MBM-200

DELTATRAC II™

SERVICE MANUAL

Doc. No. 882330

March lst, 1993

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2 WARNINGS AND CAUTIONS

A WARNING indicates a potentially harmful situation to yourself or others.

ELECTRIC SHOCK HAZARD

* Connect this equipment only to a three-wire, grounded, hospital grade receptacle. Where a two-wire receptacle is encountered, a qualified electrician must replace it with a properly grounded three-wire receptacle. Do NOT remove the grounding prong from the power plug. Do NOT use extension cords or adapters of any type. The power cord and plug must be intact and undamaged.
* Do NOT immerse the monitor in water or any liquid.
* Always turn the monitor 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. Never wear a grounding wrist strap when working on an energized monitor.
* The CRT display unit contains high voltage circuitry.

FUSE REPLACEMENT

* For continued protection against fire hazard, replace only with the same type and rating of fuse.

EXPLOSION HAZARD

* Do not use this monitor in the presence of flammable anesthetics.

PATIENT SAFETY

* Do NOT perform any testing or maintenance on medical instruments while they are being used to monitor a patient.
* Do not measure a comatose or incapacitated patient with the canopy in a place without a source of back-up power to assure continuous operation of the flow generator in the event of a power failure.

- * Constant attention by a qualified individual is required whenever a patient is mechanically ventilated. Some equipment malfunctions require immediate action. A malfunction may pass unnoticed in spite of equipment alarms.

- * Constant attention by a qualified individual is required whenever a patient is measured with the canopy. Problems in delivery of fresh gas may pass unnoticed in spite of alarms. Use a separate O_2 monitor to measure oxygen concentration in the canopy. Use a pulse oximeter to ensure that the patient is sufficiently oxygenated.

OCCUPATIONAL SAFETY

- * After monitoring a patient with hepatitis virus the monitor cover, the water trap container, the mixing chamber, and all used accessories must be disinfected with 5 % chloramine solution.

- * Handle the water trap as you would any body fluid. Infectious hazard may be present.

- * The operator should not perform any servicing except as specifically stated in the Operator's Manual.

OTHER WARNINGS

- * After performing any repair or calibration procedure to the monitor, perform a final electrical safety check and leakage current test.

- * There are special components used in this device which are vital to assure reliability and safety. Datex assumes no responsibility for damage if replacement components not approved by Datex are used.

- * The manufacturer accepts no responsibility for any modifications made to the monitor outside the factory.

Please get acquainted with other operational warnings listed in Operator's Manual.

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

STORING

* Do not store the monitor outside the specified temperature range (-5 to +50°C).

INSTALLING

* Do not apply tension to the line cord.
* Check rear panel voltage setting before connecting the monitor to AC mains power.
* Leave space behind the monitor to allow for proper ventilation.

OPERATING

* Before use, allow five minutes for warm-up and note any error messages or deviations from expected operation. See the Operator's Manual for detail.
* 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.
* Connect sampling line to the monitor prior to power up or reset to enable proper measurement of internal reference pressures.

CLEANING

* Do not use ammonia-, phenol-, or acetone-based cleaners. These cleaners may damage the monitor surface.
* Do not autoclave or gas sterilize the monitor.
* Clean rear panel fan dust filter once a month or whenever necessary.

SERVICING

* The tests and repairs outlined in this manual should only be attempted by trained personnel. Unauthorized service may void warranty of the unit.

* Servicing of this product in accordance with this service manual should never be undertaken in the absence of proper tools, test equipment and the appropriate revision of this service manual.

* 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.

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

* When assembling or disassembling any part inside the monitor, be careful **not to kink or damage the gas sampling** tubes. Leakages in the gas sampling system affect accuracy of measurement and are difficult to detect.

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

Please get acquainted with other operational cautions listed in Operator’s Manual.

3 INTRODUCTION AND APPLICABILITY OF THIS MANUAL

3.1 Introduction and Applicability of This Manual

This service manual (Doc. No. 882330) and the separate Panasonic M-K9101NB CRT Data Display service manual (available from Datex Doc. No. 572760) give the information required to maintain and repair the Datex Deltatrac II MBM-200 Metabolic Monitor. This manual is applicable for the current production revision of the monitor. 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 the 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. MBM-200-23-00 is a revision -00 unit).

Functional units of the monitor (pc boards and measuring units) **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.

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

3.2 Manual Updates

Revision -00

Initial production revision of the monitor.

3.3 Manual Updates

3.3.1 Service Manual Changes

This is update number 1 to the Deltatrac II Service Manual published on March lst, 1993. Carry out the update by replacing pages which already exist in this manual.

After updating, sign the record of updates in Section 33.2.

No	**Page**	**Change**	**Date**
1	Cover	Country code changed from sf to fin.	Feb. 1. 1994
	3-5	Software upgraded to -2 level.	
	6-l	DATEX TECHNICAL SERVICES simplified to Datex.	
	6-15	Canopy (room air) is corrected to Canopy (supplementary oxygen).	
	6-17	Figure 6.4 caption corrected.	
	6-18	Table 6.2 corrected.	

3.3.2 Record of Manual Updates Carried Out

Update number	Carried out by Name	Date
1	Datex	February 1st, 1994
2		
3		
4		
5		
6		
7		
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3.4 Software Changes

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

Revision 00 Software 882123 is the initial English language production software revision. Software 882125 is the initial German language revision. Software 882124 is the initial French language version.

Software 882123-2 is the current English language production software revision. Software 882125-2 is the current German language revision. Software 882124 is the current French language version.

Main differences to the initial software are:

1. The average RQ accuracy is improved by calculating it directly as the ratio of the average VCO_2 to the average VO_2.

2. To enable artefact supression during measurements with continuous flow ventilators with bypass flows the low alarm limit of the mixed expiratory CO_2 concentration is lowered from 1 % to 0.2 % in the mixing chamber.

3. The calculation of FiO_2 in respirator mode displayed and printed errors of several % (for instance, 52 % actual FiO_2 was displayed as 49 %). This flaw has been corrected.

4. Printer selection increased to include EPSON-type printer such as Kodak Diconix 18Osi.

4 GENERAL DESCRIPTION

4.1 Specifications

Method	Open-system indirect calorimeter for measurement of both mechanically ventilated and spontaneously breathing patients.
Gas measurement ranges	O_2 consumption 5...2000 ml/min CO_2 production 5...2000 ml/min Inspiratory sampling rate 150 ml/min
CO_2 measurement	Datex infrared sensor Range 0...l0 % Baseline drift: Automatically compensated Gain drift: <2 % of full scale / 24 hours Gain temp drift: <0.2 % of full scale / °C Linearity error: <2 % of full scale Automatic compensation for CO_2-O_2 collision broadening effect
O_2 measurement	Differential paramagnetic sensor Range - low resolution channel -100...+100 % - high resolution channel -10...+10 % Baseline drift: Automatically compensated Gain drift: <2 % / 24 hours Gain temp drift: <0.2% / °C Linearity error: <2 % Automatic compensation for respirator pressure effects

Flow measurement

Typical flow 80.0 l/min obese persons
40.0 l/min adults
12.0 l/min children
3.0 l/min babies

The flow value is calibrated specifically for each unit.

Alarms Patient disconnection and loss of fresh gas flow in canopy mode (no-breathing alarm). Loss of power (duration 1 minute). Low air flow. Tidal volume alarm in respirator mode.

Display	9" green monochrome picture tube with graphics. Resolution 1024x256 pixels. Real time clock. Running time from the beginning of the measurement.
2 selectable trend windows:	- parameters VO_2, VCO_2, RQ, EE in both measurement modes and VE only in respirator mode - normal trend 2 hours and long trend 24 hours in respirator measurement - normal trend 1 hour and long trend 4 hours in canopy measurement Numeric values of VCO_2 FiO_2 VO_2 RQ and EE in both measurement modes, additionally and VE in respirator mode.
Printer	Ink jet printer with graphics capabilities, 96 x 96 dots per inch. Speed: 150 characters per second. Interface: RS232C Noise level: 50 dB(A) Dimensions (W x D x H): 292 x 206 x 89 mm Weight: 2.5 kg Power requirements: 100/120/220/240 VAC; 50/60 Hz; 8.0 W
Time	Built-in real time clock and calendar.
External connections	RS-232C serial interface for computer and graphics printer. Composite video output for slave display. CO_2 and O_2 analog signals.
Dimensions	Depth 340 mm Width 420 mm Height 310 mm (460 mm with printer on top)
Weight	21 kg (without Printer)
Warm-up time	30 minutes after a cold start.
Power requirements	100/115/220-240 V~; 50/60 Hz, 90 VA
Operating temperature	+l0...+35°C
Storage temperature	-5...+50°C
Relative humidity	10 % to 90 %
Safety	IEC 601-l/GSA C22.2 No. 125
Ordering information	Order code MBM-200

4.2 Principle of Operation

The Deltatrac Metabolic Monitor can be used to monitor gas exchange and energy expenditure of both spontaneously breathing and mechanically ventilated patients. Figures 4.1 illustrate the three patient connections, i.e. canopy mode in room air and in supplementary oxygen, and respirator mode measurements.

The expired gases from the patient are collected into the mixing chamber part of the monitor. The Deltatrac gas measuring system takes gas samples from the inspiratory gases through a separate sampling line; the mixed expired gases from the mixing chamber; the output of the constant flow generator; and through the air reference inlet. Out of the oxygen and carbon dioxide concentrations in these gas samples it is possible to determine:

- carbon dioxide production (VCO_2)

- oxygen consumption (VO_2)

- respiratory quotient ($RQ = VCO_2/VO_2$)

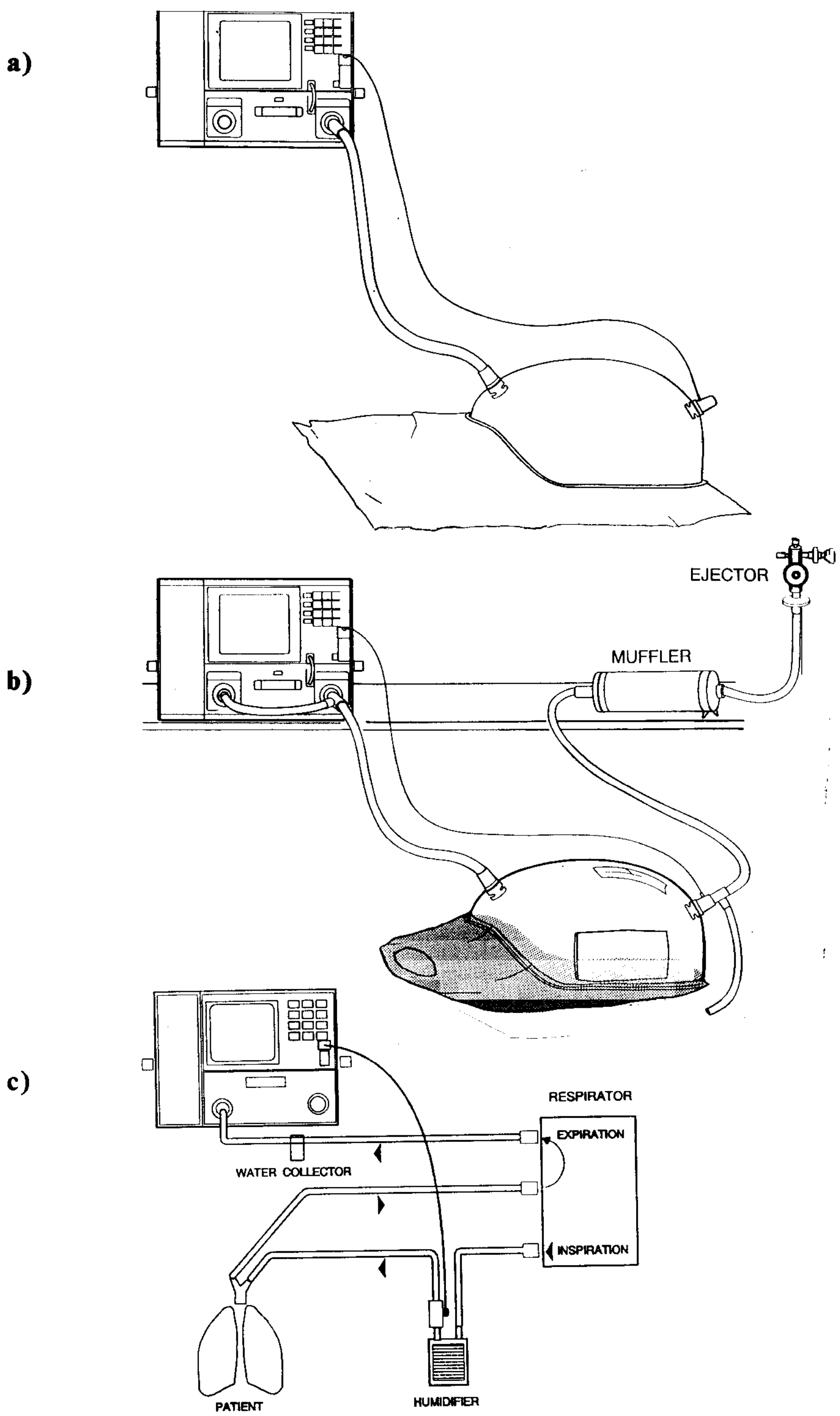
- energy expenditure (EE)

- minute ventilation (VE, displayed only in respirator mode)

The flow rates of the constant flow generator have been determined individually for each monitor.

Figures 4.1 Different Modes
a) Canopy mode in room air; b) Canopy mode in supplementary oxygen; c) Respirator mode setups

WARNING: The plug must be connected when the monitor is used in the canopy mode.



4.3 General Block Diagram

The simplified block diagram in Figure 4.2 shows the electrical configuration and the interconnection of different parts of the monitor.

The operation of the monitor is controlled by the CPU board consisting of processor, RAM, EPROM and EEPROM; analog multiplexers, A/D and D/A converters to read in and send analog voltages; and components to interface with the external bus and keyboard.

The gas concentrations are determined using infrared techniques for CO_2 measurement (CO;! measuring unit and measuring board) and a paramagnetic sensor for O_2 measurement.

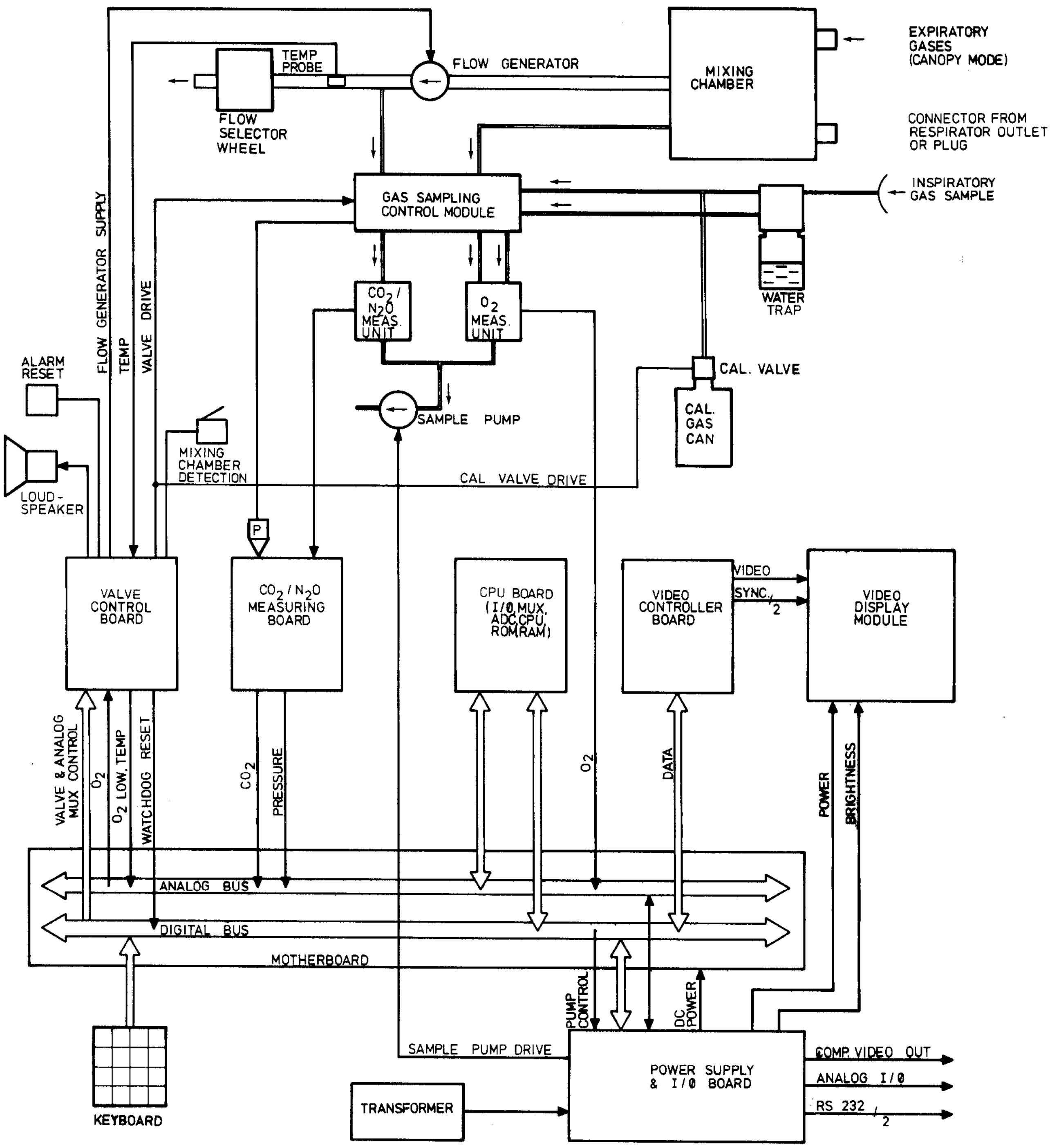
The gases are multiplexed to the gas transducers with magnetic valves in the gas sampling control module. The valve drivers are located on the valve control board and the measuring sequence is controlled by the CPU. In addition, the valve control board consists of the loud-speaker driver, an O_2 amplifier for measuring small oxygen differences and a temperature amplifier for measuring the gas temperature at the output of the constant flow generator.

The valve control, CO_2 measuring, CPU, and video controller boards are mounted directly on the mother board, whereas the power supply board and flow selector wheel are on the rear panel and the keyboard on the front panel.

Auto calibration box that houses calibration gas can is attached to the left side of the monitor.

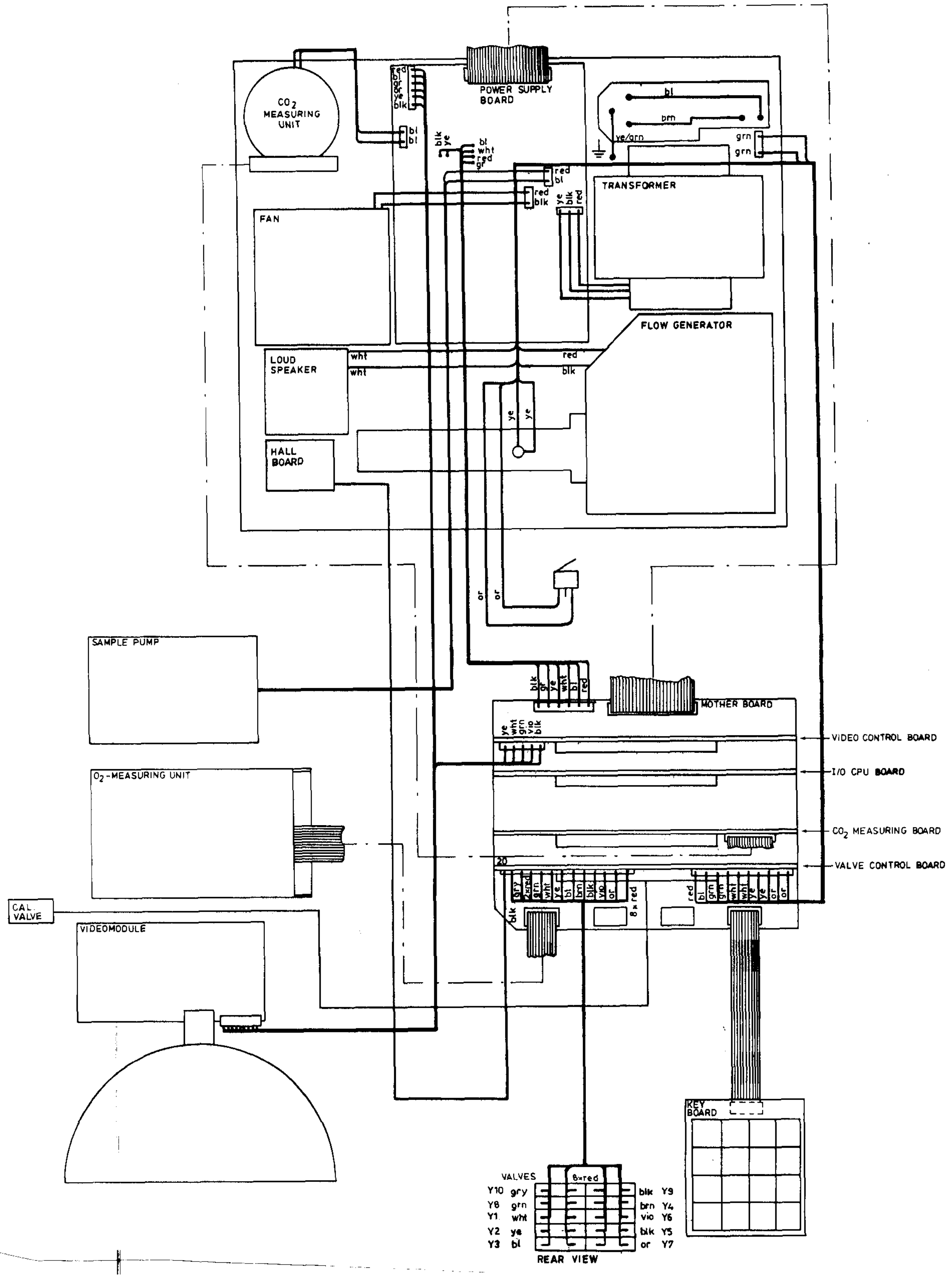
For monitor parts locations see Figure 9.1 in Chapter 9.

Figure 4.2 Simplified Block Diagram



4.4 Wiring Diagram

Figure 4.3 Wiring Diagram



4.5 Connector Configurations

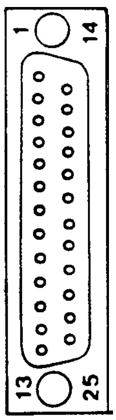
Rear panel video out connector

BNC-connector. Composite video signal: 1 Vpp, 75 Ohm, 24 MHz bandwidth.

Rear panel D-connectors

See Tables 4.1a and 4.1b

Table 4.1a Rear Panel D-connectors. Serial/Analog I/O



Pin No	I/O	Signal
1		Shield ground
2	0	TXD (RS232)
3	I	RXD -"-
4	0	RTS -"-
5	I	CTS -"-
6	I	PB4 (TTL) (do not connect)
7		Signal ground
8	I	PB3 (TTL) (not used)
9	0	+12 VDC, 50 mA max
10	0	- 12 VDC, 50 mA max
11	0	+15 VDC, 100 mA max
12	0	-15 VDC, 100 mA max
13	0	ADC6, control board mux
14	0	O_2, 10 V = 100 % O_2, DACl
15	0	5 VDC, 500 mA max
16	0	selftest, DAC7
17	0	alarm frequency, DAC6
18		ADC2 (not used)
19	0	O_2LOW, 10 V = 10 % O_2, DAC2
20	0	CO_2, 10 V = 10 % CO_2, DAC0
21	0	+26 VDC, 1 A max
22	I	ADC7 (not used)
23	0	-26 VDC, 1 A max
24	0	22 VAC, 1 A max
25	0	22 VAC, 1 A max

NOTE: The maximum current ratings for the supply voltage outputs (pins 9 through 12, 15, 21, and 23 through 25) are for the total of both serial/analog I/O, and AUX I/O.

Table 4.1b Rear Panel D-connectors. AUX I/O

Pin No	I/O	Signal
1		Shield ground
2	O	TXD1 (RS232)
3	I	RXD1 -"-
4	O	RTSl -"-
5	I	CTSl -"-
6	I	PBI (TTL) (not used)
7		Signal ground
8	I	PB0 (TTL) (not used)
9	O	+12 VDC, 50 mA max
10	O	- 12 VDC, 50 mA max
11		Not connected
12		Not connected
13	I	CTS2 (TTL) (not used)
14	O	TXD2 (TTL) (not used)
15	O	+5 VDC, 500 mA max
16	O	RXD2 (TTL) (not used)
17		PA5 (TTL) (not used)
18		PA6 (TTL) (not used)
19	O	RTS2 (TTL) (not used)
20		PA7 (TTL) (not used)
21	O	+26 VDC, 1 A max
22		Not connected
23	O	-26 VDC 1 A max
24	O	22 VAC, 1 A max
25	O	22 VAC, 1 A max

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

- RTS = request to send (not used presently).

- No serial inputs used.

- Serial channel 2 is unbuffered TTL. DO NOT CONNECT EXTERNALLY. For test purpose only.

- The maximum current ratings for the supply voltage outputs (pins 9 through 12, 15, 21, an 23 through 25 are for the total of both serial/analog I/O, and AUX I/O.

CAUTION: Connect cables manufactured or recommended by Datex to the rear panel connectors.

5 DETAILED DESCRIPTION OF MODULES

5.1 Sampling System

The function of the sampling system is to draw gas samples into the CO_2 and O_2 measuring systems at a fixed rate and to separate condensed water and impurities from the gas flow. The gas samples are taken from the inspired gas through the external sampling line, from the mixing chamber through the front panel, from the air reference through the front panel and from the diluted expiratory gas at the flow generator.

The sampling line is connected to the water trap on the front panel. The pump inside the monitor draws gas from patient circuit through the sampling line to gas measuring units. After the measurements, the gas is exhausted from sample gas out connector on the rear panel of the monitor.

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 Sections 5.2 and 5.3).

The side flow creates a slight sub-atmospheric pressure within the collection container which causes fluid to collect in it.

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

Five special tubes are 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.

> **CAUTION:** The material of these special tubes is mechanically fragile. Small leakages may occur if the tube is bent or kinked.

Gas measuring units

In the CO_2 measuring unit, infrared light is passed through a chamber 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 5.3.2 for a detailed description of this unit.

The CO_2 channel is zeroed automatically using a CO_2 absorber. Figure 5.1 shows the schematic diagram of the sampling system, the components layout is illustrated in Figure 6.6.

The oxygen sensor has two input ports. One port draws in the main flow and the other draws in room air for reference. The sensor measures the pressure gradient by exposing both gases to an oscillating magnetic field. See Section 5.3. Both gas flows exit from a single port.

Magnetic valves

Gas sampling is controlled by magnetic valves. The measuring sequence is illustrated in Figures 6.4 and 6.5 and Tables 6.1 and 6.2 give the corresponding valve positions.

The differential nature of the O_2 measuring system is utilized when measuring the difference between the inspired and mixed expired oxygen concentration.

Room air is drawn into the internal system and the gas sensors by activating the valves.

Canopy mode

In canopy mode the flow generator draws gas at a fixed rate: 80 l/min for obese person, 40 l/min for adult, 12 l/min for child, and 3 l/min for baby. The rates are adjusted with the flow selector wheel on the rear panel.

Flow cassettes

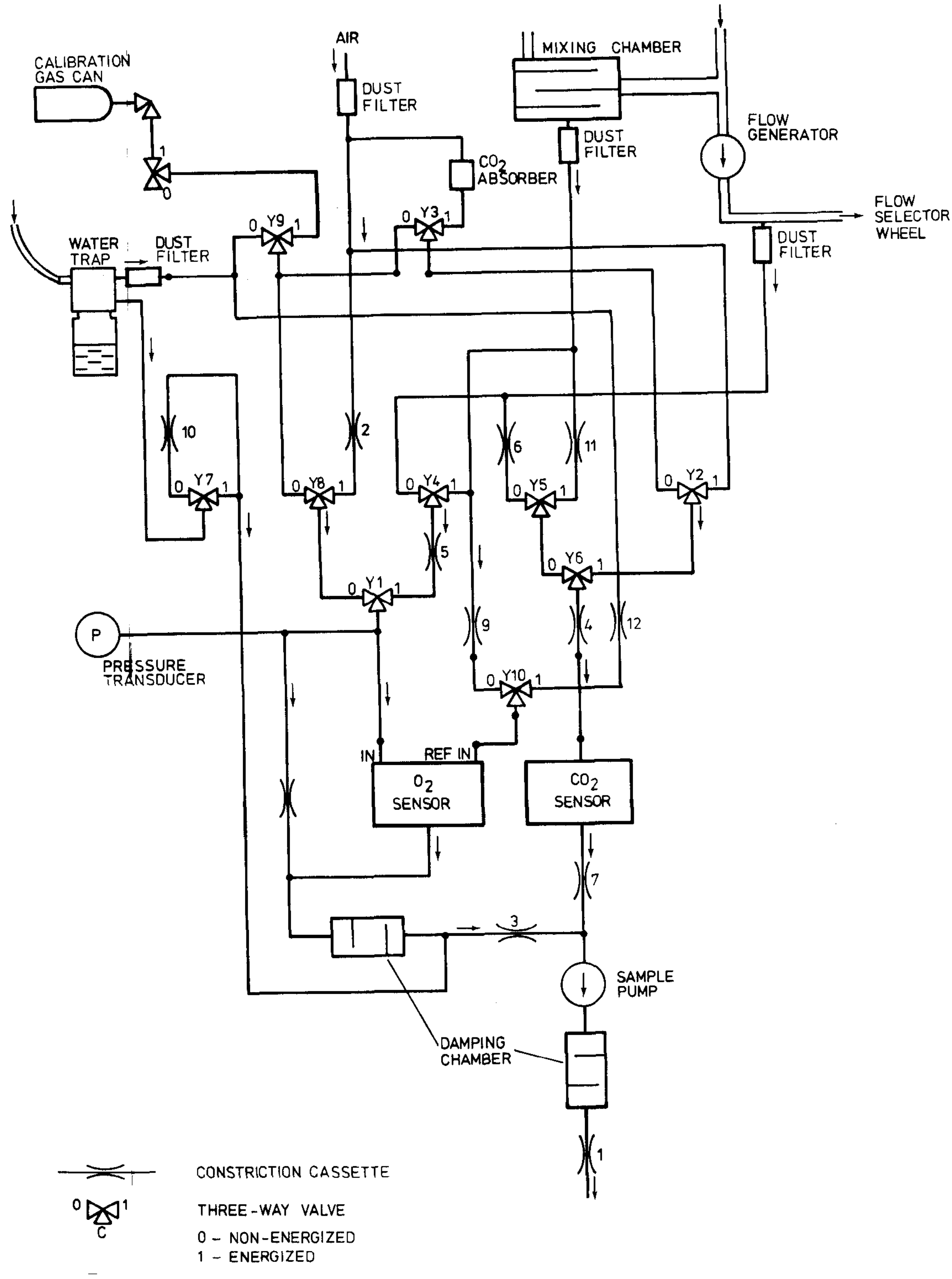
The internal flow rates are set using flow cassettes. These cassettes are used to balance flow and pressure in the O_2 and CO_2 measuring units during different stages of the measuring sequence.

Sampling pump and damping chamber

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

The damping chamber is used to even out the pulsating flow and silence the exhaust flow.

Figure 5.1 Sampling System Schematic diagram



5.2 Principle of CO_2 Measurement

5.2.1 General

The CO_2 gas measurement is 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 4.3 micrometers wavelength using an infrared detector. The signal processing electronics receive the signals from the IR detector and demodulate it to get DC component out of this signal which correspond to the content of CO_2 gas in the sample.

Figure 5.2 shows the CO_2 gas absorption spectra.

NOTE: Despite the mentioning of N_2O gas measurement in the drawings, the ability to measure N_2O concentration is not utilized in this monitor.

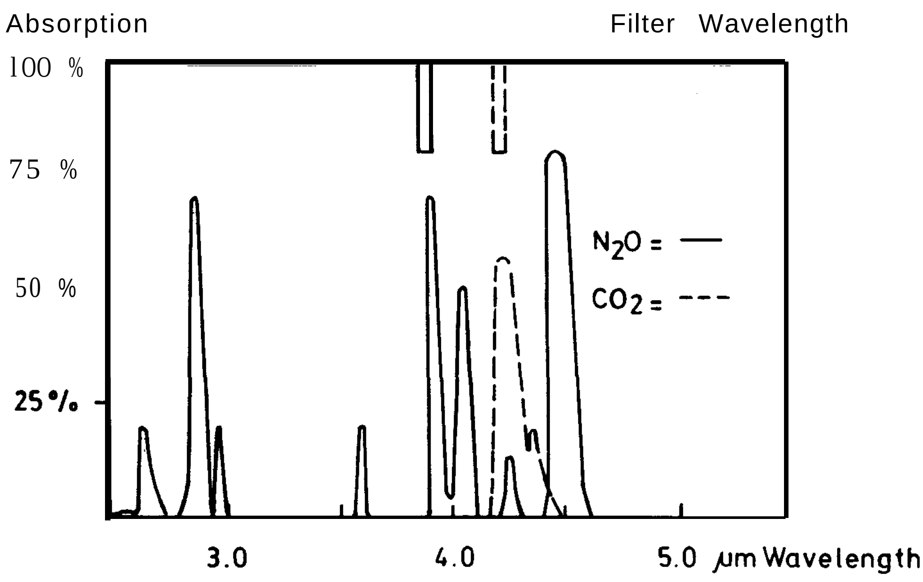


Figure 5.2 CO_2 Gas Absorption Spectra

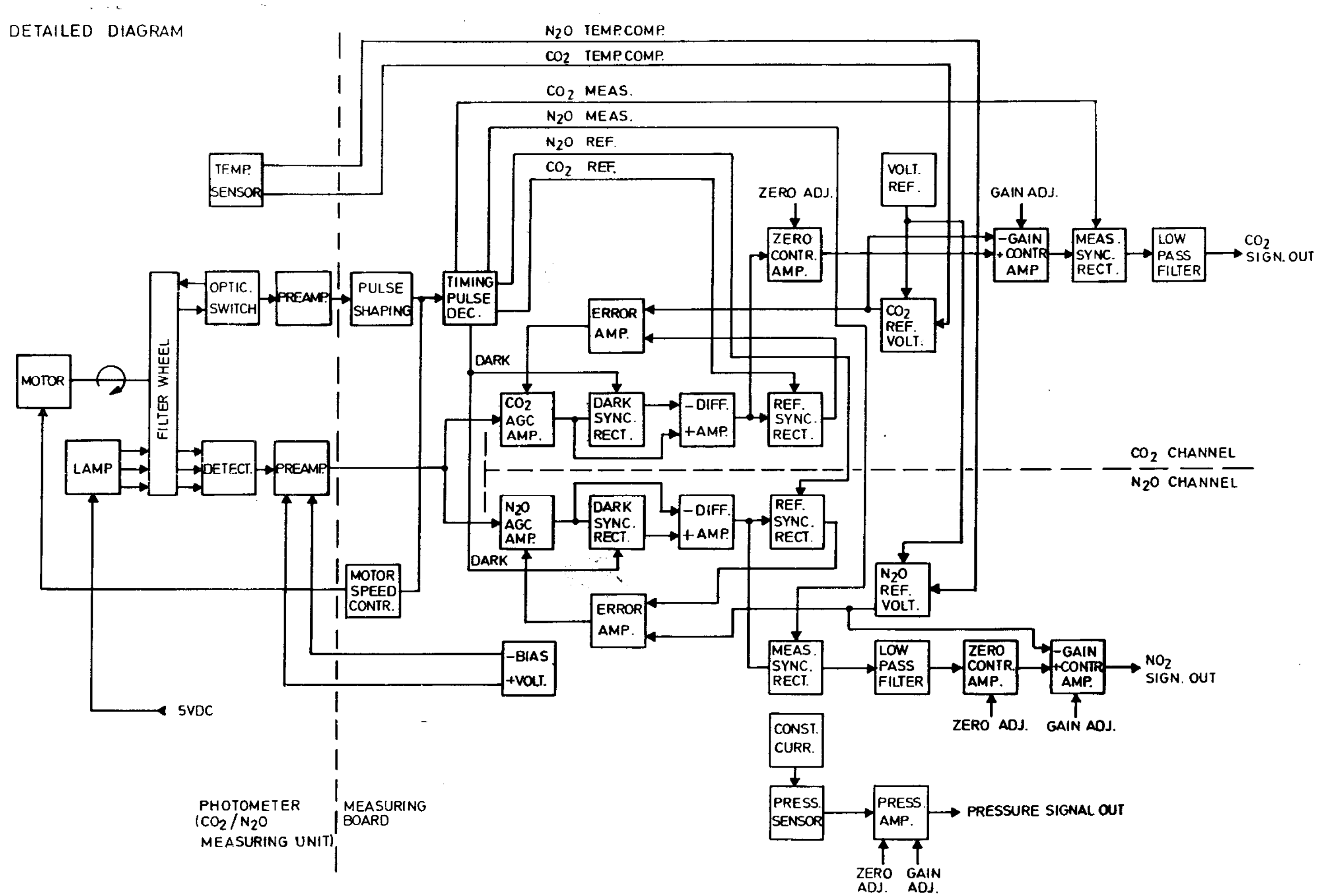


Figure 5.3 CO_2 Measuring System Block Diagram

5.2.2 Photometer

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

The exploded view of the photometer is shown in Figure 5.4.

A filter wheel is used to control the light from an incandescent lamp that passes through the photometer. The filters are arranged so that 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

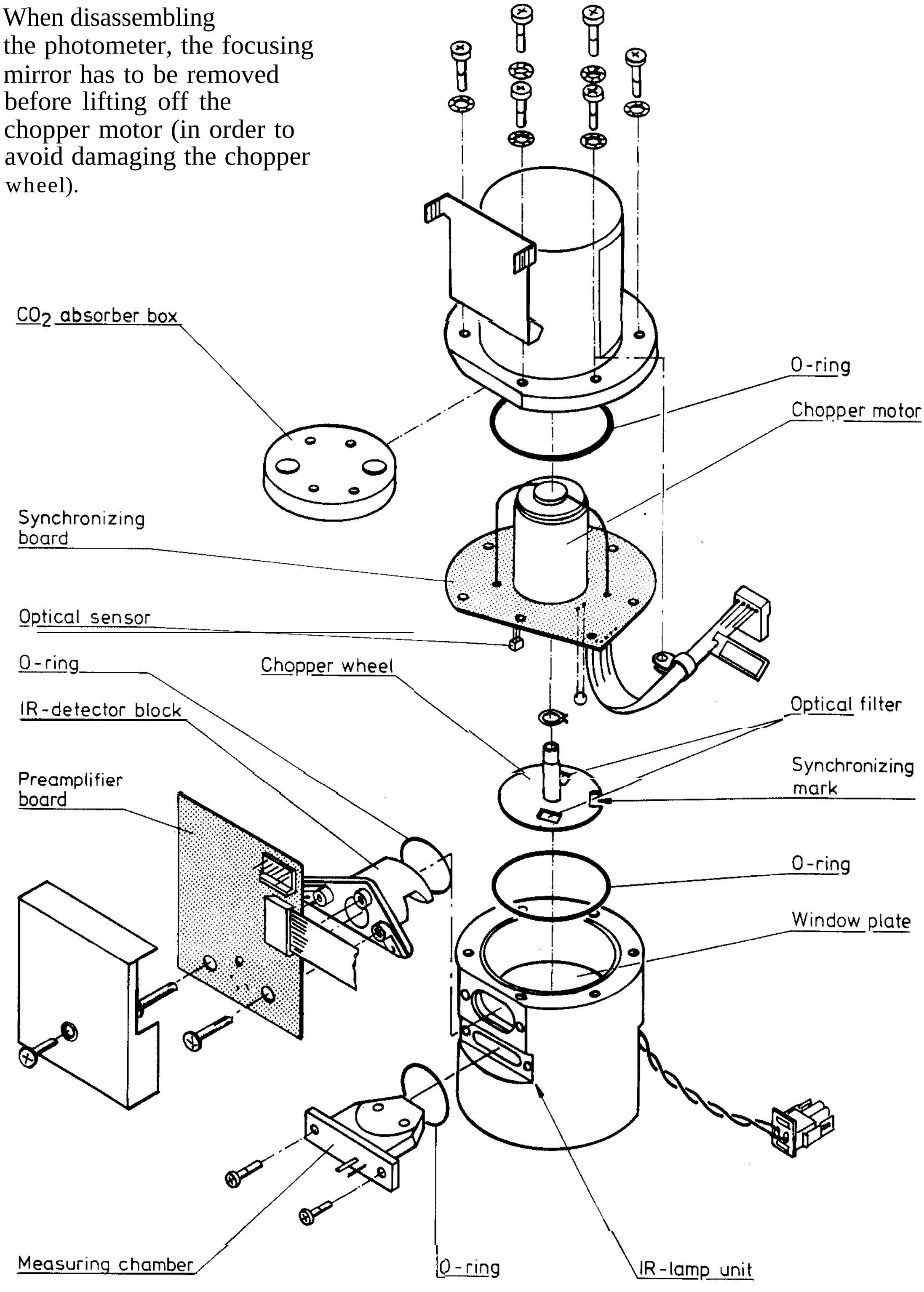
After passing through the filters the light is reflected and focused by a mirror onto the infrared detector. This detector measures the three light levels. The detector block is mounted on the preamplifier board (see 5.2.3).

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

A stabilizing diode measures the temperature which is needed to compensate for thermal drifts. The infrared detector, the optical sensor, and the stabilizing diode are mounted on the preamplifier board.

Figure 5.4 Photometer

Note: 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).



5.2.3 Preamplifier

The schematic diagram and parts layout of the preamplifier are shown in Figure 6.8.

The purpose of the preamplifier is to amplify the signals from the infrared detector, timing sensor, and thermistor and to convert them to a lower impedance level.

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

The temperature signal from the stabilizing diode is converted to voltage T+ with an inverting amplifier Al. This signal is further inverted to T- by another amplifier in Al. When the temperature rises, T+ goes up and T- down. 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 Al.

5.2.4 CO_2 Measuring Board

The measuring electronics can be divided into a few functional blocks (refer to the measuring system block diagram in Figure 5.3).

Detector bias generator

The lead selenite detector is a resistor, whose resistance changes with intensity of infrared light. The detector is supplied with a high bias voltage to produce a high signal level.

The bias voltage generator is a square wave oscillator A8 (refer to Figure 6.9), and a voltage doubler consisting of diodes V6 to V9 and capacitors C34, C35, C37, and C38. The circuit produces an output voltage range of approximately ±22 V.

Timing electronics

The timing electronics consists of a pulse shaping circuit consisting of three sections of A8, and logic circuits D3 to D7. See the timing diagram in Figure 6.9.

The phase-locked loop D6 gives an output frequency which equals the signal frequency multiplied by 40. This output is divided by 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.

CO_2 measuring electronics

The signal from the preamplifier is fed to the measuring board through X2 pin 5. It is first amplified by 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 (l/4 Dl) to capacitor C3. The dark level is subtracted from the original signal with a differential amplifier (l/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 Cl0. This voltage is compared to a preset voltage by l/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 preset voltage. The preset voltage is initially supplied by V2. To compensate for effects 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 preset voltage and consequential the gain of the AGC amplifier.

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

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 keeps the duty cycle of the pulse train constant, and consequential stabilize the speed of rotation of the motor. The transistor V15 limits the motor current to approximately 50 mA.

5.3 0_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, which usually is room air, are conducted into a gap in an electromagnet with a strong magnetic field switched on and off at a frequency of approximately 110 Hz (see Figure 5.5).

An alternating differential pressure is generated between the sample and reference inputs due to forces acting to the oxygen molecules in a magnetic field gradient.

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 sensor should not be attempted, and therefore the detailed description of the circuitry and layout of the transducer is omitted from this manual.

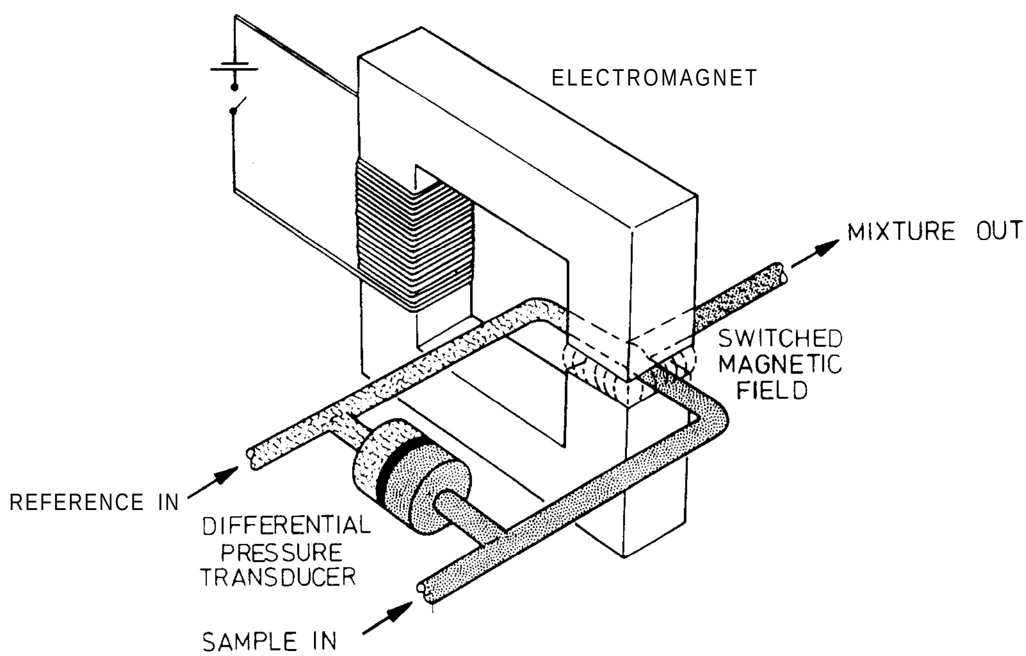


Figure 5.5 O_2 Measurement Functional Principle

5.4 Valve Control Board

The valve control board consists of several independent functions: valve drivers, watchdog circuit, loudspeaker driver and power interrupt alarm circuit, O_2 signal amplifier for measuring small oxygen signals, temperature amplifier, power regulator for the constant flow generator and gas sampling valves, and analog multiplexer. The valve control board block diagram is in Figure 5.6. The parts layout and schematic diagram are shown in Figure 6.11.

The programmable peripheral interface (PPI) circuit D2 controls the valve drivers consisting of D5, D6, D8, and D9. Auto calibration valve is controlled by D9. The analog signal to be connected to the mother board analog channel ADC6 is selected by the PPI.

Hall board in the flow control wheel base sends the detected wheel position to the PPI.

The purpose of the watchdog circuit is to make sure that the CPU and a part of the peripheral electronics is functioning properly. The CPU writes refresh pulses to the circuit via the PPI. If the pulse interval is greater than the watchdog time constant (approx. 60 ms), D4 starts sending RESET pulses to the CPU.

The alarm frequency is generated by one half of the dual oscillator D7. This frequency can be altered by the CPU board by varying the DAC6 voltage which is connected to the control pin 3 of D7. The function of the other part of the oscillator D7 is to generate an intermittent alarm sound if the refresh pulses to the watchdog circuit stop, or when the power switch is turned off or the monitor is unplugged in the canopy mode. This alarm can be reset by discharging capacitor C32 with the alarm off button switch on the rear panel.

If the voltage at pin 5 of A2 is high, the pulses from pin 5 of alarm oscillator D7 can proceed to the loud-speaker driver transistor V8 at full amplitude, i.e. the alarm is on at maximum sound level. The sound level can be altered by varying the DC voltage at pin 5 of A2. This is how the CPU can control the alarm sound level with voltage DAC5.

Signal from the microswitch for mixing chamber detection is amplified in A3 and sent to D3 for software purpose.

The gas temperature is measured with an NTC resistor located in the flow generator gas outlet tube on the rear panel. The temperature signal is amplified also in A3. Part of A3 is also used for amplifying the oxygen signal when small oxygen differences are being measured.

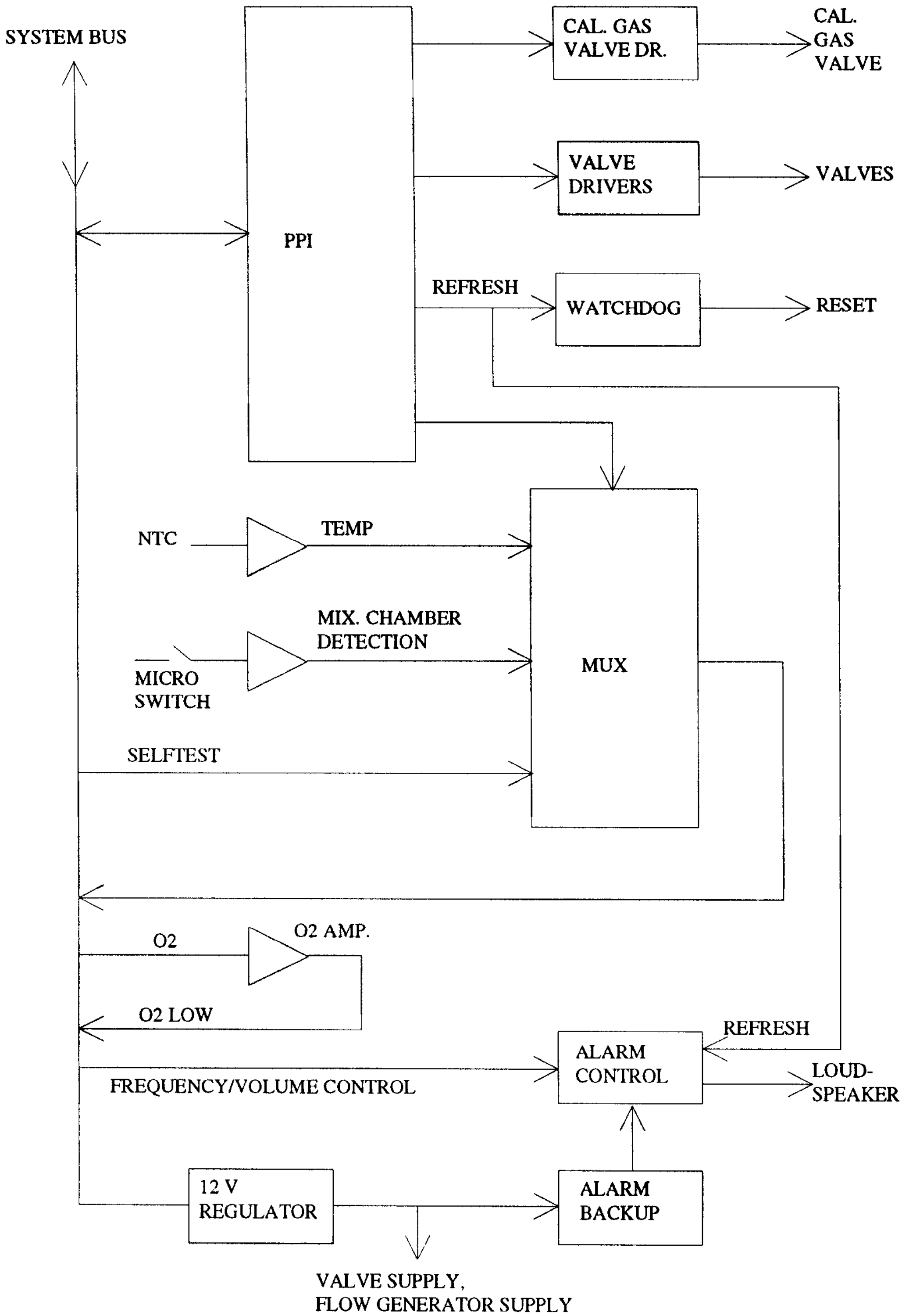
The 12 V supply voltage for the constant flow generator and the gas sampling valves is regulated with A4. Value of resistor R51 is factory set for the constant flow generator installed in the monitor. The value is either 243 ohm or 274 ohm.

If the valve control board is replaced and the new flow constant is below 38 l/min, change R51 to 243 ohm resistor.

If the constant flow generator is replaced and the new flow constant is over 45 l/min, change R51 to 274 ohm resistor.

Changing the value of R51 will increase/decrease the flow constant about 4.5 to 5.0 l/min.

Figure 5.6 Valve Control Board Block Diagram



5.5 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. The CPU board block diagram is in Figure 5.7.

The CPU (D5, refer to Figure 6.13) uses the CPU board internal bus to access most of the peripheral circuits; the on-chip peripheral ports are directly used for analog multiplexers (MUX) and serial channel 0 (ASCII computer output).

The three memory chips are jumper selected for 2Mbit program EPROM (Dl), 32 x 8 kbit low current CMOS RAM (D6) powered by the internal data retention battery voltage, and EEPROM (D4) for permanent calibration value memory.

Analog input signals are read through the multiplexer (A3) to the A/D-converter A2.

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

The microprocessor's RS-232 is connected to Serial & Analog I/O connector (computer output). Duart channel A is connected to Aux I/O connector (graphic output).

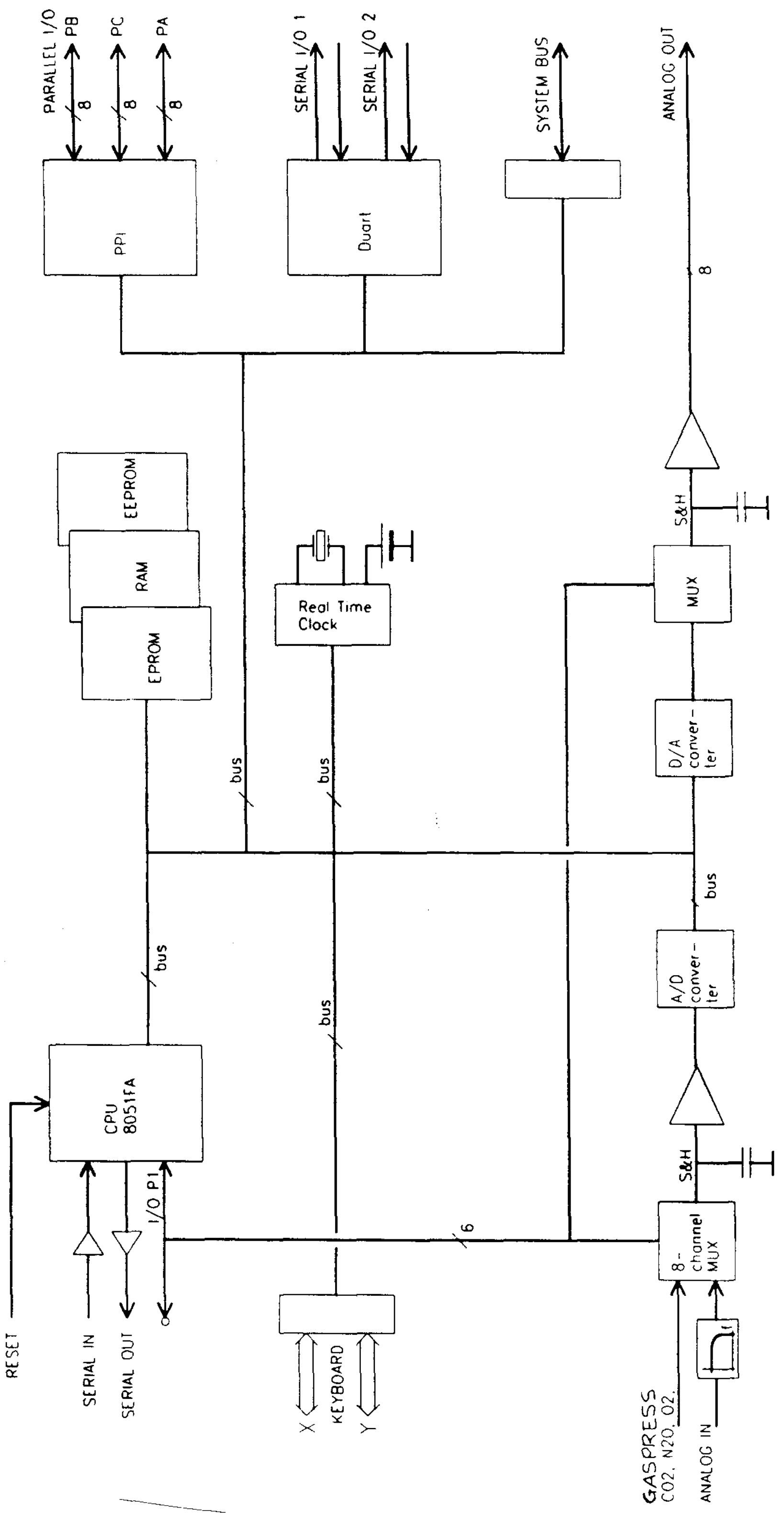
Real time clock (D16) is powered by a 3.4 V lithium battery Gl. Oscillator frequency of the clock is adjusted with trimmer capacitor C49.

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

The correct jumper positions for different memory chips are listed in Figure 6.12.

> CAUTION: There are lithium batteries (one soldered to the board and another enclosed in IC D6 (RAM). Danger of explosion if they are incorrectly replaced. Replace only with same or equivalent type recommended by Datex. Discard used batteries according to manufacturer's instruction.

Figure 5.7 CPU Board Block Diagram



5.6 Video Controller Board

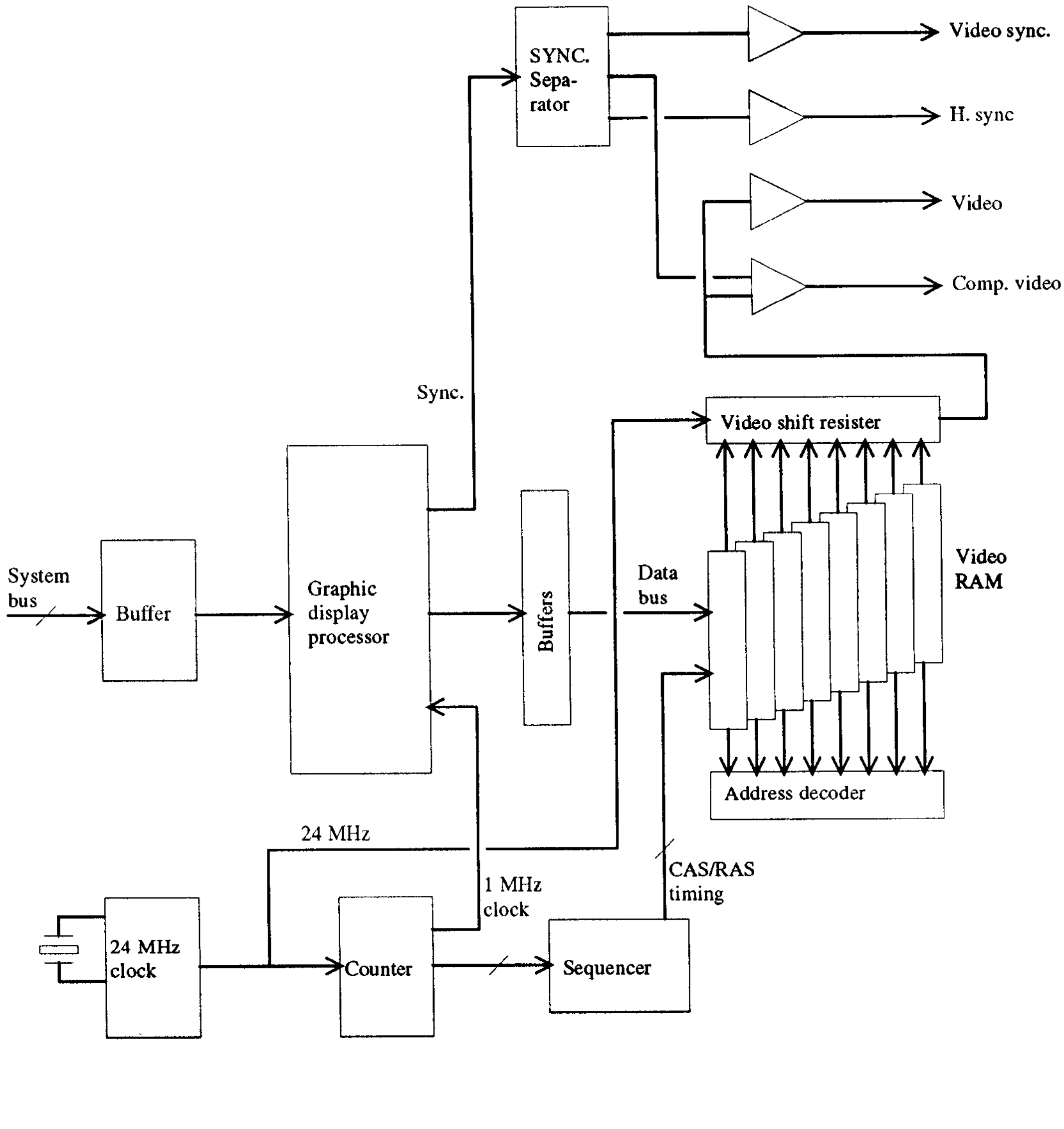
The video controller board is based on an LSI graphics display processor, which accepts commands from the CPU via the system bus and converts them to a video signal. Refer to Figure 5.8 for block diagram.

Commands from the CPU come through a buffer (D3, refer to Figure 6.15) to the video processor (D4). The processor converts the CPU commands to operations on a bit image in the video RAM memory (Dl0 through D16). The video RAM is then continuously scanned by addressing logic (D23) and a video shift register (D5) 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.

Clock and timing signals are made with the 24 MHz crystal Zl, counter D27 and sequencer D26. The timing diagram is also in Figure 6.15.

Figure 5.8 Video Controller Board Block Diagram



5.7 Power Supply and I/O 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 (refer to Figure 6.20):

+5 V switched, for the digital circuitry.

+15 V switched, for valves, pump 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/l 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.

5.8 Mother Board / Keyboard

The mother board contains the system bus interconnections and connectors. Also on the board are buffers for analog input signals (Al, refer to Figure 6.19) and a transzorb zener (V5) to protect digital electronics for possible overvoltage in the +5 V supply.

The mother board bus pin connections are in Table 5.1.

The keyboard is a simple 3 X 3 matrix which is scanned by the keyboard scanner on the CPU board.

5.9 Video Display Module

Video display module is a Panasonic M-K 9 101 NB CRT data display module. For operation information and troubleshooting instructions refer to the separate Panasonic manual (Datex P/N 572760).

5.10 Auto Calibration Box

The auto calibration box on the left side of the monitor contains one high-accuracy calibration gas can which is connected with tubes and valves to the monitor and which supplies calibration gas automatically when a calibration is started.

There is a rack for spare gas can in the box.

5.11 Flow Selector Module

The flow selector module consists of flow selector wheel and its base, and Hall board at the back of the base.

Small magnets sank in the wheel generate signal in the Hall board that corresponds to the selector position and the board transmits it to the valve control board for further processing.

Table 5.1 System Bus

Internal bus

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

* not used PPI: Mode Ø contr. ω≠83H

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 SERVICES 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

CAUTION: To prevent collapse of the monitor assembly, the mixing chamber has to be in place or the monitor lying on its side, when auto calibration box and right side panel or rear panel are removed.

CAUTION: When assembling or disassembling any part inside the monitor, be careful not to kink or damage the gas sampling tubes. Leakages in the gas sampling system affect accuracy of measurement and are difficult to detect.

For the monitor parts locations see Figure 9.1, the wiring diagram is in Section 4.4.

Top covers: Top cover of the auto calibration box can be lifted off by removing two screws in the left side panel. Then the top cover of the main monitor can be detached by removing four screws.

Auto calibration box can be detached by first removing the left side panel and then removing four screws at the lower half of the right side panel of the box.

The CO_2 **measuring unit,** the **power supply board,** the **flow control wheel** and **its base,** the **flow generator** and the **loud speaker** are attached to the rear panel. The rear panel can be tilted rearward by removing the four screws on the rear panel: two on both sides at the middle level of the panel. This gives access to those items.

The **sampling pump** and the **oxygen transducer** are located under the mother board mounting base. To get access to these parts, first remove the mixing chamber and the right side panel. To get access to the sampling pump fastening screws the rear panel must also be removed.

The **sampling system control module** with magnetic valves and constriction cassettes is held on the mother board mounting base by two of the oxygen unit fastening screws.

For removing the **video display module** first remove the mixing chamber, the top covers, the auto calibration box, and the bottom plate. Then remove the screen bezel and the front panel with the printings. Then open the four video driver board fastening screws under the electronics part mounting base and the four video screen fastening screws on the front panel, and carefully remove the video display module.

6.3 Troubleshooting

6.3.1 Monitor Start-up Sequence

Externally

After the monitor is switched on

Fan on the rear panel starts to run.

The self test text appears on the screen. Program code and the notes to user are displayed.

After several seconds SELF DIAGNOSIS -measuring sample system line pressures- text appear.

Within a half minute fields for trends and numeric values appear. The last chosen mode (Respirator or Canopy) and range (Obese, Adult, Child, or Baby) also appear.

The monitor is ready for measurement after 5 minutes (warm start) or 30 minutes (cold start).

Internally

After switching the monitor on (or resetting it) the RAM memory on the CPU board is checked with read/write tests to every memory location. The software EPROM is checked by reading the prewritten checksum. The A/D and D/A converters are checked by generating a test voltage and reading it back through the valve control board. The time read from the real time clock is verified to be rational and read/write functions on the chip are tried. If any one of these tests fails, the error message is displayed.

“Recalibrate all functions” is displayed if the checksum on EEPROM is incorrect (software has been changed or a factory reset has been performed).

If a write/read test on EEPROM fails, the message “EEPROM failed” is displayed.

“Temperature error” appears if the measured temperature is outside the range l0...55°C.

The sampling system is checked by measuring pressure gradients as the valves are connected to different sampling points:

First the ambient pressure is measured with sampling pump stopped by connecting the pressure transducer to ambient air through absorber (CHECK 1 with Y3 opened to absorber, see Figure 6.2). The measured value is used as a reference in the following measurements. “Pressure error” is displayed if the measured ambient pressure is not within 500 to 900 mmHg. In this case the pressure transducer and/or the related electronics has probably failed.

The sampling pump is started again and the pressure drop through the constriction cassette 2 to air inlet is measured (CHECK 2). If the pressure drop is not between 10 and 30 mmHg, a “Gas flow error” is given. This may be caused by loose or blocked tubing.

Similarly the pressure drop measured through Yl, the constriction cassette 5, and Y4 to the mixing chamber must be between -10 and -30 mmHg (CHECK 3). Additionally the measured pressure should be within -10 to +l0 mmHg from the previous measurement.

Finally the pressure through the water trap and the sampling line is measured (CHECK 1).

If the pressure drop is more than 40 mmHg, the message “Occlusion” is displayed and the occlusion procedure is started. It may be caused by a blocked sampling line or large amount of water in it.

If the pressure drop is less than 10 mmHg the message “Open gas circuit” is displayed. This can be caused by a missing sampling line or the water trap container.

The message “Gas flow error” is displayed if the pressure drop through the sampling line is not within 20 mmHg from those of ambient air inlet and the mixing chamber. In this case the sampling line, the water trap or the special tube may be partly blocked. If the message disappears when the sampling line is removed and power is turned off and on again, the block may be in the water trap or in the special tube.

The results of self diagnosis pressures are automatically displayed in Diagnostic mode in FACTORY SETTINGS menu (See Section 6.3.4).

NOTE: These values are not updated, but are measured only during power-on.

Acceptable values are:

Air pressure (ref.)	equal to ambient +l0 mmHg
Air line to ref.	-10...-30 mmHg
Mix. chamber to ref.	-10...-30 mmHg
Sampling line to ref.	-10...-30 mmHg
Sampling line to mix.	-10...+10 mmHg

If the air line pressure (CHECK 2) is - 14 mmHg and sampling line to ref. is -35 mmHg, then the difference between sampling line pressure and air line pressure is more than 20 mmHg and the “Gas flow error” message is displayed. In this case there is probably a partial block in the sampling line, in the water trap or in the special tube.

NOTE: All the above explanation of the sampling system self diagnosis is valid if the valves work correctly. This can be checked with Diagnostic mode checks 1...4 (see Section 6.3.4) by feeding calibration gas or breathing into the appropriate sampling points. See also Functional Check A in Section 8.1.

6.3.2 Error Messages

MESSAGE	POSSIBLE CAUSE/REMEDY
EXTERNAL RAM FAILED	Check CPU board; RAM read/write problem.
ROM CHECKSUM ERROR	Check CPU board; EPROM read error.
ADC OR DAC FAILED	Check CPU board; problem in ADC, DAC or analog multiplexers or resistor network R5 missing. Check valve control board; unable to read selftest voltage back to CPU board.
EEPROM FAILED	Check CPU board; EEPROM failure.
REAL TIME FAILED	Check CPU board; real time clock failure, check battery Gl.
RECALIBRATE ALL FUNCTIONS	Recalibrate gases, pressure, and flow. Turn power OFF/ON and if message appears again, check CPU (EEPROM).
PRESSURE ERROR	Turn power OFF/ON. If error reappears, check pressure transducer on CO_2 measuring board and sampling system.
TEMPERATURE ERROR	Check valve control board. Check temperature sensor at flow generator exhaust tube.
GAS FLOW ERROR	Check sampling system.
OCCLUSION	Sampling line blocked. Replace it. If message reappears, check sampling system.
OPEN GAS CIRCUIT	Check sampling system. Sampling line or water trap container not attached properly or missing.
BASELINE ERROR	Unsuccessful zeroing. Turn power OFF/ON and if the message reappears, check gas measuring system.

CHECK FLOW SETTING	Flow selector wheel is loose or not in correct position.
NO GAS CALIBRATION	Unsuccessful calibration. Repeat calibration. If the message reappears, check gas sampling system.
24 HOUR MEMORY FULL	Clear data from memory with END and CLEAR menus. Press the soft key for CLEAR ALL DATA.

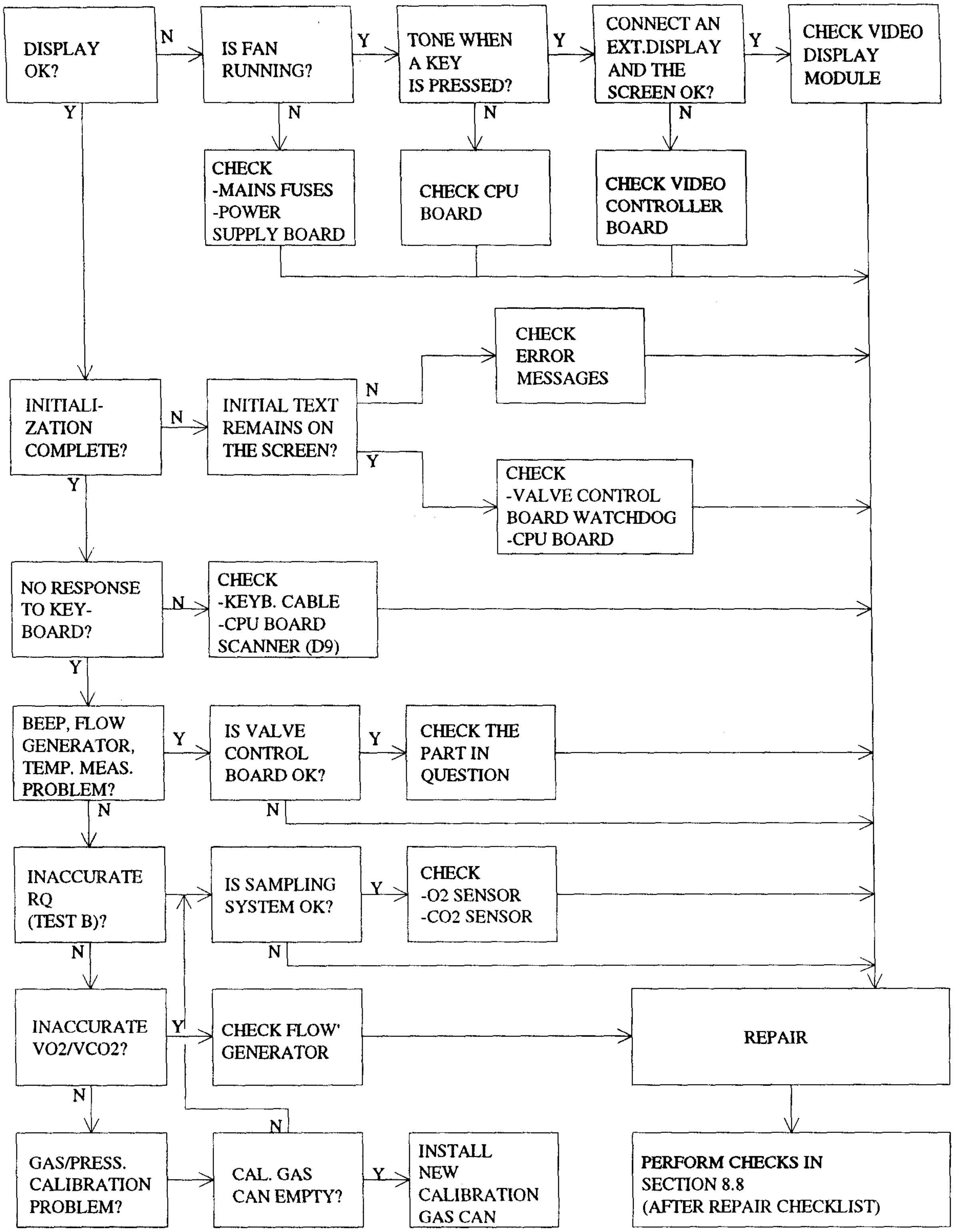
6.3.3 General Troubleshooting Chart

Field service of the Deltatrac II is intended to be done as board swapping where possible. Thus the most important part of troubleshooting is to pinpoint the faulty module.

NOTE: Whatever the trouble is, always check the AC and DC voltages on the system bus using a voltmeter.

NOTE: The parameters are normally measured at the system bus. The real time CO_2 and O_2 readings are displayed in the Diagnostic mode (see Section 6.3.4). The gas concentration in per cent and the corresponding analog voltages are listed in the linearization Table (Figure 7.1). Full scales are O_2 7.9 V and CO_2 7.5 V nominally.

Figure 6.1 General Troubleshooting Chart



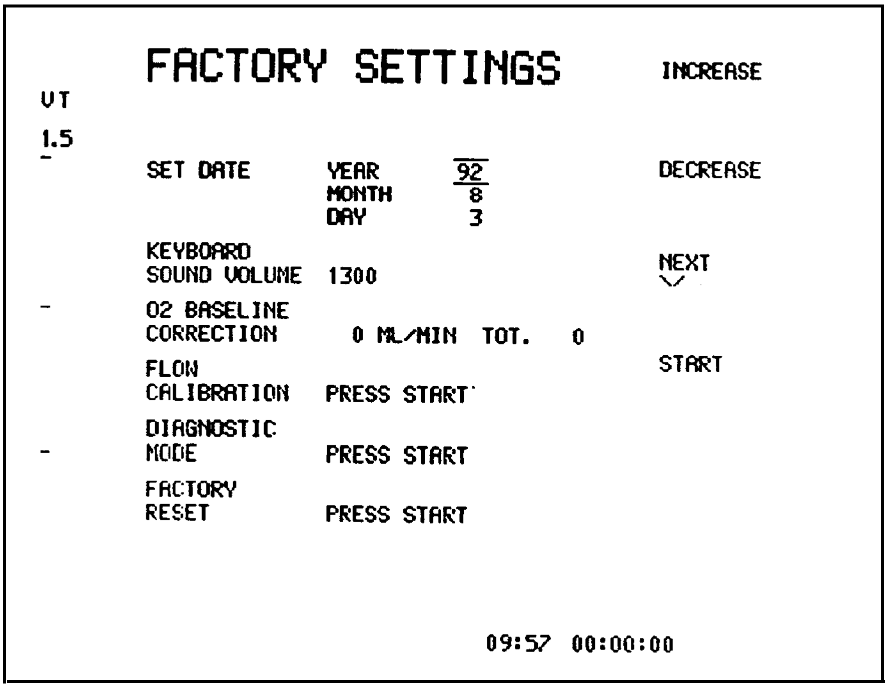
6.3.4 Diagnostic Mode

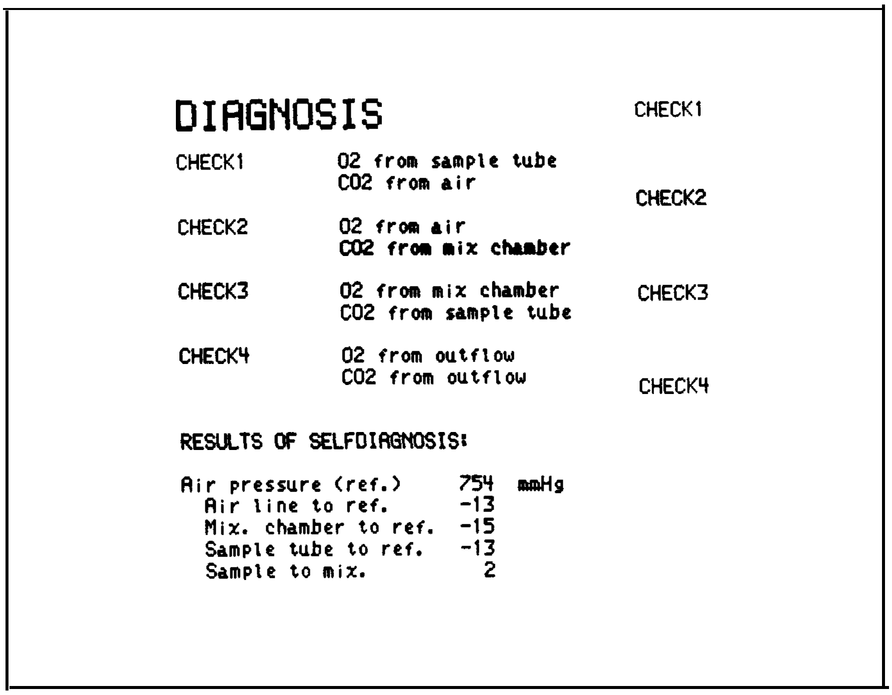
The Diagnostic mode is a useful tool for fault finding and checking the operation of the monitor.

To enter the Diagnostic mode:

1 When switching power on, keep pressing MARK/RESET key until self diagnosis text appears. If the power is already on, activate reset by pressing down the MARK/RESET key for several seconds and keep on pressing until the self diagnosis text appears.

2 After a moment factory settings is displayed. Go to Diagnostic mode and press start.





3 On the first page of the Diagnostic mode, the results of power-on self diagnosis are displayed at the bottom.

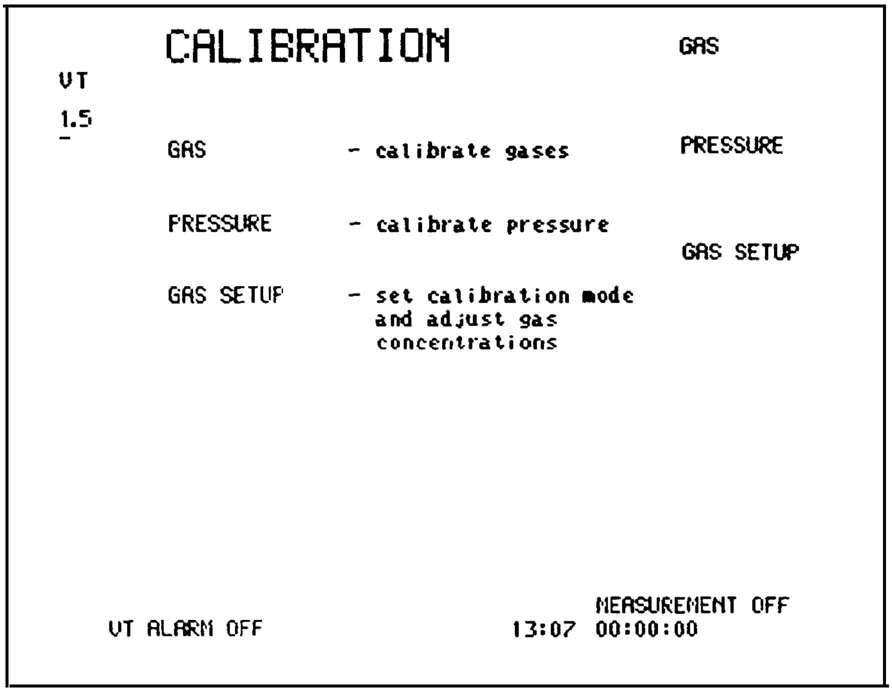
They should be:

Air pressure (ref.)	ambient air pressure +l0 mmHg
Air line to ref.	-10...-30 mmHg
Mix. chamber to ref.	- 10...-30 mmHg
Sampling line to ref.	- 10...-30 mmHg
Sample to mix.	- 10...+10 mmHg

By using softkeys (CHECK 1...4) it is possible to change the magnetic valve positions in the sample system so that gas is passed through from different sources (see Figure 6.2).

Real time gas concentrations and corresponding voltages are displayed. For CO_2 and O_2 LOW the gas concentration is shown as a ten second average as well as deviation.

4 It is also possible to calibrate the monitor in the Diagnostic mode. First press any of CHECK 1 to 4 keys. Then calibration choices appear (Gas, Pressure, Gas Set up).



a) Gas

If auto is chosen in Gas Set up, the monitor performs automatic gas calibration.

The installed cal gas can is sufficient for about 30 calibrations. If the can is empty, a message “Bottle empty” appears.

If manual is chosen, follow instructions on the screen and feed calibration gas externally.

NOTE: Perform gas calibration at least once a day. For optimum accuracy we recommend the calibration to be done before each measurement.

b) Pressure

The monitor measures ambient air pressure and displays it. Adjust it to match the value measured by separate barometer.

NOTE: Perform pressure calibration at least once every six months. The gas calibration should be done after every pressure calibration.

c) Gas Set up

In Gas Set up, automatic or manual calibration and concentrations of calibration gas are selected.

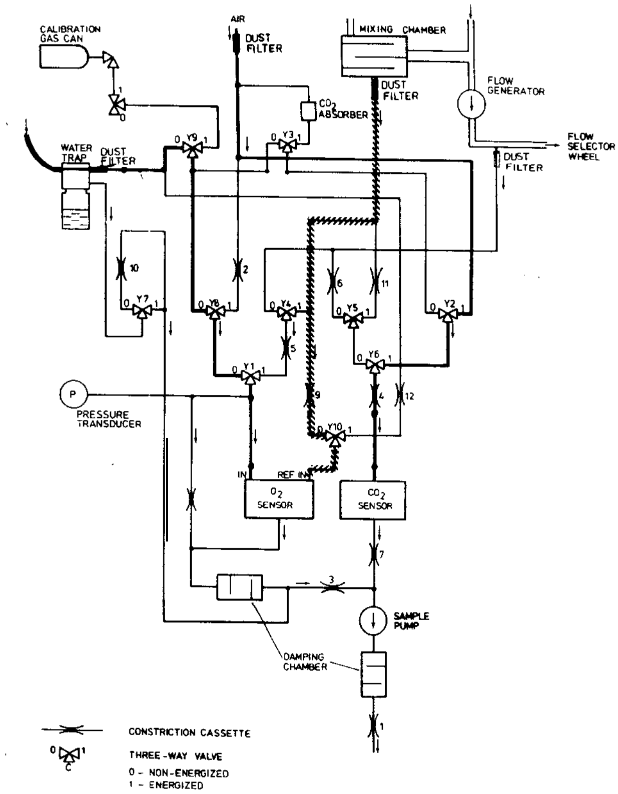
5 To exit the Diagnostic mode, press NORMAL SCREEN twice.

NOTE: The oxygen signal is the differential O_2 signal; when no gases are injected, the reading should be close to zero. When 100 % O_2 is injected, the reading should be close to 79 % (100-21).

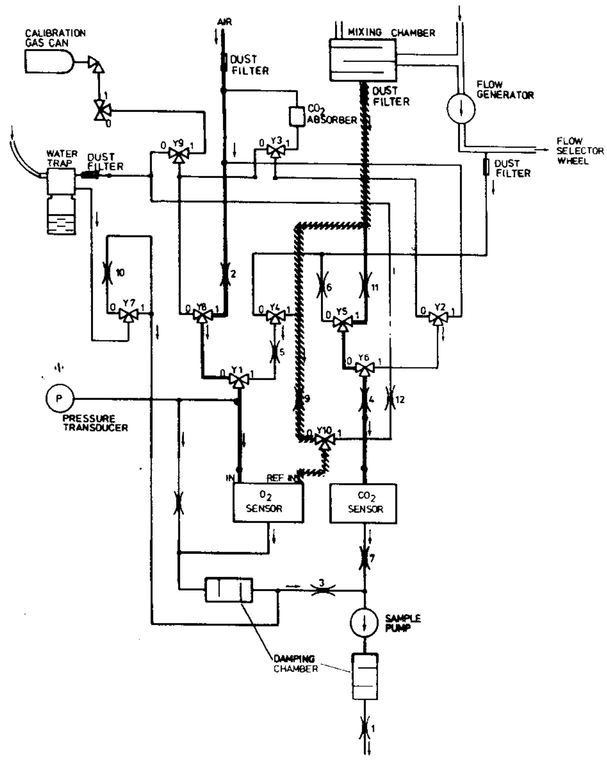
NOTE: The O_2 LOW signal is equal to the O_2 signal but the resolution is better and the range is smaller. This signal is read in through analog channel ADC4 on the mother board.

NOTE: During the measurement and calibration the CO_2 signal is corrected for the effect of the background oxygen level. This correction is not used in the Diagnostic mode. This means that even if the monitor is properly calibrated, the CO_2 gain appears to be too small if a gas sample with CO_2 and a high oxygen concentration is injected to the CO_2 measuring unit.

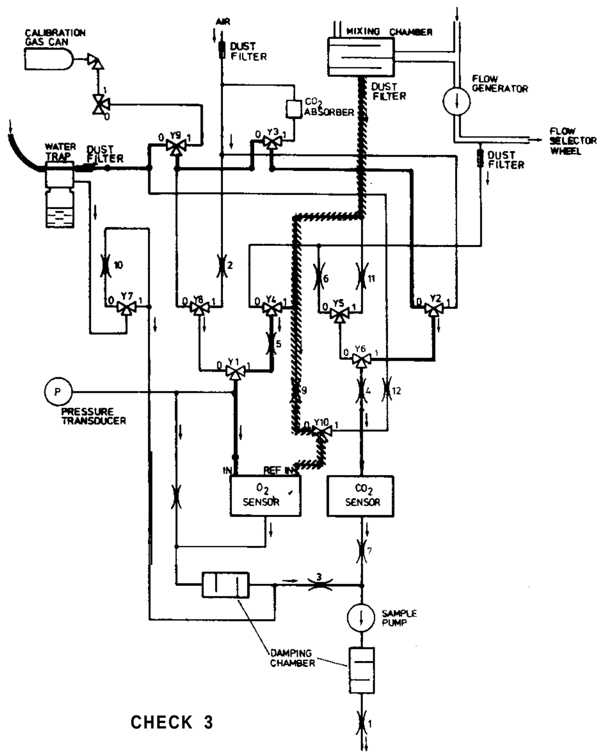
Figure 6.2 Diagnostic Mode Sample Sources



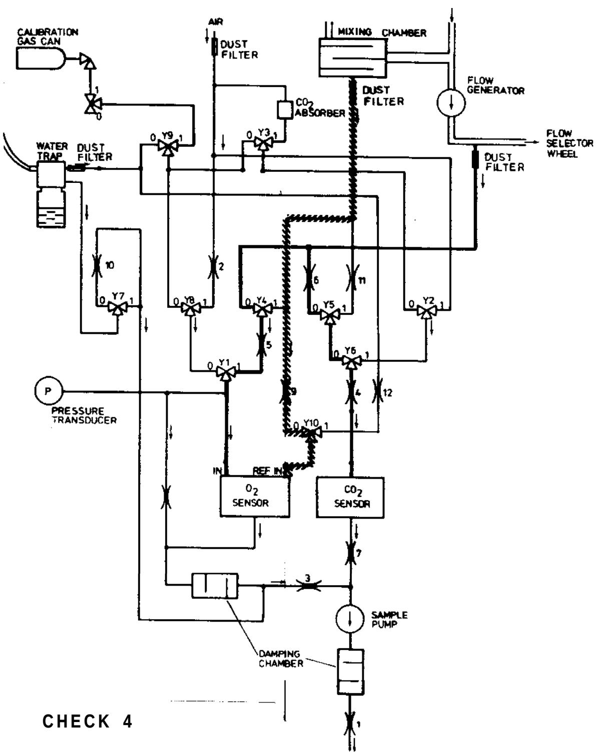
CHECK 1



CHECK 2



CHECK 3



CHECK 4

6.3.5 Sampling System Troubleshooting

Problems in the sampling system may be related to the magnetic valves (malfunction, leakage, blocked, or stuck), or the tubing (partial or total leakage, or blockage).

In case of problems with the sampling system, follow the troubleshooting chart in Figure 6.3.

The schematic diagram and parts layout of the sampling system is shown in Figure 6.6. The measuring sequences of the two modes of operation, canopy (supplementary oxygen) and respirator modes, are described in Figures 6.4 and 6.5; and in the corresponding Tables 6.1 and 6.2.

Figure 6.3 Sampling System Troubleshooting Chart

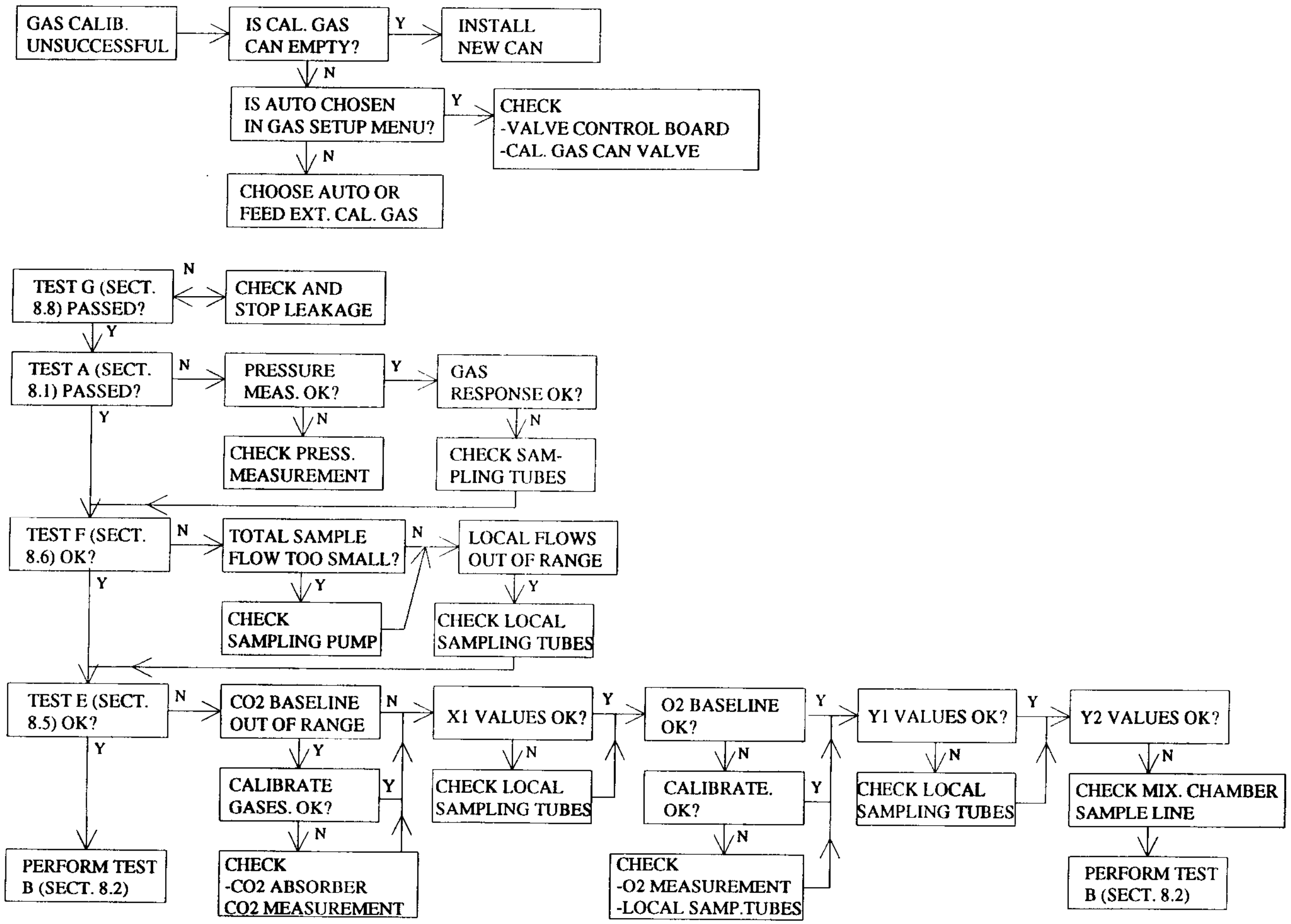


Figure 6.4 Canopy Mode Measuring Sequence (supplementary oxygen)

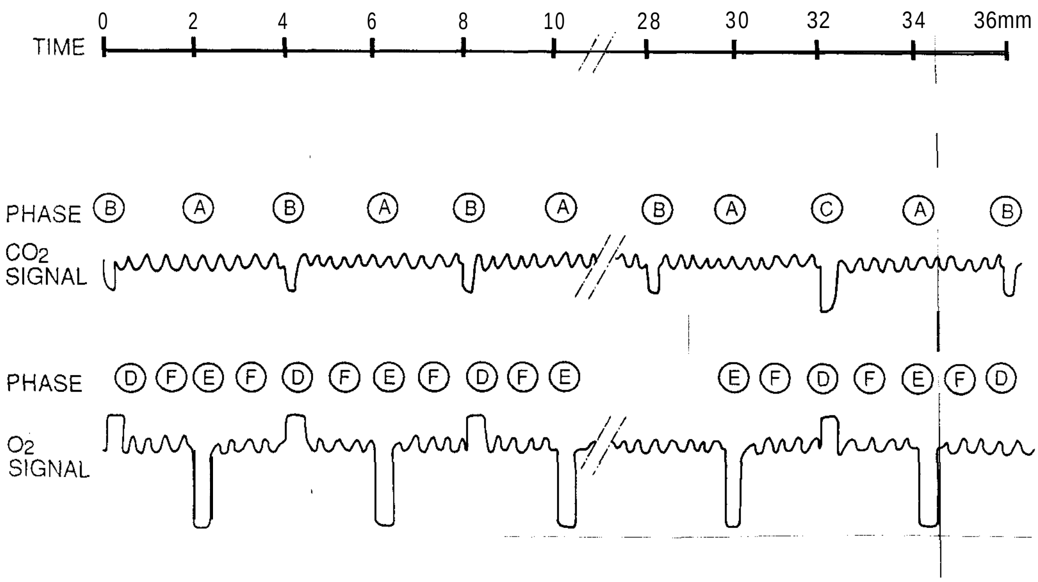


Table 6.1 Sample Sources at Different Phases of Canopy Mode Measurement

PHASE	SAMPLE SOURCE	ENERGIZED VALVES
<u>CO_2 measurement</u>		
A	CO_2 from flow generator	
B	CO_2 from sampling line	Y6
C	CO_2 through absorber, every 32 min	Y3, Y6
<u>O_2 measurement</u>		
D	O_2 from sampling line	Y10
E	O_2 from air	Y10, Y8
F	O_2 from flow generator	Y10, Y1
Sampling line occlusion		Y7

NOTE: O_2 reference is always connected to the sampling line.

Figure 6.5 Respirator Mode Measuring Sequence

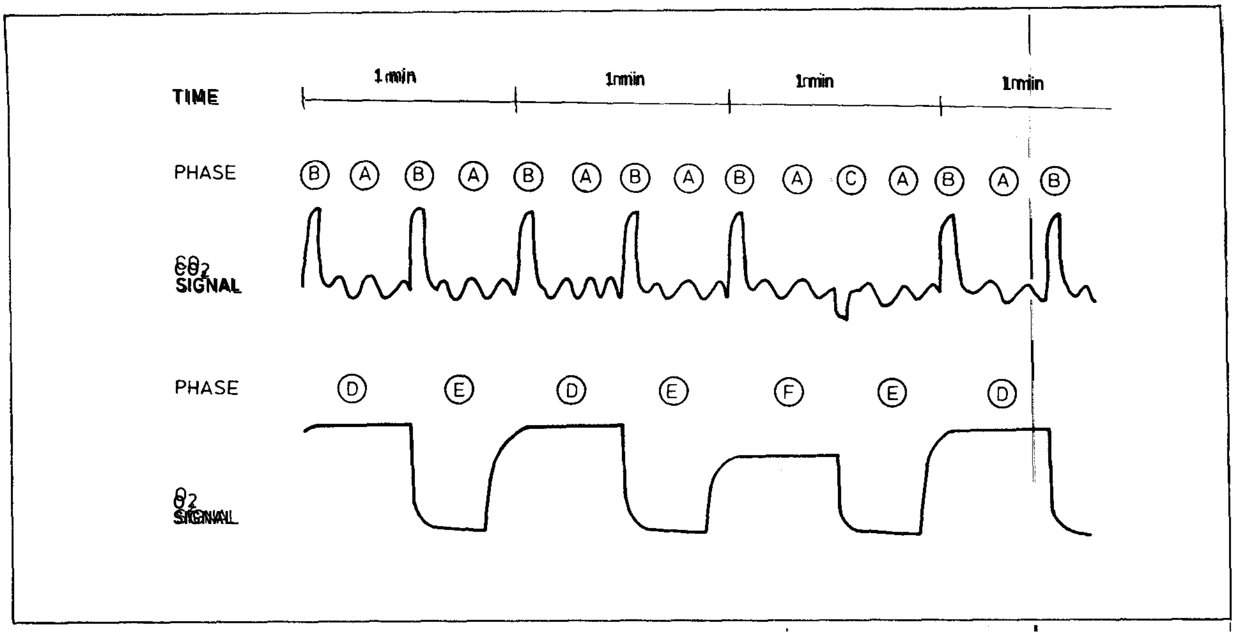


Table 6.2 Sample Sources at Different Phases of Respirator Mode Measurement

PHASE	SAMPLE SOURCE	ENERGIZED VALVES
<u>CO_2 measurement</u>		
A	CO_2 from flow generator	
B	CO_2 from mixing chamber	Y5
C	CO_2 from air, 10, 15, 20 min from start and then every 10 min.	Y2, Y6
	Absorber, 5, 30 min from start, then every 30 min.	Y3, Y6
<u>O_2 measurement</u>		
D	O_2 from sampling line	
E	O_2 from air	Y8
	O_2 from mixing chamber, 5, 10, 15, 20 min from start, then every 10 min.	Y4, Y1
Sampling line occlusion		Y7

NOTE: O_2 reference is always connected to the mixing chamber.

6.3.5.1 Sampling System Parts

NOTE: Six different tubes are used inside the monitor. When ordering independent tubes please specify the size and length needed.

NOTE: Because of complicated tube connection in the sampling system, it is recommended to replace the whole internal sampling system including magnetic valves (see the order code in spare parts list) when more than one tube are to be replaced.

Table 6.3 Sampling System Parts List

Part	Code
Special internal sample tube	878853
Small damping chamber filter	878802
Dust filter	86901
Damping chamber	57150
L-piece	733811
T-piece	733821

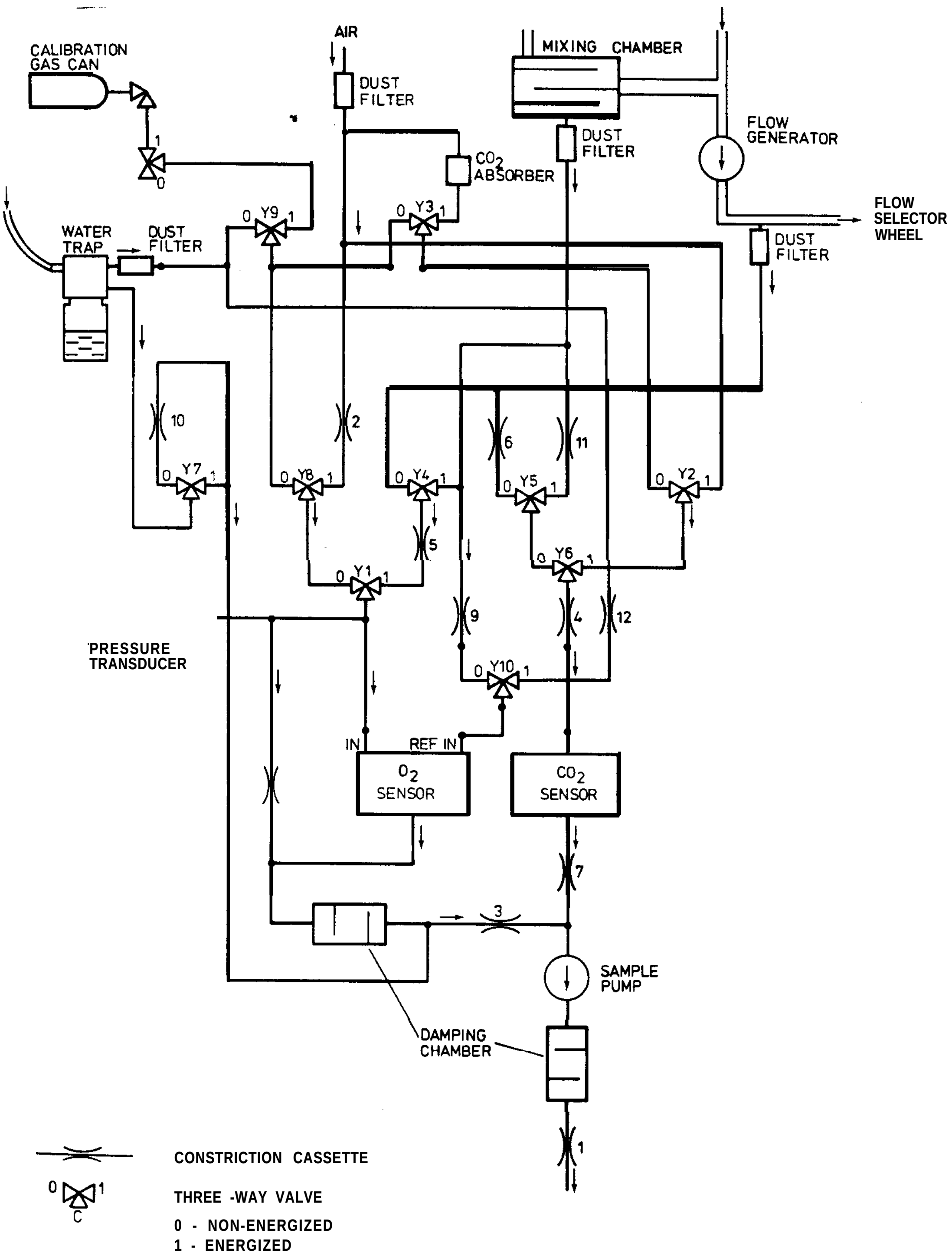
Table 6.4 Flow Constriction Cassettes

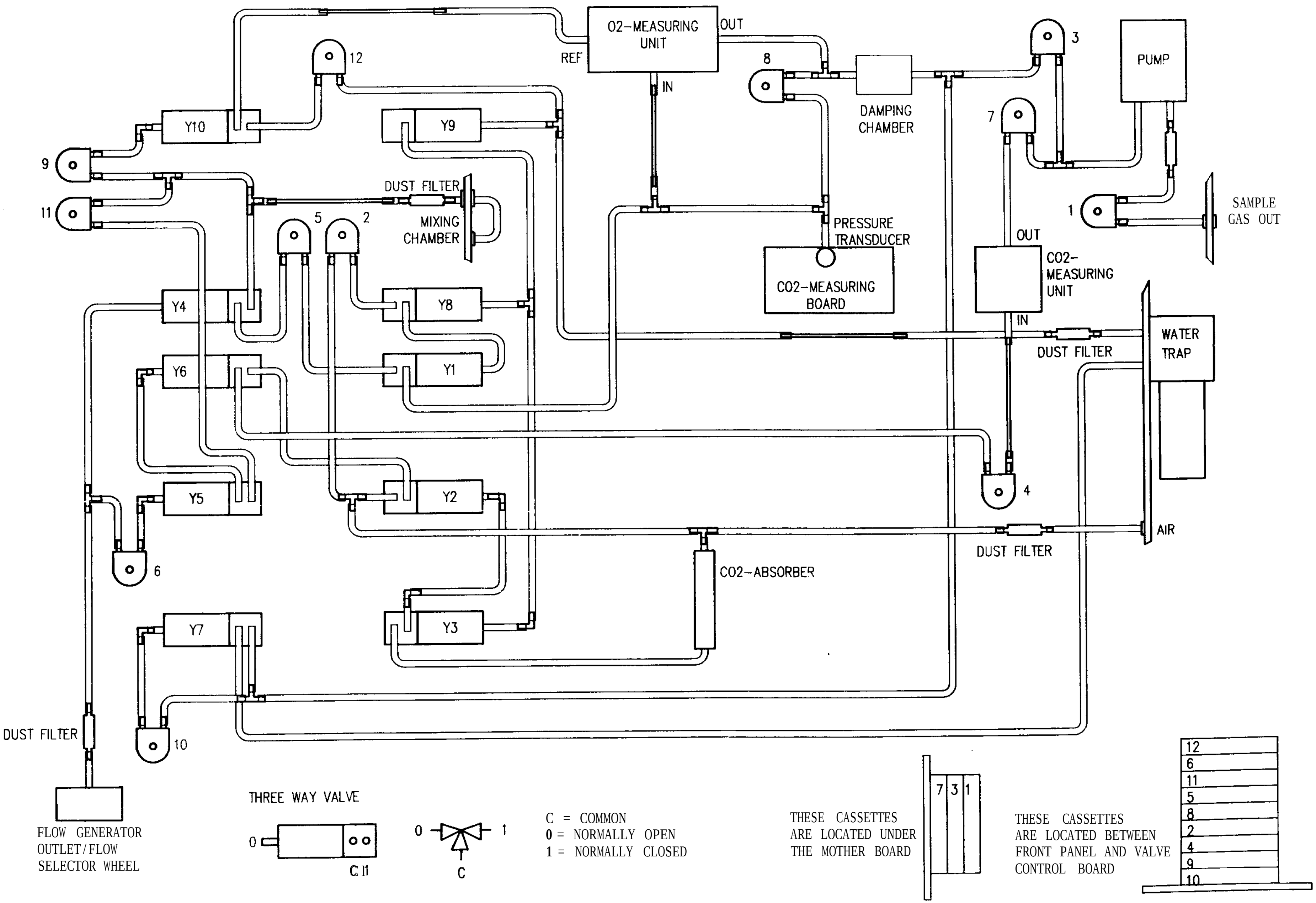
Flow cassette	Code
50/26.0	878048
50/19.0	873800
50/16.3	878047
50/15.3	873801
50/14.1	878046
50/13.1	873802
50/12.4	878045
50/11.2	874770
50/10.4	873803
50/9.2	874509
50/8.7	873804
50/7.4	873805
50/6.5	878044
50/5.8	873806
50/5.1	878043
50/4.4	873807
50/3.8	878042
50/3.2	873808
50/3.0	878040
50/2.8	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 latter number is a relative figure for the flow through the cassette, e.g., 50/26.0 is the smallest resistance and 50/1.1 the largest.

Figure 6.6 Sampling System Schematic Diagram and Parts Layout

NOTE: To gain best performance the flow cassettes are selected individually for each monitor at the factory. In case they are to be replaced, see Table 6.5 for alternatives.




O2-MEASURING UNIT
REF
OUT
IN
DAMPING CHAMBER
PUMP
SAMPLE GAS OUT
PRESSURE TRANSDUCER
CO2-MEASURING BOARD
CO2-MEASURING UNIT
OUT
IN
WATER TRAP
DUST FILTER
MIXING CHAMBER
DUST FILTER
DUST FILTER
AIR
DUST FILTER
CO2-ABSORBER
Y10
Y9
Y4
Y8
Y6
Y1
Y5
Y2
Y7
Y3
1
2
3
4
5
6
7
8
9
10
11
12
FLOW GENERATOR OUTLET/FLOW SELECTOR WHEEL
THREE WAY VALVE
0
C
1
C = COMMON
0 = NORMALLY OPEN
1 = NORMALLY CLOSED
THESE CASSETTES ARE LOCATED UNDER THE MOTHER BOARD
7 3 1
THESE CASSETTES ARE LOCATED BETWEEN FRONT PANEL AND VALVE CONTROL BOARD
12
6
11
5
8
2
4
9
10

6.3.6 CO_2 Measurement Troubleshooting

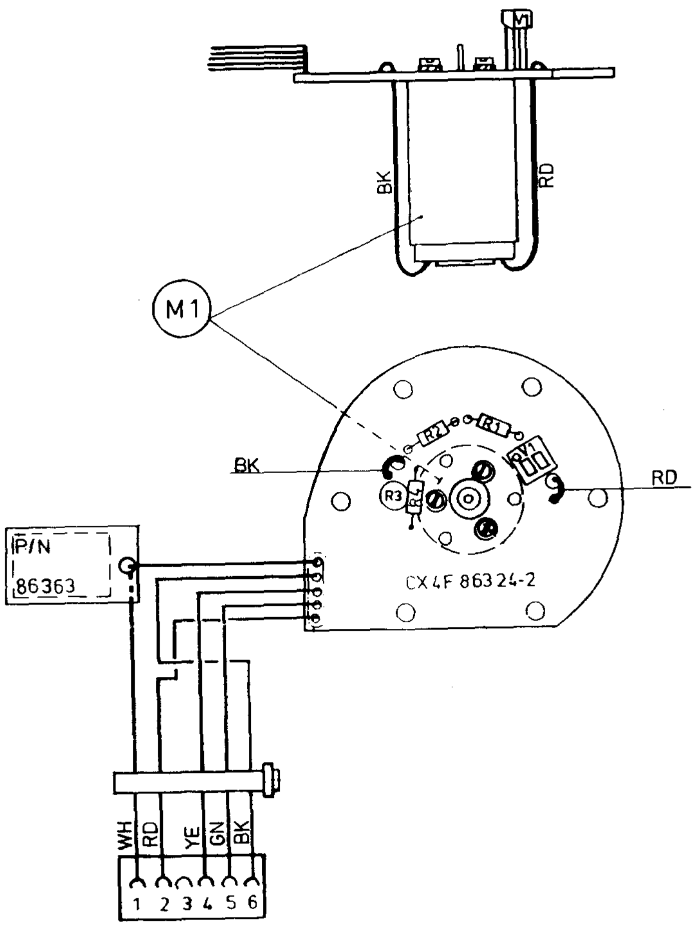
For troubleshooting the CO_2 measurement system refer to parts layouts and schematic diagrams in Figures 6.7 (synchronizing board), 6.8 (preamplifier board), and 6.9 (measuring board).

If the fault has been located to the CO_2 measurement system, the following table can be used to find the exact cause of malfunction.

SYMPTOM	FAULT
Sudden increase in CO_2 output, possibly out of scale	Measuring chamber contamination, clean (see Section 6.3.6.1).
	-15 V missing (fault in the power supply).
No response to CO_2	Missing supply voltage (fault in the power supply).
	Loose or blocked tubing. Loose cable connections.
	Sampling pump failure.
	IR lamp or power supply failed. 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 measuring board (connector pin 13b). If the line is high the mosfet V27 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. Missing timing pulses (see Figure 6.9).
Impossible to adjust zero	Measuring chamber contamination, clean (see Section 6.3.6.1).
Impossible to adjust	AGC malfunction. Check analog switches and A4.
	False reference voltage.
	Faulty temperature compensation circuit.
Strong drift	Moisture or dust in measuring chamber. Clean measuring chamber (see Section 6.3.6.1)
	Leakage in sampling or internal tubing.
	Loose screws in photometer.
	AGC malfunction. Check analog switches and control pulses.

Repeated baseline error message at calibration	Clean the measuring chamber. Check gas measurement analog zero and adjust (see Section 7.2).
Software calibration range insufficient	Check gas measurement analog output and adjust gain (see Section 7.2).
CO_2 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.
Random output (resembling noise)	Timing pulses out of sync. Check timing pulses from photometer, pulse shaping circuit, and logic circuitry on the measuring board (see Figure 6.9).
Chopper motor not running	Motor faulty or connection loose. Driver transistor C-E open circuit or current limiter short circuit.
Calib. gas not accepted	Check gas flow from cal. gas bottle. Install a new gas can. Clean the measuring chamber.

Figure 6.7 Synchronizing Board Parts Layout and Schematic Diagram (board modification level -8 and lower)



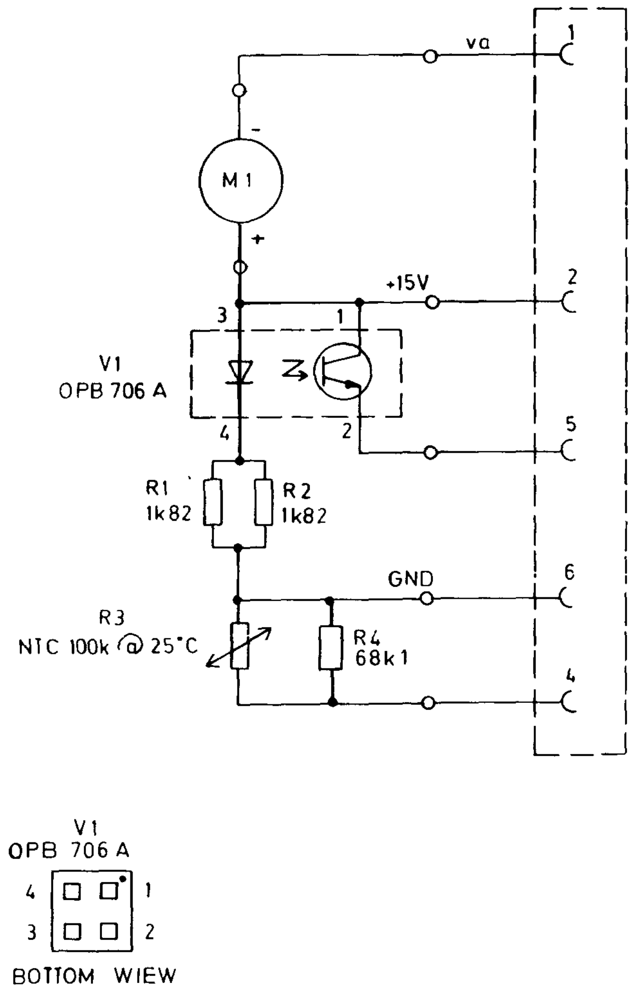
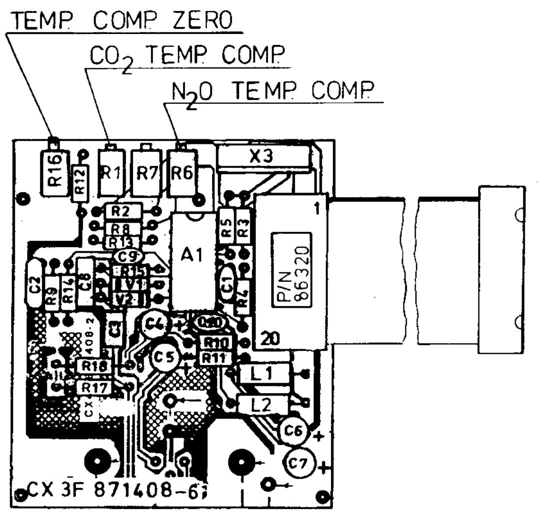


Figure 6.8 Preamplifier Board Parts layout and Schematic Diagram (board modification level -10 and lower)



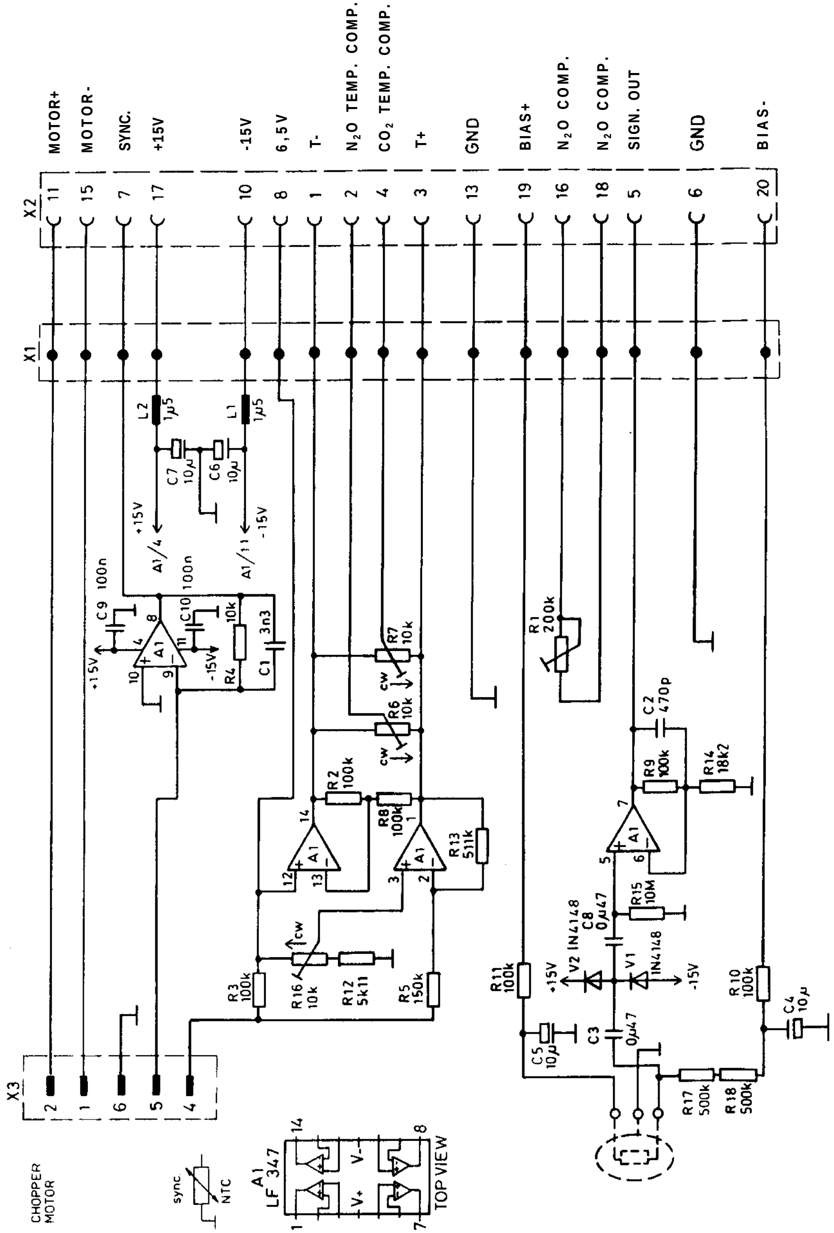
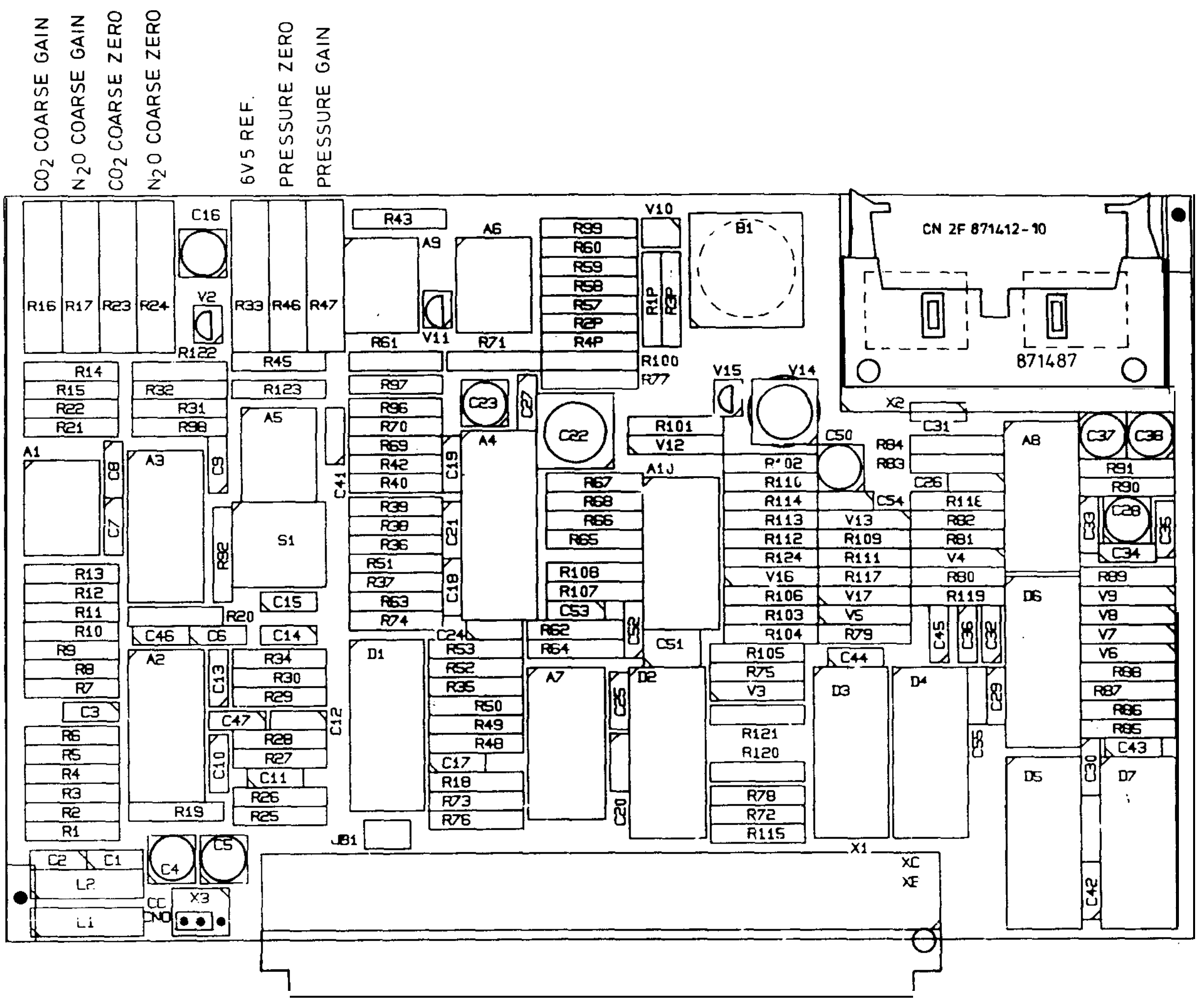
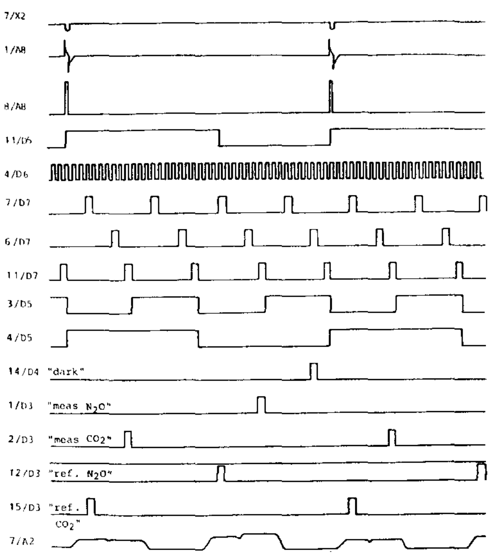
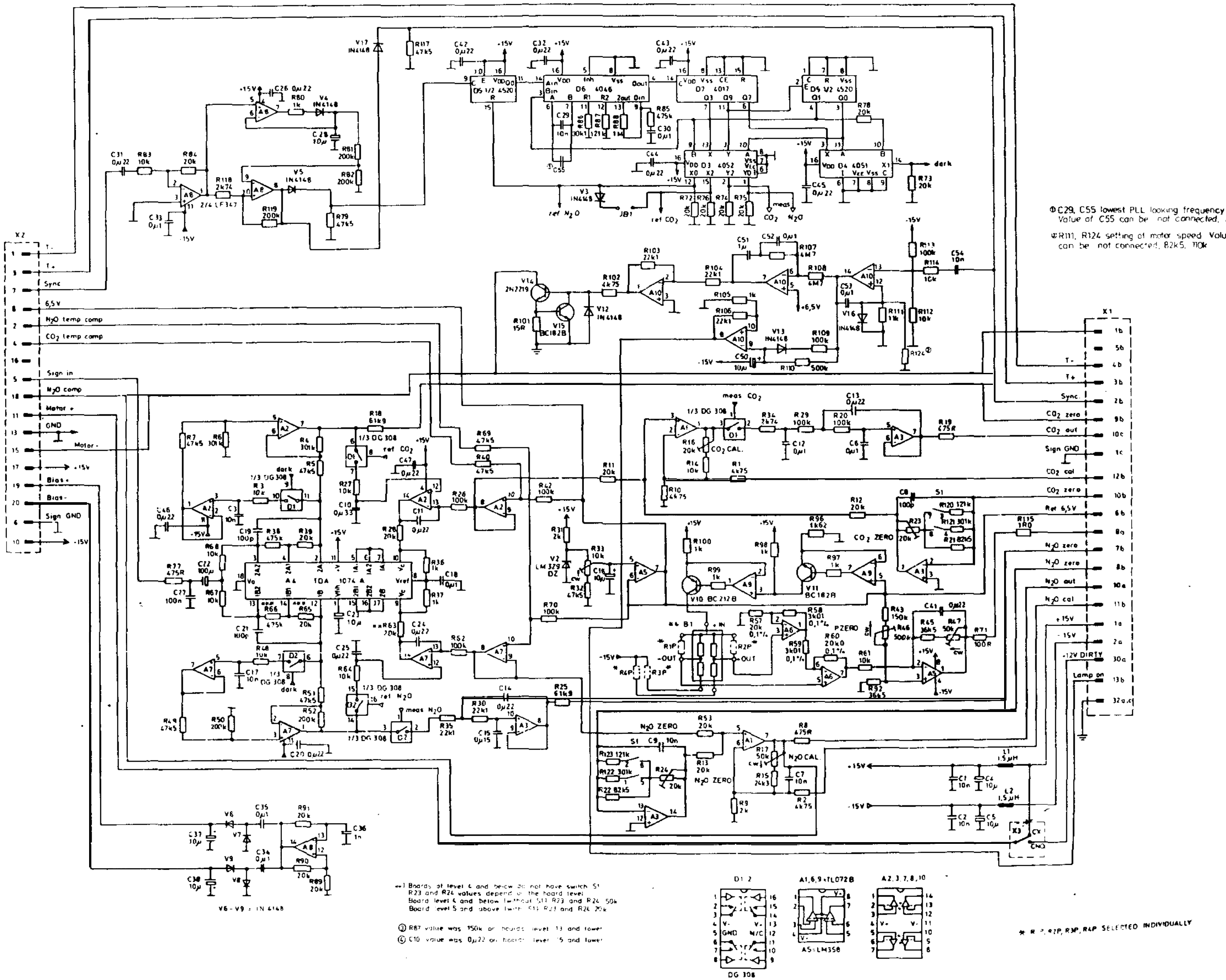


Figure 6.9 Measuring Board Parts Layout, Timing Diagram and Schematic Diagram (board modification level -21 and lower)



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





① C29, C55 lowest PLL looking frequency setting
Value of C55 can be not connected, 2n2, 3n3

② R111, R124 setting of motor speed. Value of R124 can be not connected, 82k5, 110k

**) Boards of level 4 and below do not have switch S1
R23 and R24 values depend on the board level
Board level 4 and below (without S1) R23 and R24 50k
Board level 5 and above (with S1) R23 and R24 20k

③ R87 value was 150k on boards level 13 and lower

④ C10 value was 0μ22 on boards level 15 and lower

* R 2, R2P, R3P, R4P SELECTED INDIVIDUALLY

6.3.6.1 Measuring Chamber Cleaning

The sampling system is designed to prevent any moisture or liquid from entering the gas sensors. Under some conditions the CO_2 measuring chamber may, however, be contaminated causing zero or drift problems. In this case the measuring chamber has to be cleaned using Datex Measuring Chamber Cleaning Fluid (P/N **85969).**

> **WARNING: Using alkaline detergents may cause permanent damage to the internal parts of the gas sensors.**

Clean the measuring chamber as follows:

1. Turn off the monitor.
2. Remove auto calibration box and top cover.
3. Remove the CO_2 measuring unit by removing the two screws on the rear panel. Disconnect both the CO_2 measuring unit gas inlet (thin) and the gas outlet tube (thick).

   Replace the inlet tube with a short (approximately 10 cm) piece of the sampling line and the outlet tube with silicone tube.
4. Slowly inject cleaning solution into the silicone tube (the outlet tube). Hold the tubes up so that the solution stays inside the measuring unit.
5. Leave the fluid inside from 1 to 24 hours.
6. Rinse the measuring chamber at least twice with distilled water injected in the same way.
7. Dry the measuring chamber completely by blowing air into it using a syringe.

   > **CAUTION:** Continue drying until all liquid has been blown out from the measuring chamber.
8. Reconnect the inlet and outlet tubes. Attach the CO_2 measuring unit back on the rear panel.
9. Turn on the monitor and let it run until the CO_2 reading stabilizes.

> **WARNING: Using alcohol or other flammable liquids to clean the measuring chamber causes fire hazard.**

6.3.7 O_2 Measurement Troubleshooting

In case of no response to O_2 or strong drift, check the tubing for loose connection, blockage or leakage.

If a baseline error message is displayed at calibration check the O_2 sensor analog output zero and adjust if necessary (see 7.4).

If the software calibration is not successful because the software calibration range is insufficient check the O_2 sensor analog output and adjust the gain if necessary (see 7.4).

Because of the complex and very sensitive construction of the oxygen sensor no repairs should be attempted inside the sensor. Instead, if the fault has been limited into the sensor itself, it should be replaced and the faulty sensor be sent to the factory for repair.

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

6.3.8 Valve Control Board Troubleshooting

See Figure 6.10 for troubleshooting chart and Figures 6.11 and 6.12 for the schematic diagram and parts layout of the valve control board.

Figure 6.10 Valve Control Board Troubleshooting Chart

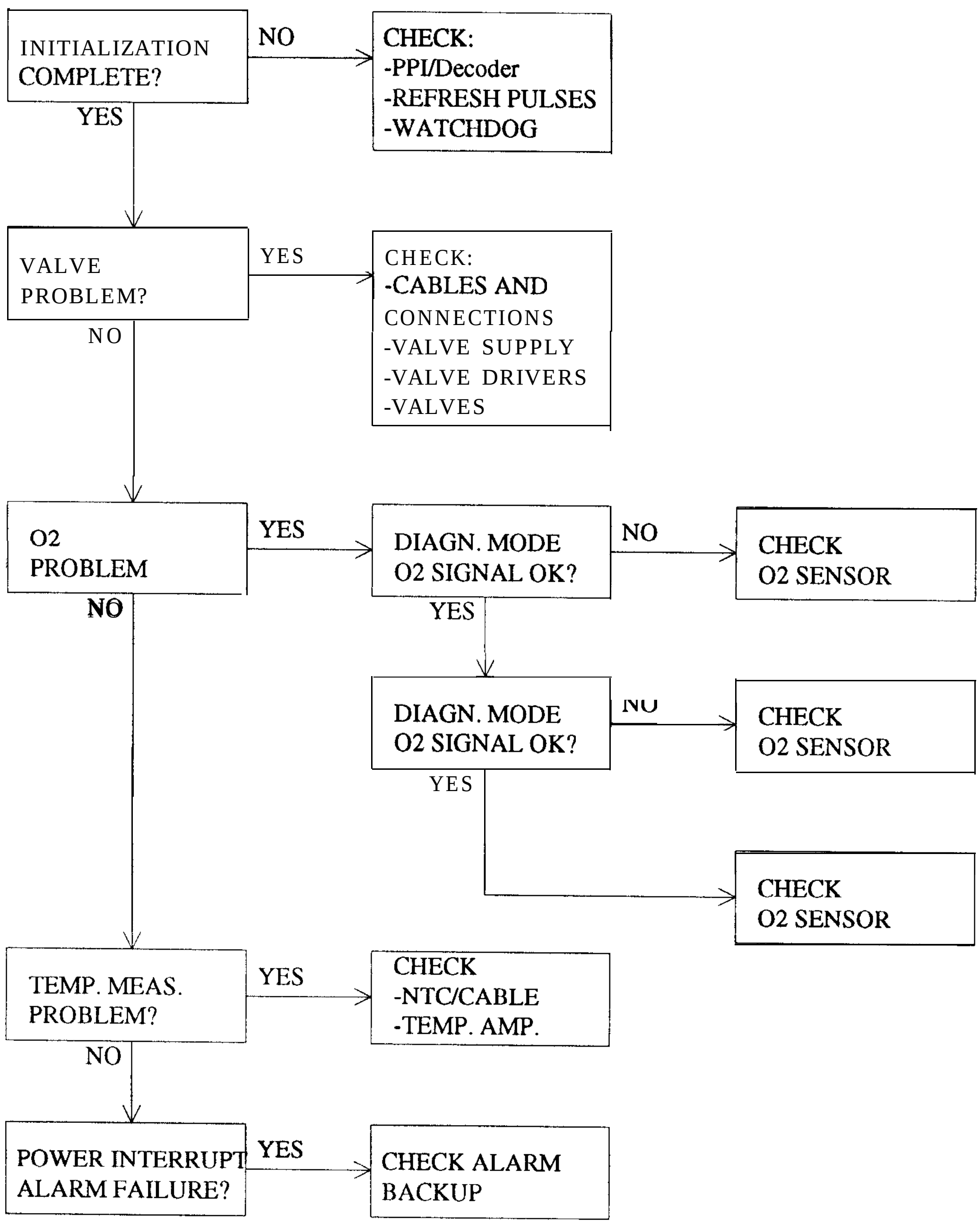


Figure 6.11 Valve Control Board Parts Layout and Schematic Diagram (part 1)

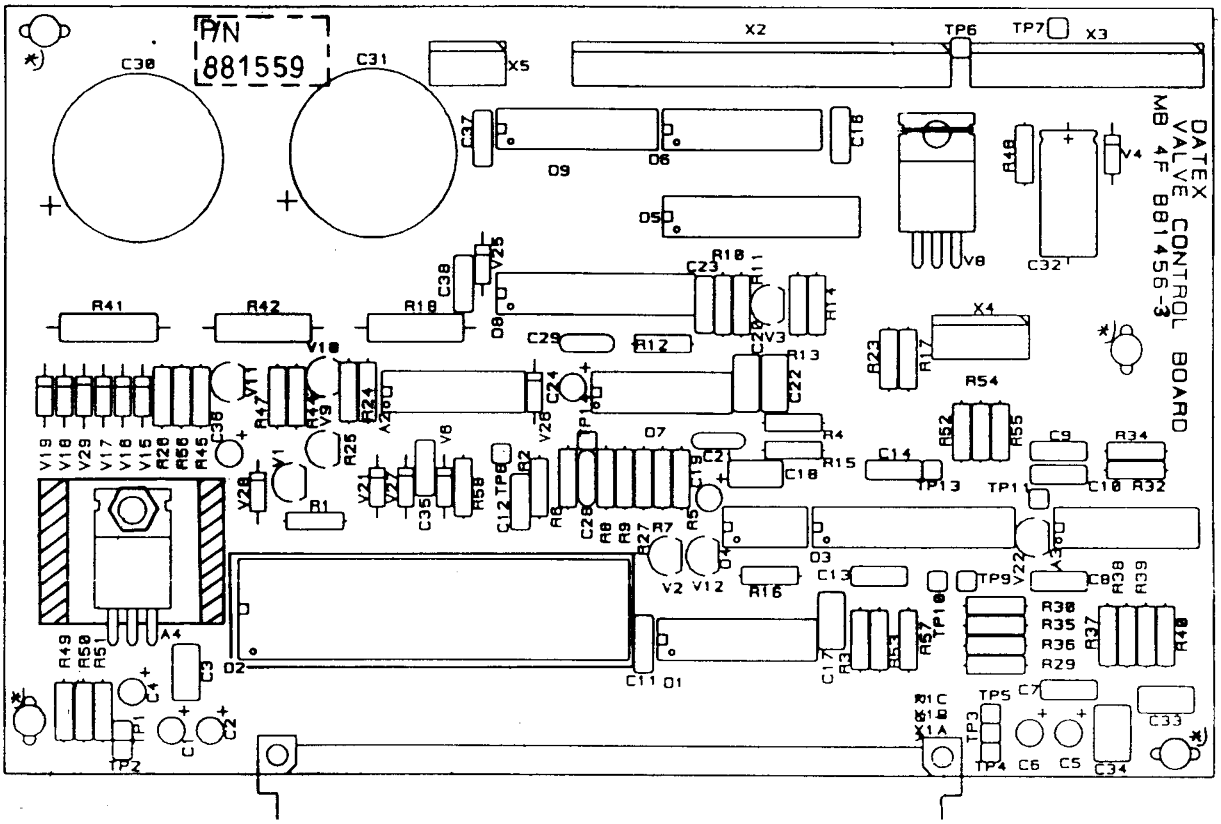
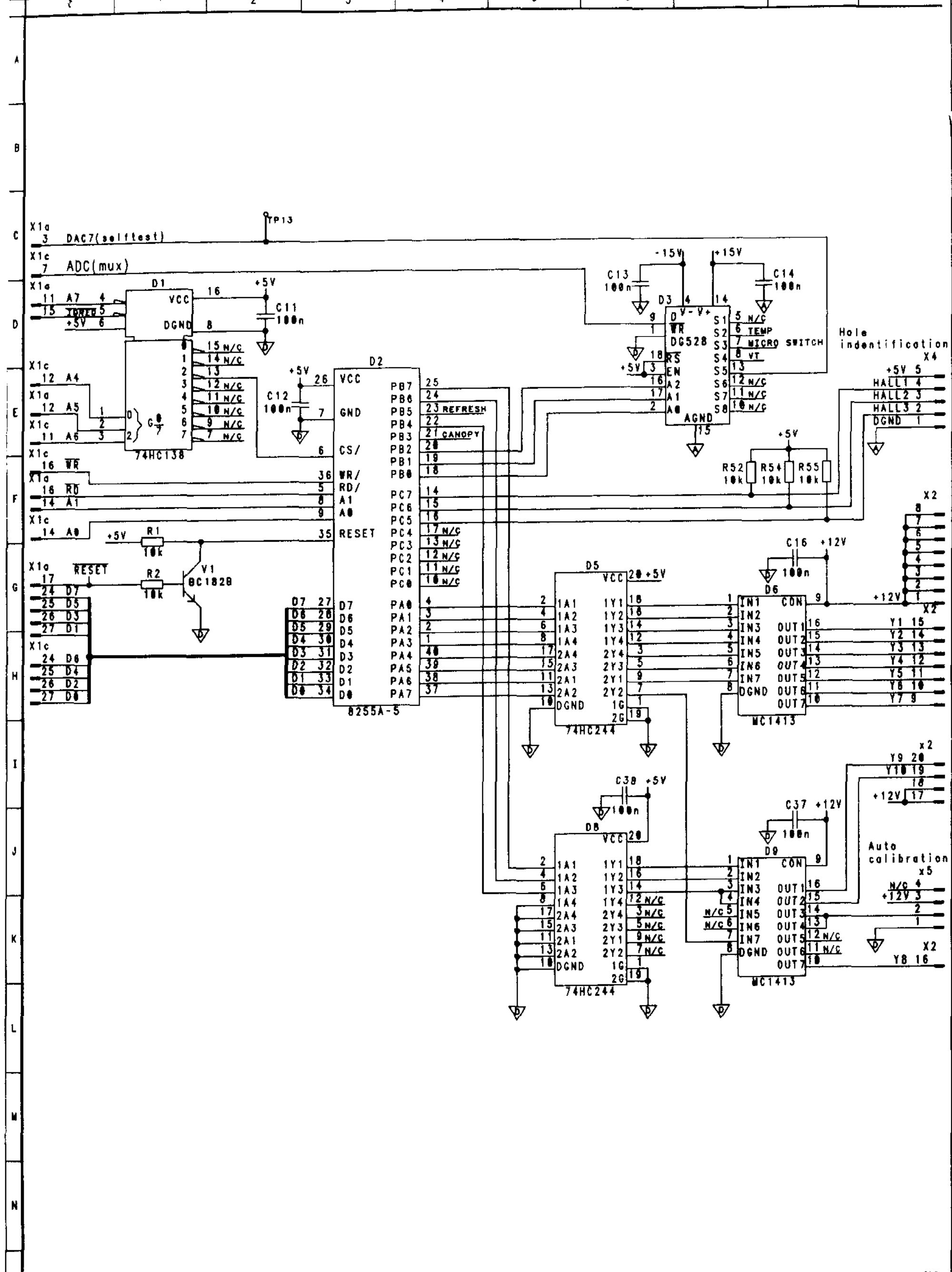
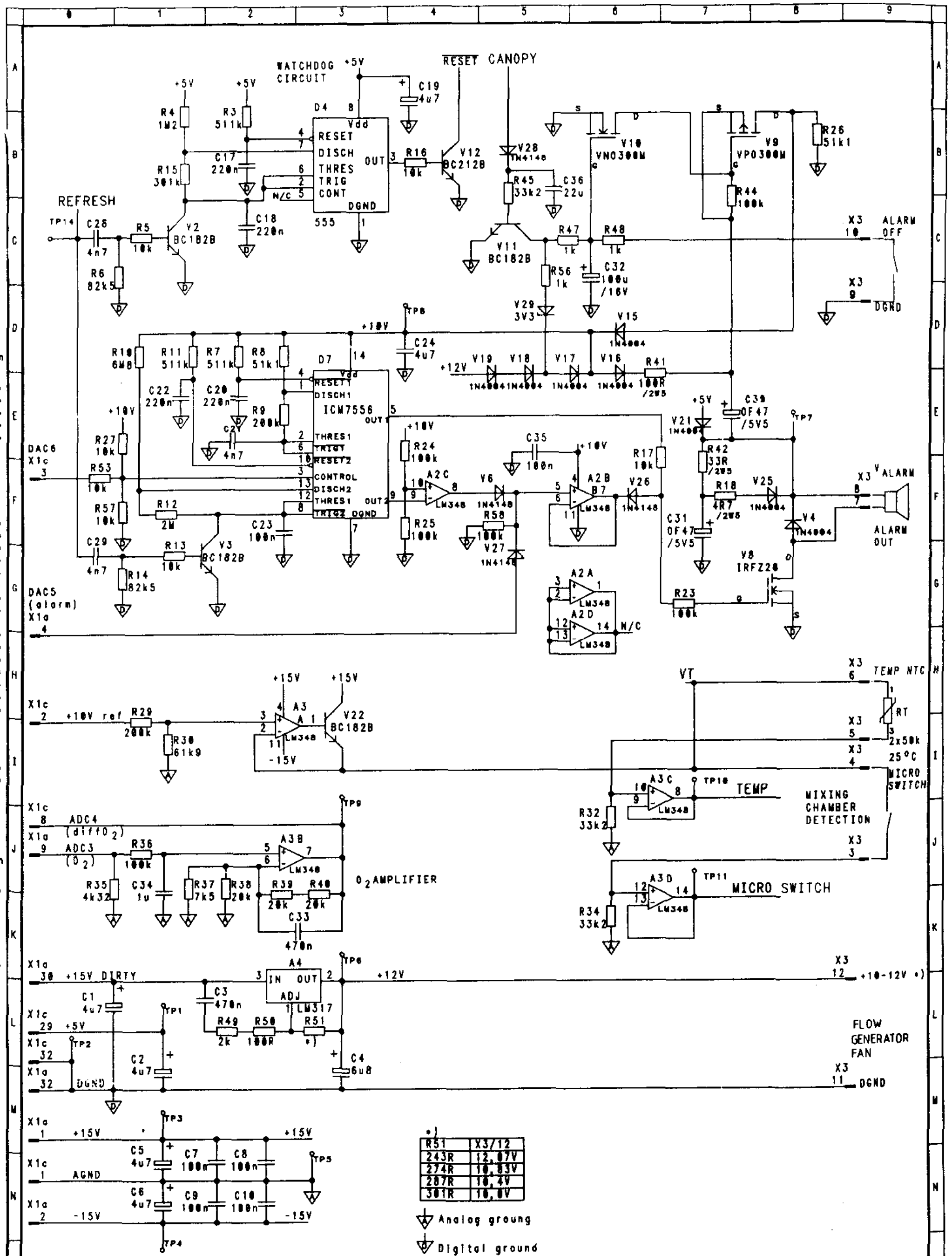


Figure 6.12 Valve Control Board Schematic Diagram (part 2)



07.09.02LEJA	26.10.92	7.12.92	6823	-1		
MUUT.	TARK.	HYV.	MUUTOS	MERKKI		

DATEX
INSTRUMENTARIUM OY
NIMI VALVE CONTROL BOARD
PIIRT. 28.05.92 LEJA
SIVU 1/2
LAITE MBM-200
N:O MB 3B 881457-1



*) R51	X3/12
243R	12,07V
274R	10,83V
287R	10,4V
301R	10,0V

MUUT.	TARK.	HYV.	MUUTOS	MERKKI

DATEX
INSTRUMENTARIUM OY
NIMI VALVE CONTROL BOARD
PIIRT. 28.05.92 LEJA
SIVU 2/2
LAITE MBM-200
N:O MB 3B 881457-1

6.3.9 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. See Figure 6.13 for the CPU board schematics diagram and parts layout.

The analog part is somewhat 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 is of 200 - 600 Hz frequency.

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.

The following checks may be performed:

1. RAM, EPROM, CPU, and other socketed I.C.‘s are properly installed and the memory configuration jumpers are correct.

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

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

4. 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.

5. If the real time clock is not running, check D16 and 23. If it always starts from 0.00 when the power is switched on, check battery Gl.

6. If the trends vanish with no apparent reason, check RAM (D6). Its internal data retention battery may be exhausted.

The correct jumper positions will be found in Figure 6.12.

6.3.9.1 Instructions When Replacing the Software or CPU Board

Before replacing;

1. Go to factory settings menu (see section 6.3.4 Diagnostic mode).
2. Write down O_2 BASELINE CORRECTION and 40% O_2 BASELINE CORRECTION values. The TOT values are the one to be remembered.
3. Go to flow calibration and start it.
4. Write down the adult flow constant in flow calibration menu.
5. All SETUP menu selections.

After replacing;

1. Perform a software reset by pressing MARK/RESET key for several seconds.
2. Enter the factory settings menu.
3. Set the correct date and desired keyboard volume.
4. Set the O_2 BASELINE CORRECTION to the value taken from the old software or CPU. The exact value can be measured by functional check procedure C (chapter 8).
5. Enter the flow calibration menu and set the adult flow constant as it was.
6. Return to the measurement mode by pressing NORMAL SCREEN twice.
7. Enter the SETUP menu, enter correct time and set other settings as they were.
8. Perform pressure calibration. The measured value must be the same as the correct ambient pressure.
9. Perform gas calibration.

Figure 6.13 CPU Board Troubleshooting Chart

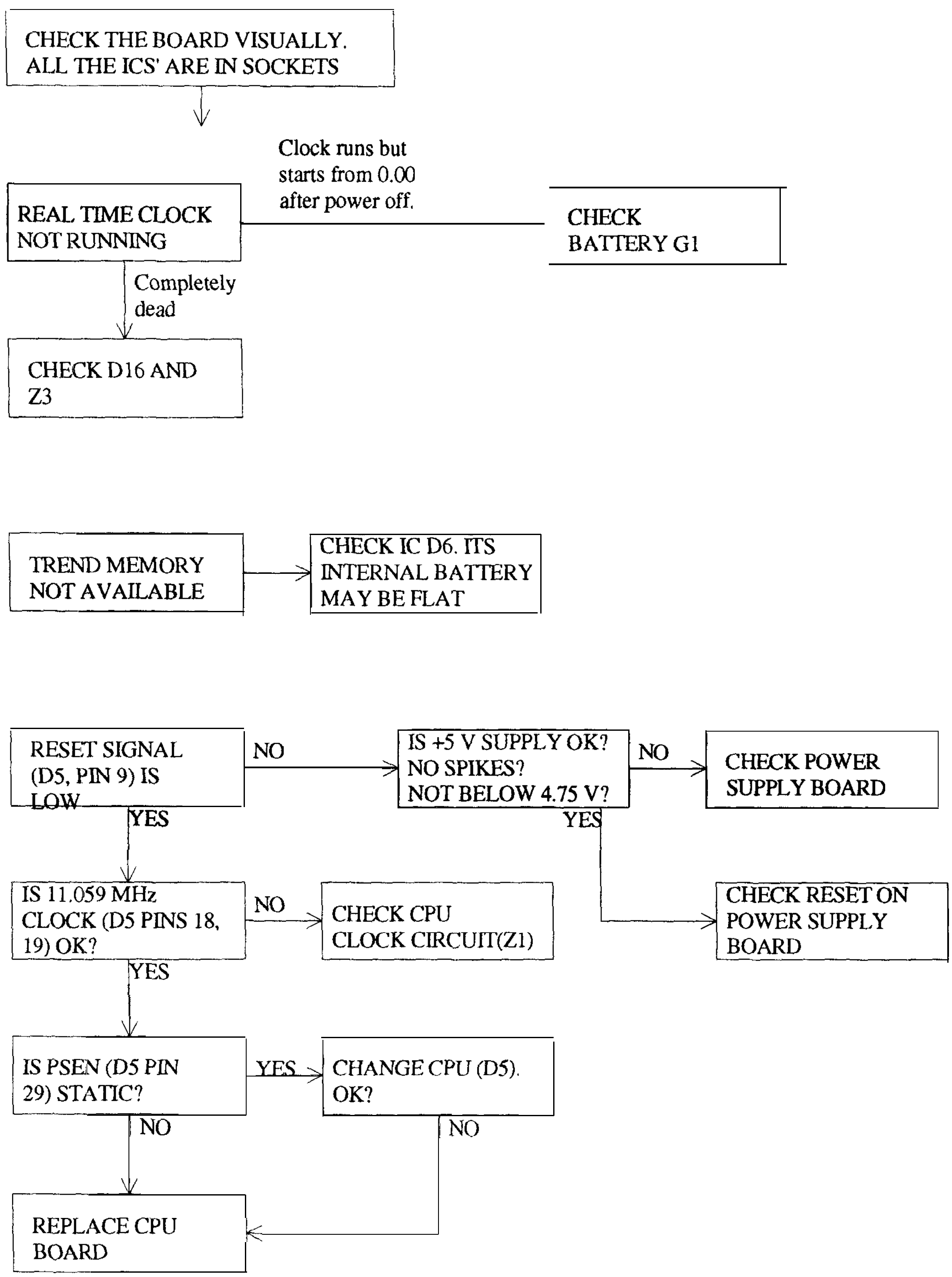
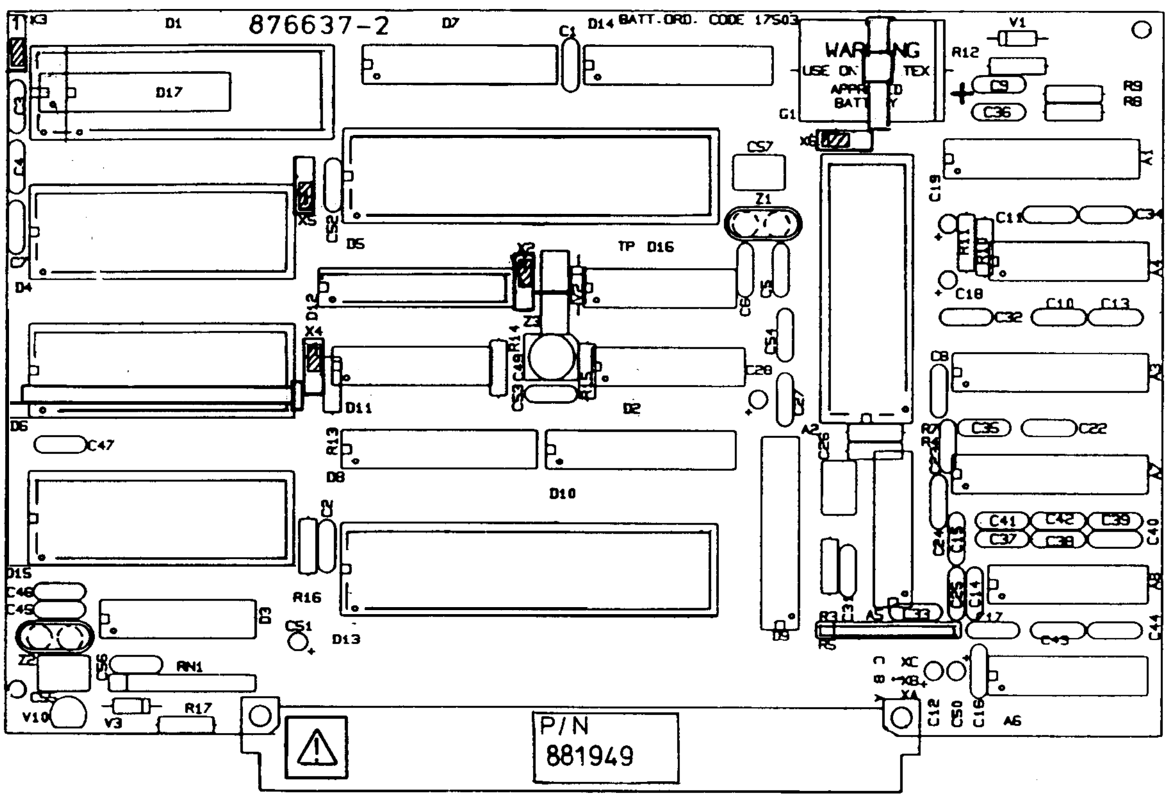
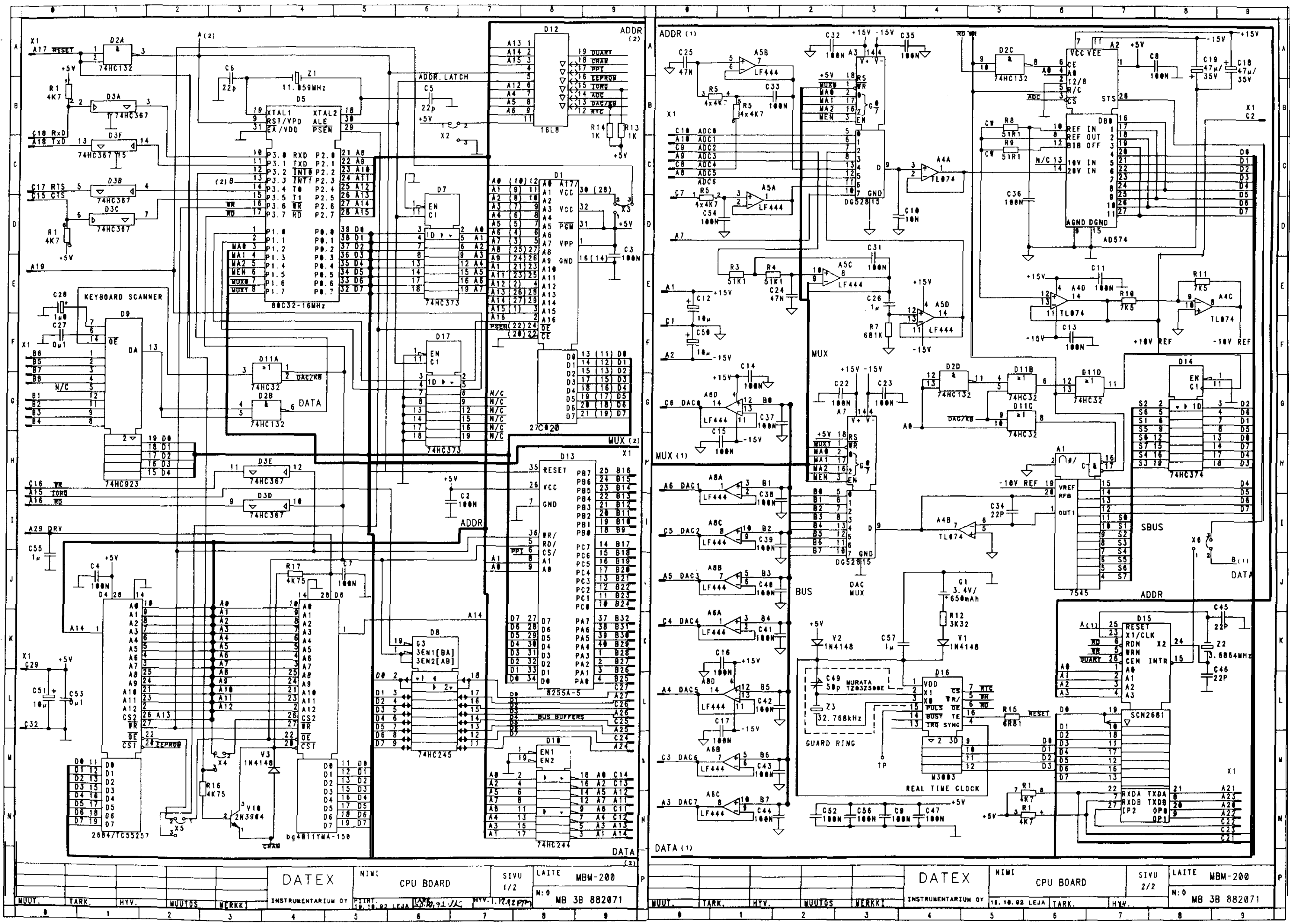


Figure 6.14 CPU Board Parts Layout and Schematic Diagram

CONNECTOR	JUMPER	MEMORY TYPE
X2, X4	1-2	D6 : 32k x 8 RAM
	2-3	D6 : 8k x 8 RAM
X3	1-2	D1 : 512k, 1M EPROM
	2-3	D1 : 2M, 4M EPROM
X5	1-2	D4 : E^{2}PROM, RAM
	2-3	D4 : EPROM
X6	1-2	Norm
	2-3	Test




DATEX
INSTRUMENTARIUM OY
NIMI
CPU BOARD
SIVU
1/2
LAITE
MBM-200
N:O
MB 3B 882071
MUUT.
TARK.
HYV.
MUUTOS
MERKKI
PIIRT.
10.10.92 LEJA
DATEX
INSTRUMENTARIUM OY
NIMI
CPU BOARD
SIVU
2/2
LAITE
MBM-200
N:O
MB 3B 882071
KEYBOARD SCANNER
REAL TIME CLOCK
GUARD RING
BUS BUFFERS
DAC MUX
SBUS

6.3.10 Video Controller Board Troubleshooting

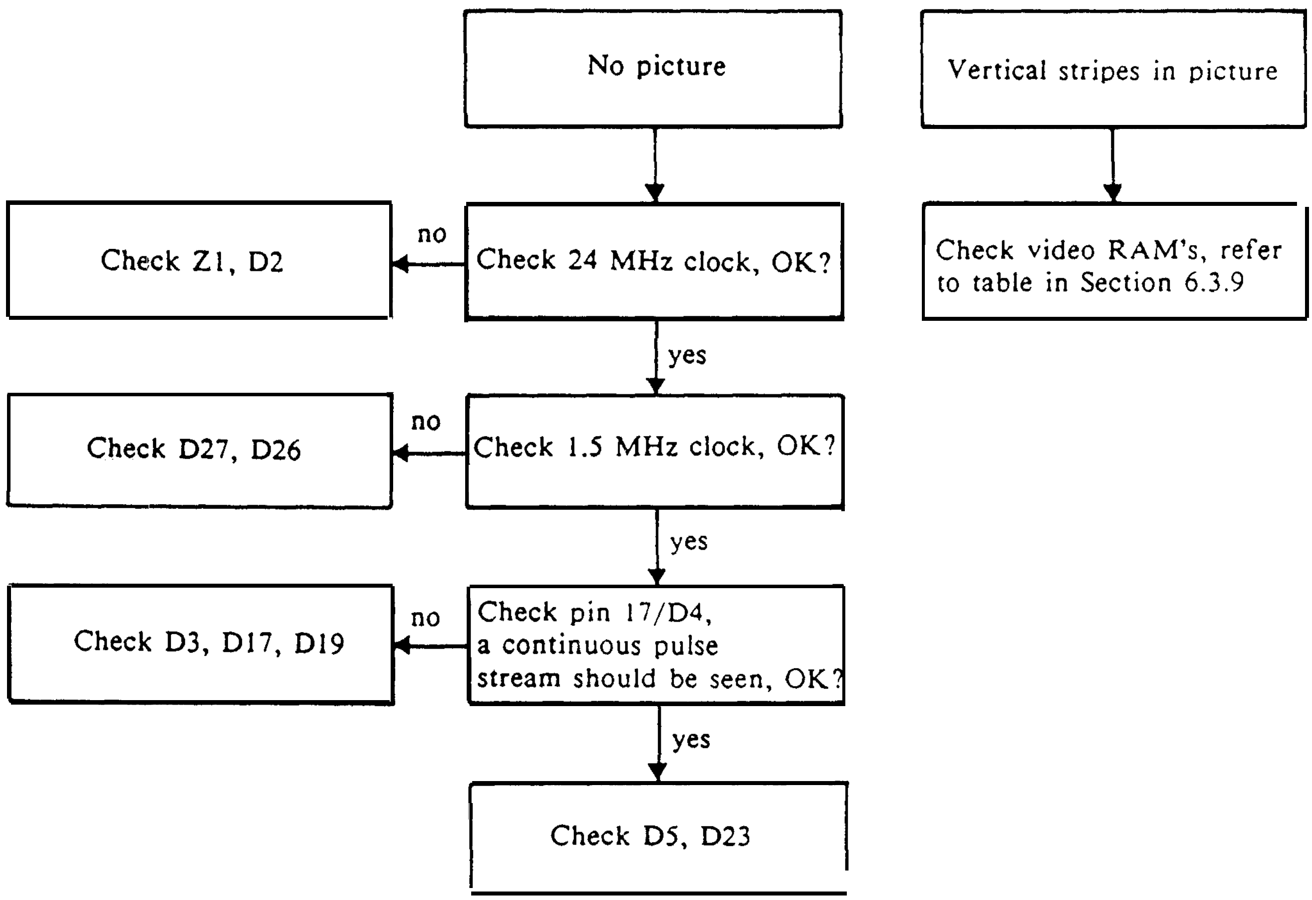
Before proceeding with the video controller board troubleshooting, check the composite video output with an external video monitor (24 MHz bandwidth required) to distinguish between faults in the controller board and faults in the CRT unit; if the composite output gives a good picture, the trouble possibly lies in the cables or in the CRT unit.

The video controller board schematic diagram and parts layout are shown in Figure 6.15. For troubleshooting the video controller board refer to Figure 6.15 and the timing diagram in Figure 6.16. For the video display module refer to the separate Panasonic service manual.

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

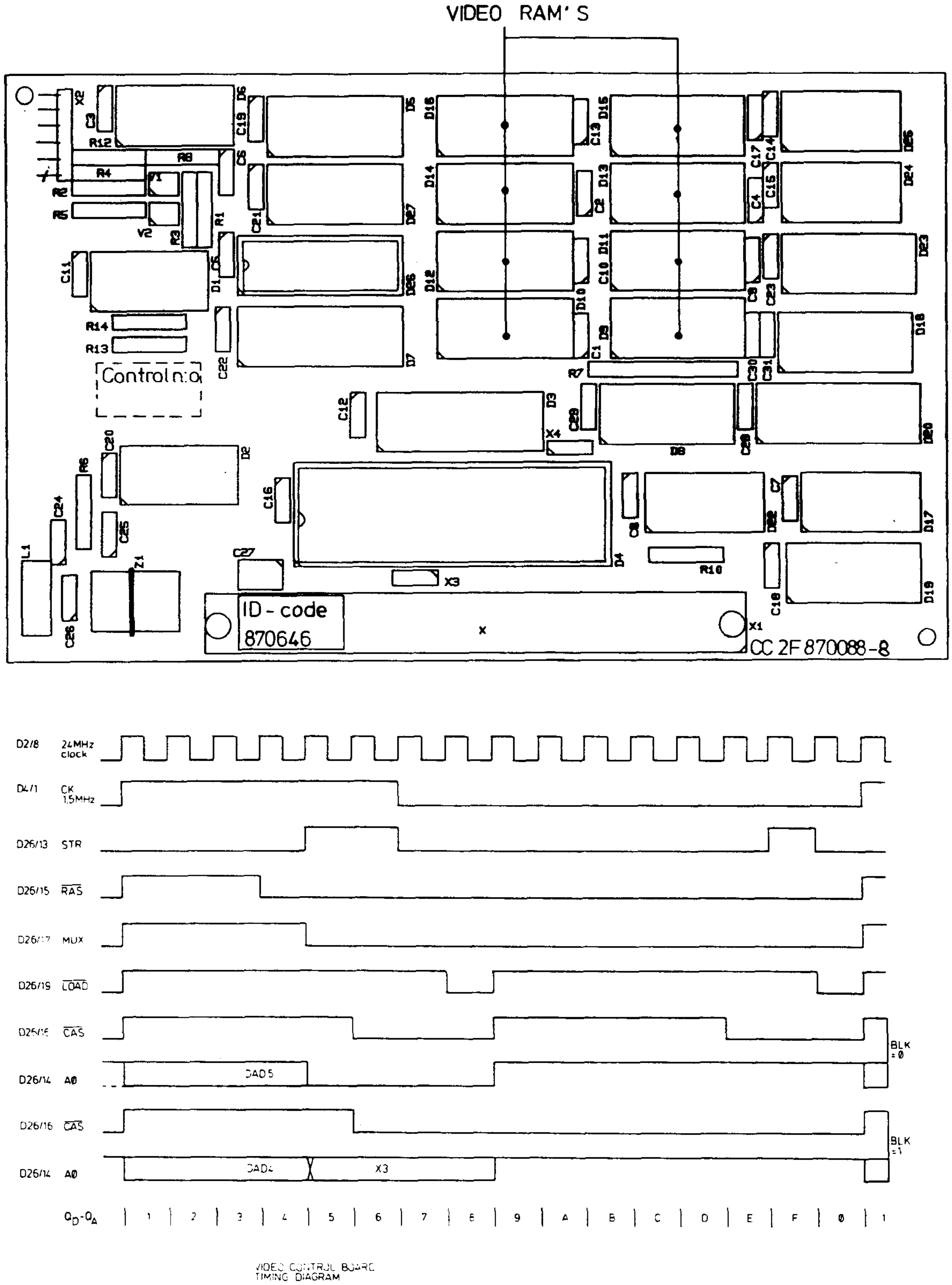
Faulty column from left edge (n = 0,1,2...)	Faulty RAM
1 + 8n	D16
2 + 8n	D15
3 + 8n	D14
4 + 8n	D13
5 + 8n	D12
6 + 8n	D11
7 + 8n	D10
8 + 8n	D9

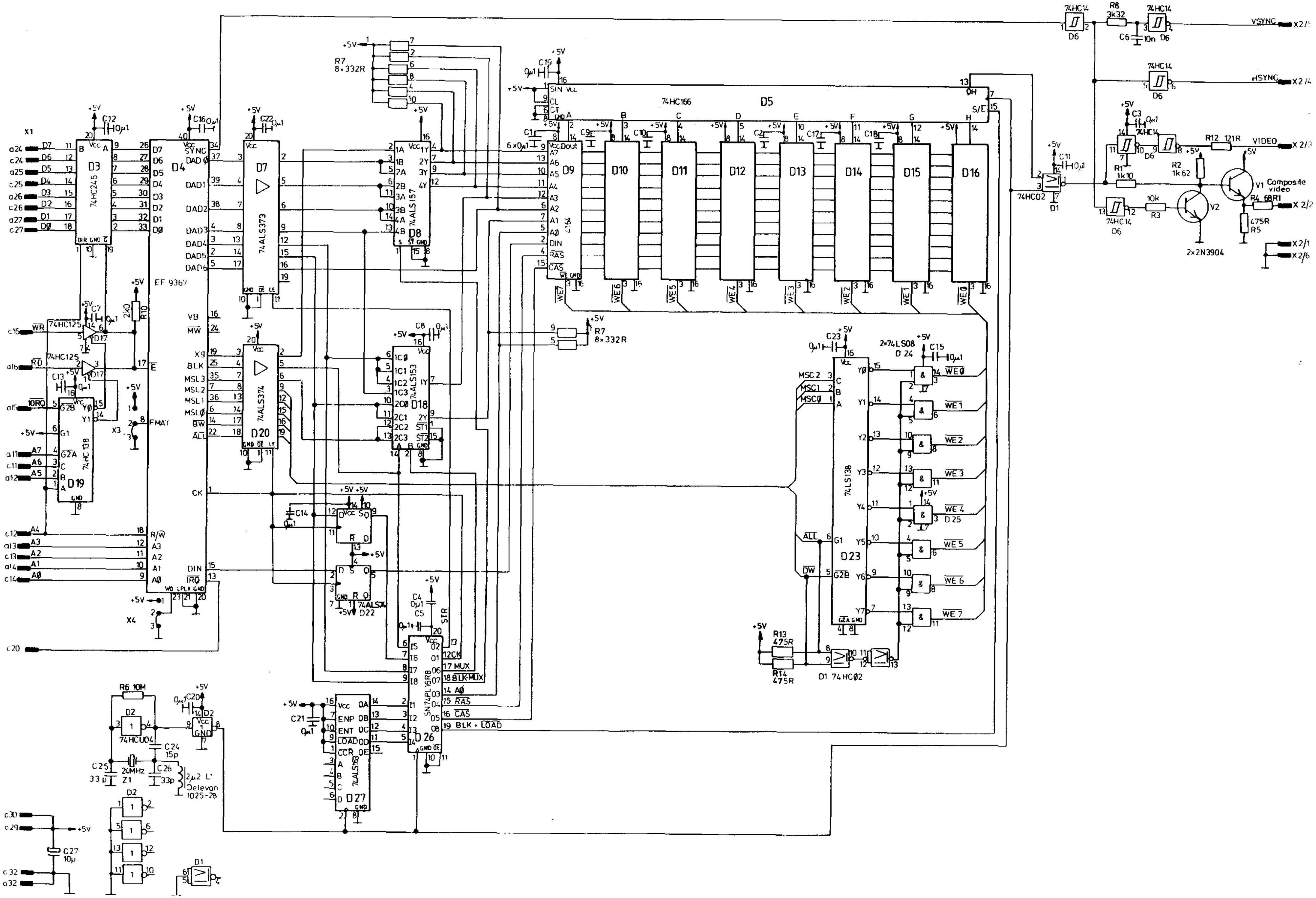
Figure 6.15 Video Controller Board Troubleshooting Chart



NOTE: Use video controller board
timing diagram (Figure 6.16) to check IC's.

Figure **6.16 Video Controller Board Schematic Diagram, Parts Layout and Timing Diagram (board modification level -8 and lower)**



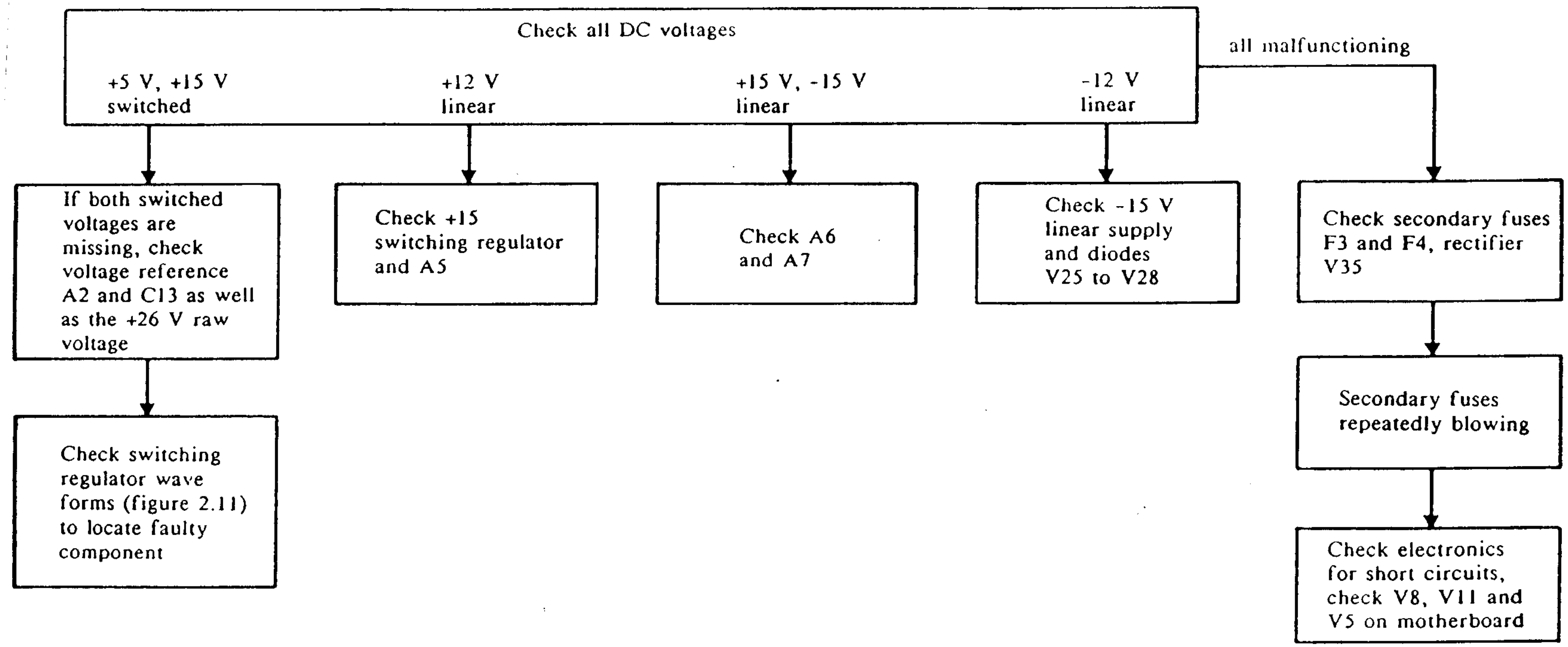


X1
D3
74HC245
D4
EF 9367
D7
74ALS373
D8
74ALS157
R7
8×332R
D5
74HC166
D9
D10
D11
D12
D13
D14
D15
D16
74HC14
D6
R8
3k32
C6
10n
VSYNC
X2/9
HSYNC
X2/4
VIDEO
X2/3
R12
121R
R1
1k10
R2
1k62
R3
10k
V1
V2
Composite video
R4
68R1
475R
R5
X2/2
X2/1
X2/6
2×2N3904
74HC02
D1
D17
74HC125
D19
74HC138
D20
74ALS374
D18
74ALS153
D22
74ALS74
D23
74LS138
2×74LS08
D24
D25
D26
SN74PL16R8
D27
74ALS163
D2
74HCU04
R6 10M
24MHz
Z1
Delevan 1025-28
C27
10µ
R13
475R
R14
475R
D1 74HC02

6.3.11 Power Supply Board Troubleshooting

The troubleshooting chart in Figure 6.17 helps in pinpointing a malfunctioning component. The only parts that require understanding of operating principles are the switching supplies. Refer to the wave form diagram (Figure 6.18) and the IC data sheet for more info on the LM 3524 switcher controller.

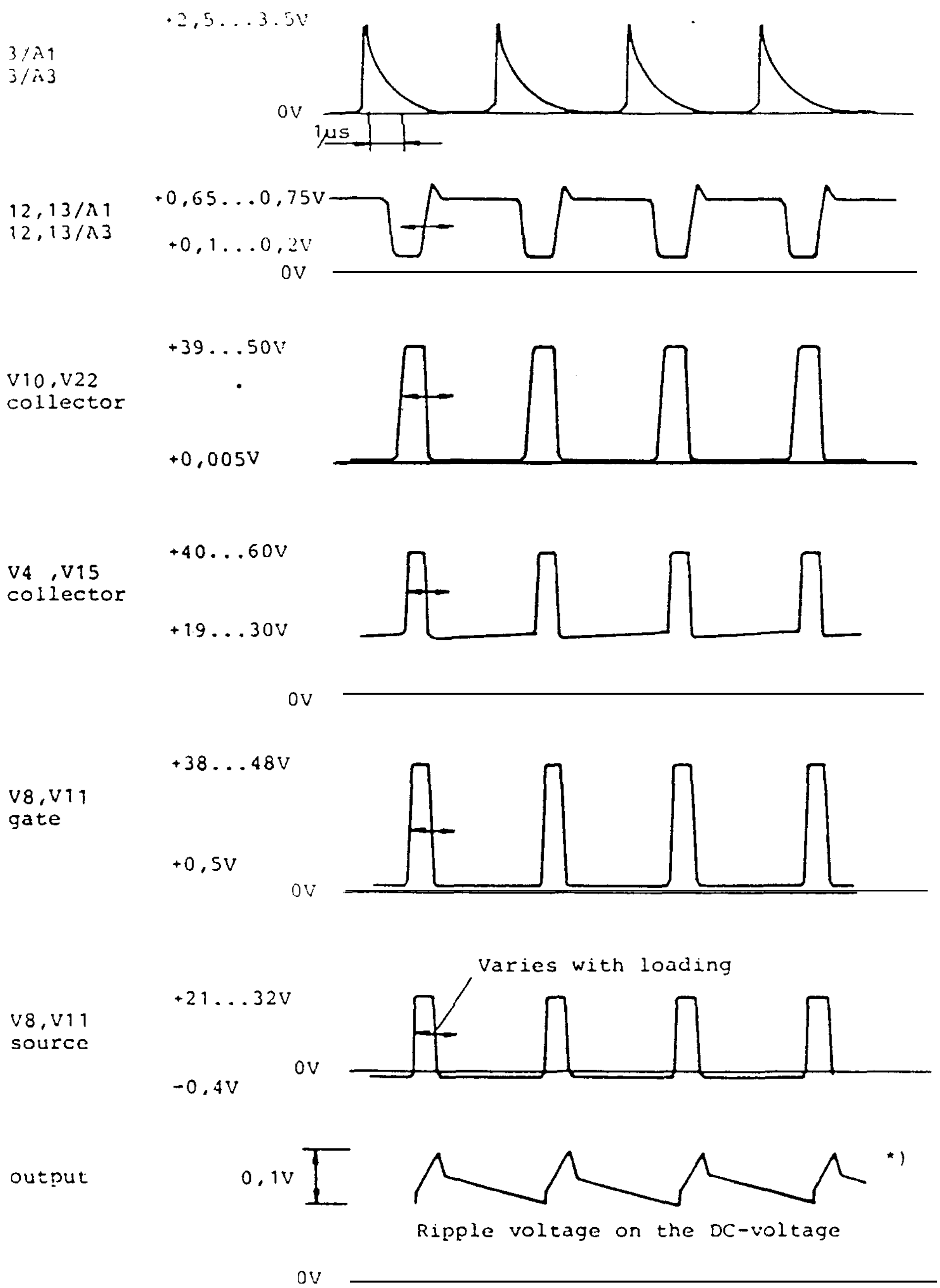
> **NOTE:** If FET V8 (V11) is shorted it usually shorts the Transzorb zener V6 (V23) and blows the secondary fuses F3 and F4.



Note: If FET V8 or V11 is shorted it usually shorts also the Transzorb zener (V6, V23) and blows the secondary fuses F3 and F4.

Figure 6.17 Power Supply Board Troubleshooting Chart

Figure 6.18 Switching Regulator Wave Forms



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

Figure 6.19 Power Entry Module Schematic Diagram and Power Supply Board Parts Layout

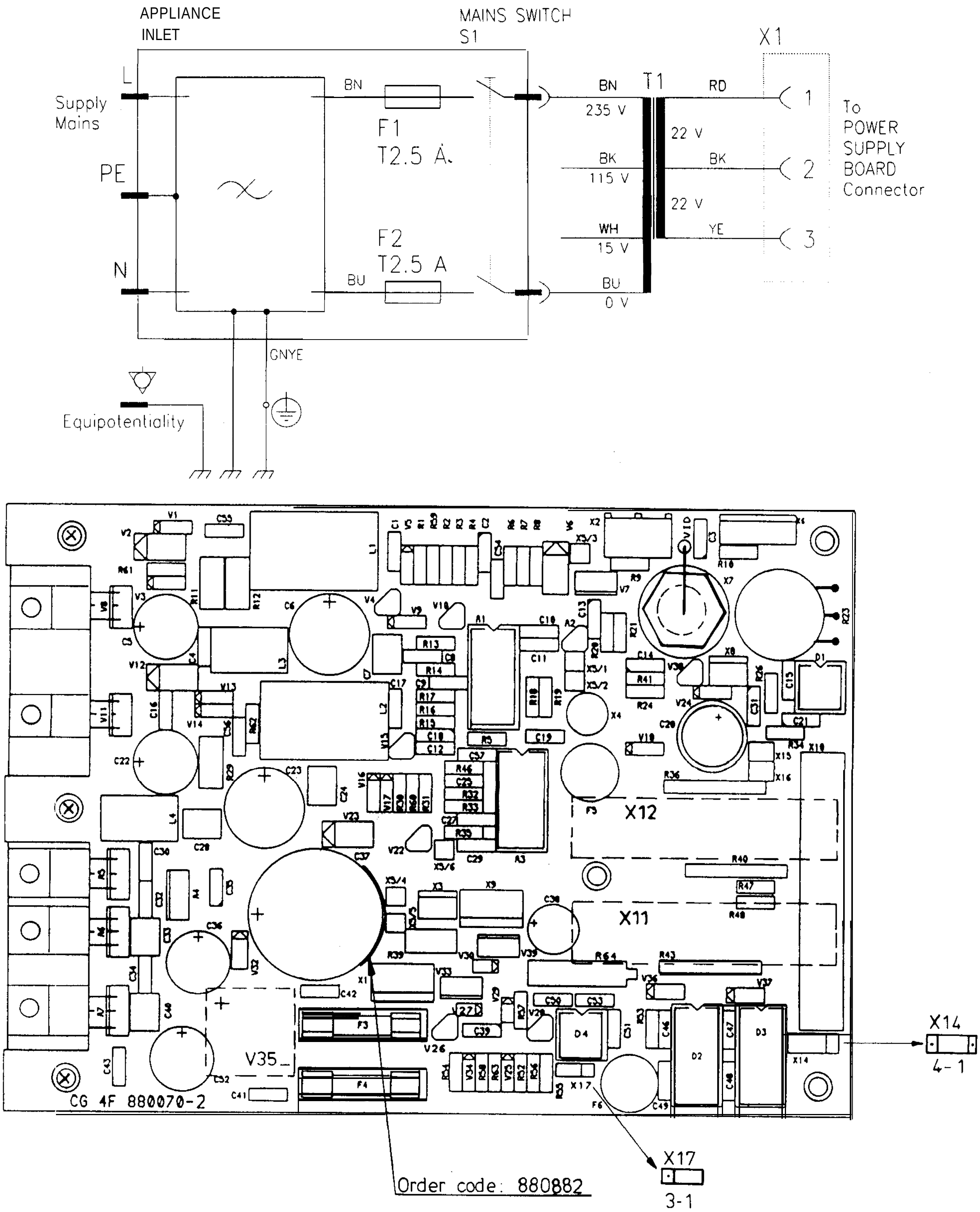
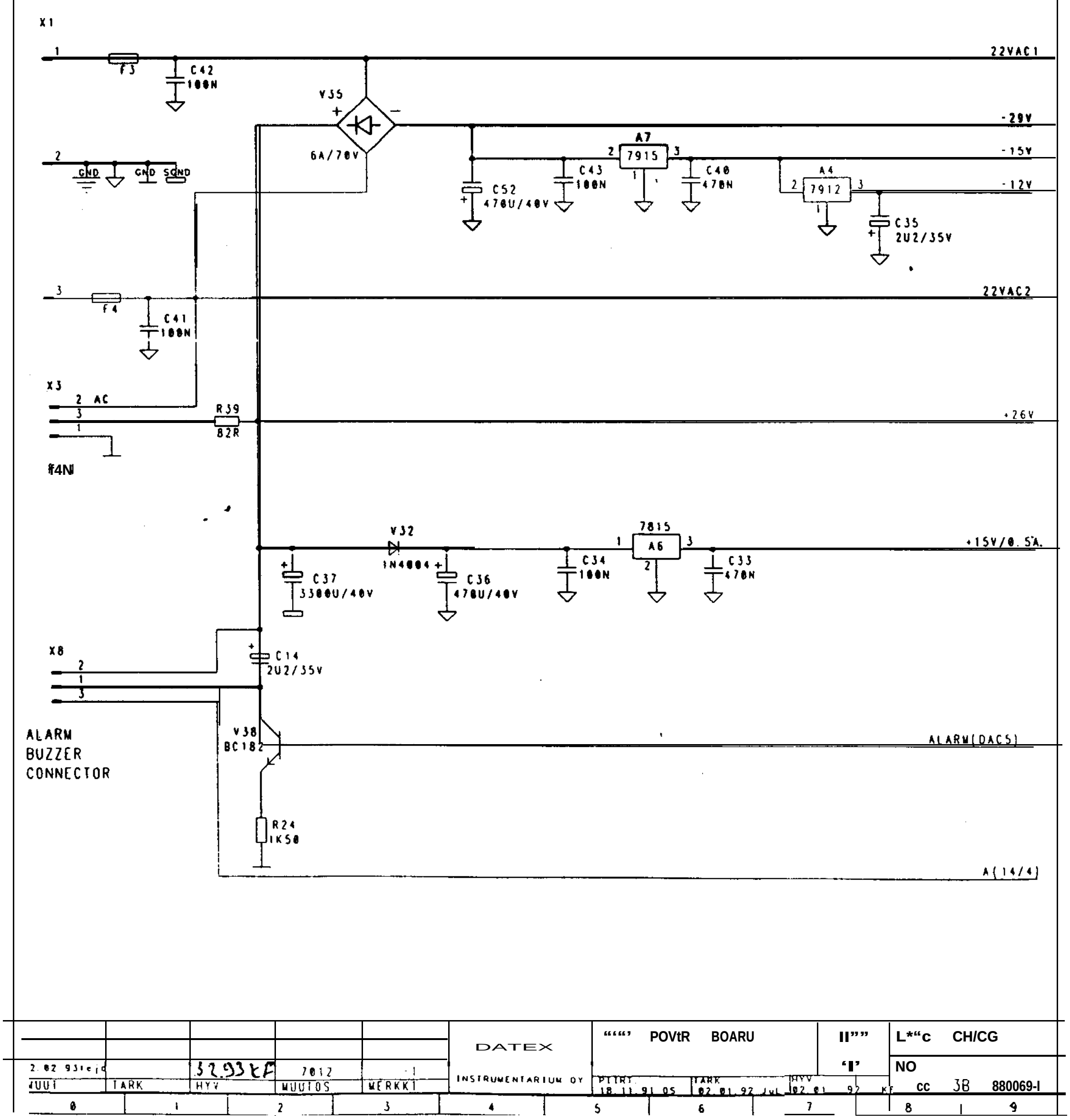
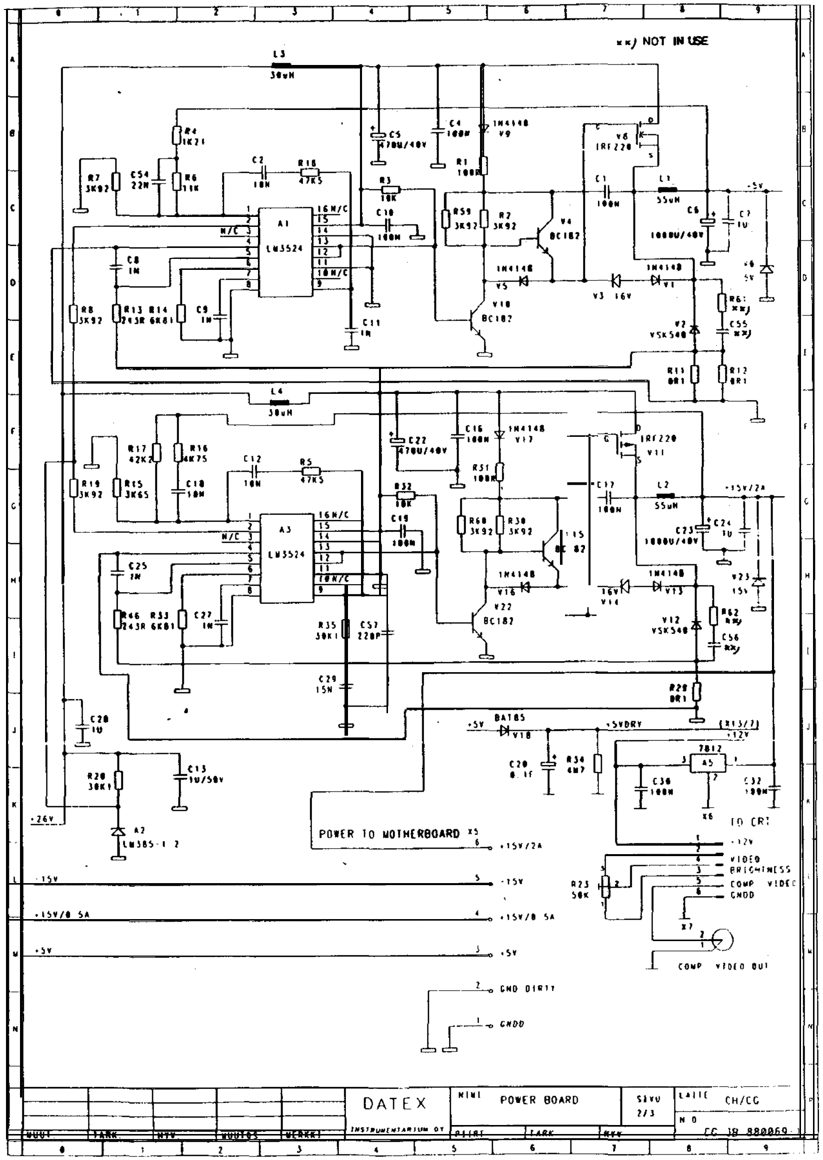


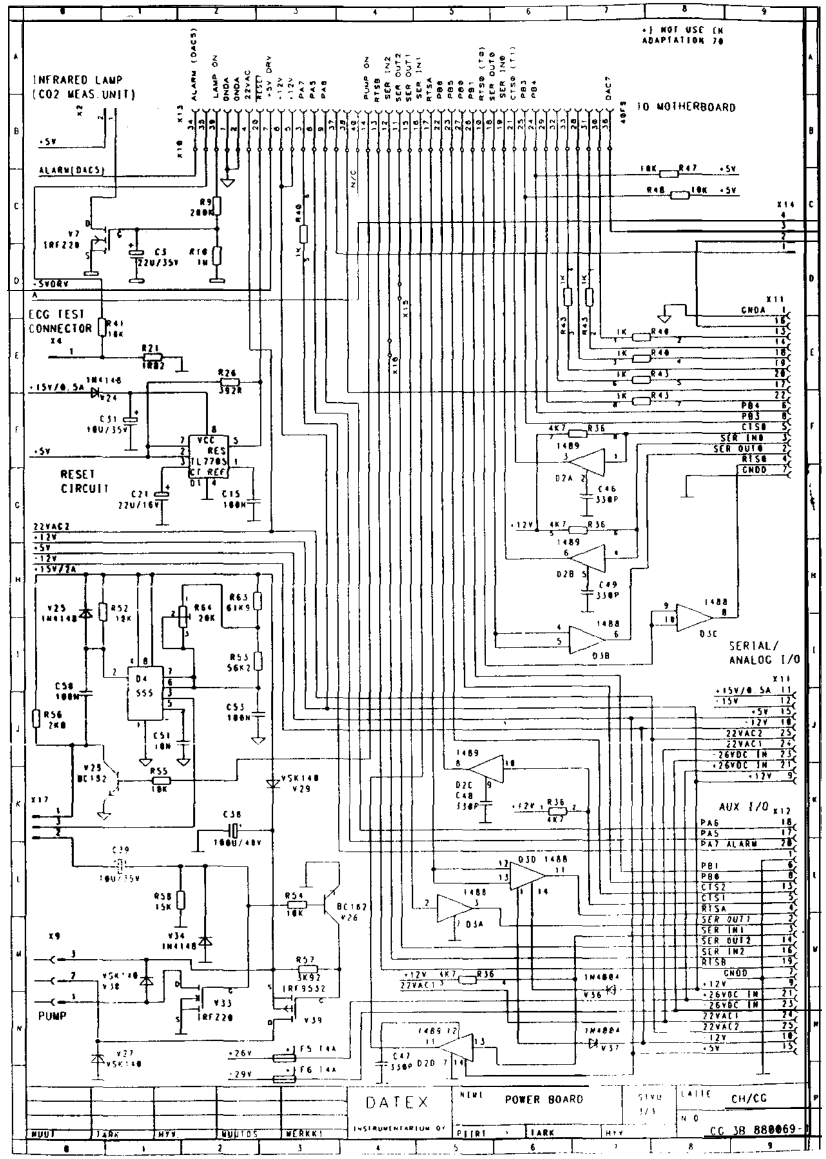
Figure 6.20 Power Supply Board Schematic Diagram

Fuses F3 and F4	Monitor	X11 Serial / Analog I/0							
	Pin.No	13	14	16	17	18	19	20	22
T3.15A	CC/CH	Uncal BP.2	O_2	SpO_2	BP.2	ECC	BP.1	CO_2	input AUX
T3.15A	MBM	Mux	O_2	Selftest	A.freq.	-	O_2 low.	CO_2	-
T3.15A	ULT	·	O_2	N_2O	A A	-	SPO_2	CO_2	pleth
T3.15A	SCO								
T2.5A	SC								
T1.6A	OS								
T1.6A	OSC								
	Pin.No	30	31	37	38	28	33	32	29
		X10 Flatcable							





**) NOT IN USE
LM3524
POWER TO MOTHERBOARD
TO CRT
VIDEO
BRIGHTNESS
COMP VIDEO
GNDD
COMP VIDEO OUT
GND DIRTY
DATEX
INSTRUMENTARIUM OY
POWER BOARD
2/3
CH/CG
CG 3B 880069



*) NOT USE IN ADAPTATION 70
INFRARED LAMP (CO2 MEAS.UNIT)
TO MOTHERBOARD
ECG TEST CONNECTOR
RESET CIRCUIT
SERIAL/ ANALOG I/O
AUX I/O
PUMP
DATEX
INSTRUMENTARIUM OY
POWER BOARD
3/3
CH/CG
CG 3B 880069

6.3.12 Mother Board / Keyboard Troubleshooting

Mother board schematic diagram and parts layout are shown in Figure 6.21.

Troubleshooting of the mother board is limited to:

-visual inspection of board surface and connectors

-continuity and short circuit testing with an ohmmeter

-measuring of power supply voltages

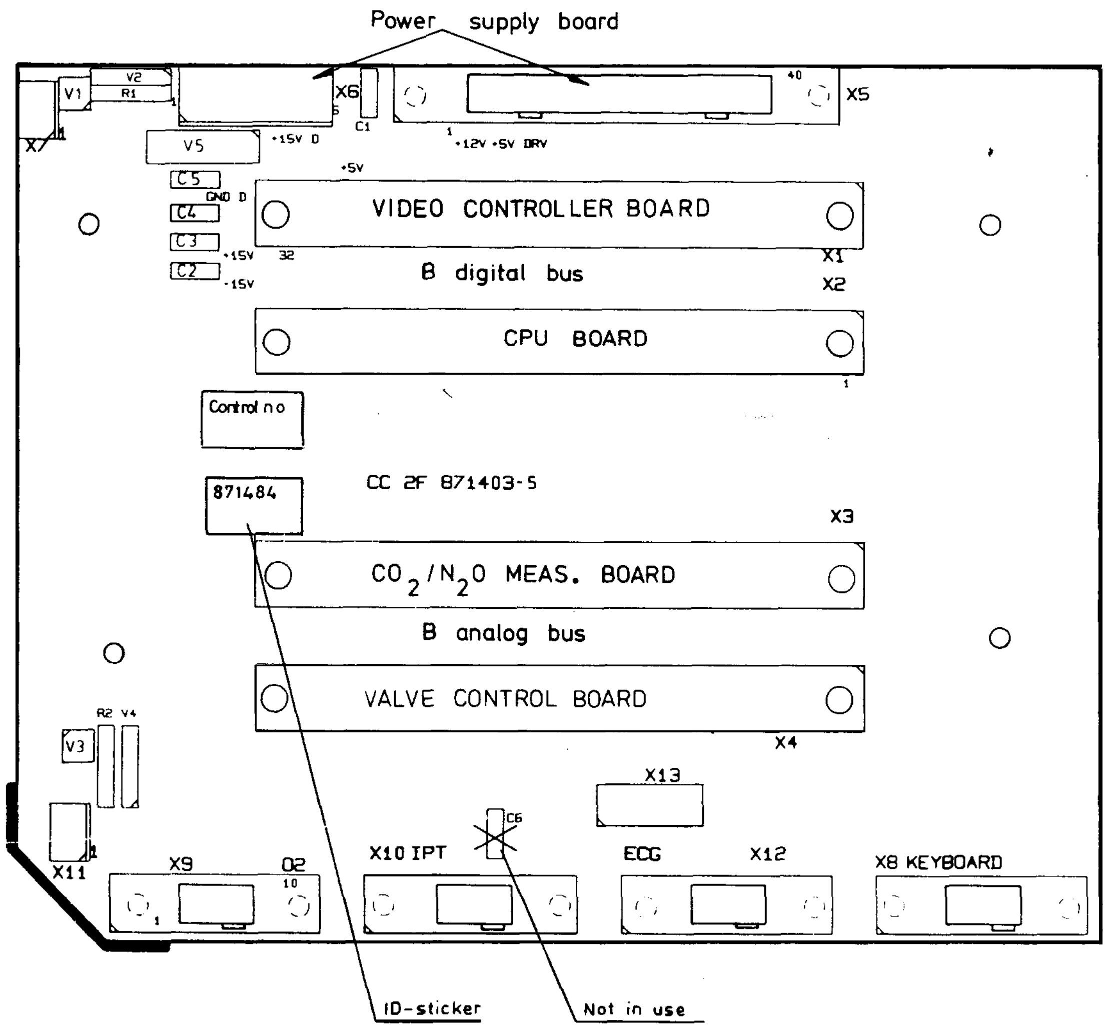
6.3.13 Video Display Module Troubleshooting

For video display module troubleshooting refer to Panasonic M-K 9101NB CRT Data Display service manual available from Datex (P/N 572760).

6.3.14 Hall Board Troubleshooting

Check the board visually. Check also magnets in the flow selector wheel.

Figure 6.21 Mother Board Parts Layout and Schematic Diagram (board modification level -4 and lower)



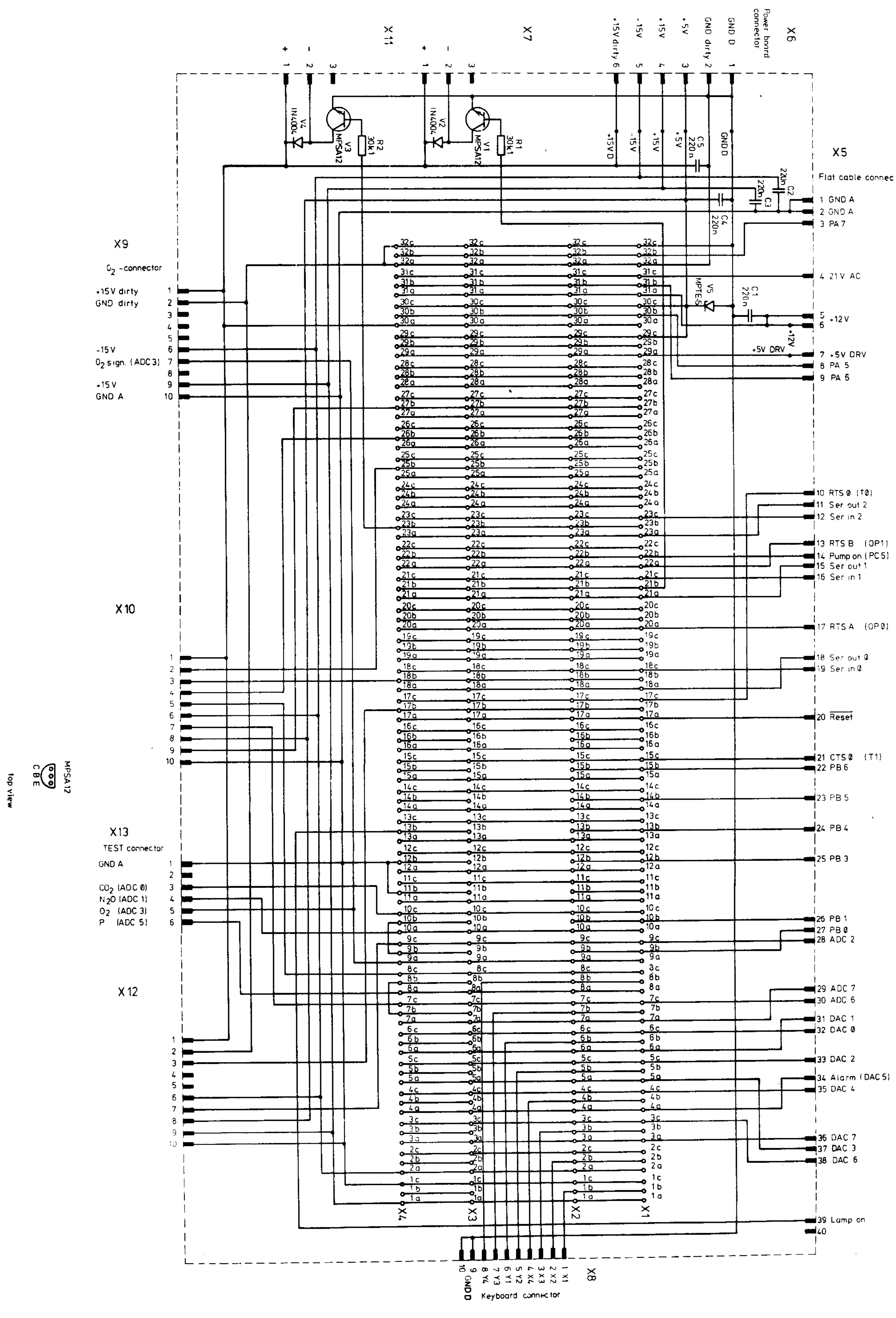

X11
X7
X6
Power board connector
+15V dirty 6
-15V 5
+15V 4
+5V 3
GND dirty 2
GND D 1
V4 1N4004
V3 MPSA12
R2 30k1
V2 1N4004
V1 MPSA12
R1 30k1
+15VD
-15V
+15V
+5V
C5 220n
GND D
X5
Flat cable connec
C2 220n
C3 220n
C4 220n
1 GND A
2 GND A
3 PA 7
4 21V AC
V5 MPTE5
C1 220n
5 +12V
6
+12V
+5V DRV
7 +5V DRV
8 PA 5
9 PA 6
10 RTS 0 (T0)
11 Ser out 2
12 Ser in 2
13 RTS B (OP1)
14 Pump on (PC5)
15 Ser out 1
16 Ser in 1
17 RTS A (OP0)
18 Ser out 0
19 Ser in 0
20 Reset
21 CTS 0 (T1)
22 PB 6
23 PB 5
24 PB 4
25 PB 3
26 PB 1
27 PB 0
28 ADC 2
29 ADC 7
30 ADC 6
31 DAC 1
32 DAC 0
33 DAC 2
34 Alarm (DAC 5)
35 DAC 4
36 DAC 7
37 DAC 3
38 DAC 6
39 Lamp on
40
X9
O2 -connector
+15V dirty 1
GND dirty 2
-15V 6
O2 sign. (ADC3) 7
+15V 9
GND A 10
X10
X13
TEST connector
GND A 1
CO2 (ADC 0) 3
N2O (ADC 1) 4
O2 (ADC 3) 5
P (ADC 5) 6
X12
MPSA12
C B E
top view
X4
X3
X2
X1
X8
1 X1
2 X2
3 X3
4 X4
5 Y2
6 Y1
7 Y3
8 Y4
9
10 GND D
Keyboard connector

Figure 6.22 Hall Board Parts Layout

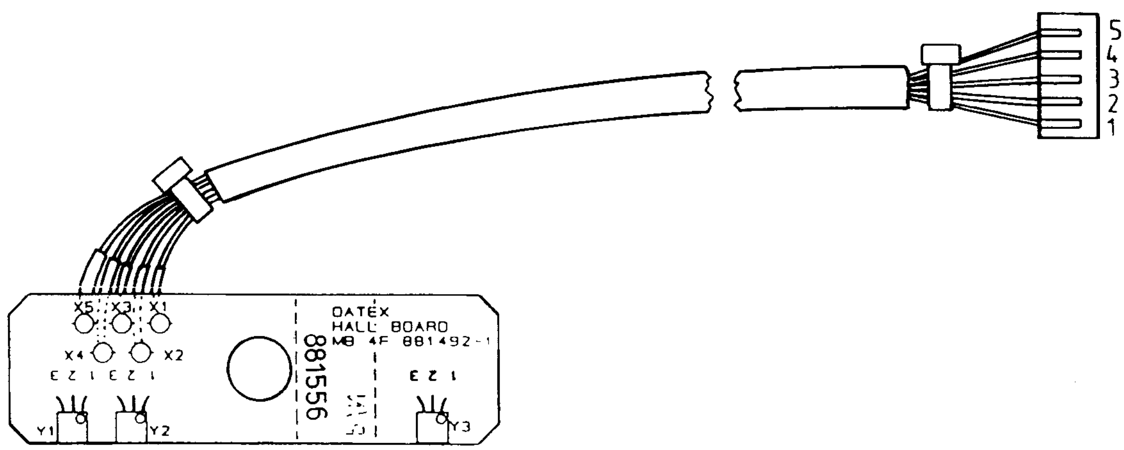
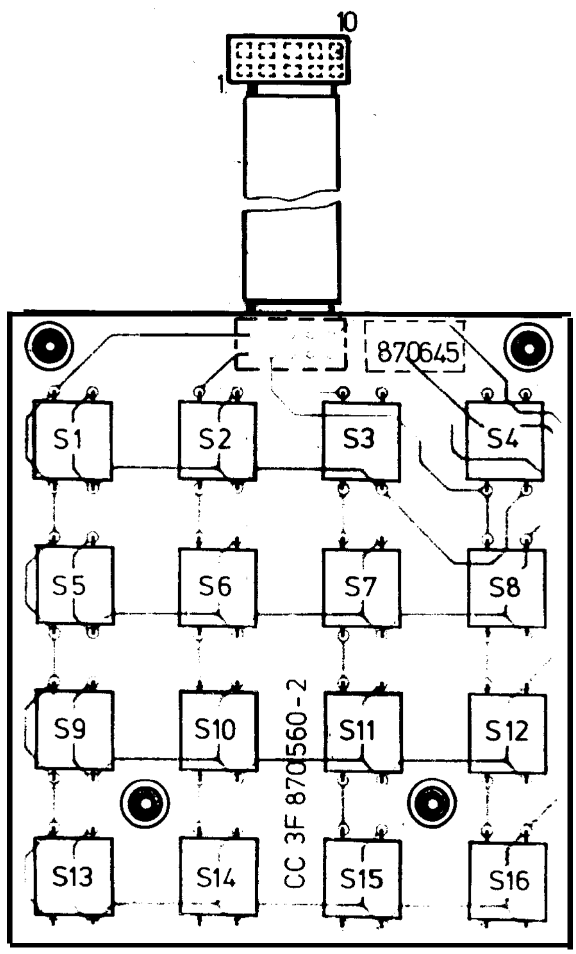


Figure 6.23 Keyboard Parts Layout (board modification level 3 and lower)



7 ADJUSTMENTS

7.1 Adjustments After Component Replacements

COMPONENT REPLACED	ADJUSTMENTS
CPU BOARD	Software or the whole board.
	See Section 6.3.8.1.
Real time clock circuit (D16) or crystal (Z3)	Real time clock frequency (Section 7.5.2).
GAS MEASUREMENT	
Flow generator, valve control board	Check flow constant (Section 5.4).
GAS MEASUREMENT	
IC's diodes, transistors or passive components	Zero and gain (Section 7.2).
Reference diode V2 (measuring board)	Reference voltage (Section 7.2).
Photodetector, measuring chamber, IR lamp, filter wheel or whole photometer	Temperature compensation, zero and gain (Section 7.2).
Preamplifier board	Temperature compensation (Section 7.2).
Measuring board	Zero and gain (Section 7.2).
Pressure transducer	Change also the zero and temperature compensation resistors. Adjust pressure measurement zero and gain (Section 7.3).

7.2 CO_2 Measurement Adjustments

The adjustment that may be occasionally needed is the analog zero adjustment to compensate for gradual contamination of the measuring chamber. **Cleaning (see Section 6.3.6.1) is, however, always the first thing to perform when contamination is detected and zero adjustment should be done only in extreme cases when the cleaning is not successful.**

> **NOTE:** The three other adjustments described below (Gain, Reference voltage, and Temperature compensation adjustments) are for reference only. They are done at the factory.

See also the table Adjustments after component replacement on the previous page.

Analog zero adjustment

1 Enter Diagnostic mode check 3 (see Section 6.3.4). Let the monitor run at least 10 minutes to eliminate errors caused by initial warm-up.

2 Connect a CO_2 absorber to the sample input.

3 Using a digital voltmeter measure the CO_2 output (mother board test connector X13 pins 3). Adjust the output to zero with the trim resistor R23 in the measuring board.

In the Diagnostic mode the output voltage is automatically displayed on the screen.

4 Detach the CO_2 absorber. Perform the software zeroing and gas calibration (refer to Operator's Manual).

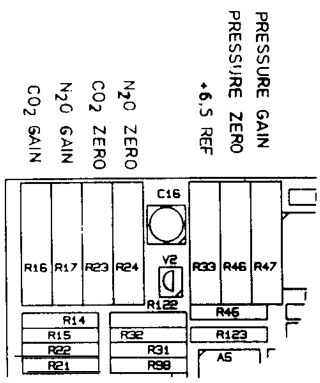


Figure 7.1 Adjustment Trimmer Locations

Gain adjustment

For the gain adjustment calibration gas is required. The CO_2 concentration should be between 5 and 10 %, and should be known to within ±5 % or better.

1. Let the monitor run at least one hour. Enter the Diagnostic mode check 3 (see Section 6.3.4) and adjust the analog zero as described before.

2. Feed the CO_2 calibration gas and adjust the output (mother board test connector X13 pin 3) with the trim resistor R16 in the measuring board to a voltage corresponding to the CO_2 content in the calibration gas. The voltage is listed in Figure 7.1.

In the Diagnostic mode the output voltage is automatically displayed on the screen.

3. Check and if necessary readjust the output voltage.

4. Perform the software zeroing and gas calibration (refer to Operator’s Manual).

Figure 7.2 CO_2 Linearization

CO_2 linearisointitaulukko

OUT/V	%CO_2	OUT/V	%CO_2	T/V	%CO_2
0.00	0.00	3.05	2.35	6.10	6.86
0.05	0.03	3.10	2.40	6.15	6.96
0.10	0.05	3.15	2.46	6.20	7.06
0.15	0.08	3.20	2.51	6.25	7.16
0.20	0.11	3.25	2.57	6.30	7.26
0.25	0.14	3.30	2.63	6.35	7.36
0.30	0.17	3.35	2.68	6.40	1.46
0.35	0.20	3.40	2.74	6.45	7.56
0.40	0.23	3.45	2.80	6.50	7.67
0.45	0.26	3.50	2.86	6.55	7.71
0.50	0.29	3.55	2.92	6.60	7.88
0.55	0.32	3.60	2.98	6.65	7.99
0.60	0.35	3.65	3.04	6.70	8.10
0.65	0.38	3.70	3.10	6.75	8.21
0.70	0.41	3.75	3.16	6.80	8.32
0.75	0.44	3.80	3.22	6.85	8.43
0.80	0.41	3.85	3.29	6.90	8.54
0.85	0.50	3.90	3.35	6.95	8.66
0.90	0.53	3.95	3.42	7.00	8.71
0.95	0.57	4.00	3.48	7.05	8.89
1.00	0.60	4.05	3.55	7.10	9.01
1.05	0.63	4.10	3.61	7.15	9.13
1.10	0.67	4.15	3.68	7.20	9.25
1.15	0.70	4.20	3.15	7.25	9.37
1.20	0.73	4.25	3.82	7.30	9.49
1.25	0.77	4.30	3.89	7.35	9.62
1.30	0.80	4.35	3.96	7.40	9.14
1.35	0.84	4.40	4.03	7.45	9.87
1.40	0.88	4.45	4.10	7.50	10.00
1.45	0.91	4.50	4.17	7.55	10.13
1.50	0.95	4.55	4.24	7.60	10.26
1.55	0.99	4.60	4.31	7.65	10.39
1.60	1.02	4.65	4.39	7.70	10.53
1.65	1.06	4.70	4.46	7.75	10.66
1.70	1.10	4.75	4.54	7.80	10.80
1.75	1.14	4.80	4.61	7.85	10.94
1.80	1.18	4.85	4.69	7.90	11.08
1.85	1.22	4.90	4.17	7.95	11.22
1.90	1.26	4.95	4.85	8.00	11.36
1.95	1.30	5.00	4.93	8.05	11.51
2.00	1.35	5.05	5.01	8.10	11.66
2.05	1.39	5.10	5.09	8.15	11.81
2.10	1.43	5.15	5.17	8.20	11.96
2.15	1.47	5.20	5.25	8.25	12.11
2.20	1.52	5.25	5.33	8.30	12.26
2.25	1.56	5.30	5.41	8.35	12.42
2.30	1.61	5.35	5.50	8.40	12.58
2.35	1.65	5.40	5.58	8.45	12.74
2.40	1.70	5.45	5.67	8.50	12.90
2.45	1.75	5.50	5.76	8.55	13.06
2.50	1.79	5.55	5.84	8.60	13.23
2.55	1.84	5.60	5.93	8.65	13.39
2.60	1.89	5.65	6.02	8.70	13.56
2.65	1.94	5.70	6.11	8.75	13.74
2.70	1.99	5.75	6.20	8.80	13.91
2.15	2.04	5.80	6.29	8.85	14.09
2.80	2.09	5.85	6.38	8.90	14.26
2.85	2.14	5.90	6.48	8.95	14.45
2.90	2.19	5.95	6.57		
2.95	2.24	6.00	6.67		
3.00	2.30	6.05	6.76		

Reference voltage adjustment

1 Connect a digital voltmeter between measuring board connector Xl pin 6b and ground.

2 Using trimmer R33 adjust the DVM to read 6.50 V.

Temperature compensation adjustment

For adjusting the temperature compensation the following gas mixture is needed:

- 5 to 9 % CO_2 in air

The exact percentage is not critical, but the same gas must be used throughout the adjustment.

For most accurate result, the adjustment is performed in a temperature controlled room if available.

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

1 Before the adjustment, let the monitor be at room temperature with power off at least 4 hours.

2 Connect a digital voltmeter between test points T+ and T- (pins 1 and 3 at the preamplifier board flat cable connector or 3b and 4b at Xl of the measuring board).

3 Switch power on and enter Diagnostic mode check 2 to draw the CO_2 sample through the sampling line (see Section 6.3.4). Let the monitor run approximately 10 minutes. Adjust R16 on the preamplifier board until the DVM reads zero.

4 Adjust the analog zero of CO_2 as described before.

5 Feed the CO_2 test gas and make a note of the reading obtained.

6 Let the unit run at least three hours with covers closed. Best result is obtained if the room temperature is simultaneously raised by about 10 degrees.

7 After the warm-up, adjust the zero and feed the CO_2 test gas. Adjust the output with the preamplifier board trimmer R7 to the same reading as was obtained in the step 5.

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

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

9 Switch the monitor on and let it run 10 minutes. Adjust zero and check the span readings. If they deviate more than 2 % of full scale from those of the warm device, repeat the adjustment.

7.3 Pressure Measurement Offset and Gain Adjustments

If the adjustment is needed because of replacing the offset trimmer, it is enough to adjust the output to equal to the atmospheric pressure with the trimmer.

Otherwise, these two adjustments must be made simultaneously because they have a strong mutual influence.

The adjustment procedure is as follows. Some method of generating a pressure differing from the ambient, e.g. a vacuum pump, is needed in addition to an instrument for measuring the pressure.

1 Disconnect tube from pressure transducer on the measuring board.

2 Apply low pressure (P_1) to the transducer and adjust the offset trimmer R46 until the output voltage (pin 8a of the pcb connector) is at the voltage:

$V_1 = (P_1\ (mmHg)/l000)\ 20\ V - 10\ V$

3 Apply high pressure (e.g., atmospheric) and adjust the output with the gain trimmer R47 to the voltage:

$V_2 = (P_2\ (mmHg)/l000)\ 20\ V - 10\ V$

4 Repeat the steps 2 and 3 until the readings remain stable. A number of adjusting cycles is usually necessary to reach this state.

5 Perform pressure calibration.

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 Unit Adjustments

The adjustments for the O_2 measuring unit are zero, gain, and frequency adjustments.

In case of any other trouble the sensor should be replaced and the faulty one be sent to Datex for repair.

Zero adjustment

Because the O_2 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.

1 Connect a digital voltmeter to the output of the O_2 sensor (mother board test connector X13 pin 5).

2 Let the monitor draw in room air and adjust the voltage to zero with the trimmer ‘OS (see Figure 7.3).

3 Perform gas calibration (refer to Operator’s Manual).

Gain adjustment

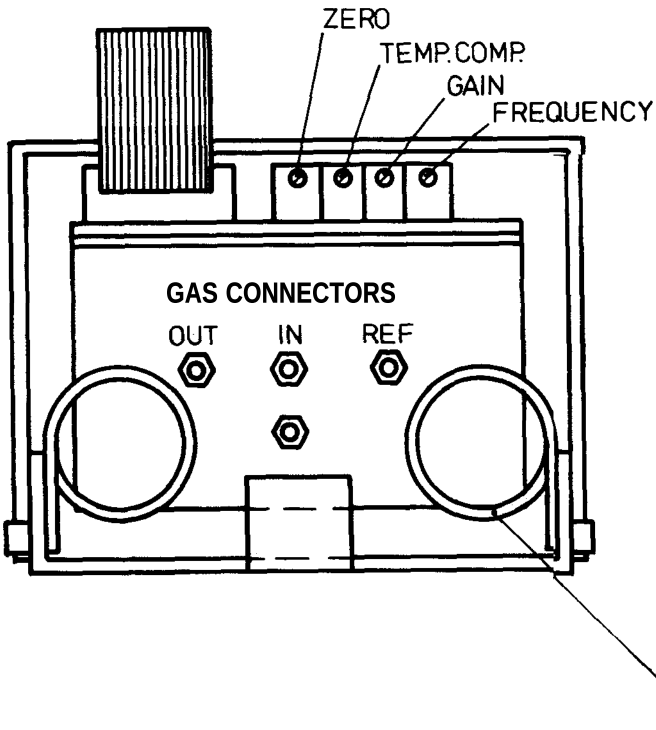
1 Adjust the zero as described in the previous section. Enter Diagnostic mode check 1 (see Section 6.3.4).

2 Feed 100 % oxygen gas and adjust the output to 7.9 V with the trimmer ‘G’ (see Figure 7.3).

3 Check and if necessary readjust the zero and gain until the readings remain stable.

4 Perform the gas calibration (refer to Operator’s Manual).

Figure 7.3 O_2 Measuring Unit Adjustments



Temperature compensation adjustment

Factory adjustment only.

Frequency adjustment

The switching frequency of the electromagnet of O_2 sensor has been selected to be 110 Hz to avoid interference from harmonics of both 50 Hz and 60 Hz mains 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.

7.5 CPU Board Adjustment

Real Time Clock Frequency 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.

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.

7.6 Canopy Mode VO_2 Baseline Adjustments

In room air

Imbalance in the sampling system may cause an offset drift in the O_2 signal. This may alter the measurement results in the canopy mode. If the drift is small, it is possible to correct as follows:

Settings:
Press STOP, END, CLEAR, CLEAR-NEW PATIENT.
Choose Canopy mode.
Flow selector wheel in adult mode.
Artifact suppression OFF in SETUP menu
Averaging OFF in SETUP menu.
Printer option numeric in SETUP menu.

1 Perform test C (baseline test in room air) of Chapter 8 FUNCTIONAL CHECK PROCEDURES.

2 Calculate the fifteen-minute average of VO_2.

3 Enter FACTORY SETTINGS menu by resetting the monitor and holding MARK/RESET key during initialization.

4 Move the cursor to the line BASELINE CORRECTION and enter the fifteen-minute average value with the opposite sign (if the average value is +5, then enter -5).

"TOT" value is automatically calculated and displayed.

5 Repeat test C and make sure that the fifteen-minute average is within ±6.

6 Write down the "TOT" value on the rear panel.

In elevated oxygen level

Before this adjustment, be sure that the previous adjustment (in room air) is done and possible baseline correction is performed. Also make sure that the monitor has been on for more than one hour.

Settings:

Press STOP, END, CLEAR, CLEAR-NEW PATIENT.
Choose Canopy mode.
Flow selector wheel in adult mode.
Artifact suppression OFF in SETUP menu
Averaging OFF in SETUP menu.
Printer option numeric in SETUP menu.

1 Perform test C (baseline test in elevated oxygen level) of Chapter 8 FUNCTIONAL CHECK PROCEDURES. Start measurement when oxygen level is raised to 40 ±2 % level,

2. Disregard the results of first 10 minutes. Keep the results of the following 30 minutes.

3 Disregard the 5 largest and 5 smallest results. Calculate the average of VO_2.

4 Enter FACTORY SETTINGS menu by resetting the monitor and holding MARK/RESET key during initialization.

5 Move the cursor to the line 40 % O_2 BL CORRECTION and enter the average value with the opposite sign (if the average value is +5, then enter -5).

"TOT" value is automatically calculated and displayed.

6 Repeat test C and make sure that the average is within ±9.

7 Write down the "TOT' value of the elevated oxygen on the rear panel.

7.7 Flow Constant Adjustment

VCO_2 and VO_2 measurement is based on the principle that the gas flow through the flow generator is a known constant. This constant can be programmed in the FACTORY SETTINGS menu.

The following test is based on the fact that when an amount of 5 ml pure ethanol burns, the reaction yields 3820 ml of CO_2.

> **NOTE:** Commercially available ‘pure’ ethanol is usually not 100 % pure. Correct the CO_2 yield to correspond to actual alcohol content. See detail in Alcohol Burning Test Kit for Deltatrac Monitor in Appendix.

It is recommended that the flow constant is checked and possibly adjusted every 2 months by the following procedure:

1 Turn power on and let the monitor run for at least 30 min. The results are best recorded using a printer in continuous numeric output form.

2 If the ambient pressure is known accurately, perform pressure calibration. Perform gas calibration.

Settings:

Press END to clear data.
Choose Canopy mode.
Flow selector wheel in adult mode.
Artifact suppression OFF in SETUP menu
Averaging OFF in SETUP menu.
Printer option numeric in SETUP menu.

3 Connect the alcohol burner for a canopy mode test (see Figure 8.1).

4 Using a pipette, fill the alcohol burner vessel with 5 ml of ethanol.

> **NOTE:** Alcohol evaporates. The test should be started within 2 minutes after the step 4.

5 Start the measurement by pressing START key. Wait 30 seconds. The actual measuring sequence will start (measurement time will restart from zero).

6 Light up the ethanol and immediately place the cover over it.

7 Let the measurement run until the flame dies (approx. 20 minutes. NO BREATHING alarm will be triggered). Wait until the measured VCO_2 goes below 10 ml. Check that all the alcohol has burned. If not, repeat the whole test.

8 Press STOP key.

9 Calculate the total amount of CO_2 produced during the test by summing up all minute to minute VCO_2 values on the printout.

10 Determine the new flow constant by the following formula:

N. F. C. = 1.03 x (3820/TOTAL CO_2 PRODUCTION) x OLD FLOW CONSTANT

The limits are 38 to 45 l/min (see Section 5.4).

9 Enter FACTORY SETTINGS menu by resetting the monitor and pressing MARK/RESET key during initialization.

10 Move the cursor to FLOW CALIBRATION. Press softkey 4 and enter the new value.

> **NOTE:** If an adjustment greater than 4 liters has been done, the gas calibration and the flow constant adjustment should be repeated.

11 Write down the value on the rear panel.

8 FUNCTIONAL CHECK PROCEDURES

8.1 TEST A RAPID CHECK

1 Enter Diagnostic mode as described in section 6.3.4. Verify that initial messages with software revision appear on the screen.

No error messages should be displayed.

2 Perform pressure calibration (enter any diagnostic check and then choose Calibration and finally choose Pressure calibration).

Adjust pressure if the correct value is known.

3 Perform gas calibration.

4 Note pressure, temperature, CO_2, O_2, and O_2LOW readings in all diagnostic checks (1, 2, 3, and 4). Limits are:

pressure: all check points 10 to 30 mmHg below ambient pressure checks 1, 3, and 4...within 10 mmHg of each other

temperature: 0 to 10 °C above ambient temperature (equal to flow generator exhaust gas temperature)

CO_2: 0.01 - 0.15 (equal to ambient CO_2 level)

O_2: -0.2 - +0.2

O_2LOW: -0.20 - +0.20

5 If pressure levels are not within limits, check sampling system (or pressure transducer). If temperature is not within limits, check temperature measurement. If gas levels are not within limits, check gas measurement system or repeat calibration.

6 Select different diagnostic checks. Breath into the sampling line, air inlet and mixing chamber sample inlet and verify that the gas signals respond accordingly. O_2 and O_2LOW should be close to each other.

NOTE: In diagnostic check 3, both the O_2 reference and O_2 measurement flows are taken from the mixing chamber sample inlet. Normally the O_2 signal should settle to zero, independent of what gas mixture is being fed into the mixing chamber sample inlet.

8.2 TEST B RQ TEST

NOTE: In tests B, C, and D, connect a printer in numeric mode.

1 Turn power on and let the monitor run for at least 30 minutes. Perform gas calibration.

2 Prepare the alcohol burner for a canopy mode test. Light the burner and start the test. Let the measurement run for at least 15 minutes (see Figure 8.1 for alcohol burner set-up).

3 The fifteen-minute average of the measured RQ should be within 0.64-0.69.

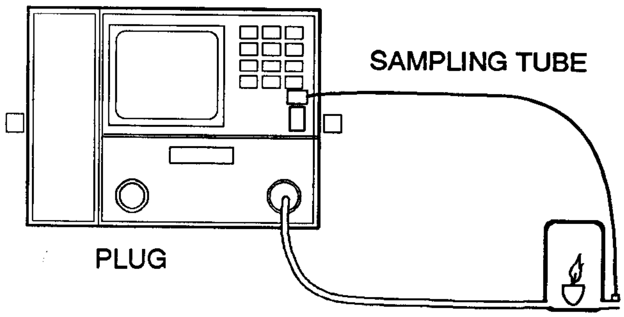


Figure 8.1 Alcohol Burning Test in Room Air

8.3 TEST C BASELINE TESTS IN CANOPY MODE

In room air and in elevated oxygen level

1. Start a canopy mode measurement without anything connected to the monitor (VO_2 and VCO_2 should be zero).

2. Let the measurement run for at least 30 minutes after it has warmed up.

3. The fifteen minute average of VCO_2 should be within ±5 ml/min and that of VO_2 within ±10 ml/min.

4. The VO_2 baseline error should be corrected according to Section 7.6. If the error is greater than 40 ml/min, check the sampling system.

5. Repeat the test in elevated oxygen level. The fifteen minute average of VCO_2 should be within ±8 ml/min and that of VO_2 within ±15 ml/min.

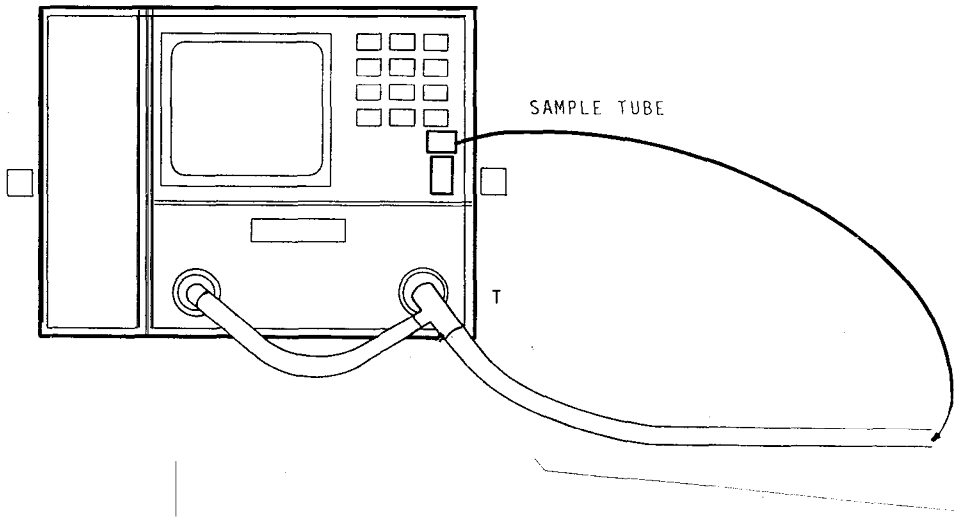


Figure 8.2 Baseline Test in Room Air in Canopy Mode

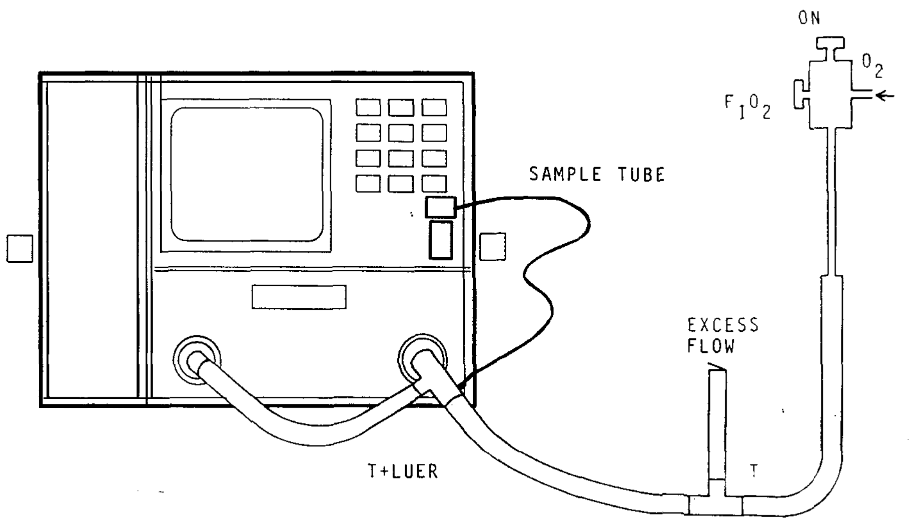


Figure 8.3 Baseline Test in Elevated Oxygen Level in Canopy Mode

8.4 TEST D BASELINE TEST AT ELEVATED OXYGEN LEVEL IN RESPIRATORY MODE

1 Set up a complete respirator mode measurement configuration according to Figure 8.4.

2 Start ventilating the test lung using relevant respirator settings and nominal O_2 concentration of 60 %.

3 Start the respirator mode measurement.

4 Allow at least 10 minutes to let the system reach steady state. Follow the O_2 difference numbers in the numeric printout. The deviations should stay within -0.1 and +0.l % O_2. If the deviation is more, but relatively stable, the reason can be a leakage either in the mixing chamber or in the FIO_2 sampling adapter connection.

If deviation fluctuates considerably up and down, the O_2/air blender of the respirator may not be capable to produce stable enough mixture. Then an additional pressure regulator at the air outlet of the wall supply usually helps.

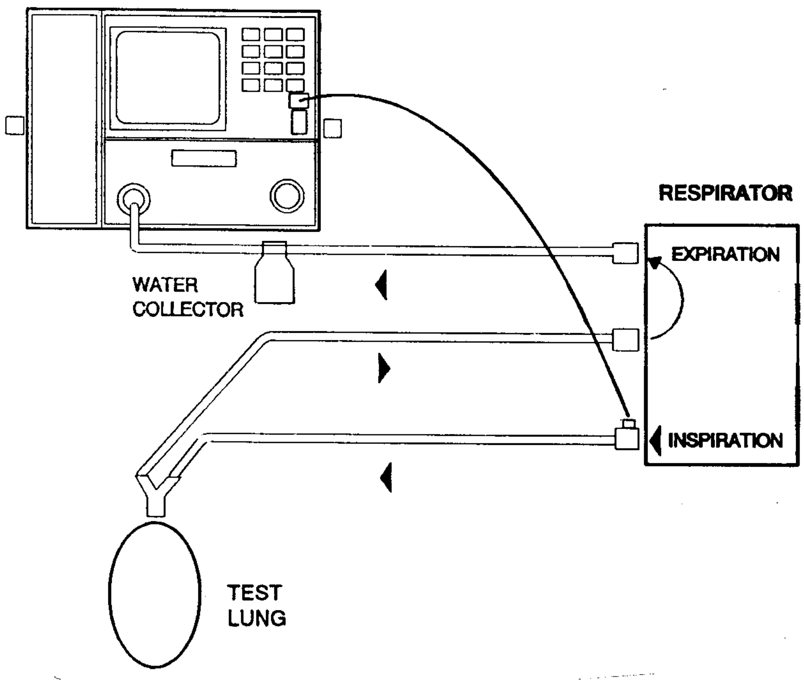


Figure 8.4 Baseline Test in Elevated Oxygen Level in Respiratory Mode

8.5 TEST E COMPLETE TEST

1 Perform Test A (rapid check).

2 Perform test G (leakage test).

2 Draw a table like Table 8.1.

3 Arrange test gas (preferably 5 % CO_2 and 95 % O_2).

4 Go to Diagnostic mode and choose check 1.

5 Feed the test gas to the monitor through the sampling line (S.L.). After 20 seconds, note down the CO_2, O_2 and O_2LOW readings and fill in the first row of the table.

6 Feed the gas through mixing chamber sample inlet (MC.). After 20 seconds, note down the gas readings and fill in the second row of the table.

7 Feed the gas through air sample inlet (AIR). After 20 seconds, note down the gas readings and fill in the third row of the table.

8 Repeat these tests in Diagnostic mode checks 2 and 3 and fill the table accordingly.

NOTE: In Diagnostic mode check 4, feed the gas through flow generator sample port (F.G.).

9 Limits are:

The CO_2 values marked X_0 (CO_2 baseline) in the table should be within 0.03 - 0.15. The CO_2 values marked X_1 may deviate 0.4 % CO_2 from each other.

The O_2 values marked Y_0 (O_2 baseline) should be within -0.3 - +0.3.

The values marked Y_1 may deviate -2 - +2 % O_2 from each other.

The values marked Y_2 may deviate -1 - +l % O_2 from each other.

$Y2 = Y_0 - Y_1$. However, a tolerance of -3 - +3 % O_2 is allowed.

Y3 = -3 - +3 % O_2.

Table 8.1 Test Table for Sampling System

Check No.	Sample source	CO_2	O_2	LOW
1	S.L.	X_0	Y_1	-
1	M.C.	X_0	Y_2	-
1	AIR	X_1	Y_0	Y_0
2	S.L.	X_0	Y_0	Y_0
2	M.C.	X_1	Y_2	-
2	AIR	X_0	Y_1	-
3	S.L.	X_1	Y_0	Y_0
3	M.C.	X_0	Y_3	Y_3
3	AIR	X_0	Y_0	Y_0
4	F.G.	X_1	Y_1	-

8.6 TEST F SAMPLE FLOW TEST

1. Draw a table like Table 8.2.

2. Measure total exhaust flow by connecting a rotameter to the sample outlet connector on the rear panel.

   The total flow should be between 170 and 260 ml/min.

3. Connect the rotameter to sampling line (S.L.) and select Diagnostic mode check 1. Measure the flow in ml/min. Measure the same flow in Diagnostic mode checks 2, 3, and 4. Fill in the first row of the table.

4. Connect the rotameter to mixing chamber sample inlet (M.C.). Measure the flow in Diagnostic mode checks 1, 2, 3 and 4. Fill in the second row of the table.

5. Repeat the procedure with the rotameter in AIR inlet and flow generator (F.G.) sample inlet.

6. See Table 8.2 for the limits.

Table 8.2 The Allowed Ranges for Different Total Flows

The total flow is between 170 and 200 ml/min.

	CHECK 1	CHECK 2	CHECK 3	CHECK 4
S.L.	70...130	10...40	60...120	10...40
M.C.	14...50	70...130	85...140	14...50
AIR	55...110	60...110	0...0	0...0
F.G.	0...0	0...0	0...0	85...180

The total flow is between 200 and 230 ml/min.

	CHECK 1	CHECK 2	CHECK 3	CHECK 4
S.L.	80...140	15...45	70...120	15...45
M.C.	15...55	80...140	90...160	16...55
AIR	60...120	60...125	0...0	0...0
F.G.	0...0	0...0	0...0	100...200

The total flow is between 230 and 260 ml/min.

	CHECK 1	CHECK 2	CHECK 3	CHECK 4
S.L.	90...150	15...50	70...135	15...50
M.C.	20...60	85...150	90...165	20...50
AIR	65...120	70...120	0...0	0...0
F.G.	0...0	0...0	0...0	115...225

8.7 TEST G LEAKAGE TEST

1. Block the sampling line inlet, air inlet, mixing chamber sample inlet and flow generator sample inlet.

2. Connect a silicone tube (length about 50 cm) to the sample gas outlet on the rear panel. Drop its other end into a glass of water.

3. Let the monitor run for several minutes in Diagnostic mode. There should be less than one bubble per 10 seconds coming out of the tube.

4. If a leakage has been detected, it can be localized by closing the sample line at different locations starting from the sampling pump inlet and moving upstream. Use also different diagnostic checks to localize the leakage.

CAUTION: Only silicone tubes may be blocked by clamp. Other tubes may be damaged.

8.8 AFTER REPAIR CHECKLIST

NOTE 1: Baseline adjustments and flow constant adjustment should always be performed if several months have elapsed since the last adjustment.

NOTE 2: When performing flow constant calibration, check that the steady state RQ is between 0.64 and 0.69. Follow the steps described in the test kit manual (including pressure and gas calibration).

NOTE 3:- O_2 should be calibrated with test gas that contains oxygen as high concentration as possible, e.g., 5 % CO_2/95 % O_2 or 100 % O_2.

After every repair:

- Baseline adjustment (Section 7.6).
- Flow constant adjustment (Section 7.7).

1 **O_2 transducer replaced**

- Test G leakage test.
- Test F sample flow test.
- Offset and gain adjustment (Section 7.4).
- Test E complete test.
- Test C baseline tests in canopy mode.
- Test D baseline test at elevated oxygen level in respiratory mode.

2.1 **CO_2 transducer replaced**

- Test G leakage test
- Test F sample flow test
- Test A rapid check
- Test C baseline tests in canopy mode
- Test D baseline test at elevated oxygen level in respiratory mode

2.2 **CO_2 transducer repaired**

- Follow Table 7.1
- Test G leakage test
- Test F sample flow test
- Test A rapid check
- Test C baseline tests in canopy mode
- Test D baseline test at elevated oxygen level in respiratory mode

3 **Repairs in the sampling system**

- Test G leakage test
- Test F sample flow test
- Test A rapid check
- Test C baseline tests in canopy mode
- Test D baseline test at elevated oxygen level in respiratory mode

4 **Magnetic valve replaced**

- Test G leakage test
- Test A rapid check
- Test C baseline tests in canopy mode
- Test D baseline test at elevated oxygen level in respiratory mode

5 **Flow generator replaced**

- Baseline adjustment (see Section 7.6)
- Check flow constant (see Sections 5.4 and 7.7)

6 **Valve control board replaced**

- Check temperature measurement in Diagnostic mode with a thermometer placed in the flow generator outlet on the rear panel. Allowed tolerance ±4 °C.
- Test A rapid check
- Check flow constant (see Sections 5.4 and 7.7)

7 **Video processor board replaced**

- Check picture on the screen
- Check video output on the rear panel with a slave monitor

8 **CRT module replaced**

- Display adjustments on CRT driver board

9 **Power supply board replaced**

- Check data retention: Start a measurement, turn power off for 10 to 14 minutes (15 minutes maximum). Turn power on and verify that unit enters 'MEASUREMENT INTERRUPT' state.
- Test A rapid check.

10 **Mother board replaced**

- Check picture on the screen
- Test A rapid check

11 **Keyboard replaced**

- Check for audible feedback from each key (adjust volume if necessary).

9 SPARE PARTS

9.1 Spare Parts

Item numbers refer to the exploded view of the monitor in Figure 9.1.

Mains power related parts

Item	Item description	Order No.
3	Fuse 2.5 A, slow	51118*
4	Fuse 3.15 A, slow	51119*
8	Mains cable (EUR)	54563*
8	Mains cable (USA)	86236*
33	Mains transformer, 100 V	882531
33	Mains transformer, 115 V	882532
33	Mains transformer, 220-240 V	882529
	Button switch for silencing power failure	52280
7	Power entry module w switch and fuses	54017

External housing parts

30	Top cover	872894
39	Side panel, right	882543
	Side panel screw	61655
	Front panel w plastic sticker (ENG)	882539
	Front panel w plastic sticker (GER)	882541
	Front panel w plastic sticker (FRE)	882542
	Screen frame	872761
48	Bottom plate	881611
	Rear panel (ENG)	882096
	Rear panel (GER)	882401
	Rear panel (FRE)	882395
12	Foot front	65160
13	Foot rear	65161

Sampling system parts

22	Water trap, complete	882623
	O-ring for water container (1 of 2 pcs)	65344
26	Sampling line connector (Luer compatible)	877068
23	Sampling pump	870678*
	CO_2 absorber	874643
	Internal sampling system (incl. magnetic valves)	881562
10	Magnetic valve, without port plug	58534
	Special internal sample tube (MBM) (see Fig. 6.6)	733382
35	Constriction cassettes	see Table 6.5
31	Sample out connector	871981

Gas measuring parts

14	Preamplifier board CO_2	872290*
15	Sync board assy (incl. motor) CO_2	86323*
16	Measuring chamber CO_2	86542*
17	IR-detector block CO_2	86543*
29	IR-lamp unit CO_2	871497
18	Chopper wheel, CO_2	86622
	NTC-resistor CO_2	48220
25	CO_2 absorber box (CO_2 meas. unit)	870724*
32	Chopper motor CO_2	872454*
24	O_2 measuring unit, complete	874892*
	Spring for O_2 meas. unit (R)	873938
	Spring for O_2 meas. unit (L)	873939

PC boards and their parts

59	Hall board	881556
28	CO_2 measuring unit & board, complete	878582
34	Measuring board pressure transducer	873022
20	Keyboard	870645*
46	Valve control board	881559*
2	Valve control board back up capacitor 0.47 F	35390
21	Video control board	870646*
37	Power supply board	880882*
36	CPU board, without software	881949*
	Software (ENG)	882123
	Software (GER)	882125
	Software (FRE)	882124
	RAM IC w internal battery	139890
	Plastic binder for RAM IC	64011
1	Lithium battery 3.4 V, 650 mA	17503
9	Video display unit, complete	875244

Value of resistor R51 on the **valve control board** is factory set for the flow generator installed in the monitor. The value is either 243 ohm or 274 ohm.

If the valve control board is replaced and the new flow constant is below 38 l/min, change R51 to 243 ohm resistor.

If the flow generator is replaced and the new flow constant is over 45 l/min, change R51 to 274 ohm resistor.

Changing the value of R51 will increase/decrease the flow constant about 4.5 to 5.0 l/min.

Rear panel parts

	Dust filter	880832*
19	Fan	870641
60	Flow control wheel	882557
61	Flow control wheel base	882556
	Flow control wheel O-ring	65370
5	Loudspeaker	51449
43	Gas temperature probe	874529
45	Flow generator	874535

Mixing chamber parts

44	Mixing chamber	874530
	Mixing chamber panel (ENG)	881352
	Mixing chamber panel (GER)	881920
	Mixing chamber panel (FRE)	881925
	Mixing chamber handle	66455
38	Mixing chamber drain plug	874500
	Microswitch for mixing chamber	52653*

Auto calibration box parts

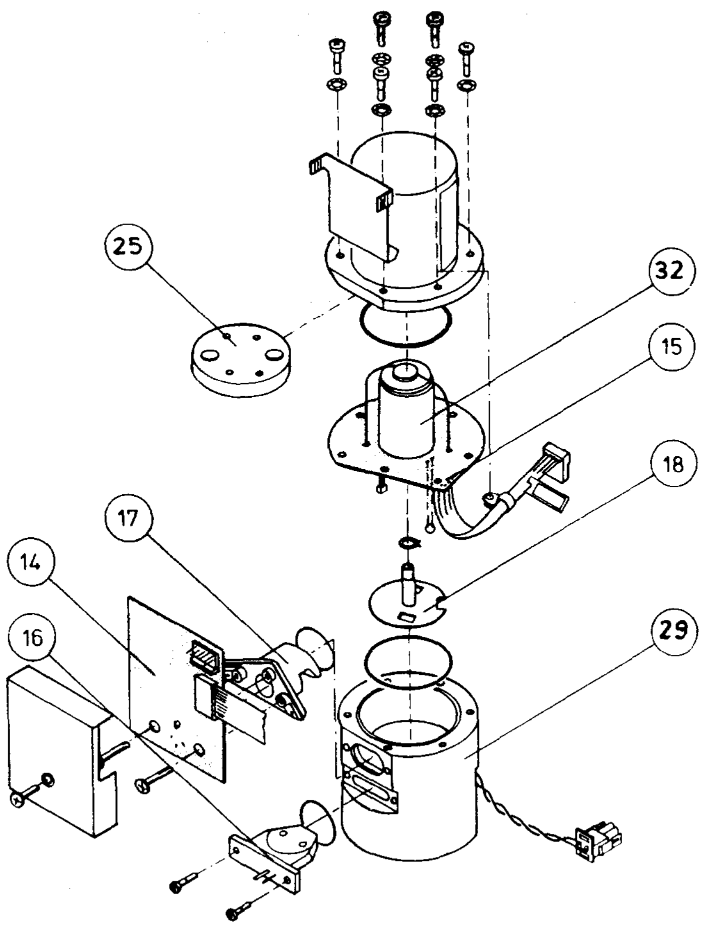
40	Auto cal box side panel, left	882544
42	Auto cal box side panel, right	881526
49	Front panel	881553
57	Bottom plate	881524
58	Rear plate	881525
42	Top cover	881523
50	Front panel sticker	881903
52	Magnetic valve	882625
53	Tube connector on top of mag. valve	640640
54	Cal gas can reusable gas valve unit	882624
55	Can support block upper, base	881522
51	Can support block upper, extension	881521
56	Cushion	65503

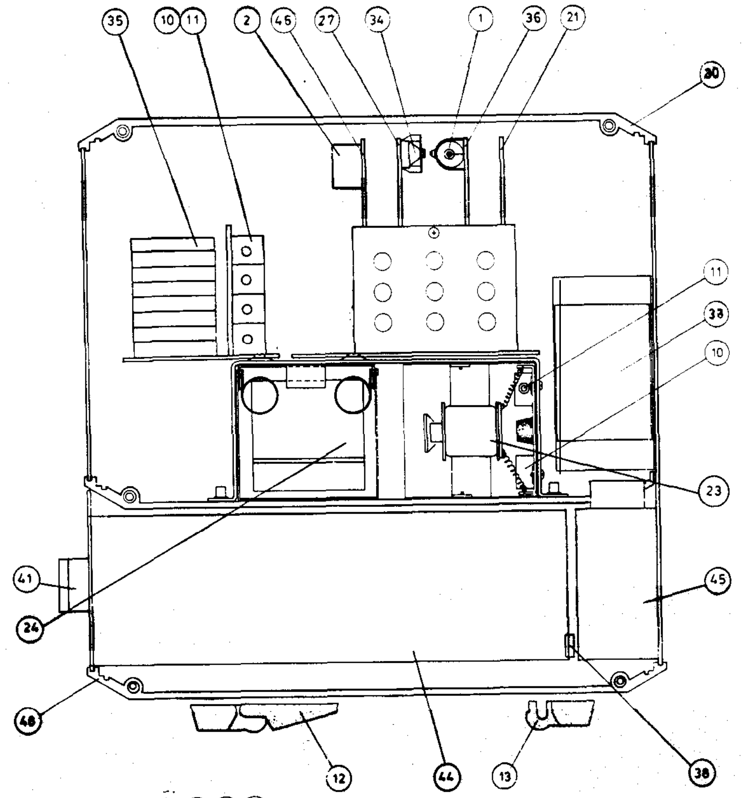
If the **magnetic valve** is replaced, use sealing tape to avoid leakage when reconnecting threaded ports.

9.2 Service Accessories

Item description	**Order No.**
Extension board (lifts the board above the stack of boards to allow measurements)	872930
Alcohol burning test kit	882908
Measuring chamber cleaning fluid	85969

Figure 9.1 Exploded View of The Monitor

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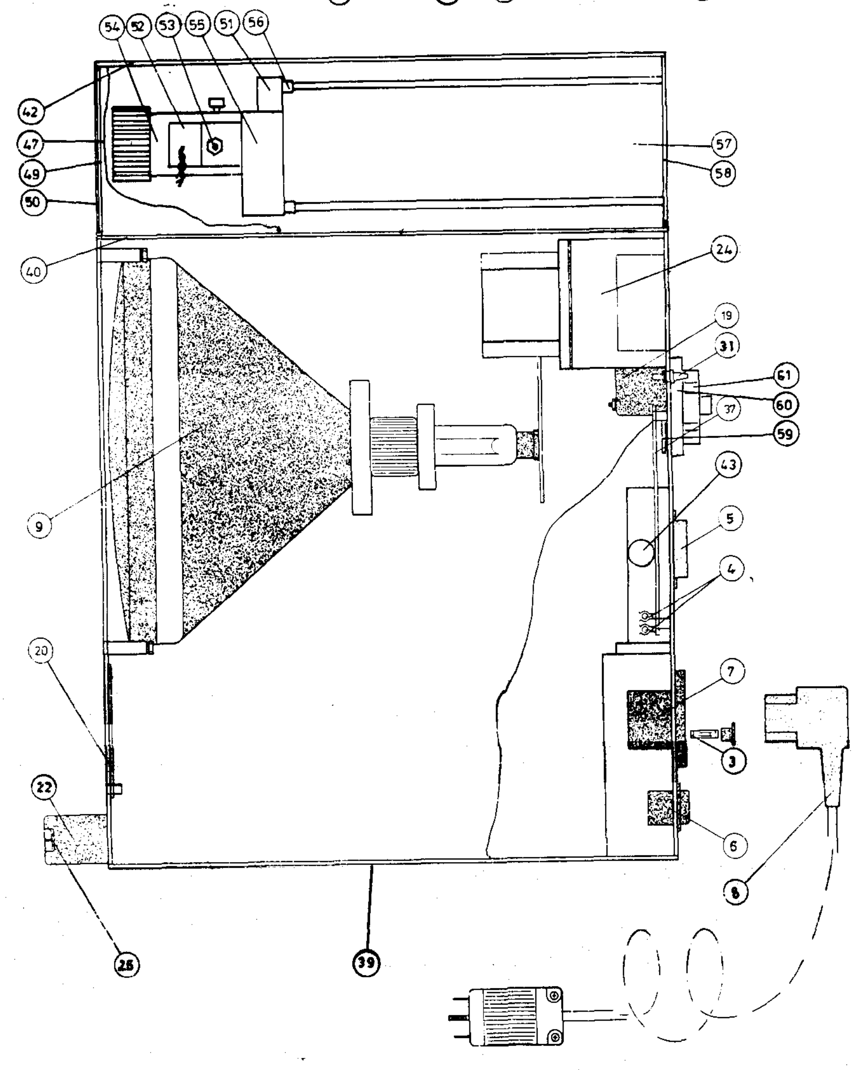
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12 APPENDICES

12.1 Short Instructions for Use

Performing a Measurement

* Empty the water trap and connect sampling line.
* Position flow selector wheel on the rear panel to suit the patient.
* Turn on the monitor and graphics printer.
* Check that no error messages appear on the screen. If does, troubleshoot the monitor (see section 6: SERVICE AND TROUBLESHOOTING).
* If performing a cold start, let the monitor warm up for 30 minutes, otherwise 5 minutes.
* Calibrate the monitor as described in CALIBRATION in the following page.
* Change the operating mode with the CHANGE MODE key if necessary.
* Connect the tubes as shown in PATIENT CONNECTIONS.
* Start the measurement with the START/STOP key.
* Interrupt and restart the measurement with the START/STOP key if necessary.
* Finish the measurement by first pressing the START/STOP key to interrupt the measurement and then press the END key.

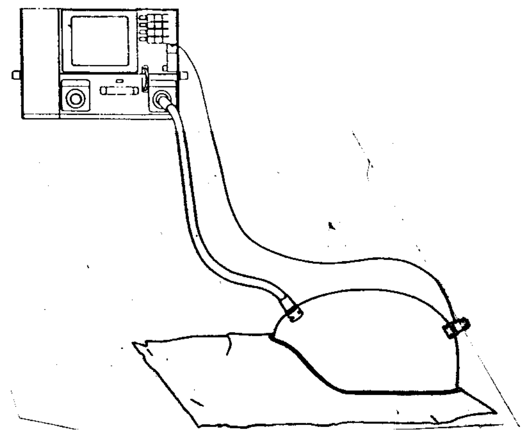
During the measurement the PATIENT DATA key can be used to enter the patient data and the DISPLAY/PRINTER key to rearrange the display as well as activate the printer.

See Keyboard Functions section in this chapter for a more detailed description of the key functions.

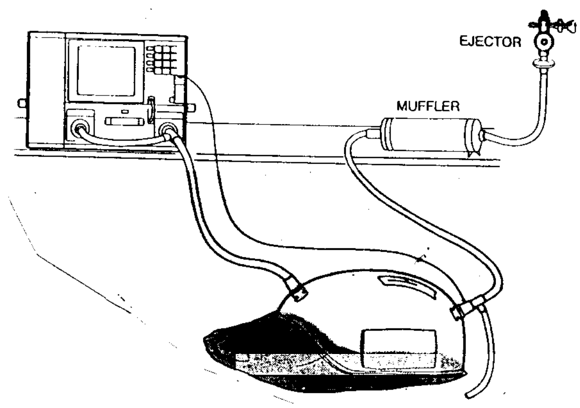
NOTE: Refer to the Operator’s Manual for more details.

12.2 Patient Connections

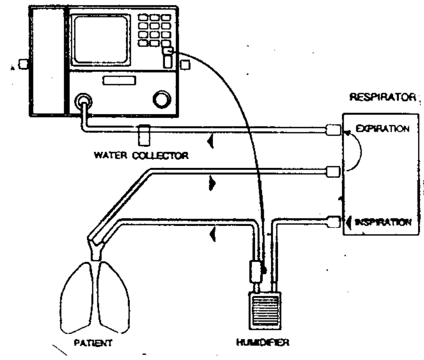
a) Canopy connection in room air



b) Canopy Connection at elevated oxygen level



c) Respirator Connection



12.3 Calibration

* DATEX High-Accuracy Calibration Gas (P/N 874617) containing O_2 and CO_2 is installed into the monitor. This gas allows easy calibration of both sensors.

  The gas can will provide about 30 calibrations.

* Calibrate the monitor at least once a day after a 30 minute warm-up.

* Press the CAL key to start the calibration procedure when the measurement is in INTERRUPTED or OFF state.

* Select GAS with the softkey.

* First, baseline is checked and then calibration gas is automatically fed to the monitor.

  If manual calibration is chosen in Gas setup, start feeding the calibration gas when the message FEED CALIBRATION GAS appears on the screen. Feed gas until messages CO_2 ACCEPTED and O_2 ACCEPTED appear on the screen. This will take approximately 15 to 30 seconds.

* Adjust the readings to their nominal values with the DECREASE and INCREASE softkeys.

* Move to the next gas with the NEXT softkey.

* When both sensors are calibrated, move back to the monitor mode with the NORMAL SCREEN key.

NOTE: If separate gas sources are used for calibration, repeat the procedure gas by gas.

12.4 Alarms

The following alarms are included in the monitor.

Tidal volume alarm

* In the respirator mode

No-breathing alarm

* In the canopy mode

* Triggered by patient disconnection and/or loss of fresh gas flow

Low air flow alarm

* In both modes

* Triggered by too high $FiCO_2$ (more than 2.5 %)

Power off/Power disconnection alarm

* In both modes

* Duration 1 minute. Can be silenced by pressing the white button on the rear panel.

12.5 Keyboard Functions

> NOTE: Display returns to normal screen when 60 seconds have elapsed since the last key touch in Setup, Patient data, Display/Printer, and Set alarms menu.

Press SETUP to	* Select units of measurement * Make starting selections * Set real time clock This key is valid only in the MEASUREMENT OFF state. Press NORMAL SCREEN key to exit.
Press DISPLAY/ PRINTER to	* Rearrange the display * Activate the printer Press NORMAL SCREEN key to exit.
Press PATIENT DATA to	* Enter patient data (sex, weight, height, age, and nitrogen excretion), press SAVE to store data. Press NORMAL SCREEN key to exit.
Press SET ALARMS to	* Set the digital volume alarm on or off. * Set the tidal volume alarm level Press NORMAL SCREEN key to exit.
Press SILENCE ALARM to	* Silence the tidal volume alarm in the respirator mode. * Silence the no-breathing alarm in the canopy mode. * Silence the low air flow alarm in both modes.

> NOTE: To silence power off/power disconnection alarm, press the white button on the rear panel for several seconds.

Press CHANGE MODE to	* Change the measurement mode (only in the MEASUREMENT OFF state).
Press LONG TREND to	* Display a long trend for 15 seconds. The display returns to normal screen automatically or by pressing the NORMAL SCREEN key.
Press CAL to	* Start the calibration procedure (only in the measurement OFF or INTERRUPTED state).
Press START/ STOP to	* Start/stop (interrupt) the measurement.
Press END to	* End the measurement after it has been stopped.
Press MARK/ RESET to	* Mark an event. Press for 5 seconds to reset the monitor.

12.6 Computer Output

Patient and measurement data is sent to the PC via a serial & analog I/O connector. The data format is 9600 baud, 8 bits, no parity, 1 stop bit, when all data is dumped after the measurement. During continuous output the baud rate will be 1200 baud. CTS is also used.

Dumping mode

Measurement results are sent when requested from END-menu all at once. All calibration results, which are stored, are then sent. Up to ten last calibrations after the last power-up or key reset are sent. The sending continues with “patient data”-string and then minute-by-minute measurement results of that patient. If multiple patients are measured, the sending continues with the next patients “patient data”-string and measurement results. Maximum data storage on DELTATRAC II is 24 hours of measurement either continuous or piece by piece from several days. End of sending is not indicated separately, but can be detected by e.g. 5 second timeout.

Continuous mode

During measurement the results are continuously sent minute-by-minute. The patient data string is sent when measurement is started. If patient data on DELTATRAC II is entered after starting the measurement, it will not be sent to the PC. The patient data input on the PC should be used instead. The result of the last calibration before the measurement is sent when measurement is started. After that calibration results are sent after each calibration.

Calibration result string format

e.g.
D97, CAL, 092, 001, 001, 000, 000, 000, 000, 000, 000, 000 CRLF

Contents of the three digit fields:

monitor ID (D) and string type ID (97= info)
CAL string type: calibration
calibration time: year (88..00..87 = 1988...2087
month
day
hours
minutes
ambient CO_2 0...999 = 0...9.99%
CO_2 measured 0...999 = 0...9.99%
CO_2 set value 0...999 = 0...9.99%
O_2 measured 0...999 = 0...99.9%
O_2 set value 0...999 = 0...99.9%
CR carriage return, hex D
LF line feed, hex A

Patient data output string format

e.g.
D96, PAT, 093, 001, 029, 014, 052, 015, 006, 053, FEM, 160, 050000, 039, 007, 002, 009800 CRLF

Contents of the three digit fields:

monitor ID (D) and string type ID (96= info)
PAT string type: patient data
calibration time: year, month, day, hours, minutes
date of birth: day, month, year
sex FEM = female, MAL= male
height cm
weight kg & g
age years & months & weeks
urinary nitrogen g/24 h & mg/24 h
CR carriage return, hex D
LF line feed, hex A

Measurement result output string format

The string is identical in continuous sending and data dump option, except EE and temperature are zero in data dump string since they are not stored.

e.g.
D0l, 000, 014, 053, 030100, 020200, 068, 000000, 209, 295, 406, 031, 068000, 276, 766, 001, 000 CRLF

Contents of the three digit fields:
monitor ID (D) and string type ID (0l= meas. data)
marker number
real time hours
real time minutes

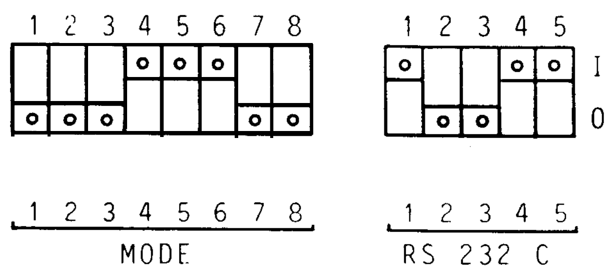
V_{CO2}	x 0.01 ml/min in STPD, 0...9999.99
V_{O2}	x 0.01 ml/min in STDP, 0...9999.99
RQ	0...999 = 0...9,99
EE	x 0.l kcal/24 h (= 0 in data dump), 0…99999.9
F_{IO2}	x 0.1 %
F_{ECO2}/F^*_{CO2}	x 0.01 %
$F_{IO2}-F_{EO2}/F_{IO2}-F^*_{O2}$	x 0.01 %
RR	respiration rate /min
V_E	x 0.001 l/min (in resp. mode, in canopy mode = 000), 0...999.999
temperature	x 0.l°C (= 0 in data dump)
pressure	mmHg
artefact	0 = no artifact 1 = artifact
status	NOT USED =000
CR	carriage return, hex D
LF	line feed, hex A

12.7 CCP-104 Graphics Printer

The CCP-104 is an HP ThinkJet graphics printer. Except for the oldest version models, it is an IEC 601-l class II devices and do not require an isolated cable. The nonisolated connecting cable is available from Datex (P/N 875370).

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

See below for the correct DIP switch settings.



MBM-200 DELTATRAC METABOLIC MONITOR

PREVENTIVE MAINTENANCE CHECK LIST

We recommend that the following checks and tests are performed at least once every six months to keep the monitor in good condition.

1. Visual Inspection

OK

☐ 1. Rear panel dust filter (clean at least once a month).

☐ 2. External sampling system tubes for proper connection.

If the monitor is serviced internally:

☐ 3. Internal sampling system for sharp bends and dirt.

☐ 4. CO_2 absorber (when saturated, ambient CO_2 will be below 0.03 % at calibration.

At calibration, the displayed ambient CO_2 is the value of its concentration in air (normally 0.04 % or more) minus its concentration in air filtered by absorber (0 % when the absorber is new but increases as it gets gradually saturated).

☐ 5. O-rings' conditions in mixing chamber and plugs. (Grease with silicone. Replace if necessary.)

2. Preliminary Functional Checks

OK

☐ 6. Screen for distortion (adjust if necessary).

☐ 7. Mixing chamber for leaks (clean if dirty).

Detached the chamber from the monitor and perform this test.

Airtightness is checked by plugging the chamber and pumping 20 mmHg pressure air into it through luer-connector. The pressure must not drop below 5 mmHg in 3 seconds.

3. Main Functional Checks

OK

☐ 8. Perform TEST A (RAPID CHECK)
(See Chapter 8; Functional Check Procedures).

☐ 9. Enter Diagnostic mode check 1 and observe the baseline voltages when the monitor is drawing in room air. The voltages of CO_2, O_2, O_2 low should be within ±l V.

☐ 10. Perform TEST G (LEAKAGE TEST).

☐ 11. Perform TEST F (SAMPLE FLOW TEST).

☐ 12. Perform pressure calibration.

☐ 13. Perform gas calibration.

Gas calibration is performed properly when the monitor has been on for more than 30 minutes and is warmed up.

At gas calibration, the ambient CO_2 level must be more than 0.03 %. If not, the CO_2 absorber may be saturated.

☐ 14. Perform TEST C (BASELINE TESTS).

The difference between the maximum and the minimum values during 30 minutes should be within 25 ml/min. for CO_2 and 35 ml/min. for O_2 after the highest and the lowest five values are discarded.

Set the baselines and write the values on the rear panel sticker.

☐ 15. Check RQ with the alcohol burning test kit (see appendix of this manual; Alcohol Burning Test Kit).

☐ 16. Measure flow constant (see section 7.7).

The difference between the maximum and the minimum values during 30 minutes should be within 25 ml/min. for CO_2 and 35 ml/min. for O_2 after the highest and the lowest five values are discarded.

Write the flow constant value on the rear panel sticker.

☐ 17. Go to Factory settings menu. Check date and adjust keyboard volume if necessary.

☐ 18. Check real time in Setup menu.

☐ 19. Check conditions of the accessories (plugs, connectors, canopy, etc)

☐ 20. Check the printer operation. Check ink cartridge and printer paper stock.

DELTATRAC SERVICE DIAGNOSIS SHEETS

DATE: ____________________

SERIAL NUMBER: ____________________

Results of Selfdiagnosis

These values are shown when you enter into Diagnostic mode.

Air pressure (ref): ____________________ (Ambient air pressure ±10 mmHg)

Air line to ref.: ____________________ (-l0...-30 mmHg)

Mix chamber to ref.: ____________________ (-l0...-30 mmHg)

Sampling line to ref.: ____________________ (-l0...-30 mmHg)

Sample to mix.: ____________________ (-l0...+10 mmHg)

☐ **OK** ☐ **FAIL**

Test A (Rapid Check)

	CHECK 1		CHECK 2		CHECK 3		CHECK 4	
	%	V	%	V	%	V	%	V
CO_2								
O_2								
O_2 low								
Pressure								

Normal values:
CO_2: 0.01...0.15 % (-l...+l V)
O_2: -0.2...+0.2 % (-1...+1 V)
O_2 low: -0.2...+0.2 % (-l...+l V)
Pressure: 4...5 V

☐ **OK** ☐ **FAIL**

Test G (Leakage Test)

Sampling system: ☐ **OK** ☐ **FAIL**

Flow Constant

Previous flow constant (adult): ____________________

Alcohol used: ____________________ %

Estimated CO_2 production: _________________

Total CO_2 production: ____________________

New flow constant (adult): _________________

If an adjustment greater than 4 liters has been done, the gas calibration and the flow constant adjustment should be repeated.

Other new flow constants: obese __________

child __________

infant _________

☐ **OK** ☐ **FAIL**

Test F (Sample Flows)

Total flow ____________________ ml/min. (allowed range 170...260 ml/min.)

	CHECK 1	**CHECK 2**	**CHECK 3**	**CHECK 4**
S.L.				
M.C.				
AIR				
F.G.				

NOTE:
- S.L. Sampling line
- M.C. Mixing chamber sample inlet
- AIR Air sample inlet
- F.G. Flow generator sample inlet

See the next page for the correct limit values.

☐ **OK** ☐ **FAIL**

The total flow is between 170 and 200 ml/min.

	CHECK 1	CHECK 2	CHECK 3	CHECK 4
S.L.	70... 130	10...40	60...120	10...40
M.C.	14-50	70…130	85...140	14..50
AIR	55...110	60...110	0...0	0...0
F.G.	0...0	0...0	0...0	851..180

The total flow is between 200 and 230 ml/min.

	CHECK 1	CHECK 2	CHECK 3	CHECK 4
S.L.	80...140	15-45	70...120	15...45
M.C.	15...55	80-140	90...160	16...55
AIR	60...120	60-125	0...0	0...0
F.G.	0...0	0...0	0...0	100-200

The total flow is between 230 and 260 ml/min.

	CHECK 1	CHECK 2	CHECK 3	CHECK 4
S.L.	90...150	15...50	70...135	15...50
M.C.	20-60	85...150	90-165	20..50
AIR	65...120	70...120	0...0	0...0
F.G.	0...0	0...0	0...0	115...225

Gas Feeding Test

Separate calibration gas can is needed in this test.

Feed gas to the source listed below and fill the table in % unit.

	SOURCE	CO_2	O_2	O_2 low
CHECK 1	S.L. M.C. AIR	X_0 X_0 X_1	Y_1 Y_2 Y_0	--- --- Y_0
CHECK 2	S.L. M.C. AIR	X_0 X_1 X_0	Y_0 Y_2 Y_1	Y_0 --- ---
CHECK 3	S.L. M.C. AIR	X_1 X_0 X_0	Y_0 Y_3 Y_0	Y_0 Y_3 Y_0
CHECK 4	F.G.	X_1	Y_1	

NOTE:

X_0	0.03...0.15 %
X_1	within 0.4 % of each other
Y_0	-0.3...+0.3 %
Y_1	within 4 % of each other
Y_2	within 2 % of each other
Y_3	within ±3 % of Y_0

$Y_2 = Y_0 - Y_1$ (A tolerance of ±3 % is allowed)

☐ **OK** ☐ **FAIL**

Test C (Baseline Tests)

Calculate the 15 minutes' average values and fill the table.

	VCO_2 ml/min.	VO_2 ml/min
Canopy mode In room air	A	B
Canopy mode In elevated O_2 level	C	D

NOTE:

NOTE:	A	within ±5 ml/min.
	B	within ±10 ml/min.
	C	within ±8 ml/min.
	D	within ±15 ml/min.

If the VO_2 baseline error is greater than 40 ml/min., check the sampling system.

In elevated O_2 level in respiratory mode

O_2 difference in printout in 10 minutes time should be within ±0.1 %.

☐ **OK** ☐ **FAIL**

Test B (RQ Test) ______________________________

RQ value should be between 0.64 and 0.69.

Service/Repair Action Taken

____

____

____

Customer Name and Address

____

____

ALCOHOL BURNING TEST KIT FOR

DELTATRAC™ II METABOLIC MONITOR

Document No. 882700

March, 1993

Datex/Division of Instrumentarium Corp.
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CONTENTS

1 BACKGROUND

The Deltatrac II Metabolic Monitor measures oxygen consumption and carbon dioxide production. Therefore its performance can be evaluated by burning a known chemical compound and analyzing the produced gases. A suitable material for this purpose is ethanol, which is oxidized as follows:

$$C_2H_2OH + 3\ O_2 = 2\ CO_2 + 3\ H_2O$$

RQ (Respiratory Quotient) is:

$$RQ = VC0_2/VO_2 = 2/3 = 0.67.$$

The atomic weight of carbon, hydrogen and oxygen, as well as the calculated molecular weight of ethanol are:

C	12.011 g
H	1.008 g
O	15.999 g
C_2H_2OH	46.069 g

The molar volume of gases in STPD (Standard Temperature and Pressure, Dry gas) conditions is 22.4138 L. Using the chemical reaction noted above, it is possible to calculate that 1 gram of ethanol will produce 0.973 liters of CO_2. The density of ethanol is 0.78522 g/mL at 25°C. A dose of 5 mL of pure (100 %) ethanol will produce 3820 mL of CO_2.

If pure ethanol is not available, it is possible to use different mixtures as the following examples show.

Example 1: Lower ethanol concentration

If the ethanol concentration is, e.g. 96 volume %, and the rest is essentially water, 5 mL of this mixture will produce:

$$\frac{96}{100} \times 3820 \text{ mL} = 3667 \text{ mL } CO_2 \text{ (STPD)}$$

> **NOTE:** Normally the best ethanol grade available is 99.5 vol % and the corresponding CO_2 production for a dose of 5 mL is 3801 mL (STPD).

Example 2: Denatured alcohol

A mixture containing 96 volume % ethanol and 4 % water is denatured with 30 mL of Isobuthanol per liter. How much CO_2 will be produced when 5 mL of this mixture is oxidized?

The ethanol in this mixture will produce 0.97 x 0.96 x 3820 mL = 3557 mL CO_2 (STPD).

Isobuthanol is oxidized as follows:

$$2\ C_4H_9OH + 13\ O_2 = 10\ H_2O + 8\ CO_2$$

Using this reaction and the atomic weights given above, it can be calculated that 1 g of Isobuthanol will produce 1.210 L of CO_2 (STPD). The density of Isobuthanol is 0.81 g/mL. The amount of Isobuthanol in the denatured mixture is 0.15 mL. When oxidized, an amount of 147 mL of CO_2 (STPD) is produced.

The total CO_2 production, when 5 mL of the denatured alcohol is burned, is 3557 mL + 147 mL = 3704 mL.

2 ALCOHOL BURNING KIT

The test kit consists of the components shown in Figure 1. The kit can be used for long-term tests for demonstrating or checking the performance of the Deltatrac II Metabolic Monitor (Chapter 3, RQ TEST), or for calibrating the flow constant of the monitor (Chapter 4, FLOW CALIBRATION).

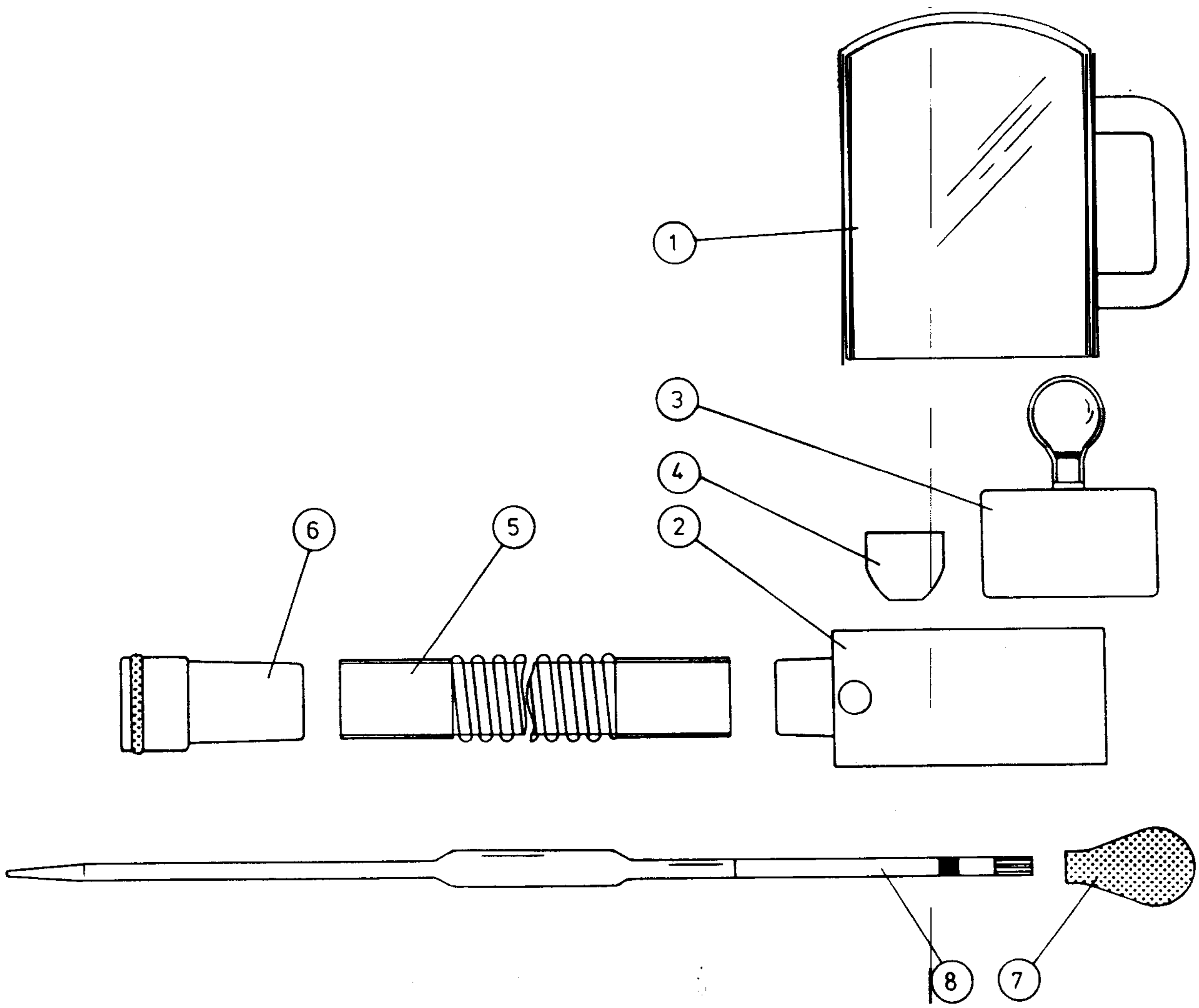
For the tests, absolute ethanol is needed (concentration e.g. 99.5 %). Other mixtures can also be used but this must be taken into account when performing flow calibration (see the examples in Chapter 1, BACKGROUND).

NOTE: The burner base decreases the total flow by 3 % compared to the flow during patient measurement. The correction in the formula is shown in Chapter 4.

NOTE: When dealing with absolute alcohol, close the cover of the bottle immediately after use, because it absorbs water from ambient air.

WARNING: The cover and the base warms up during test. There is a risk of burn damages. Let the parts cool down between successive tests.

CAUTION: The aluminium base of the test kit can be cooled down by sinking it into cold water. However, this should not be attempted with the glass cover, because large temperature variations may crack the cover.



		Code
1	Cover	874868
2	Burner base	874867
3	Alcohol burner	57246
4	Alcohol burner vessel	57249
5	Canopy hose	73321
6	35 mm fitting	874271
7	Pipette pump	57247
8	One-mark pipette	57248

Figure 1 Alcohol Burning Kit

3 RQ TEST

1. Turn power on and let the monitor run for at least 30 minutes to warm up. Connect a printer.

2. If the ambient pressure is known accurately, perform pressure calibration.

3. Perform gas calibration carefully.

4. Select the following settings:

   a) Clear possible old results by pressing 'END'

   b) CANOPY mode. Press 'CHANGE MODE' key if necessary.

   c) Averaging OFF in 'Setup' menu.

   d) Artifact suppression OFF in 'Setup' menu.

   e) Numeric printer output in 'Setup' menu.

5. Prepare a test setup as shown in Figure 2.

6. Light up the alcohol burner filled with alcohol.

7. Start the measurement by pressing 'START' key.

8. Continue the test for at least 30 min. The average RQ value for the last 15 min should be within 0.64 and 0.69

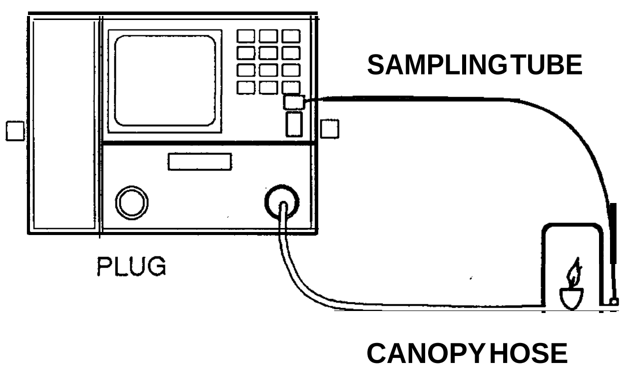


Figure 2 Alcohol Burning Test Setup

4 FLOW CALIBRATION

Read the instructions thoroughly before starting the flow calibration. It is recommended that once the calibration has been made, it should be confirmed by repeating the test.

1 Do the preparations described in steps 1 to 4 of Chapter 3, RQ TEST.

2 Prepare a test setup as shown in Figure 2. However, the alcohol burner is replaced with the burner vessel.

3 Using the pipette of the test kit, fill the alcohol burner vessel with 5 mL of ethanol.

> **NOTE:** Care must be taken when using the pipette; no air bubbles are allowed to enter the pipette. The calibration is only as accurate as the dose of alcohol.

4 Start the measurement by pressing 'START' key. Wait for 30 seconds. The actual measuring sequence will start (measurement time will restart from zero).

5 Light up the alcohol and put on the cover.

> **NOTE:** Alcohol evaporates. The test should be started within 2 minutes after step 3.

6 After approximately 20 minutes the flame will die by itself (NO BREATHING alarm will result). Wait until the VCO_2 goes below 10 mL/min.

7 Calculate the total amount of CO_2 produced during the test by summing up all minute to minute VCO_2 values on the printout.

Alternative method: Press 'LONG TREND' key and read average VCO_2 and the measurement time (excluding seconds). The total amount of CO_2 produced is the multiplication of these two quantities. **When using this method it is important that both averaging and artifact suppression are OFF.**

8 Make sure that all alcohol has burned out. If not, repeat the test starting from step 3 in Section 4, FLOW CALIBRATION.

9 The new flow constant (adult) can be determined by the following formula:

$$\text{New flow} = 1.03 \times \frac{3820\ \text{mL}}{\text{total } CO_2 \text{ in mL}} \times \text{old flow}$$

> **NOTE:** If pure ethanol is not being used, replace the figure 3820 mL with the appropriate reading. See the examples in Chapter 1, BACKGROUND.

10 To adjust the flow constant and to read the old flow value enter ‘Factory Settings’ menu by holding down softkey ‘1’ during power up. Move the cursor to line ‘Flow calibration’ and press softkey ‘4’ to start.

Adjust the ADULT flow constant.

11 If an adjustment greater than 4 liters per minute has been done, the test including gas calibrations should be repeated.

12 Write the new flow constant in the calibration label on the rear panel.

4.1 Sources of error in flow calibration

Alcohol burning is an accurate and reliable method to calibrate flow if the procedure is followed carefully. There are, however, certain sources of error and the most common of which are listed below.

a) Inaccurate gas calibration - A relative error of 1 % in CO_2 gain (e.g. CO_2 is calibrated to 5.05 % instead of 5.00%) will cause an error of 1 % in the flow constant. O_2 calibration is not important. The monitor should be calibrated with an accurate calibration gas and the warm-up period should be at least 30 min to ensure good stability during the test.

b) Inaccurate pressure calibration - An error of 8 mmHg will cause an error of approximately 1 % in the flow constant.

c) The alcohol dose is not accurate - An error of 1 % in the dose causes an error of the same magnitude in the flow constant. Use only one-mark-pipettes. Avoid air bubbles i the pipette.

d) Alcohol evaporates from the burner vessel - If the burner vessel and burner base are still warm after the preceding test, approximately 1 % of the alcohol will evaporate during 1 minute. Even if the burner vessel is allowed to cool down.

between successive tests, the test should be started within 2 minutes after the dose has been delivered into the burner vessel.

e) The flow provided by the Deltatrac II Metabolic Monitor should not be restricted. Use only the hose and connectors supplied with the test kit. Make also sure that the produced gases are allowed to flow freely from the flow selector wheel on the rear panel.

f) The density of ethanol varies with temperature. The given value for ethanol density is at 25°C. If the temperature is 10°C higher the density will be approximately 1 % lower and the flow constant will be 1 % too high.

g) Pure ethano1 will absorb water from ambient air until an equilibrium concentration of 96 volume % is achieved. In order to avoid this, the cover of the alcohol container should be closed immediately after use.