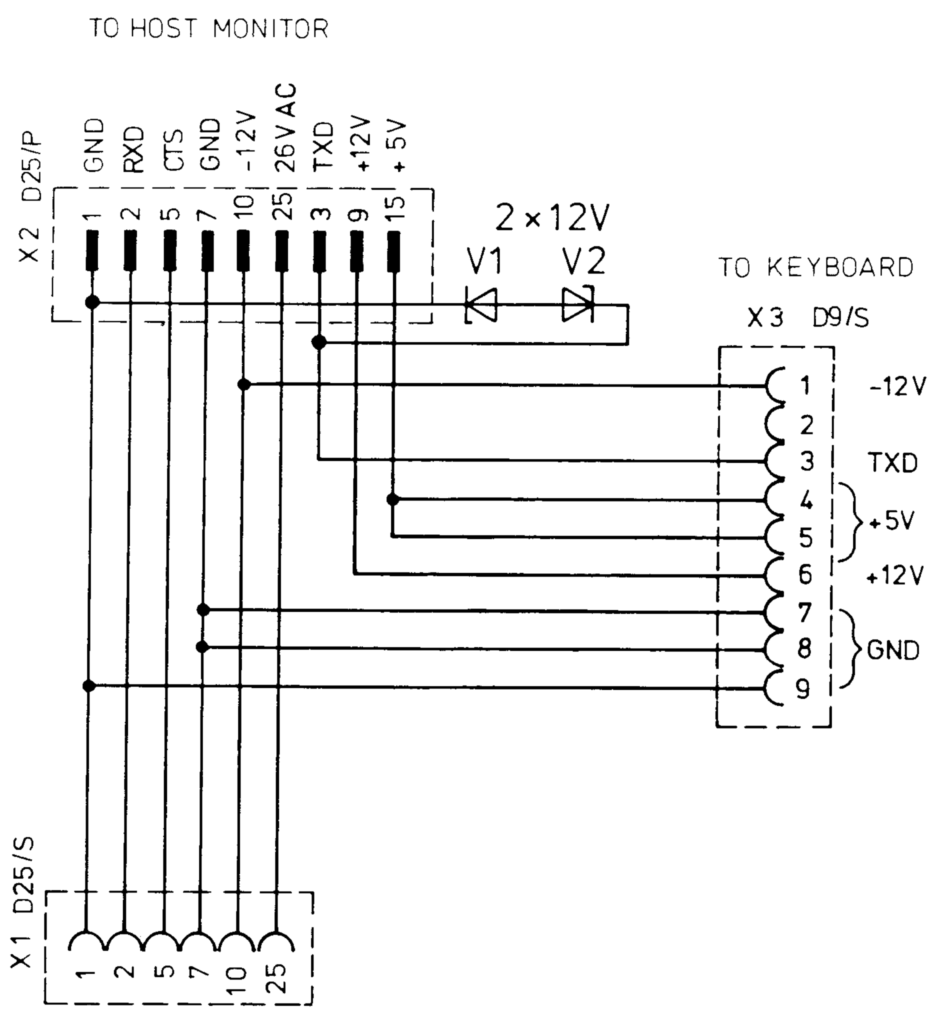

74HC374
MC1413
SCANNING LINES
LED DRIVERS
SCANNING LINE INPUTS
74HC244
DATEX
OHJAINLEVY
CCK-104
INSTRUMENTARIUM OY

Figure C.8 Connecting cable schematic diagram



4 SPARE PARTS

4.1 Spare parts

Item	Item description	Order No.
1	Keyboard	874717
2	Control board	874718*
3	Connecting cable	874720
5	Enclosure, complete	874723
9	Keyboard support plate	874727
10	Plastic keyboard panel	874598*
11	Plastic function key advisory	874732
12	Fuse 630 mA	51114*
13	Loud-speaker	51448
	Keyboard key	52042*

Item number refers to the exploded view in Figure C.9.

* = the part is recommended for stock

Figure C.9 Exploded view of CCK-104 Keyboard