Model 7600

Service Manual

Feb 5, 2005

Part Number 1024826 Rev C

Service Policy

The Respironics Hospital Services Group provides depot service for monitors and 24-hour a day access to technical support through its Technical Support Department in Murrysville, PA. (Outside the U.S., primary technical support is handled through our qualified international sales and service distributors.)

Contact the Technical Support Department by telephone toll free at 800-345-6443 ext 5; by facsimile at 724-387-5236; or by e-mail at service@respironics.com for technical inquiries or clinical@respironics.com for clinical inquiries. After hours telephone support requests (before 8:00 AM and after 5:00 PM Eastern Time) will be responded to promptly by the Technical Support on-call staff. After hours facsimile and e-mail requests will be answered the next business day. It is suggested that any person calling in for technical support have the equipment available for product identification and preliminary troubleshooting.

Respironics reserves the right to repair or replace any product found to be defective during the warranty period. Repair may be provided in the form of replacement exchange parts or accessories, on-site technical repair assistance or complete system exchanges. Repairs provided due to product abuse or misuse will be considered "non-warranty" and invoiced at the prevailing service rate. Exchanged materials are expected to be returned to Respironics within 10 days for full credit. Return materials should be cleaned as necessary and sent directly to Respironics referencing the RA number provided. (Transferring return materials to a local sales or dealer representatives does not absolve you of your return responsibility.).

If the customer requires the return of their original product, the exchange material will be considered "loaner material" and exchanged again after the customer equipment is repaired.

Please contact Technical Support for information on these additional programs and services:

Technical & Clinical Training

Test Equipment and Test Kits

Service Contract / Parts Insurance Plans

On-Site Service Support

Warranty

The warranty period for the $NICO_2$ Respiratory Profile Monitor with Optional Non-invasive Cardiac Output, Model 7600, is two years. Equipment manufactured or distributed by Respironics, Inc. is fully guaranteed, covering materials and workmanship, for a period of one year from the date of shipment, except for certain disposable products and products with stated guarantees other than one year. Respironics reserves the right to perform guarantee service(s) at its factory, at an authorized repair station, or at the customer's installation.

Respironics' obligations under this guarantee are limited to repairs, or at Respironics' option, replacement of any defective parts of our equipment, except fuses, batteries, and calibration gasses, without charge, if said defects occur during normal service.

Claims for damages during shipment must be filed promptly with the transportation company. All correspondence concerning the equipment must specify both the model name and number, and the serial number as it appears on the equipment.

Improper use, mishandling, tampering with, or operation of the equipment without following specific operating instructions will void this guarantee and release Respironics from any further guarantee obligations.

Customer Service & Product Support:

USA and Canada
Phone 1-800-345-6443
Customer Service Fax 1-800-886-0245
Product Support Fax 1-724-387-5236

International
Phone 724-387-4000
Fax 724-387-5012

service@respironics.com
clinical@respironics.com
www.respironics.com

Caution: Federal (U.S.A.) law restricts this device to sale, distribution, or use by or on the order of a licensed medical practitioner.

Respironics Hospital Division

Customer Service: 1-800-345-6443 or 724-387-4000

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About this manual

Trademarks and Patents

The $NICO_2$® monitor and its sensors and accessories are covered by the following USA patents: 4,859,858, 4,859,859, 4,914,720, 5,146,092, 5,153,436, 5,190,038, 5,251,121, 5,369,277, 5,379,650, 5,398,680, 5,448,991, 5,535,633, 5,616,923, 5,693,944, 5,789,660, 5,793,044, 5,820,550, 5,891,026, 5,999,834, 6,042,550, 6,059,732, 6,073,038, 6,098,622, 6,099,481, 6,126,610, 6,149,481, 6,179,784, 6,200,271, 6,210,342, 6,227,196, 6,238,351, 6,241,681, 6,258,038, 6,306,098, 6,312,389, 6,393,311, 6,408,848, 6,471,658, 6,519,486, 6,540,689, 6,575,164, 6,648,831, 6,648,832, 6,671,532, 6,763,829, 6,810,277, 6,908,438, 6,955,651, D424,193.

Revision History

20-Jul-05	CO_N2209 Revision A.
31-Aug-05	CO_N2424 Revision B.
5-Feb-07	CO_N3545 Revision C.

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1 Safety

For maximum patient and operator safety, observe the following warnings and cautions.

1.1 General Warnings and Cautions

WARNING: Never troubleshoot while a patient is connected to the monitor, since normal operation is suspended.

WARNING: If the monitor has been operating, internal components, including the display and power supply may be hot. Use caution.

WARNING: Explosion hazard. Do not operate the monitor in the presence of flammable anesthetic agents.

WARNING: Electrical shock hazard. Always turn the monitor off before servicing. Do not use with a damaged external power source. When connected to AC power, always use a properly grounded hospital grade outlet.

Caution: Always ensure that you are following proper electrostatic discharge (ESD) grounding procedures before handling static-sensitive devices.

Caution: Be careful not to pull or crimp any cables, tubes or wires.

Caution: Troubleshooting and repair should be performed only by a qualified service technician.

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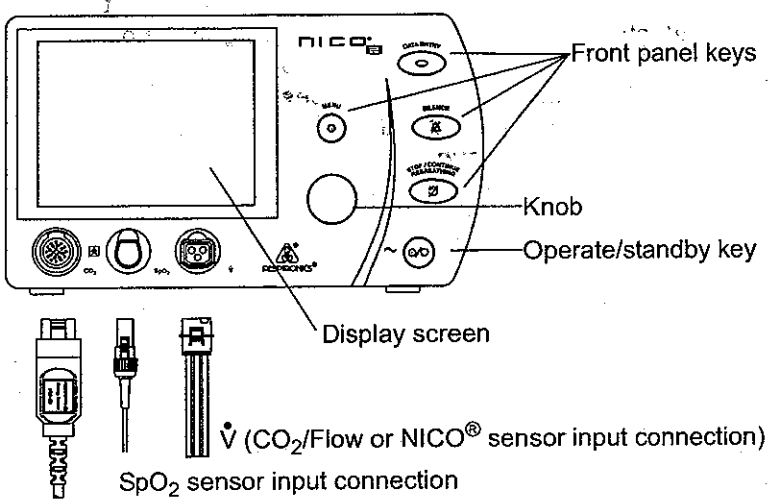
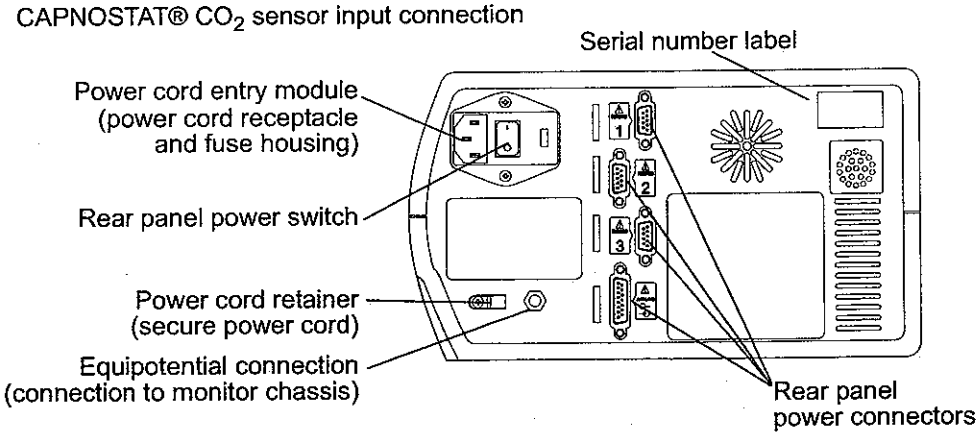
2 Theory of Operation

2.1 Front and Rear Illustrations





2.2 $NICO_2$® Model 7600 Respiratory Profile Monitor

The $NICO_2$® monitor, a Respiratory Profile Monitor from Respironics, Inc., displays various respiratory monitoring parameters including CO_2 elimination (VCO_2), CO_2/SpO_2 and alveolar minute ventilation. With the optional Cardiac Output software installed, the $NICO_2$ monitor, Model 7600, also non-invasively measures and displays cardiac output (C.O.) and displays cardiac index, stroke volume and pulmonary

capillary blood flow. In either mode, the monitor provides the clinician with important information to aid in precise and efficient patient management.

2.3 Digital Board 2783-01

2.3.1 Microprocessor

Refer to sheet 1 of the 2783-03 schematic.

The generation of the logic and control signals for the purpose of acquiring the raw physiological parameters, and management of the data needed to produce an accurate Non-Invasive Cardiac Output, are the responsibilities of microprocessor **IC1**. This device, a Motorola MC68332, is a highly integrated 32-bit microcontroller that combines high-performance data manipulation capabilities with powerful peripheral subsystems. These subsystems include circuitry for timing generation, peripheral chip selection and data control, interrupt generation, as well as synchronous and asynchronous serial communication. Also included is a sophisticated timing co-processor, the TPU (Time Processor Unit), that can generate complex timing waveforms independent of the main processor. In general, the signals for subsystems are functionally grouped into ports which can be independently programmed by software to be a pre-defined port function or discrete I/O. Additionally, the functionality for several ports (Ports C, E and F) can be pre-defined by the state of specific data bus lines on system power-up. Included is a special "background mode" port that allows the device to be externally controlled, facilitating system debugging and testing. Also integrated on-chip are several activity monitors as well as a software watchdog to ensure proper device and system operation. Refer to table 1.

Port	Defined Function	Functionality & Power-up Control
TPU 16 Channels	Timing Signal Generation	Each channel independently user programmable as TPU function or as Discrete I/O
QSM 4 Synchronous Serial Chip Selects & one asynchronous serial channel	Serial Communications Port: QSPI: Queued Serial Peripheral Interface SCI: Serial Communications Interface	QSPI chip selects independently user programmable, can be used as Discrete I/O or decoded to create up to 16 chip selects. SCI transmit can be programmed as Discrete I/O
Background Mode	System debugging	Allows an appropriate external device to control the microprocessor and system
C	Chip Selects	D0: CSBOOT* Data Width, 8 or 16-bit D1: CS1*-CS3* or BR*,BG*,BGACK* D2: CS3*-CS5* or FC0-FC2 D3-D7: CS6*-CS10* or A19-A23
E	Bus Control	D8: Control Signals or Discrete I/O
F	MODCK and Interrupts	D9: MODCK & IRQ or Discrete I/O

Table 1: CPU Port Functions

The operating frequency of the system clock in the *NICO*$_2$® system is 24.117 MHz. It is generated by an internal VCO (Voltage Controlled Oscillator) derived from **Y1**, a 32.768KHz watch crystal, and is software programmable. The Timing Processor Unit (TPU) co-processor of the MC68332 provides complex timing functions generated from

the system clock. This feature is utilized to control the precise timing required for the acquisition of the End Tidal Carbon Dioxide ($ETCO_2$) and saturation (SpO_2) signals. The TPU is also used to generate the PWM (Pulse Width Modulation) control for the Capnostat Case and Detector heaters, and to provide the frequency generation for the audio tones. See Tables 2 and 3.

Signal	Name	Function / Timing
CO2AZ	Auto Zero	Clears the Sample/Hold circuitry prior to data acquisition. Active High, 90 us
CO2PWENB	Pulse Width Enable	Defines the active time for both phases of the bipolar source pulse, used for pulse width protection circuitry. Active High, 810 us
SRCDRV0	Source Drive 0	First source drive signal. Active High, 405 us
CO2CSHL	Current Sample/Hold	Enables circuitry for source current measurement. Sample is taken when SRCDRV0 is active. Low = Sample, 90 us, High = Hold
SRCDRV1	Source Drive 1	Second source drive signal delayed for 10 microseconds after SRCDRV0 ends. Active High, 395 us
CO2SSH	Signal Sample/Hold	Enables circuitry for CO_2 and Reference channel data acquisition. Low = Sample, 90 us, High = Hold
CASEPWM	Case Heater PWM	PWM control for the case heater servo
DETPWM	Detector Heater PWM	PWM control for the detector heater servo
TOUT1, TOUT2	Tone Generation	Variable frequency outputs to generate system audio

Table 2: TPU Timing Generation for the $etCO_2$ subsystem

Signal	Name	Function / Timing
ASAMPL	Auto Zero	Clears the Sample/Hold circuitry prior to data acquisition. Active Low
RDLEDL	Red Channel LED control pulse	Defines the active time for the Red LED. Active Low
IRLEDL	Infrared Channel LED control pulse	Defines the active time for the Infrared LED. Active Low
RSAMPL	Red Channel Sample/Hold	Enables circuitry for the Red Channel signal measurement. Sample is taken when SRCDRV0 is active. Low = Sample, 90 us, High = Hold

Table 3: TPU Timing Generation for the SpO_2 subsystem

ISAMPL	Infrared Channel Sample/Hold	Enables circuitry for the Infrared Channel signal measurement. Sample is taken when SRCDRV0 is active. Low = Sample, 90 us, High = Hold

Table 3: TPU Timing Generation for the SpO_2 subsystem

To help reduce and suppress the radiation of electromagnetic interference, ferrite filters (**L1-L11**) have been placed on clock signals with fast rise and fall times. Other digital signals, including address and data lines, are rise-time limited by the addition of small valued resistors and / or capacitors. In addition, good EMI/EMC design techniques have been incorporated in the component layout and printed circuit board manufacture.

Table 4 lists the chip select, control and discrete I/O functions for the *$NICO_2$*® system module. On power-up, Ports E and F are programmed as discrete inputs by pulling down their controlling data lines, DB8 and DB9. After power-up, the software sets up each pin function individually and performs a series of self-tests to check the integrity of the system. During this period, the MPU holds the SYSUP line low which keeps the system in the initialization state. The state of configuration inputs on Port E (CNFG0, CNFG1 and CNFG2) and on data input buffer **IC10** (JP1, JP2, JP3, JP4, TP4, and TP5) are read. These inputs allow the software to identify different operating conditions, such as Manufacturing Diagnostic Mode, or to recognize different hardware configurations. After the initialization period is complete and all system functions have been set, the MPU brings the status signal SYSUP high, indicating that the system is ready for patient monitoring operation.

Port	Pin Functions	System Signal Name	I/O	Comments
C	DATA0 through DATA7		O	D0-D7 pulled high, Pins are Chip Select on power-up
	CSBOOT*	ROMOEL	O	Program PROM Chip Select Word (16-bits) wide mode, D0 = HIGH
	CS0* / BR*	UBRAMWRL	O	Upper Byte SRAM Write Enable Allows for byte (8-bit) or word writes
	CS1*/ BG*	LBRAMWRL	O	Lower Byte SRAM Write Enable Allows for byte (8-bit) or word writes
	CS2* / BGACK*	SRAMOEL	O	SRAM Read Enable, Word
	CS3* / PC0 / FC0	ROMWRL	O	FLASH PROM Write Enable, Word
	CS4* / PC1 / FC1	UARTCSL	O	High Speed quad UART Chip Select
	CS5* / PC2 / FC2	BOOTWE	O	Port C Discrete Output, prevents unintentional writes to FLASH EPROM. This signal must be asserted before ROMWR* in order to overwrite the FLASH
	CS6* / PC3 / A19	A19	O	High Address line A19
	CS7* / PC4 / A20	RTCCSL	O	Real Time Clock Chip Select
	CS8* / PC5 / A21	DISPCSL	O	EL Display Chip Select
	CS9* / PC6 / A22	VRAMCSL	O	Video Memory Chip Select
	CS10* / ECLK / A23	CASCADEL	O	Cascaded Chip Select for Additional Parallel Peripherals
E	DATA8		O	D8 pulled low, Discrete I/O on power-up
	DSACK0* / Port E0	CNFG2	I	Configuration Switch 2
	DSACK1* / Port E1	DS1L	I	Data and Size Acknowledge 1*
	AVC* / Port E2	CNFG0	I	Configuration Switch 0
	RMC* / Port E3	CNFG1	I	Configuration Switch 1
	DS* / Port E4	DSL	O	Data Strobe
	AS* / Port E5	ASL	O	Address Strobe
	SIZ0* / Port E6	SIZ0	O	Signifies current operation is 8-bit data
	SIZ1* / Port E7	CNFG2	I	Configuration Switch 2
	R/W*	RDL	O	Data Read Strobe
		WRL	O	Data Write Strobe

Table 4: Chip Select, Control and Discrete I/O

F	DATA9		O	D9 pulled low, Discrete I/O on power-up
	MODCLK / Port F0	LED	O	LED CPU Activity Indicator
	IRQ1* / Port F1	SYSUP	O	System Initialization Complete
	IRQ2* / Port F2	CSOFTOT	O	Case Heater Over Temperature Shut Down
	IRQ3* / Port F3	DSOFTOT	O	Detector Heater Over Temperature Shut Down
	IRQ4* / Port F4	UARTIRQL	I	External UART Interrupt
	IRQ5* / Port F5	EXTDCIN	I	Indicates external AC MAINS power operation
	IRQ6* / Port F6	PWRDWN	O	System power down enable
	IRQ7* / Port F7	NMIL	I	Non-Maskable Interrupt

Table 4: Chip Select, Control and Discrete I/O

2.3.2 Background Mode Debugging and Application Development

Refer to sheet 1 of the 2783-03 schematic.

Background debugging of the system during applications development or during system testing is possible by connecting an appropriate external device (emulator or debugger) to header **J1**. The signals present on this header enable an external device to halt the current microprocessor bus activity. This turns control of the microprocessor system over to the external device, placing the microcontroller into Background Debugging Mode. In this mode, the internal MPU registers can be viewed and altered, special test features can be invoked and the system's memory, and peripherals can be read and written to.

In addition to the inherent debugging capabilities of the microprocessor, the digital board also contains circuitry to monitor events during application development. Output latches **IC15** and **IC17** along with Profiling header **J4** are used to determine CPU utilization during system development, latching various status bits out on the header.

2.3.3 System Memory

Refer to sheet 1 of the 2783-03 schematic.

A 16-bit wide data path is used for FLASH PROM and SRAM transfers to maximize system throughput. Non-volatile memory, used for the storage of the boot-up and main program code, is contained in **IC4**, a 1024K x 8-bit, 5V FLASH ROM. To initiate the data transfer process, the MPU brings the ROMOEL output signal LOW, causing a word of program data stored in the FLASH ROM to be sent out on the data bus from the appropriate memory address. Program data may be updated by commanding the device to erase a block of its present programmed data then using the ROMWRL signal to place new program data into the address specified by the MPU. The FLASH ROM is internally protected from unintentional over writes of the boot code by requiring an independent signal, BOOTWE, going active in addition to ROMWRL. The BOOTWE line must be high prior to writing new boot code into the FLASH device. Two 512K x 8-bit Static RAMs (**IC3 and IC6**) contain volatile data storage for use as a temporary data scratch pad during system operation and for recording patient trend information. To retain patient trending data during periods of power down, the SRAMs are battery backed to retain their contents. A 2.5 Volt level, VBACK, generated from the main

battery via IC30 on the 2784 Power Board (sheet 5), is supplied when the system is turned off and removed from the AC MAINS. During this battery backed-up state, transistor **Q1** keeps the chip enable control line of the SRAMs high and in a low power, inactive state. This forces the SRAMs data bus to a high impedance state, isolating the parts from the rest of the system. True non-volatile storage for system parameters is provided by a serial EEPROM (**IC8**), which has the ability to retain programmed information in the absence of power.

2.3.4 *User Interface Control Circuitry*

Refer to sheet 3 of the 2783-03 schematic.

The user interface features a high contrast, 320 row by 240 column Electroluminescent Display module. Patient and system information is presented in both graphical and textual formats organized into several screen configurations. An integrated display controller, **IC19**, works in conjunction with the MC68332 MPU, and provides the necessary timing signal generation and housekeeping functions to display the visual information generated by the system. Programmable logic device **IC2** is designed to condition the logic signals between the MPU and display controller, making sure that the critical timing specifications of the two devices are met. SRAMS **IC18** and **IC22** provide video RAM storage for the display system. In addition to buffering the signals for the display interface, CPLD **IC2** also decodes chip selects for the system input buffers and output latches off of CASCADEL.

A 5-switch silicon keypanel and multifunctional rotary encoder provide operator control of screen selection, patient data entry and user selectable input. The keypanel also contains several LEDs which represent various system conditions such as input power status (AC or Battery) and alarm state. Control of the user interface is generated from the CASCADEL chip select signal along with the appropriate address line state and WRL signals from the microprocessor. **IC10** and **IC13** are input buffers, which read in the present state of the keypanel and rotary encoder. Depressing a key or activation of the encoder causes the associated signal line to be pulled low, in contrast to its normally high state. Input buffer **IC14** provides a latched output for controlling the front panel LEDs as well as several other latched control outputs.

To supplement the visual indicators associated with the membrane keypanel and display, an audio output signal is generated to provide an additional mode to convey information to the user. The TPU processor of the MC68332 (TOUT1 and TOUT2) can generate two-tone frequencies. These signals are fed into separate reference inputs of the Quad 8-bit DAC, **IC20**, providing a means for independently attenuating each signal under CPU control. From the DAC, the individual signals are summed together by **IC21B** and filtered by **L11** and **C50**. Audio amplifier **IC23** drives the system speaker to produce system audio. Inverter **IC7F**, controlled by the SYSUP signal from the MPU, disables the audio amplifier until system initialization has been completed. DAC **IC23** also supplies two separate output voltage levels, which are amplified through IC26A and IC26B to produce SPO2VIR and SPO2VRD. SPO2VIR and SPO2VRD are used to set the current gain of the saturation drive circuits. The saturation drive circuits are located on the *NICO2*® Power PCB, 2784-01.

2.3.5 *Real Time Clock, Power on RESET Generation and Glue Logic*

Refer to sheet 2 of the 2783-03 schematic.

Time keeping for date and time stamping of patient trend information is provided by Real Time Clock **IC16**. This device contains a built in crystal for precise time and date measurement. In the absence of digital power, the time keeping function is maintained by the battery backed-up supply, VBACK.

On power-up, the system is forced into a RESET state by **IC9**. This chip creates the master active low system reset signal SRST*, holding up system initialization until a stable 5 VDC logic level is maintained. An inverter is used to generate RESET for devices that require an active high reset signal.

2.4 Serial Communication & Power Supply PCB, 2784-01:

2.4.1 Serial Communications UART

Refer to sheet 3 of the 2784-03 schematic.

To enable serial communication with up to three external devices simultaneously, a Quad UART (Universal Asynchronous Receiver/Transmitter), **IC14**, is provided for buffered high-speed data communication. The connection to external, non-patient contact-type devices is electrically isolated from the patient applied sections by optical data couplers (**IC21**, **IC23, IC26, IC48, IC49, IC50, IC51**) and an isolated winding off of the power supply flyback transformer, **T1**. Transceiver **IC13**, located on the patient-isolated circuit, provides signal translation between the system's TTL logic level and the RS-232 level requirements. Serial Ports A and C (**J1** and **J3**) are configured for a simple 3-wire (Transmit, Receive and Ground) connection, while Serial Port B (**J2**) has additional hardware handshaking capabilities. Connection to an external device is through a null-modem type of interface cable. The fourth UART channel is available on internal connector J5 for future product expansion. In addition, the system is capable of outputting four channels of analog output data through **IC22** and receiving four channels of analog input through buffer amplifiers **IC18** and A/D Converter **IC20** on connector **J4**. Voltage reference **IC19** supplies the analog I/O circuitry with a stable voltage level. Connector **J4** allows sensing of external cable connection by shorting pin 15 (IOSNSE) of the external cable to ground. Refer to Tables 5 to 8 for the pinout and signals of interface connectors.

J1		
Pin Number	**Signal**	**Function**
1	NC	No Connection
2	RxA	Serial Channel A Receive
3	TxA	Serial Channel A Transmit
4	NC	No Connection
5	GND	Non-Patient Signal Ground
6	NC	No Connection
7	NC	No Connection
8	NC	No Connection
9	NC	No Connection

Table 5: Serial Channel A, 9-pin D-subminiature connector located on the rear panel

J2		
Pin Number	**Signal**	**Function**
1	NC	No Connection
2	RxB	Serial Channel B Receive
3	TxB	Serial Channel B Transmit
4	NC	No Connection
5	GND	Non-Patient Signal Ground
6	NC	No Connection
7	RTSB	Request to Send Channel B, Hardware Handshake Output
8	CTSB	Clear to Send Channel C, Hardware Handshake Input
9	NC	No Connection

Table 6: Serial Channel B, 9-pin D-subminiature connector located on the rear panel

J3		
Pin Number	**Signal**	**Function**
1	NC	No Connection
2	RxC	Serial Channel C Receive
3	TxC	Serial Channel C Transmit
4	NC	No Connection
5	GND	Non-Patient Signal Ground
6	NC	No Connection
7	NC	No Connection
8	NC	No Connection
9	NC	No Connection

Table 7: Serial Channel C, 9-pin D-subminiature connector located on the rear panel

J4		
Pin Number	**Signal**	**Function**
1	GND	Non-Patient Signal Ground
2	ADCIN0	ADC Input Channel 0

Table 8: Analog Connector, 15-pin D-subminiature connector located on the rear panel

3	ADCIN1	ADC Input Channel 1
4	ADCIN2	ADC Input Channel 2
5	ADCIN3	ADC Input Channel 3
6	GND	Non-Patient Signal Ground
7	GND	Non-Patient Signal Ground
8	GND	Non-Patient Signal Ground
9	GND	Non-Patient Signal Ground
10	GND	Non-Patient Signal Ground
11	DACOUT0	DAC Output Channel 0
12	DACOUT1	DAC Output Channel 1
13	DACOUT2	DAC Output Channel 2
14	DACOUT3	DAC Output Channel 3
15	IOSNSE	Cable connect sense input

Table 8: Analog Connector, 15-pin D-subminiature connector located on the rear panel

2.4.2 CO_2 Pulser Source Drive

Refer to sheet 1 of the 2784-03 schematic.

The source drive circuitry is designed to drive the source with a bipolar signal to prevent the migration of charges within the source that may result from unidirectional electrical fields. The resistance of the source is monitored constantly to ensure the integrity of the system by sampling the current through the source while it is active.

The TPU co-processor in the MC68332 generates the timing signals that drive the power to the broadband infrared source located in the Capnostat sensor. The SRCDRV0 and SRCDRV1 lines are used to control the direction of the current flow through the source. On the falling edge of CO2AZ (Auto Zero) and the rising edge of CO2PWENB (Pulse Width Enable), the SRCDRV0 signal goes High, enabling drivers **IC1A** and **IC2B** to turn on one half of the MOSFET H-Bridge formed by **Q1** and **Q2**. This causes current to flow through the P-Channel half of MOSFET **Q1**, through the Capnostat source, through the N-Channel half of MOSFET **Q2** and finally through **R23** to the negative supply rail, completing the first part of the Source Pulse cycle. The duration of SRCDRV0 is 405 us (microseconds). After the SRCDRV0 line goes Low, there is a 20 us software delay until the SCRDRV1 line goes High, enabling drivers **IC1B** and **IC2A** to turn on the other half of the MOSFET Bridge formed by the P-Channel half of **Q2** and the N-Channel half of **Q1**. This drives the current through the source in the opposite direction. The 20us software delay between the SRCDRV0 and SRCDRV1 signals is to prevent the possibility of both halves of the MOSFET bridge being active at the same time, thus creating a low impedance path between the two power supply rails.

When current flows through the source, it will also flow through current sensing resistor **R23**, creating a differential voltage proportional to the source current. This voltage is measured during the last part of the SCRDRV0 period by differential amplifier **IC3A**, and is inputted to **IC9**, a 12-bit, 11-channel A/D Converter after being conditioned by the sample / hold circuit consisting of **IC4**, **IC5** and **C11**. The converter output of the

sample / hold is processed in software to represent the current flowing through the Capnostat source:

$V_{SRC} = (V_{SR} / R_{SR}) * R_S * A_{V(DA)}$ where V_{SRC} = voltage out of difference amplifier proportional to current through the source element

= 24V +/- 0.625V

V_{SR} = differential voltage across the source element

R_{SR} = resistance of the source element

R_S = resistance of the current sensing resistor

= 1 ohm

$A_{V(DA)}$ = difference amplifier gain

= 10

V_{SRC} = [120 (Volts*Ohms) / R_{SR} (Ohms)]

For compatibility with present Respironics monitors, the software displays the source current scaled by (1.1Vsrc) +17mV. In addition to monitoring the source current, the A/D Converter **IC9** also digitizes the feedback signals from the Saturation sensor and Power Supply.

In order to prevent the source from being driven until the system is up and ready, there is protection circuitry that inhibits the source drive until enabled. During system power-up, the RESET line keeps **Q3** on, preventing source pulses by pulling down SRCDRV0 and SCRDRV1 through **D3**. Protection circuitry also guards against extended pulse width as well as shortened duty cycle. On the rising edge of CO2PWENB, the trip point of **IC6B** is exceeded, bringing the output of **IC6B** high as **C12** charges through diode **D4**. This allows capacitor **C8** to charge up through **R22**. If the CO2PWENB signal does not turn the Source Pulser off within 200 us after the 810 us pulse period, the voltage across **C8** will exceed the trip point for **IC6A**, pulling the SRCDRV0 and SCRDRV1 lines low and turning the Pulser off. After the CO2PWENB signal returns Low, capacitor **C12** is allowed to discharge through **R26**, keeping the output of comparator **IC6B** at the voltage acquired during the period when CO2PWENB was High. After approximately 7.2ms, **C12** will have discharged below comparator **IC6B**'s trip point. The comparator output goes low, discharging **C8** and the circuit is ready for the next source pulse cycle.

2.4.3 *Capnostat Case and Detector Heater Control*

Refer to sheet 2 of the 2784-03 schematic.

The temperature of the Capnostat sensor system directly affects its ability to accurately measure CO_2. Two separate heaters and control circuits are used to maintain the sensor temperature at a precise value. One heater regulates the temperature of the detectors that detect the amount of infrared energy passing through the sample chamber; the other regulates the temperature of the transducer case (and loosely maintains the temperature of the airway adapter). While the purpose of the Detector heater is to keep the detectors' sensitivity to infrared radiation constant, the function of the Case heater is to keep condensation from forming on the airway windows by elevating the window temperature above the ambient airway temperature. Both heaters use an efficient Pulse-Width Modulation scheme designed to decrease power consumption, with the PWM timing generated by the TPU under microprocessor control. The MPU senses the voltage output from the Capnostat Case and Detector thermistors (circuit described in the Analog 2754-01 PCB discussion) and regulates the

output pulses from the TPU, creating a pulse duty cycle that is proportional to the amount of energy required to maintain the heater temperature. Dual MOSFET Driver **IC10** buffers the TPU signals to drive the gates of Dual P-Channel MOSFET **Q7**. These drive signals are AC coupled by capacitors **C24** & **C31** to ensure that if PWM pulses are lost for any reason, the MOSFET gates will be pulled up by resistors **R42** and **R47** which will turn the MOSFETs Off, removing power to the Capnostat heaters. Dual MOSFET **Q4** also controls power to the heaters, allowing independent over-temperature cut-off of each heater by both software and hardware watchdogs. **D6**, **L1** and **C25** help turn the pulses for the Case Heater from **Q7A** into a steady DC output, while **D8**, **L2** and **C32** smooth out the Detector Heater output from **Q7B**. Since the TPU-generated PWM signal is based on the system clock, it is synchronized with the generation of the source pulse timing. This minimizes the effect of any random disturbance caused by the heater circuit on the detection of the CO_2 Data and Reference signals.

2.4.4 *Saturation LED Power Generation and LED Drive*

Refer to sheet 2 of the 2784-03 schematic.

Adjustable voltage regulator **IC11** is configured as a constant current supply for the Red and Infrared (IR) saturation sensor LEDs. **R50** limits the current to Vref/R {1.25V/26.7 ohms} or 47mA, while Zener diode **D9** sets the maximum output voltage at 7.5 Volts. Capacitors **C36** and **C37** provide a reservoir for providing the instantaneous current demanded when the LEDs are turned on. Transistor **Q11** allows shutting down the power to the sensor LEDs by the microprocessor.

Connector **J4** on the *NICO*® 2765-01 Analog Board connects the saturation sensor to the monitor. Both of the saturation sensor LEDs are controlled by an amplifier configured as a constant current driver. The voltage signals SPO2VIR and SPO2VRDO which control the constant current drive signals SPO2RDRV and SPO2VIR, are generated from **IC20** and **IC26** on the *NICO2*® Digital Board, 2783-01. The SPO2VRD is passed through a CMOS analog switch IC55 and renamed SPO2VRDO. The CMOS analog switches IC54 and IC55 (Refer to sheet 5 of the 2784-03 schematic) are for providing backward compatibility with the 2763-01 Digital Board. The cathode of the Red LED channel is tied to the driver consisting of amplifier **IC12A**, MOSFET **Q10** and resistor **R57**. Since the amplifier is connected as a non-inverting amplifier, the voltage appearing at the positive terminal will also appear at the negative terminal and across **R57**. This voltage, nominally 0.74V, creates a current through **R57** of 224mA {0.74V/ 3.3 ohms} when the RDLEDL signal is asserted which also flows through the Red LED of the Saturation sensor via **Q10**. The driver for the IR LED (**IC12B**, **Q13** and **R64**) creates a constant current source of 111mA across **R64** and is controlled by asserting the IRLEDL signal. The two control signals operate at 33 kHz with a 10% duty cycle and are staggered so that one LED is on during the middle of the other LED's off time.

2.4.5 *Power Supply and Voltage Reference Generation*

Refer to sheet 4 of the 2784-03 schematic.

The monitor operates either on isolated AC Mains power or on the internal 12-Volt Lead-Acid Battery. To provide isolation from the MAINS lines as well as AC/DC voltage conversion, the *NICO2*® monitor utilizes a Medical Grade, universal input off-line switching power supply. The DC output of this supply is 15 VDC at 40 Watts, and is brought to the Power board on connector **J6**. The heart of the power supply design for the system is a 100 kHz switching regulator, **IC34**, which utilizes a flyback transformer configuration to generate the DC supply voltages and provide the required isolation between the primary, secondary and isolated power planes. Power On / Off control is achieved by sensing the state of the Power Switch located on the front panel. A high to

low transition on the PWRSW line is debounced by **C85** and **IC31A**, and clocked into Flip-flop **IC32A**, which causes the Flip-flop output to toggle its present state. A high output causes switching regulator **IC34** to be turned on, supplying power to the system. Flip-flop **IC32B** provides control over the state of the system when the user turns the system "Off". When the monitor is operated from an AC MAINS power source the green AC ON indicator on the front panel is lit. If the monitor is on, pressing the power key on the front membrane keypanel will not power the monitor down. Instead, the monitor is placed in a standby operating mode. The display and other non-essential control functions are inactivated by the software, giving the monitor the appearance of power down. While in standby, however, the core system continues to operate, keeping the Capnostat heaters within temperature regulation. This reduces the time required to bring the system up to full operating specifications during the following power-up cycle. While on battery operation, depressing the Power Key on the front keypanel will turn off the switching regulator, thus powering down the system. Stand by mode is disabled and power to the system is turned off. The monitor enters a low power mode where only circuitry required for SRAM and real-time clock battery back-up and Power Key sensing is kept supplied. Power for the SRAM and Real-time clock, VBACK, is determined by the state of VDD. When VDD is available and transistor **Q23** is turned on, VDD is supplied through transistor **Q21**. In the absence of VDD, VBACK drops down to a low power level supplied through diode **D36**.

During system initialization, the switching frequency is synchronized to the main system clock by the components associated with **Q17** to reduce system data acquisition errors due to power supply interference. The nominal synchronized frequency is 156 kHz. The primary of transformer **T1** is designed to accept 10 to 24 V DC input and provides secondary outputs of nominally 5 VDC, +14 VDC, and -14 VDC. An additional winding pair is isolated by 2KV from the other transformer windings to provide 9VDC output for the earth connected and patient isolated serial and analog input and output circuitry. The 5VDC supply (VDD) provides feedback to the switching regulator by resistor divider **R108** and **R112**. The other windings are loosely regulated by the requirements of the 5 VDC supply by the ratio of the transformer windings, creating a secondary voltage at +VAR of approximately +14VDC and a secondary voltage at -VAR of approximately -14VDC. +VAR and -VAR are supplied to the 2765-01 Analog Board via **J7**. The 5V supply is L-C filtered to provide clean logic supplies for both the digital logic (VDD) and the analog sections of the Digital and Power Boards (DVDD). Another filter isolates the 5-Volt supply for the Flow Pneumatics (VVDD) from the rest of the system. Regulators **IC33** and **IC36** are designed as a tracking regulator pair to provide a 24VDC differential voltage for powering the Capnostat source (+VSRC, -VSRC). The voltage level of the +VA supply is monitored by **IC35B** to ensure that a tight voltage range is maintained and not exceeded in the event that the +5 VDC feedback to the switching regulator, **IC34**, is lost. Linear regulator **IC27** provides the logic and analog supply for the patient-isolated circuits.

Power for the Capnostat heaters and the display are derived off of the main 15 Volt input from the offline switching regulator during connection to an AC MAINS power source. During AC operation, the signal LINEST is High, indicating the presence of AC MAINS. **IC37**, also a switching voltage regulator, and its associated circuitry provide these functions with a well-regulated 12 VDC supply. When the monitor is operating off of the internal battery, LINEST is Low, disabling the switching regulator and turning on MOSFET **Q19A** which is controlled by voltage comparator **IC35C**. In this mode, the heaters and display are supplied directly with battery power, minimizing power losses that occur during the conversion of one voltage level to another. The output from comparator **IC35C** also controls the Reset input to Flip-flop **IC32B**, determining whether the monitor is in AC stand-by or DC Power Down operating mode.

Charging the battery takes place as long as the unit is connected into a viable source of AC MAINS power and the power entry module switch is in the "On" position. In order to charge the battery as quickly and efficiently as possible, a two-step charging process is employed. Assuming the battery is in a depleted charge state, feedback to the low drop-out linear regulator, **IC39**, (2784-03 sheet 5) sets the voltage output at a fast-charge level of approximately 14 VDC. Sensing the voltage drop across **R144**, comparator **IC40A** monitors the current draw of the battery, limiting it to approximately 250mA for a maximum charge rate of C/10. If the battery tries to draw current in excess of the amount allowed, **IC40A** turns off the regulator, thus limiting the charging current. As the battery reaches a fully charged state and the current draw decreases to approximately 50mA, **IC40B** turns transistor **Q27** off which causes the regulator to change its output to a float charge voltage of approximately 13.2 VDC, which maintains the battery in a constant state of readiness.

If AC power is lost or is not available, the monitor automatically operates from its internal battery without interruption. The AC ON indicator is extinguished and a BATTERY ICON appears on the display, indicating the current power level of the battery. While on internal DC power, the current state of the battery is monitored by both software and hardware (**IC29**, **IC28A** and **IC35A**). Should the battery power level get critically low, the monitor software, which monitors the VBATTADC signal into A/D Converter **IC9**, alerts the user. If the monitor is not placed on AC MAINS power within approximately ten minutes, the software will turn the unit off. Should the software fail to turn the monitor off, the hardware cutoff, controlled by comparator **IC35A**, activates, turning the unit off.

Stable reference voltages for the analog circuitry are derived from **IC7** (2784-03 sheet 1), a precision 2.5V voltage reference with low drift. 5V and 2.5V references are generated by **IC8**.

Refer to Table 9.

Signal	Supply	Description
VDCIN	+15 VDC	Main DC input generated from offline switcher or internal battery
VBATT	+12VDC	Internal Battery DC input
VBACK	+2.5VDC or +5VDC	Supply for SRAMs, either VDD or 2.5V to maintain SRAM data during power down
VHTR	+12.15VDC or VBATT	Supply for the Capnostat Case and Detector heaters and Fan, regulated at 12V when MAINS power available or from VBATT when unit is on battery power
DISPVA	+12.5VDC or VBATT	Supply for the EL Display, regulated at 12V when MAINS power available or from VBATT when unit is on battery power
VDD	+5VDC	Regulated digital logic supply
VVDD	+5VDC	Regulated and filtered supply for the valves
CVDD	+5VDC	Regulated and filtered logic supply for CO_2 analog sub-system
DVDD	+5VDC	Regulated and filtered logic supply for general analog sub-systems
ADCVDD	+2.14VDC	ADC input for monitoring VDD

Table 9: Power Supply Outputs

+VAR	+14.5VDC	Loosely regulated off of the 5VDC feedback line
+VA	+12VDC	Regulated and filtered analog supply.
+VSRC	+12VDC	Linearly Regulated and filtered positive supply for the Capnostat Source. Tracks -VSRC to provide a 24V +/- 2.5% differential voltage across the source
ADCPVSRC	+0.85VDC	ADC input for monitoring +VSRC
-VSRC	-12VDC	Linearly Regulated and filtered negative supply for the Capnostat Source. Tracked by +VSRC to provide a 24V +/- 2.5% differential voltage across the source
ADCNVSRC	+0.75VDC	ADC input for monitoring -VSRC
-VAR	-14.5VDC	Loosely regulated off of the 5VDC feedback line
IRAW	+9VDC	Loosely regulated off of the 5VDC feedback line, isolated from the other transformer windings
IVDD	+5VDC	Linearly Regulated to provide an isolated digital and analog power source
-VA	-12VDC	Regulated filtered analog supply.

Table 9: Power Supply Outputs

2.4.6 Logic and Input / Output Signal Control

Refer to sheet 6 of the 2784-03 schematic.

Chip selection for the serial peripherals are provided by decoders **IC43** and **IC46** and by the inverters **IC47**, **IC45E** and **IC45F**. Latch **IC41** is used mainly to control the system pneumatics, with Latch **IC42** providing additional control signals for the *NICO2*® 2765-01 Analog Board. Input buffer **IC44** allows the digital system to read various status signals from the Analog Board.

2.5 Analog Board 2765-01

2.5.1 Capnostat Interface

Refer to sheet 1 of the 2765-03 schematic.

A twenty pin connector, **J2**, interfaces the Capnostat with the system electronics. Ferrite filters have been placed on all lines to suppress radiated EMI and reduce susceptibility from high frequency external sources of interference.

Stable reference voltages for the sensors and analog circuitry are derived from **IC1**, a precision 2.5V reference with low drift. Five Volt and 2.5 Volt references for the CO_2 and Saturation circuits are generated by **IC2**. Positive and negative supply rails for the analog circuitry are derived from linear regulators **IC6**, **IC7** and **IC50**, while regulators **IC3** and **IC49** provide regulated voltage supplies for the Capnostat itself.

2.5.2 CO_2 Input Signal Path

Refer to sheet 2 of the 2765-03 schematic.

The signals from the sensor CO2DATAIN (CO_2 Data) and CO2REFIN (Reference Signal) have similar signal paths. The CO2DATAIN passes through a high pass filter with a gain of 7.65 consisting of **C60**, **R68** and buffer amplifier **IC15B**. The signal is fed

to a Butterworth low pass filter **IC15A** and associated components. This filter has a gain of 2 with a corner frequency of 1.5 kHz. The output from the low pass filter is fed into the feedback pin of the 12-bit Digital to Analog converter **IC14**. Here, under processor control, the signal's gain is adjusted to an acceptable level for conversion. The gain setting is adjusted using the digitized signal out of A/D Converter **IC4** as part of the feedback loop. Similarly, CO2REFIN is conditioned by high pass filter **IC16B** with a gain of 3.5 and low pass filter **IC16A** with a gain of 2. The equivalent fixed gains for the two input signals are not equal in order to compensate for differences in the output signal levels of the infrared detectors in the Capnostat.

The output from DAC **IC14** corresponding to signal CO2DATAIN is buffered by **IC12A** and AC coupled through **C49** to **IC11A**. The CO2DATA signal received from the Capnostat is AC coupled prior to the high pass filter to remove any DC bias by **C60**. Prior to sampling a CO_2 signal, the CO2AZ (Auto Zero) pulse turns **Q1** on causing any residual charge on **C49** to discharge to ground. At the start of the source pulse, the CO2AZ pulse goes Low and the CO_2 signal from the sensor is acquired. The signal is buffered by **IC11A** before appearing at the input of the sample and hold amplifier, **IC13A**. Near the end of the source pulse, the CO2SSH (CO_2 Signal Sample and Hold) goes Low and the peak signal is acquired on the internal sample and hold capacitor. CO2SSH returns high at the end of the cycle, and the CO_2 signal on the sample capacitor is held at the peak value. The signal then passes through a low pass filter and resistive divider network consisting of **R51**, **R53** and **C51** before being converted by the A/D Converter **IC4** into digital data and analyzed by the processor. The signal CO2REF follows an identical zeroing and acquisition path.

2.5.3 *CO_2 Case and Detector Heater Regulation*

Refer to sheet 2 of the 2765-03 schematic.

For the purpose of describing the regulation loop, the case heater circuitry will be considered. The detector and case heater circuitry are identical.

Inside the Capnostat, a sensing thermistor is thermally connected to the heater module. Initially, the Capnostat is at ambient temperature and the resistance of the thermistor is large. A small current flows through the signal path CASETHERM and only a small voltage is developed across **R47**. The microprocessor programs the TPU to allow an initial maximum duty cycle of 70% to power the PWM heater circuitry. This causes the heater control MOSFET on the *NICO$_2$*® 2784-01 Power Board to be pulsed on and off with a duty cycle that is under direct control of the program software. As the heater warms up the case, the thermistor's resistance decreases, raising the voltage appearing at the input of the control loop. As described below, the MPU looks at this output voltage and decreases the duty cycle of the PWM control circuitry, gradually reducing the power output into the heater. When the desired temperature set point is reached, a balance is struck between the energy delivered into the system and the heat flow out of the system.

The case thermistor is sensed by amplifier **IC9B**. The difference between the signal at the non-inverting input and the reference appearing at the inverting terminal generates an error voltage proportional to the sensed temperature at the amplifier's output:

$e_{o\,(T)}$ (V) = [83.133 x 10^3 VΩ/ (R_{th}+3.32KΩ)] - 10.02V where e_o = amplifier output voltage

R_{th} = resistance of the thermistor

= 4.36933KΩ at 45°C

Temp (°C) = 4.1288 (°C/V) * $e_{o\,(T)}$ V + 41.7321°C

where e_o = amplifier output voltage at temperature T

This error voltage is low pass filtered by amplifier **IC8B**, sent to the ADC and processed by the CPU to regulate the output pulses from the TPU. The error voltage out of amplifier **IC9B** also appears at the temperature watchdog comparator **IC10A**. If the error voltage reaches approximately 56 degrees Celsius, the comparator trips, causing the output to go Low and turning off the heater supply on the Power Board.

2.5.4 *Flow Zeroing and Patient Line Purging*

Refer to sheet 5 of the 2765-03 schematic.

The zero process begins when the CPU brings the VALVE1, VALVE2, VALVE3, VALVE4 and NICOV2 lines high, energizing valves **V1**, **V2**, **V3**, **V4** and **V6**. This action disconnects the differential pressure transducer **IC18** (via **V1** and **V2**) and the absolute pressure transducer **IC29** (via **V2**) from the patient airway, shunts the differential pressure sensor ports (**V4**) and opens all pressure transducer ports to atmosphere through **V3**. Valve **V6** switches the pump output from the external *NICO*® Valve to the internal patient tubing and flow sensor. The differential pressure transducer is "zeroed" by capturing the digital output of the 20-bit sigma delta A/D Converter, **IC25**, during this zero flow condition, and using this value to set the software. The patient airway pressure transducer is "zeroed" by adjusting the output of the DAC, **IC26**, until the Airway Pressure signal into the ADC, **IC4**, reads mid-scale. The barometric (ambient) pressure, as sensed by **IC28**, is recorded after the airway pressure zero is completed. IC30 acts to filter the signals from the barometric pressure and airway pressure channels. After the result from each channel is stored in SRAM to be used as an offset in the flow and pressure calculations, valves **V1**, **V2**, **V3**, **V4** and **V6** are then de-energized, reconnecting the pressure transducers with the patient airway.

If patient line purging is enabled by the software, the system turns on the pump by bringing the PURGE line high after the zero values are recorded. A slight pressure is allowed to build in the pump tubing line that will aid in flushing out the patient airway tubing. To purge patient line 1, the CPU brings the VALVE1 and VALVE4 signals high, energizing Valves **V1** and **V4**. **V1** connects the pump with the P1 patient line, flushing out the patient P1 line while **V4** shunts across the differential pressure transducer, preventing a differential pressure from appearing across the transducer. During purging, the system is able to monitor the pressure that is present in the selected patient line by reading the AWPRESS signal. VALVE1 is brought low and **V1** is de-energized, once again isolating the pump from the patient airway and allowing a pressure head to build once more. The VALVE2 line is then brought high and valve **V2** is then energized, flushing out the patient P2 line. After all lines have been flushed out, **V1** and **V3** are re-energized allowing any residual pressure to be vented to atmosphere. All valves are then de-engerized and the PURGE signal is brought low, turning the pump off. The purging process is complete and normal patient monitoring continues.

A hardware watchdog, consisting of **IC44A** and the surrounding circuitry, limits the maximum pump-on time, preventing overpressure from building in the patient lines.

2.5.5 *Flow Circuitry*

Refer to sheet 3 of the 2765-03 schematic.

Differential Pressure Transducer, **IC18**, is a silicon based, piezoresistive bridge with four active elements. When a pressure is applied between transducer ports P1 and P2, a differential output voltage proportional to the applied pressure is produced. The full-scale output range for the transducer is 0 to 10 inches of water (P1>P2). By setting the 0 differential pressure (no-flow) point to mid-scale (during the zeroing process described earlier), negative pressure readings (P2>P1) are also available. The

transducer is temperature compensated at 25 degrees Celsius and designed to be driven by a constant voltage source.

In the normal system operating mode, all valves are de-engerized and the pump is inactive. Transducer ports P1 and P2 are connected to the patient airway. As air flows through the airway adapter pneumotach, a pressure difference between P1 and P2 is created. This signal is dependent on both the magnitude and the direction of the airflow. The greater the flow volume, the larger the pressure difference created between the two transducer ports. The transducer senses an inspired flow as a positive pressure difference (P1>P2), while an expiratory flow is seen as a negative pressure (P2>P1). With a supply voltage of 2.5V, the sensor transforms this pressure difference into an electrical signal with a nominal absolute magnitude of 23 mV Full-scale Output. This signal is conditioned and amplified by **IC23**, which is a monolithic Instrumentation Amplifier (IA). A positive pressure difference (inspiratory flow) creates a signal above the no-flow zero baseline obtained during the zeroing process. A negative pressure difference (expiratory flow) is below the set baseline. The nominal gain of **IC23** is set by fixed resistors **R85, R83** and variable resistor **VR1**. The output for the transducer is adjusted using **VR1** and a known pressure input as a calibration reference. With an input differential pressure of 20 cmH_2O, the gain of the amplifier is set to give an ADC count of 412160.

The signal out of the flow IA is taken through a two-pole low pass filter **IC22A** with a 31 Hz cutoff frequency to remove unwanted high frequency electronic noise. It is then passed on to the 20-bit sigma delta ADC, where it is transformed from an analog voltage into a digital code for processing by the CPU, located on the 2783-01 Digital Board.

2.5.6 *Barometric and Airway Pressure*

Refer to sheet 3 of the 2765-03 schematic.

IC29 is a piezoresistive differential pressure transducer with port P2 held at zero psi. It measures the absolute pressure difference at port P1 relative to the vacuum at port P2. The transducer is calibrated for a full scale output of 0 to 15 psi, has internal temperature compensation and is designed to be driven by a constant voltage source. Instrumentation amplifier (IA) **IC28** conditions this signal to correspond to the current barometric pressure, which is set by adjusting **VR3**. The nominal gain of this amplifier is 67, which corresponds to a 12-bit ADC count of 4012 at 760 mmHg. The output signal from **IC28** is low pass filtered by **IC30B** and appears as an input to both the 12-bit ADC and a second IA, **IC27**. **IC27** provides gain adjustment via **VR2** and offsets the output signal from the barometric amplifier to mid-scale during the zeroing state. The nominal gain of the airway pressure amplifier is 5. This signal connects to the P1 (proximal to the patient) side of the differential pressure transducer during monitoring and provides patient airway pressure sensing.

2.5.7 *Patient Airway Adapter Type Sensing*

Refer to sheet 5 of the 2765-03 schematic.

Given a specific flow sensor type (i.e., Adult), the physical characteristics of the sensor will be consistent from one adapter to another. However, due to the differences in the physical size and geometry of the various flow sensor types, each type (i.e., Adult, Adult Combo) requires different coefficients be used in the calculation of flow. Each flow sensor type has a unique 4-bit code associated with it. This pattern molded into the connector body can be optically reflective or non-reflective and is read by the system. A pulse is generated by the CPU that turns on the LED component of an opto-coupler mounted directly beneath each pattern segment. If the pattern segment associated with

that opto-coupler is reflective, the LED's light will cause its photodetector mate to be turned on, which generates a signal that is sensed by the system and relayed back to the CPU. If the segment is non-reflective, no signal is returned to the sensing circuitry. A four-bit code can generate 16 unique pattern combinations. One code condition, all zeros (no reflection), is reserved for detecting when the sensor unplugged. The circuitry to decode the flow sensor type consists chiefly of connector J5 and comparator IC40.

2.5.8 *NICO® Sensor Rebreathing Valve Control*

Refer to sheets 3 and 5 on 2765-03 schematic.

To initiate a *NICO®* cycle and switch the external *NICO®* Valve from non-rebreathing to rebreathing mode, valve **V5** is energized, which switches the tubing to the external valve from atmosphere to the pump. The pump is turned on, causing the diaphragm in the *NICO®* valve to switch to rebreathing mode. The pressure in the airline is monitored by pressure transducer **IC32** and IA **IC31**. When adequate pressure to switch the valve is reached, the pump turns off and the software continues to monitor the airline pressure to ensure pressure is maintained. Valve **V6** has a time-out watchdog, **IC44B**, to ensure that software control over the external *NICO®* valve is maintained.

2.5.9 *Saturation Input Signal Path and Signal Conversion*

Refer to sheet 4 of the 2765-03 schematic.

On power up, the system performs a self-calibration cycle to establish the level of background circuit offset. Calibration is performed by coordinating the control signals SPO2CAL, SPO2SC1, ASAMPL, RSAMPL, ISAMPL, SIGNDL and INSIGL. Once the system baseline has been acquired, the Red and Infrared ADCs, **IC33** and **IC37**, adjust their output to compensate for any system offsets found. Since the LED drives are staggered, a single detector is used to multiplex the individual signals on a common signal input line. Amplifier **IC36B** performs a current to voltage conversion on the input signal, and analog switch **IC35** steers the signal to the proper 20-bit ADC based upon the LED channel (Red or Infrared) that is currently active. A sample and hold circuit for each channel made up of **IC35** and **IC34** transform the pulsed input signal into a constant voltage level for signal conversion. The main timing signal generation for saturation signal acquisition is generated by the TPU. Amplifier **IC38A** generates an analog signal, SPO2PROB, that varies with the saturation probe type. SPO2PROB is converted to digital form by ADC **IC9** on the *$NICO_2$®* 2783-01 Digital Board Schematic.

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3 Functional/Accuracy Testing

The functional/accuracy testing verifies overall functional integrity and performance accuracy of the monitor and sensors. If the Model 7600 does not pass these tests, remove from use and contact Respironics for repair/replacement assistance.

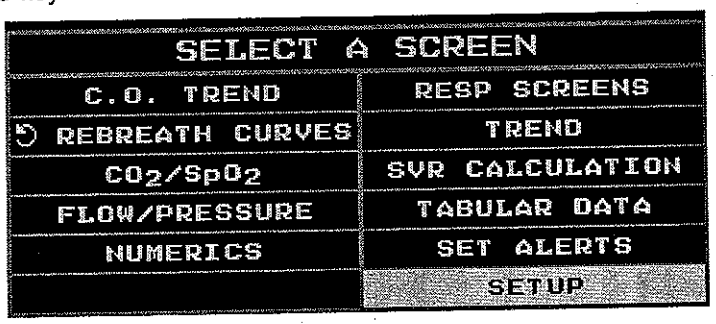
This procedure assumes the technician performs each step as indicated - leaving the monitor in a known state prior to performing the next step. If steps are omitted or performed out of order, be sure that the monitor is set to the correct state before continuing.

3.1 Disabling the NICO-Esprit Interface

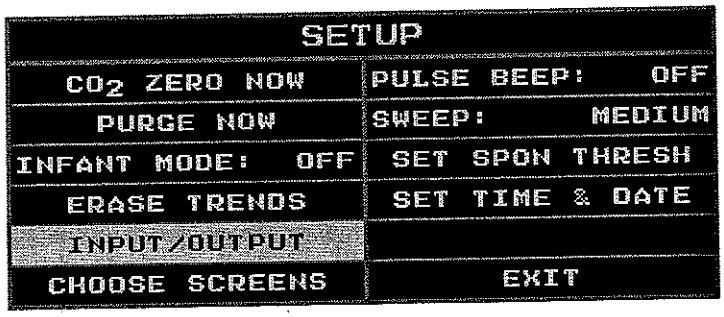
⚠ Prior to starting these tests, verify that the Esprit Interface is not enabled. If the Esprit interface is enabled the Respiratory Rate (RR) and Tidal Volumes (Vti and Vte) will not be displayed on the $NICO_2$ monitor

⚠ Resetting the monitor to the factory defaults does not clear the Esprit Interface setting.

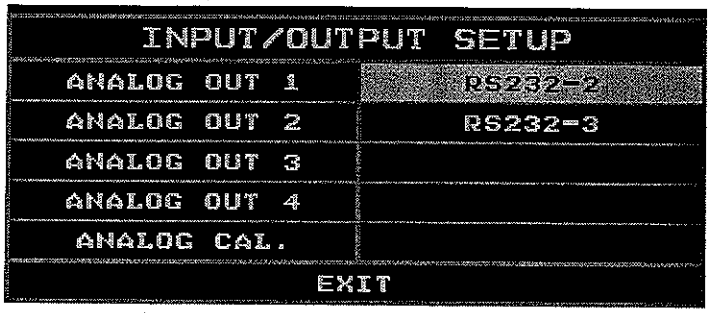
1. Press the MENU key to activate the SELECT A SCREEN menu.



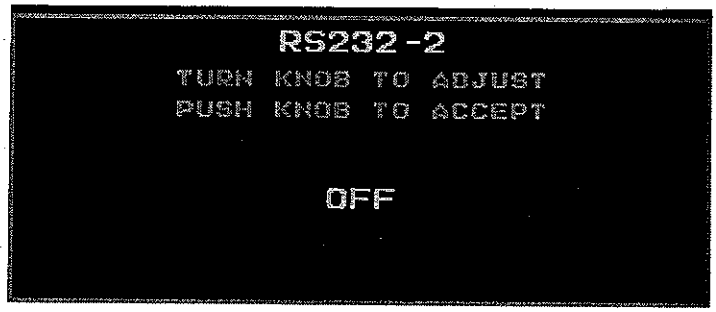
2. Turn the knob to highlight SETUP and then press the knob. The SETUP screen appears



3. Turn the knob to highlight INPUT/OUTPUT and then press the knob. The INPUT/OUTPUT screen appears.



4. Turn the knob to highlight RS232-2 and then press the knob. The RS232-2 screen appears.



5. Turn the knob to highlight OFF and then press the knob. The INPUT/OUTPUT screen appears. Press the MENU key then press the knob to return to the monitoring screen.

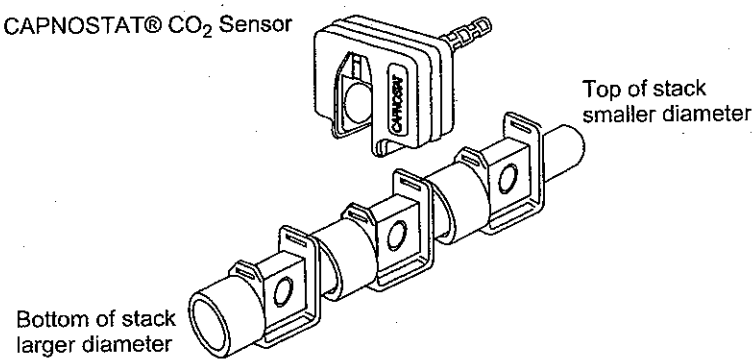
3.2 Equipment Required

1. CAPNOSTAT® CO_2 Sensor, PN: 9567-00 or PN: 9567-37
2. Adult CO2/Flow Sensor, PN: 9767-00
3. Leak Tester, TM Electronics MDT-50 or Leak test adapter, PN: 1038980
4. NICO Leak Test Adapter, PN: 9633-48 (for use with MDT-50)
5. 500ml Calibration syringe, Hans Rudolph Model 5550 or equivalent
6. Model 1298 Gas Calibrator, PN: 6081-00
7. Low point calibration gas, PN: 8364 or 8964-00
8. Adult airway adapter PN: 7007-01 or equivalent Qty. 3
9. Barometer (basic accuracy of ±0.2 mmHg or better)
10. TB500B Saturation simulator, PN: 5530-00
11. Patient Leakage Test Fixture, PN: 1038004
12. Digital Safety Analyzer, Model LT554D-20 or equivalent

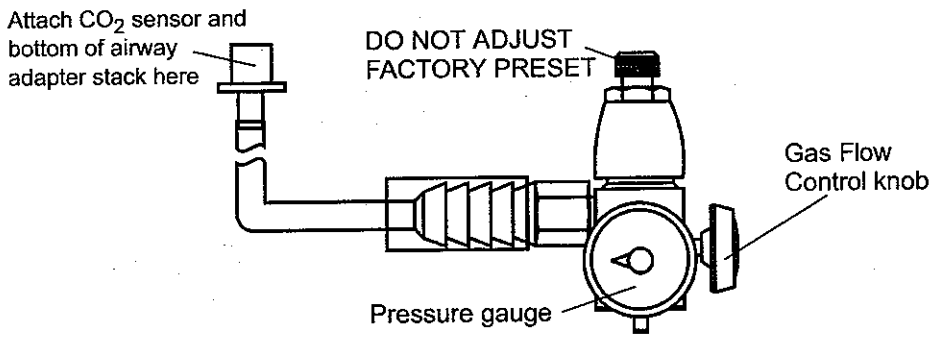
3.3 Functional/Accuracy Test

In this procedure the term "select" refers to highlighting a selection on the screen by turning the knob, then pressing it in to select the highlighted option.

1. Connect the monitor to the AC line. Set the rear panel power entry module switch ON. Verify the AC LED turns on.
2. Press the OPERATE/STANDBY button. Verify the display shows the $NICO_2$® start up routine followed by the main display screen (reference the Users Manual for display appearance). Verify no MONITOR INOPERABLE messages are displayed.
3. Connect the CAPNOSTAT CO_2 sensor to the monitor. Verify the WARMUP message is displayed.
4. Create a stack (attach end to end) of three Adult Airway Adapters P/N 7007-01.
5. Place the CAPNOSTAT CO_2 sensor on the middle airway adapter (observe polarity).



6. Press the MENU button. Select the SETUP screen.
7. Select CO_2 ZERO NOW. Follow the screen prompts to perform an airway zero. When the zeroing is complete, select EXIT.
   NOTE: The CAPNOSTAT CO_2 sensor must reach operating temperature before zeroing.
8. Connect the low point calibration gas to the Model 1298 Gas Calibrator. Before attaching gas, check the Gas Flow Control knob and ensure that it is turned fully clockwise (off position).
9. Attach the low point calibration gas to the Gas Cylinder Regulator connection by screwing on in a clockwise direction. Ensure a tight fit, but do not over tighten. Check the Pressure Gauge to ensure there is sufficient pressure in the cylinder.



10. Press and hold the MENU and DATA ENTRY keys simultaneously until the CONFIGURATION MENU appears. Select DIAGNOSTIC SCREENS, then select CO2.
11. Connect the output of the Gas Cylinder Regulator to the bottom of the airway adapter stack, ensure that the stack is held in a vertical position with the gas entry point at the bottom of the stack.
12. Refer to 'Determining CO2 Value' on page 30 to determine nominal CO_2 value.
13. Turn the Gas Flow Control knob fully counter clockwise to start gas flow. Flow gas for thirty seconds. Verify the displayed CO_2 value is ±2mmHg of the expected nominal CO_2 value determined from the previous step.
14. Turn the calibration gas off by turning the Gas Flow Control knob fully clockwise. Remove the Model 1298 Gas Calibrator and remove residual gas from the airway adapter stack.
15. Verify the following displayed parameters in the CO_2 Diagnostic Screen:

DATA CHAN	3400 ± 200
REF CHAN	3400 ± 200
SRC CUR	180 - 300
DET T	45.00 ± 0.2
CASE T	45.00 ± 0.2

EXIT the diagnostic screen.

16. Select CO_2/SpO_2.
17. Breathe into the airway adapter stack, verify both $ETCO_2$ and RR values are displayed and reasonable.
18. Stop breathing into the airway adapter stack. Wait for 20 seconds, verify that an alert is generated and NO RESP: X:XX is displayed where X:XX starts at 0:20 and counts up in seconds.
    *The NO RESP timer must be set for 20 seconds.
19. Unplug the CAPNOSTAT CO_2 sensor from the front of the $NICO_2$ monitor.
    Press the SILENCE key to acknowledge the disconnect alert if present.

3.4 SpO_2 Testing

20. Press and hold the MENU and DATA ENTRY keys simultaneously until the CONFIGURATION MENU appears. Select DIAGNOSTIC SCREENS, then select SPO_2 from the DIAGNOSTIC SCREEN.
21. Verify the STATUS: is "9 Probe Disconnect".
22. Set the controls on the TB500B as follows:
    SENSOR TYPE: 87XX
    SIGNAL ATTENUATION:3
    SATURATION SETTING:100
    POWER:ON
23. Connect the TB500B to the monitor.
24. Set the saturation switch on the TB500B to "0". Verify the status is "2 LOW SIGNAL".

25. Set the saturation switch on the TB500B to "100". Verify the status returns to "1 NO ERROR".
26. Turn the TB500B OFF. Verify the status line reads "3 LOW LIGHT".
27. Turn the TB500B ON. Verify the status returns to "1 NO ERROR".
28. Press and hold the RED open test button on the TB500B. Verify the status is "12 LED FAIL".
29. Release the RED open test button. Verify the status returns to "1 NO ERROR". Press and hold the INFRARED open test button on the TB500B. Verify the status is "12 LED FAIL".
30. Release the INFRARED open test button. Verify the status returns to "1 NO ERROR".
31. EXIT the diagnostic screen.
32. Select CO_2/SpO_2 in the SELECT A SCREEN menu.
33. Verify the SpO_2 (Saturation) and ♥ (Pulse) values for the following TB500B Saturation settings. Verify the pleth waveform is consistent and free of noise.

Test Box Switch Settings

Saturation Setting	Signal Attenuation	Saturation Tolerance Range
100	3	98 - 100
82	3	80 - 84
62	7	58 - 66
72	7	70 - 74
92	7	90 - 94

Verify Pulse rate is 60 ± 1 for all settings

34. Press the MENU key. Select SET ALERTS.
35. Select the low pulse ♥ (bpm) alert.
36. Record the current value of the low pulse limit. Follow the screen instructions and set the low pulse limit to 99. Verify that the bell icon is active (does not have a line through it). If not select it to enable audible alerts.
37. Select the AUDIO. Follow the screen instructions and scroll through the audio levels. Verify the audio increments with each audio level. Set the audio level to 5.
38. EXIT the SET ALERTS screen. The monitor displays the CO_2/SPO_2 screen.
39. Verify an SpO_2, pulse rate and pleth waveform are present. Verify the pulse value is blinking, LOW PULSE message is displayed, and an audio alert is heard.
40. Press the SILENCE button. Verify the audio alert is silenced and the SILENCE button is flashing between yellow and red.
41. Disconnect the TB500B from the unit and turn it OFF. Press the SILENCE key to acknowledge the disconnect alert.
42. Press the MENU key. Select SET ALERTS. Select the low pulse ♥ (bpm) alert. Verify the ENTER LOW PULSE LIMIT screen is displayed. Follow the screen instructions and set the low pulse limit to the value recorded in step 36.

3.5 Flow Testing

43. Turn the knob until the CO_2/SpO_2 screen is displayed.
44. Plug the Adult CO_2/Flow sensor into the front panel connector. Connect the 500ml calibration syringe to the ventilator port of the Adult CO_2/Flow sensor.
    NOTE: The ventilator port of the Adult CO_2/Flow sensor is the port closest to the clear tubing.
45. Pump the calibration syringe back and forth with a steady motion at a rate of 20 cycles per minute. Verify the Vte and Vti are 500 ± 25 mL.
46. Disconnect the 500ml calibration syringe from the Adult CO_2/Flow sensor.
47. Disconnect the Adult CO_2/Flow sensor from the monitor. Press the SILENCE key to acknowledge the disconnect alert if present.
48. Press and hold the MENU and DATA ENTRY keys simultaneously until the CONFIGURATION MENU appears. Select DIAGNOSTIC SCREENS, then select FLOW.
49. To perform the Leak Test using the 1038980 $NICO_2$ Leak Test Adapter, do the following steps.
    To use the MDT 50, follow step 50.
    - 49.a Set the stop cock open.
    - 49.b Pull the syringe back.
    - 49.c Connect the 1038980 $NICO_2$ Leak Test Adapter to the unit.
    - 49.d Push in the syringe until the airway pressure (Paw) reads 100 cmH_2O.
    - 49.e Close the stop cock.
    - 49.f Verify the airway pressure (Paw) remains above 90 cmH_2O after 30 seconds.
    - 49.g Disconnect the 1038980 $NICO_2$ Leak Test Adapter from the unit. Press the SILENCE key to acknowledge the disconnect alert if present.
50. To perform the Leak Test using the MDT 50 Leak Tester, do the following steps. To use the 9695-48 Leak Test Adapter, follow step 49.
    - 50.a Set up the MDT 50 Leak Tester. Connect an external air source (clean filtered air between 50 - 70 psi). Power up the MDT 50 Leak Tester and allow Self-Test to complete.
    - 50.b Adjust MDT 50 Leak Tester's pressure knob for a displayed pressure of 3.50 psi. Set the MDT 50 Leak Tester's operating parameters as follows:

MDT 50 Parameters	Setting
Charge Timer	2 seconds
Settle Timer	2 seconds
Test Timer	5 seconds
Fine Leak Flag	0.20 inH2O
Gross Leak Flag	2.00 inH2O

    - 50.c Press the "Start" button on the MDT 50 Leak Tester.

50.d Connect the quick disconnect connector on the 9633-48 NICO Leak Test Adapter to the MDT 50 Leak Tester. Connect the flow connector end of the NICO Leak Test Adapter to the unit.

50.e Press the "Start" button on the MDT 50 Leak Tester. Verify the MDT 50 displays "Pass" when the leak test completes.

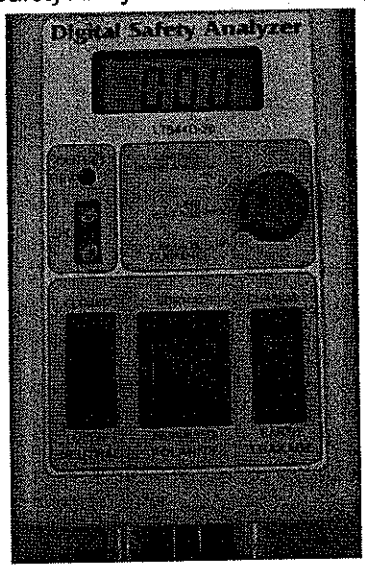
50.f Disconnect the 9633-48 NICO Leak Test Adapter from the unit. Press the SILENCE key to acknowledge the disconnect alert if present.

3.6 Time/Date Setting

51. Press the MENU key. Select the SETUP screen.
52. Select SET TIME & DATE item. Follow the instructions and set the correct time and date. Exit the SET TIME & DATE screen then exit the setup screen.
53. Set the power entry module switch on the rear panel to the O (OFF) position. Verify the green AC indicator turns off, a battery icon is displayed and the monitor continues to operate on battery power. Set the power entry module switch back to | (ON).
54. Turn the monitor off.

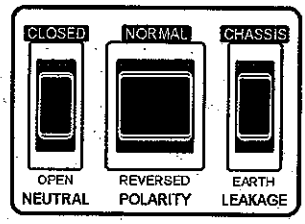
3.7 Safety Testing

55. Verify there is no loose hardware inside the $NICO_2$.
56. Plug the Safety Analyzer into AC power. Connect the black coil cord to the CHASSIS connector on the Safety Analyzer. Switch the Safety Analyzer to LEAKAGE CURRENT.

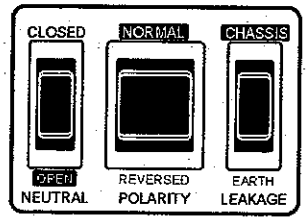


57. Connect the Safety Analyzer's CHASSIS connection (black coil cord) to the Equipotential Post ⏚ on the rear panel of the $NICO_2$.
58. Plug the AC power cord from the $NICO_2$ into the receptacle of the Safety Analyzer. Turn the $NICO_2$ AC mains to ON (|). Ensure the $NICO_2$ is not turned on.

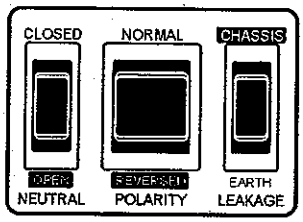
59. Set NEUTRAL to CLOSED and POLARITY to NORMAL. Rock the LEAKAGE to the CHASSIS position and verify the leakage current for Unit Grounded is < 50 uA.



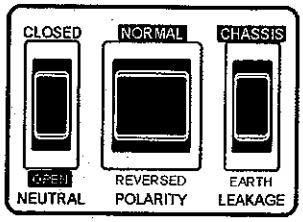
60. Set NEUTRAL to OPEN and POLARITY to NORMAL. Rock the LEAKAGE to the CHASSIS position and verify the leakage current for Unit Ungrounded is < 50 uA.



61. Set NEUTRAL to OPEN and POLARITY to REVERSED. Rock the LEAKAGE to the CHASSIS position and verify the leakage current for Unit Ungrounded Reverse Polarity is < 50 uA.



62. Plug the Patient Leakage Test Fixture (P/N:1038004) into the SpO_2 input connector of the $NICO_2$. Plug the other end of the fixture into the A/C outlet.
63. Set NEUTRAL to OPEN and POLARITY to NORMAL. Rock and hold the LEAKAGE to the CHASSIS position and depress the button on the fixture (P/N:1038004). Verify the leakage current reading for Shorted Sensor to AC MAINS (Unit grounded) is < 50 uA.



64. Unplug the test fixture and Safety Analyzer from AC power. Disconnect all cables from the $NICO_2$. This completes the test.

3.8 Determining CO_2 Value

Use the attached tables to determine the nominal CO_2 value for the calibration gas in use. The gas temperature and the barometric pressure affect the nominal torr value.

1. Get the current barometric pressure from a barometer.
2. Get the current gas temperature (room temperature is adequate provided the gas has had time to acclimate).
3. Find the nominal torr value by locating the current barometric pressure in the first column then go across until the correct temperature column intersects. The corresponding number is the nominal torr value. The "TB1265" column is the column used if a TB1265 Sensor Simulator, PN: 5776-00 is used in place of gas.
4. Use the nominal torr value as the base number when performing CO_2 gas measurements. The tolerance for the CO_2 gas value is the base number ± 2 for 5% gas.
   - Monitor O_2 compensation setting % = 40
   - Test gas O_2 concentration percentage = 0
   - Low point Calibration Gas CO_2 concentration percentage = 5%

Baro. Press. mmHg	Gas Temperature (°C)							
	21	22	23	24	25	26	27	TB1265
735	39.4	39.3	39.2	39.1	39.0	38.8	38.7	42
736	39.5	39.4	39.3	39.1	39.0	38.9	38.8	42
737	39.5	39.4	39.3	39.2	39.1	38.9	38.8	42
738	39.6	39.5	39.4	39.2	39.1	39.0	38.9	42
739	39.7	39.5	39.4	39.3	39.2	39.0	38.9	42
740	39.7	39.6	39.5	39.3	39.2	39.1	39.0	42
741	39.8	39.6	39.5	39.4	39.3	39.2	39.0	42
742	39.8	39.7	39.6	39.4	39.3	39.2	39.1	42
743	39.9	39.7	39.6	39.5	39.4	39.3	39.1	42
744	39.9	39.8	39.7	39.6	39.4	39.3	39.2	42
745	40.0	39.9	39.7	39.6	39.5	39.4	39.2	42
746	40.0	39.9	39.8	39.7	39.5	39.4	39.3	42
747	40.1	40.0	39.8	39.7	39.6	39.5	39.4	42
748	40.1	40.0	39.9	39.8	39.6	39.5	39.4	41
749	40.2	40.1	39.9	39.8	39.7	39.6	39.5	41
750	40.2	40.1	40.0	39.9	39.8	39.6	39.5	41
751	40.3	40.2	40.1	39.9	39.8	39.7	39.6	41
752	40.4	40.2	40.1	40.0	39.9	39.7	39.6	41
753	40.4	40.3	40.2	40.0	39.9	39.8	39.7	41
754	40.5	40.3	40.2	40.1	40.0	39.8	39.7	41
755	40.5	40.4	40.3	40.1	40.0	39.9	39.8	41
756	40.6	40.4	40.3	40.2	40.1	39.9	39.8	41
757	40.6	40.5	40.4	40.2	40.1	40.0	39.9	41
758	40.7	40.5	40.4	40.3	40.2	40.1	39.9	41
759	40.7	40.6	40.5	40.4	40.2	40.1	40.0	41
760	40.8	40.7	40.5	40.4	40.3	40.2	40.0	41
761	40.8	40.7	40.6	40.5	40.3	40.2	40.1	41
762	40.9	40.8	40.6	40.5	40.4	40.3	40.1	41
763	40.9	40.8	40.7	40.6	40.4	40.3	40.2	41

764	41.0	40.9	40.7	40.6	40.5	40.4	40.2	41
765	41.1	40.9	40.8	40.7	40.5	40.4	40.3	41
766	41.1	41.0	40.9	40.7	40.6	40.5	40.4	41
767	41.2	41.0	40.9	40.8	40.7	40.5	40.4	41
768	41.2	41.1	41.0	40.8	40.7	40.6	40.5	41
769	41.3	41.1	41.0	40.9	40.8	40.6	40.5	41
770	41.3	41.2	41.1	40.9	40.8	40.7	40.6	41
771	41.4	41.2	41.1	41.0	40.9	40.7	40.6	41
772	41.4	41.3	41.2	41.0	40.9	40.8	40.7	41
773	41.5	41.4	41.2	41.1	41.0	40.8	40.7	41
774	41.5	41.4	41.3	41.2	41.0	40.9	40.8	41
775	41.6	41.5	41.3	41.2	41.1	41.0	40.8	41
776	41.6	41.5	41.4	41.3	41.1	41.0	40.9	41
777	41.7	41.6	41.4	41.3	41.2	41.1	40.9	40
778	41.7	41.6	41.5	41.4	41.2	41.1	41.0	40
779	41.8	41.7	41.5	41.4	41.3	41.2	41.0	40

If the barometric pressure, gas temperature, monitor compensations, or the O_2 concentration in the test gas differs from the values listed in the table then use the formula below to calculate the nominal torr value.

$$\frac{(CO_2 \text{ Gas } \%) * (\text{Barometric Pressure}) * (\text{Gas Compensation})}{1 - (0.003 * (33 - \text{Gas Temperature}))}$$

If a TB1265 Sensor Simulator, PN: 5776-00 is used the following formula applies:

$(\%CO_2)$ * (760) * (Gas Compensation) * (Pressure Compensation) * (Ambient ratio correction)

The *gas compensation* factor if only O_2 gas is present:

0.000865 * (Monitor O_2 Compensation setting - Gas O_2 Concentration) + 1

The *gas compensation* factor if O_2 and N_2O gas is present:

0.00249133 * (Monitor O_2 Compensation setting - Gas O_2 Concentration) + 1

The *pressure compensation* factor is calculated by linear interpolation into the PBCV table below. Take the current barometric pressure and locate the high and low values from the Pressure column in the table below (e.g. a barometric pressure of 752 would give a *Pressure Max* of 760 and a *Pressure Min* of 720). Calculate the rise over run or slope (m) for the range that the barometric pressure falls under. Determine the difference between the barometric pressure and the lesser pressure value and multiply that by the slope then add one.

The formula for *pressure compensation* is:

PBCV for pressure min + (m * (Barometric Pressure - Pressure Min)) + 1

Where:

$$m = \frac{\text{PBCV for pressure max - PBCV for pressure min}}{\text{(Pressure Max - Pressure Min)}}$$

Pressure Table:

Pressure (mmHg)	PBCV
800	-0.0321
760	0.0000
720	0.0356
680	0.0754
640	0.1202
600	0.1710
560	0.2290
520	0.2959
480	0.3741
440	0.4662
400	0.5770

The TB1265 Sensor Simulator does not simulate the slight CO_2 levels present in the ambient air. Therefore apply the following corrections:

(Ambient Ratio Correction) =1.044211 for 5% CO_2 concentration
1.050789 for 10% CO_2 concentration

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4 Electronic Tests

The Electronic Tests verify the calibration and operation of the electronic circuits within the Model 7600. These tests DO NOT need to be performed on a regular (preventative) basis. Perform these tests only if the monitor fails to operate as expected or fails the Accuracy Tests or the Functional Tests. The Electronic Tests should be performed only by qualified service personnel.

The Electronic Tests require access to the internal components of the monitor. Refer to the Maintenance section for disassembly instructions.

CAUTION: The Model 7600 contains static sensitive devices. Be sure to follow proper grounding procedures when handling the internal components to avoid damage from static discharge.

WARNING: Electrical shock hazard, internal assemblies contain high voltage, refer servicing to qualified service personnel.

This procedure assumes the technician performs each step as indicated - leaving the monitor in a known state prior to performing the next step. If steps are omitted or performed out of order, be sure that the monitor is set to the correct state before continuing.

4.1 Equipment Required

1. TB1265 Sensor Simulator, PN: 5776-00
   The Novametrix TB1265 Sensor Simulator emulates a functioning CAPNOSTAT CO_2 Sensor, and can be used in place of the CAPNOSTAT CO_2 Sensor for monitor test purposes. The TB1265 will verify the functionality of the monitor's CO_2 front end circuitry. Certain error conditions can be simulated to verify responses from the monitor under test.
   The TB1265 is an optional test device and is not mandatory for testing the Model 7600. Its purpose is to increase test efficiency by simulating a working CAPNOSTAT. The TB1265 Sensor Simulator is available from the Service Department.
2. TB1265 Adapter cable, PN: 5776-48 (not required for TB1265 units with a "T" suffix in the serial number)
3. Current limit test jack, PN: 5693-48
4. TB500B Saturation simulator, PN: 5530-00
5. Optical encoder "5" test jack, PN: 9635-48
6. Optical encoder "A" test jack, PN: 9635-14
7. Shorted saturation test jack, PN: 6573-48
8. Battery charger test fixture, PN: 9634-48
9. Oscilloscope

10. Analog loopback test fixture, PN: 9637-48
11. Serial loopback test fixture, PN: 9639-48
12. Digital Volt Meter (DVM)
13. Adult Standard NICO Sensor, PN: 8951-00
14. Pneumatic Calibration Test Fixture, PN: 9820-14

4.2 Definitions/References

2783-01 $NICO_2$® Digital Board (see 2783-03 in Section 13)

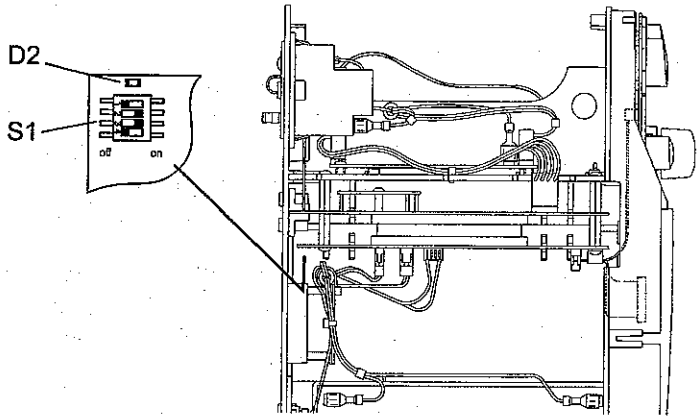
2784-01 $NICO_2$® Power Board (see 2784-03 in Section 13)

2765-01 NICO Analog Board (see 2765-03 in Section 13)

4.3 Power Supply

In this procedure the term "select" refers to highlighting a selection on the screen by turning the knob, then pressing it in to select the highlighted option.

1. Set switches 2 and 3 on S1 on the digital board to the "ON" position to enable Production Test Mode.
2. Connect the monitor to the AC line. Set the rear panel power entry module switch ON. Verify the AC LED turns on.
3. Press the power switch. Verify the display shows the NICO2® start up routine followed by the main display screen. Verify the red LED (D2) on the digital board flashes and "PRODUCTION TEST" is displayed in the message area.



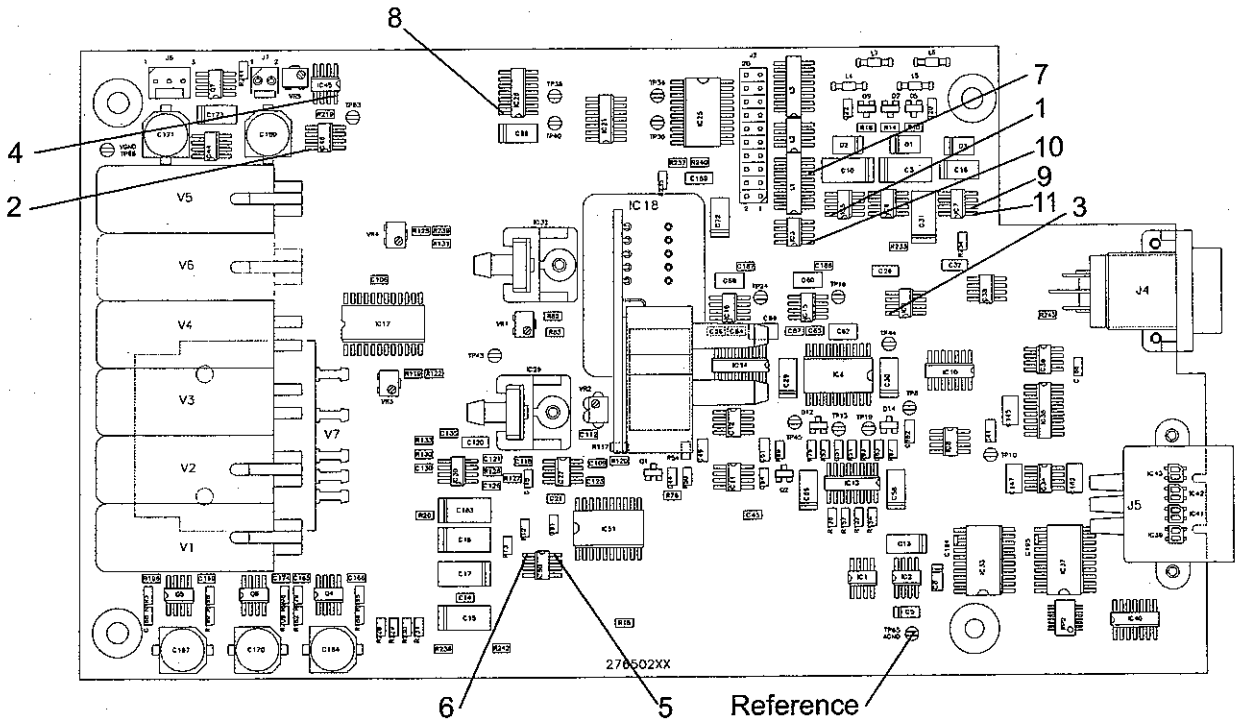
4. Using a DVM, measure the power supply voltage VIN at F5 on the power board (Use TP1 on the digital board for ground reference). Verify 14.2 to 15.00VDC.
5. Disconnect the connectors from the battery terminals. Measure the voltage at D42 (anode). Verify 13.5V ± 600mV.
6. Connect the battery charger test fixture, PN: 9634-48, to J7 on the digital board and set it to the 100Ω position. Measure the voltage at fuse F1 on the digital board. Verify 13.77V ± 500mV. Remove the resistor.
7. Set the battery charger test fixture to the 30Ω position. Verify voltage at D42 (anode) is less than 0.7VDC.

8. Disconnect the test fixture. Reconnect the battery wiring harness to J7 on the digital board. Reconnect the battery wiring harness to the battery terminals, ensuring proper polarity hookup.

4.4 Voltage Checks

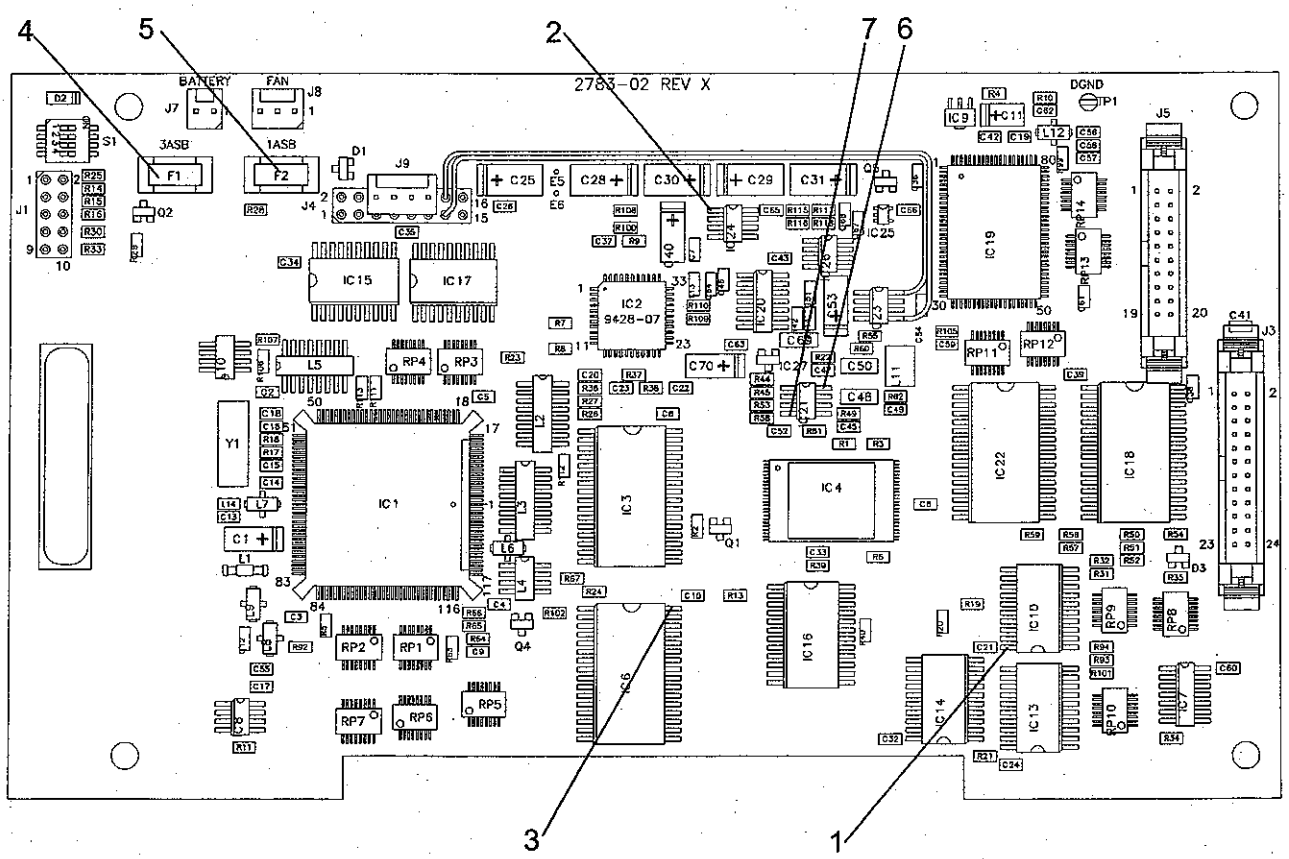
9. Use TP65 on the analog board as ground reference for all measurements unless otherwise specified. Measure the following voltages on the analog board (2765-01) using a DVM:

	Supply Name	Location	Voltage Range
1	VDD	IC5 pin 8	5.00V ± 250mV
2	VVDD	IC46 pin 8	4.750V to 5.750V
3	CVDD	IC9 pin 8	5.00V ± 250mV
4	DISPVA	IC45 pin 8	12.15V ± 500mV
5	AVCCIN	IC50 pin 8	16.00V ± 2.50V
6	AVCC	IC50 pin 1	12.00V ± 600mV
7	VCAPNO	L1 pin 6	12.00V ± 500mV
8	FVDD/FVCC	IC26 pin 14	5.00V ± 250mV
9	-VA	IC7 pin 2	-18.5V to -13.775V
10	-VCAPNO	IC3 pin 1	-12.00V ± 500mV
11	-AVCC	IC7 pin 1	-5.00V ± 250mV



10. Measure the following voltages on the digital board (2783-01) with a DVM, use TP1 as ground reference.

	Supply Name	Location	Voltage Range
1	VDD	IC10 pin 20	5.00V ± 250mV
2	DVDD	IC24 pin 1	5.00V ± 250mV
3	VBACK	IC6 pin 32	4.350V to 5.250V
4	VBATT	F1	13.5V ± 600mV
5	VHTR	F2	12.15V ± 500mV
6	+VA	IC21 pin 8	12.00V ± 600mV
7	-VA	IC21 pin 4	-12.00V ± 600mV



4.5 CO_2 Testing

11. Set the TB1265 switches as follows:
    INSPIRED CO_2: OFF
    %CO_2: 0
    SENSOR LOCATION: A/A
    SOURCE CURRENT: NORMAL
    CO_2 MODE: CONTINUOUS
    TEMPERATURE: NORMAL
12. Connect the TB1265 to the monitor, using the TB1265 adapter cable PN: 5776-48 if necessary.
13. Press the MENU key, then select SETUP.
14. Select CO_2 ZERO NOW. Follow the screen prompts to perform an airway zero. When the zeroing is complete, select EXIT.
    NOTE: The CAPNOSTAT CO_2 sensor simulator must reach operating temperature before zeroing.
15. Set the TB1265 simulator controls as follows:
    CO_2 MODE: RESPIRATION
    %CO_2: 5%
16. Press the MENU button and select the CO_2/SpO_2 screen.
17. Verify an $ETCO_2$ value as determined from Section 3.8, and a RR (respiration rate) of 24 ± 5.
18. Press and hold the MENU and DATA ENTRY keys simultaneously until the CONFIGURATION MENU appears. Select DIAGNOSTIC SCREENS, then select CO_2.
19. Verify DET T and CASE T stabilize at 45.00 ± 0.2.
20. Use TP65 as reference and monitor L5 on the analog board. Set the TB1265 TEMPERATURE to CASE OVERTEMP. Verify the voltage is at < 0.7V and CASE T is >50.00 and DET T remains at 45.00 ± 0.2.
21. Set the TEMPERATURE back to NORMAL. Verify CASE T stabilizes at 45.00 ± 0.2 within 2 minutes.
22. Monitor L4 on the analog board. Set the TB1265 TEMPERATURE to DETECTOR OVERTEMP. Verify the voltage is less than 0.7 volts and DET T is > 50.00 and CASE T remains at 45.00 ± 0.2.
23. Set the TEMPERATURE back to NORMAL. Verify DET T stabilizes at 45.00 ± 0.2 within 2 minutes.
24. Verify the SRC CUR is between 240 and 280.
25. Set the TB1265 SOURCE CURRENT to HIGH. Verify the SRC CUR slowly increases to a value > 340 and the CASE T and DET T are < 42.00.
26. Set the SOURCE CURRENT back to NORMAL. Verify SRC CUR is between 240 and 280 and CASE T and DET T slowly rise and stabilize at 45.00 ± 0.20 within two minutes.
27. Set the TB1265 SOURCE CURRENT to LOW. Verify the SRC CURR slowly decreases to less than 160, and the CASET and DETT are less than 42.00.
28. Set the SOURCE CURRENT back to NORMAL. Verify SRC CUR is between 240 and 280 and CASE T and DET T slowly rise and stabilize at 45.00 ± 0.20 within two minutes.

29. Disconnect the TB1265 from the monitor. Press the SILENCE key to acknowledge the disconnect alert if present.

4.6 SpO_2 Testing

30. Select SpO_2 from the CO_2 DIAGNOSTIC SCREEN.
31. Connect the current limit test jack PN: 5693-48 to the monitor. Verify the LED on the fixture is on.
32. Press the switch on the current limit test jack. Verify the red LED turns off.
33. Remove the current limit test jack.
34. Verify the STATUS is "9 Probe Disconnect".
35. Set the controls on the TB500B as follows:
    SENSOR TYPE: 87XX
    SIGNAL ATTENUATION: 3
    SATURATION SETTING: 100
    POWER: ON
36. Connect the TB500B to the monitor.
37. Set the saturation switch on the TB500B to "0". Verify the status is "2 LOW SIGNAL".
38. Set the saturation switch on the TB500B to "100". Verify the status returns to "1 NO ERROR".
39. Turn the TB500B OFF. Verify the status line reads "3 LOW LIGHT".
40. Turn the TB500B ON. Verify the status returns to "1 NO ERROR".
41. Press and hold the RED open test button on the TB500B. Verify the status is "12 LED FAIL".
42. Release the RED open test button. Verify the status returns to "1 NO ERROR".
43. Press and hold the INFRARED open test button on the TB500B. Verify the status is "12 LED FAIL".
44. Release the INFRARED open test button. Verify the status returns to "1 NO ERROR".
45. EXIT the diagnostic screen.
46. Select CO_2/SpO_2 in the SELECT A SCREEN menu.
47. Verify the Saturation and Pulse values for the following TB500B Saturation settings. Verify the pleth waveform is consistent and free of noise.

Test Box Switch Settings		Saturation
Saturation Setting	Signal Attenuation	Tolerance Range
100	3	98 - 100
82	3	80 - 84
62	7	60 - 64
72	7	70 - 74
92	7	90 - 94

Verify Pulse rate is 60 ± 1 for all settings

48. Disconnect the TB500B from the unit and set POWER: OFF. Press the SILENCE button to acknowledge the disconnect alert.

4.7 Flow, Barometric Pressure and Rebreathe Valve Testing

49. Press and hold the MENU and DATA ENTRY keys simultaneously until the CONFIGURATION MENU appears. Select DIAGNOSTIC SCREENS, then select FLOW.
50. Verify a "(0) UNPLUGGED" is displayed next to SENSOR.
51. Connect the optical encoder "5" test jack, PN: 9635-48, to the flow connector on the $NICO_2$. Verify "(5) NOT USED" is displayed next to SENSOR. Disconnect the test jack.
52. Connect the optical encoder "A" test jack, PN: 9635-14, to the $NICO_2$. Verify "(10) 9766-01 PED. FLOW/CO2" is displayed next to SENSOR.
    Note:If the monitor exits the FLOW DIAGNOSTIC screen when the "A" test jack is connected, re-enter the FLOW DIAGNOSTIC screen.
53. Disconnect the optical encoder "A" test jack and connect the Adult Standard NICO® Sensor to the monitor.
    NOTE: If necessary, follow previous steps to re-enter the FLOW DIAGNOSTIC SCREEN.
54. Select REBREATHE. Verify the pump starts and the PRESS2 rises above 140.
55. Select REBREATHE again, verify the PRESS2 drops to 0.

4.8 Flow Calibration

If the Model 7600 requires calibration, it must be returned to the factory or a specialized Respironics Service Center. Calibration of the Model 7600 requires specialized test equipment that is not commercially available.

Note:All fixtures that are connected to the flow input connector on the $NICO_2$ monitor are to be free of dirt and debris. Using compressed air, clean fixtures prior to connection.

56. Record the current barometric pressure from the calibrated barometer.
57. Adjust VR3 on the $NICO_2$ analog pcb if necessary until the TOT PRESS equals the current barometric pressure.
58. Select ZERO. Verify the BARO PRESS equals the value from the previous step. Readjust VR3 if necessary.
59. Connect the Pneumatic Calibration Test Fixture's serial communications cable to RS232 port 1 on the back of the $NICO_2$ monitor
60. Disconnect the NICO® Sensor. Connect the Triple Line Adapter, PN: 9911-14, from the Pneumatic Calibration Test Fixture output to the flow sensor input connector of the $NICO_2$ monitor.
    Note:If the monitor exits the FLOW DIAGNOSTIC screen when the Triple Line Adapter is connected, re-enter the FLOW DIAGNOSTIC screen.
61. Select "Adjust Pressures" from the Pneumatic Calibration Test Fixture's main screen.
    Note:Or select the manual mode by selecting "Enter Manual Mode" from the Pneumatic Calibration Test Fixture's main screen.

62. Set the Pneumatic Calibration Test Fixture for an output pressure of 10 cmH_2O by selecting the Adjust Differential Pressure (+) option from the Pneumatic Calibration Test Fixture's "Adjust Pressures" screen.
63. Adjust VR1 on the NICO Analog PCB for a 20b ADC value of 206080 counts ± 320 counts.
    Note:If using the manual mode on the Pneumatic Calibration Test Fixture, set the Unit 0 pressure to 10 cmH_2O, connected to: UUT to Unit 0, and the output to left port.
64. Using the encoder switch, select ZERO to perform a flow zero.
65. At the conclusion of the flow zero, verify the 20b ADC value remains 206080 counts ± 320 counts.
    Note:The source pressure must stabilize to its initial value before verifying the 20b ADC reading.
66. Select the Adjust Differential Pressure (-) option from the Pneumatic Calibration Test Fixture's "Adjust Pressures" screen.
    Note:If using the manual mode on the Pneumatic Calibration Test Fixture, set the Unit 0 pressure to 10 cmH_2O, connected to: UUT to Unit 0, and the output to right port.
67. Using the knob, select ZERO to perform a flow zero.
68. At the conclusion of the flow zero, verify the 20B ADC value is -206080 counts ± 1280 counts.
    Note:The source pressure must stabilize to its initial value before verifying the 20b ADC reading.
69. Select the Adjust Airway Pressure option from the Pneumatic Calibration Test Fixture's "Adjust Pressures" screen. Adjust VR2 on the $NICO_2$ analog pcb for a Paw of 80.0 cmH_2O ± 0.1 cmH2O.
    Note:If using the manual mode on the Pneumatic Calibration Test Fixture, set the unit 1 pressure to 80 cmH2O, connected to: UUT to Unit 1, and the output port to common mode.
70. Using the encoder switch, select ZERO to perform a flow zero.
71. At the conclusion of the flow zero, verify the Paw value remains 80.0 cmH_2O ± 0.1 cmH_2O.
    Note:The source pressure must stabilize to its initial value before verifying the Paw reading.
72. Place a tubing clamp on the NO port of V5 on the $NICO_2$ analog pcb.
73. Select the Adjust NICO Valve Pressure option from the Pneumatic Calibration Test Fixture's "Adjust Pressures" screen. Adjust VR4 on the $NICO_2$ analog pcb for a PRESS2 value of 120.0 cmH_2O ± 1.0 cmH_2O. Record the result on the data sheet.
    Note:If using the manual mode on the Pneumatic Calibration Test Fixture: set the unit 1 pressure to 120 cmH_2O, connected to: UUT to Unit 1, and the output port to NICO port.
74. Check the NICO port tubing for leaks by using another tubing clamp to clamp off the tubing that connects the Pneumatic Calibration Test Fixture to the NICO port on the flow input connector. Verify the PRESS2 value remains 120 cmH2O ± 10.0 cmH2O.
75. Remove the clamps.
76. Click on the "Exit" option in the Pneumatic Calibration Test Fixture's "Adjust Pressures" screen. The Pneumatic Calibration Test Fixture's main screen is displayed.

4.9 Tubing Balancing

Note:All fixtures that are connected to the flow input connector of the $NICO_2$ are to be free of dirt and debris. Using compressed air, clean fixtures prior to connection.

77. Connect the NICO Balance Test Adapter, PN: 9905-14, from the Pneumatic Calibration Test Fixture's output to the flow sensor input connector of the $NICO_2$ monitor.
78. Select the FLOW/PRESSURE option in the SELECT A SCREEN menu.
79. Select the "Adjust Balance Tubing" option from the Pneumatic Calibration Test Fixture's main screen. Verify the pneumatic calibration test fixtures status display shows "Pass".
80. Adjust the balance tubing length by clamping it until the pneumatic calibration test fixture's status display shows Pass.
81. Cut the balance tube excess off and remove the clamp.
82. Click on the "Exit" option in the Pneumatic Calibration Test Fixture's "Adjust Balance Tubing" screen. The Pneumatic Calibration Test Fixture's main screen is displayed.
83. Disconnect the NICO Balance Test Adapter and serial communications cable from the $NICO_2$ monitor. Press the SILENCE key to acknowledge the disconnect alert if present.

4.10 Serial / Analog Testing

84. From the DIAGNOSTIC SCREENS select SYSTEM, verify the Analog Connected status is "NO".
85. Connect the analog I/O loopback test fixture, PN: 9637-48, to the rear panel ANALOG connector. Verify the Analog Connected status is "Yes".
86. Select ANALOG from the SYSTEM DIAGNOSTIC SCREEN. Press the knob to cycle through the different Output values listed, verify the Input values for each analog channel 1 - 4:

Output	Input
0	0 + 5
128	64 ± 5
255	128 ± 5

87. Connect the serial loopback test fixture, PN: 9639-48 to the RS232 "1" connector. Set S1 on the fixture to the "1" position. Select SERIAL 1, press the knob, and verify TESTING-Ch1 appears followed by PASS-Ch1.
88. Connect the serial loopback test fixture, PN: 9639-48 to the RS232 "2" connector. Set S1 on the fixture to the "O" position. Select SERIAL 2, verify FAIL TMO-Ch2 is displayed. Set S1 on the fixture to the "1" position. Select SERIAL 2, press the knob, and verify TESTING-Ch2 appears followed by PASS-Ch2.
89. Connect the serial loopback test fixture, PN: 9639-48 to the RS232 "3" connector. Set S1 on the fixture to the "1" position. Select SERIAL 3, press the knob, and verify TESTING-Ch3 appears followed by PASS-Ch3.
90. Select EXIT to leave the DIAGNOSTIC SCREENS.

91. Set switches 2 and 3 on S1 on the digital board to the "OFF" position. Verify the red LED (D2) stops flashing.
92. Turn the monitor OFF and disconnect all test fixtures.

5 Alert Limit Functional Testing

This section details testing to verify the functionality of the alert limits and the visual and audio alarms on the $NICO_2$ monitor. This section uses a CAPNOSTAT® CO2 Sensor for CO_2 parameters, a test box to simulate SpO_2 parameters, and the monitor's DEMO MODE to simulate Cardiac Output and VCO_2 parameters. Similar testing may be performed with an SpO_2 Finger/Y-Sensor (simulating LOW SpO_2 is difficult considering normal SpO_2 values are greater than 96% and the highest setting for LOW SpO_2 limit alert is 95).

5.1 Equipment Required

- CAPNOSTAT CO_2 Sensor, PN: 9567-00 or 9567-37
- Adult CO_2/Flow Sensor, PN: 9767-01 or Adult Airway Adapter, PN: 7007-01
- TB500B SpO_2 Test Box (P/N: 5530-00), or equivalent test box

5.2 Setup

NOTE: The following steps are intended to be performed in order. Verify all pre-requisite steps have been performed if not performing each section.

NOTE: Turn and press the knob to select MENU options and adjust parameters.

NOTE: To select the SET ALERTS screen, press the MENU key and select the SET ALERTS menu option.

NOTE: The $NICO_2$ monitor features tiered, prioritized alarms. Higher priority alerts override lower priority ones. Audio Alert patterns are as follows:

High Priority = Three beeps every five seconds

Medium Priority = Two beeps every ten seconds

Low Priority = One beep every fifteen seconds

1. Power on the $NICO_2$ monitor. As part of the power-on procedure, an audio and key indicator test will be performed. Verify that there are two beeps on power-up, and that all indicators in the front-panel keys illuminate.
2. Set the $ETCO_2$ averaging mode ($ETCO_2$ AVG) to 10 sec using the CONFIGURATION SCREEN (press and hold the MENU and DATA ENTRY keys). Exit the screen.

NOTE: For this test, all CO_2 values are given in mmHg. The test itself does not require mmHg to be the current CO_2 units setting; make appropriate unit conversions for % or KPa. If the current barometric pressure is 600 mmHg or lower, adjust the limits in the $ETCO_2$ Limits section appropriately.

3. Connect the CAPNOSTAT CO_2 Sensor, PN: 9567-00 or 9567-37 to the $NICO_2$ monitor. Connect the CAPNOSTAT CO_2 Sensor to the adult airway adapter, or adult CO_2/Flow sensor.
4. The message CO_2 SENSOR? will be replaced by WARMUP. Wait for the temperature to stabilize.
5. If the CO_2 ZERO REQUIRED or CHECK/CHANGE AIRWAY ADAPTER messages are displayed, zero the CAPNOSTAT CO_2 Sensor (MENU -> SETUP -> CO_2 ZERO NOW).
6. Press the MENU button and select the CO_2/SpO_2 WAVEFORM screen.
7. Breathe through the airway adapter. Verify reasonable $ETCO_2$ and RR values are displayed.
8. Connect the TB500B SpO_2 Test Box to the $NICO_2$ monitor and set the following settings:
   SENSOR TYPE: 87XX
   ATTENUATION: 3
   SpO_2: 92
9. Verify SpO_2 and Pulse Rate values are displayed.
10. Enter the SET ALERTS screen. Select AUDIO and set the audio volume to an appropriate level such that the alarms can be heard over the background noise. Press the knob after adjusting to accept the volume level.

5.3 $ETCO_2$ Limits

11. Continue breathing through the CAPNOSTAT CO_2 Sensor and airway adapter.
12. Enter the SET ALERTS screen and set the following:

	LOW	HIGH
$ETCO_2$	OFF	20

NOTE: Adjust the HIGH limit such that it is at least 10mmHg less than the current $ETCO_2$ value.

13. The current $ETCO_2$ value is greater than the HIGH alert limit. Verify the following:
    - The HIGH limit value begins to flash.
    - After a delay of 10 seconds (of the value exceeding the alert limit), a High Priority Audio Alarm will sound.
    - The message HIGH $ETCO_2$ is displayed.
    - The SILENCE key will flash red.
14. In the SET ALERTS screen, set the following:

	LOW	HIGH
$ETCO_2$	60	OFF

NOTE: Adjust the LOW limit such that it is at least 10mmHg greater than the current $ETCO_2$ value.

15. The current $ETCO_2$ value is than the LOW alert limit. Verify the following:
    - The LOW limit value begins to flash.
    - After a delay of 10 seconds (of the value exceeding the alert limit), a Medium Priority Audio Alarm will sound.
    - The message LOW $ETCO_2$ is displayed.

16. In the SET ALERTS screen, set the following:

	LOW	HIGH
$ETCO_2$	OFF	OFF

5.4 RR Limits

Note: The Respiratory Rate alert limits are not available when the NICO-Esprit Interface is active.

17. Continue breathing through the CAPNOSTAT CO_2 Sensor and airway adapter.
18. In the SET ALERTS screen, set the following:

	LOW	HIGH
RR	50	OFF

NOTE: Adjust the LOW limit such that it is at least 10br/min greater than the current Respiration Rate value.

19. The current Respiration Rate value is less than the LOW alert limit. Verify the following:
    - The LOW limit value begins to flash.
    - After a delay of 10 seconds (of the value exceeding the alert limit), a Medium Priority Audio Alarm will sound.
    - The message LOW RESP RATE is displayed.
20. In the SET ALERTS screen, set the following:

	LOW	HIGH
RR	OFF	10

NOTE: Adjust the HIGH limit such that it is at least 10br/min less than the current Respiration Rate value. If necessary, increase your respiration rate while breathing through the CAPNOSTAT CO_2 Sensor and airway adapter.

21. The current Respiration Rate value is greater than the HIGH alert limit. Verify the following:
    - The HIGH limit value begins to flash.
    - After a delay of 10 seconds (of the value exceeding the alert limit), a Medium Priority Audio Alarm will sound.
    - The message HIGH RESP RATE is displayed.
22. In the SET ALERTS screen, set the following:

	LOW	HIGH
RR	OFF	OFF

23. Disconnect the CAPNOSTAT CO_2 Sensor from the monitor.

5.5 SpO_2 Limits

24. In the SET ALERTS screen, set the following:

	LOW	HIGH
SpO_2	85	95

25. Set the TB500B Test Box to 82%.

26. The current SpO_2 value will change to less than 85%. Verify the following:
    - The LOW limit value begins to flash
    - After a delay of 10 seconds (of the value exceeding the alert limit), a High Priority Audio Alarm will sound.
    - The message LOW SpO_2 is displayed.
    - The SILENCE key will flash red.
27. Set the TB500B Test Box to 100%.
28. The current SpO_2 value will change be greater than 95%. Verify the following:
    - The HIGH limit value begins to flash.
    - After a delay of 10 seconds (of the value exceeding the alert limit), a Medium Priority Audio Alarm will sound.
    - The message HIGH SpO_2 is displayed.
29. In the SET ALERTS screen, set the following:

	LOW	HIGH
SpO_2	OFF	OFF

5.6 Pulse Rate Limits

30. In the SET ALERTS screen, set the following:

	LOW	HIGH
PR (♥)	65	OFF

31. The current Pulse Rate (♥) value is less than 65 bpm. Verify the following:
    - The LOW limit value begins to flash.
    - After a delay of 10 seconds (of the value exceeding the alert limit), a High Priority Audio Alarm will sound.
    - The message LOW PULSE RATE is displayed.
    - The SILENCE key will flash red.
32. In the SET ALERTS screen, set the following:

	LOW	HIGH
PR (♥)	OFF	55

33. The current Pulse Rate value is greater than 55 br/min. Verify the following:
    - The HIGH limit value begins to flash.
    - After a delay of 10 seconds (of the value exceeding the alert limit), a Medium Priority Audio Alarm will sound.
    - The message HIGH PULSE RATE is displayed.
34. In the SET ALERTS screen, set the following:

	LOW	HIGH
PR (♥)	OFF	OFF

5.7 C.O. Limits

35. Press the OPERATE/STANDBY key to turn off the $NICO_2$ monitor.
36. Disconnect the TB500B from the NICO2 monitor.

37. Power the $NICO_2$ monitor ON while holding the DATA ENTRY and SILENCE keys.
38. Select the NICO - OR Demo Mode from the selection screen.
39. Complete the power-up sequence. Press the STOP/CONTINUE REBREATHING button to start the NICO rebreathing cycle. Wait for a C.O. value to be displayed on the screen (approximately 3 minutes).
40. Enter the SET ALERTS screen and set the following:

	LOW	HIGH
C.O.	7.0	OFF

41. The current Cardiac Output value is less than 7.0 L/min. Verify the following:
    - The LOW limit value begins to flash.
    - After a delay of 10 seconds (of the value exceeding the alert limit), a High Priority Audio Alarm will sound.
    - The SILENCE key will flash red.
    - The message LOW C.O. is displayed.
42. In the SET ALERTS screen, set the following:

	LOW	HIGH
C.O.	OFF	3.0

43. The current Cardiac Output value is greater than 3.0 L/min. Verify the following:
    - The HIGH limit value begins to flash.
    - After a delay of 10 seconds (of the value exceeding the alert limit), a Medium Priority Audio Alarm will sound.
    - The message HIGH C.O. is displayed.
44. In the SET ALERTS screen, set the following:

	LOW	HIGH
C.O.	OFF	OFF

5.8 VCO_2 Limits

45. Press the OPERATE/STANDBY key to turn off the $NICO_2$ monitor.
46. Power the $NICO_2$ monitor ON while holding the DATA ENTRY and SILENCE keys.
47. Select the RESP. MECHANICS - ADULT Demo Mode from the selection screen.
48. Complete the power-up sequence. Wait for a VCO_2 value to be displayed on the screen.
49. Enter the SET ALERTS screen and set the following:

	LOW	HIGH
VCO_2	500	OFF

50. The current VCO_2 value is less than 500 mL/min. Verify the following:
    - The LOW limit value begins to flash.
    - After a delay of 10 seconds (of the value exceeding the alert limit), a Medium Priority Audio Alarm will sound.
    - The message LOW VCO_2 is displayed.

51. In the SET ALERTS screen, set the following:

	LOW	HIGH
VCO_2	OFF	300

52. The current VCO_2 value is greater than 300 mL/min. Verify the following:
    - The HIGH limit value begins to flash
    - After a delay of 10 seconds (of the value exceeding the alert limit), a Medium Priority Audio Alarm will sound.
    - The message HIGH VCO_2 is displayed.
53. In the SET ALERTS screen, set the following:

	LOW	HIGH
VCO_2	OFF	OFF

5.9 Conclusion

54. Power off the $NICO_2$ monitor. Remove any connected sensors.

6 Diagnostic Screens

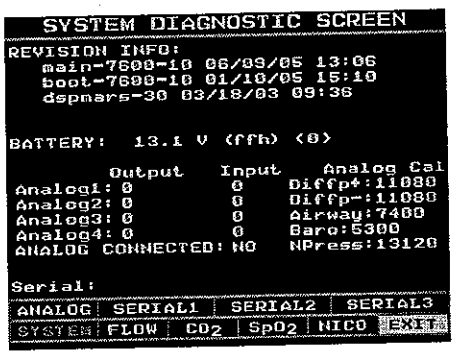
This section presents the Diagnostic Screens that are included in the software which can be used for troubleshooting. The access the diagnostic screens, press and hold the DATA ENTRY and MENU keys to display the CONFIGURATION MENU. Select the DIAGNOSTIC SCREENS menu item and press the Knob. There are five Diagnostic screens available: System, Flow, CO_2, SpO_2 and NICO. To navigate between the screens, use the knob to highlight the appropriate selection

When the monitor is in the Production Test mode, additional options and information are displayed on the various Diagnostic Screens. The screens in this section are detailed with Production Test Mode enabled. To enable Production Test mode, open the outer enclosure and locate the Digital Board (2783-01). On the top rear of the board is switch block S1. Set switch 2 to ON. The message PRODUCTION TEST mode will be displayed in the monitor's main message area.

6.1 System Diagnostic Screen

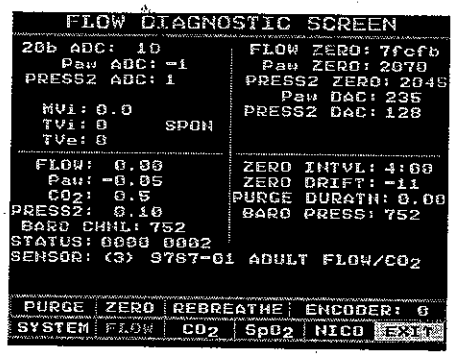
The System Diagnostic screen displays information on the software revisions, analog I/O, Analog Board calibration and options to test the Analog and Serial port hardware. The software revisions displayed are: system code (main-7600-10 in the screen shot example), boot code (boot-7600-10) and the MARS DSP code (dspmars-30). The current battery voltage, ADC and state are displayed (0 = AC power, 1-7 = battery discharge level). The Analog Board calibration information is for factory-calibration only.

Use the Analog Loopback connector (PN: 9637-48) and RS232 Loopback connector (PN: 9639-48) when testing the analog and serial port hardware.



6.2 Flow Diagnostic Screen

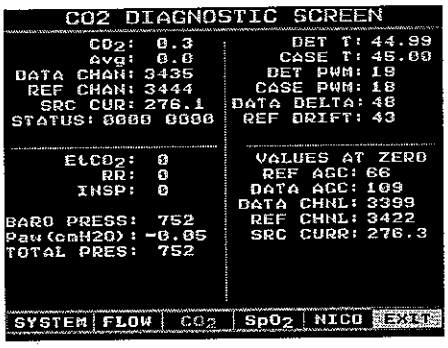
The Flow Diagnostic Screen displays information on the flow measurement subsystems. This includes the differential pressure and airway pressure transducers, current zero information, and core flow, pressure and CO_2 waveform values.



Item	Description	Item	Description
20b ADC Paw ADC PRESS2 ADC	Current ADC values for differential pressure, airway pressure and NICO Sensor pressure, zero compensated	FLOW ZERO Paw ZERO PRESS2 ZERO	Values of the transducer ADCs at zero (atmosphere).
MVi TVi TVe SPON/MECH	Inspired Minute Volume, L/min Inspired Tidal Volume, mL Expired Tidal Volume, mL Breath type	Paw DAC PRESS2 DAC	Current setting of the pressure transducer DACs at zero
FLOW Paw CO_2 PRESS2	Current Flow value (L/min), airway pressure value (cmH2O), CO_2 value (mmHg) and NICO Sensor pressure value (cmH2O)	ZERO INTVL ZERO DRIFT PURGE DURATN	Interval and change between subsequent Flow Zeros.
BARO CHNL BARO PRESS	Current Barometric pressure channel value, and barometric pressure (read from BARO CHNL after a Flow Zero)	STATUS	Status flags for the flow/CO_2 subsystem
PURGE ZERO	Initiate a Flow Purge or Flow Zero	SENSOR	Details the currently connected Flow Sensor or NICO Sensor
REBREATHE	Place the NICO Sensor into or out-of rebreathing	ENCODER	Turn on each of the Flow sensor optical encode channels independently

6.3 CO_2 Diagnostic Screen

The CO_2 Diagnostic Screen displays information on the CO_2 measurement subsystem. This includes the data and reference channel values, calculated waveforms and parameters, and zero information.



Item	Description	Item	Description
CO_2 Avg	Current calculated CO_2 value with a 10 second average	DET T CASE T DET PWM CASE PWM	Current measured CO_2 temperatures (case and detector) and PWM settings
DATA CHAN REF CHAN SRC CUR	Current measured data and reference channel and source current values (from ADC)	DATA DELTA REF DRIFT	Drift values for the data and reference channels from the zero values
STATUS	Status flags for the CO_2 subsystem	REF DATA AGC AGC DATA CHNL REF CHNL SRC CURR	Airway zero values of the various data and reference channel parameters
$EtCO_2$ RR INSP	End-Tidal CO_2, mmHg Respiration Rate, br/min Inspired CO_2 value, mmHg	BARO PRESS Paw(cmH_2O) TOTAL PRES	Current barometric pressure, airway pressure and total circuit pressure measurements

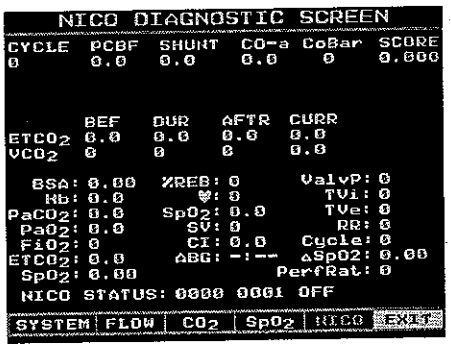
6.4 SpO_2 Diagnostic Screen

The SpO_2 Diagnostic Screen displays information on the SpO_2 measurement subsystem. This includes the IR and Red channel values, power and current measurements, calculated waveforms and parameters, and 20-bit ADC calibration information.

Item	Description	Item	Description
IR ADC RED ADC Front DC	ADC values for the IR, RED and Front-End DC measurements	CAL MAX IR CAL MAX RED CAL LAST IR CAL LAST RED	Maximum and previous values for the IR/RED 20-bit ADC converters, calibrated periodically and on startup
IR LedPwr RED LedPwr IR CURR RED CURR	LED Drive Power DAC settings and the corresponding IR/RED current measurements (in mA)	IR/RED DELTA, AVG, and STD	For measurement of IR/RED ADC channels on fixed-absorbers
SpO_2 Pulse Update T	Oxygen Saturation (in %) Pulse Rate (in beats/min) Update Timer (in seconds)	SPO_2 TYPE LAST MARS RESET DSP Time Avg DSP Time Max	Internal MARS DSP information
STATUS	Status for the SpO_2 subsystem	SET MARS ERROR	(For Engineering Use Only)

6.5 NICO Diagnostic Screen

The NICO Diagnostic Screen displays information on the current Cardiac Output measurements. This includes current Blood Gas parameters, parameter inputs and cardiac output calculation outputs. Parameter data is only displayed when the NICO Cycle is active.



Item	Description	Item	Description
CYCLE PCBF SHUNT CO-a CoBar SCORE	Parameters from the most-current cardiac output calculation	$ETCO_2/VCO_2$ BEF/DUR/AFTR and CURR	Cardiac output calculation outputs and the current $ETCO_2/VCO_2$ parameters
BSA Hb $PaCO_2$ PaO_2 FiO_2 $ETCO_2$ SpO_2 ABG	Current blood gas inputs to the Cardiac Output calculation algorithms	%REB PULSE SpO_2 ValvP TVi Ve RR Cycle	Current parameters used by the Cardiac output calculation algorithms
STATUS (OFF)	Status for the NICO subsystem and current NICO cycle state	SV CI SpO_2 PerfRat	Additional parameters from the most-current cardiac output calculation

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7 Maintenance

7.1 General

This section presents information on general maintenance, such as battery and fuse replacement, disassembly and assembly instructions, and system software updates for the Model 7600.

7.2 Monitor Maintenance Schedules

The $NICO_2$® monitor performs a diagnostic self-test at powerup that checks the internal electronics. If this self test fails, the normal monitoring display will not appear. Remove the $NICO_2$ monitor from use and contact qualified service personnel.

The $NICO_2$ monitor should undergo inspection and patient safety checks on a regular basis or according to institutional protocol.

7.3 Battery Maintenance

The monitor may not power up on battery power if the battery is not sufficiently charged. If the $NICO_2$® monitor has not been used or powered by the AC Mains for an extended time—3 months or more—allow the battery to charge for 12 hours before use. (The internal battery may slowly discharge over long periods of non-use.)

To charge the battery, connect the line cord to an AC source and set the rear panel power switch ON (|). Check that the AC Mains Power Indicator on the front panel is illuminated (green). Allow the battery to charge for 12 hours. (Refer battery replacement to qualified service personnel.)

7.4 Disassembly

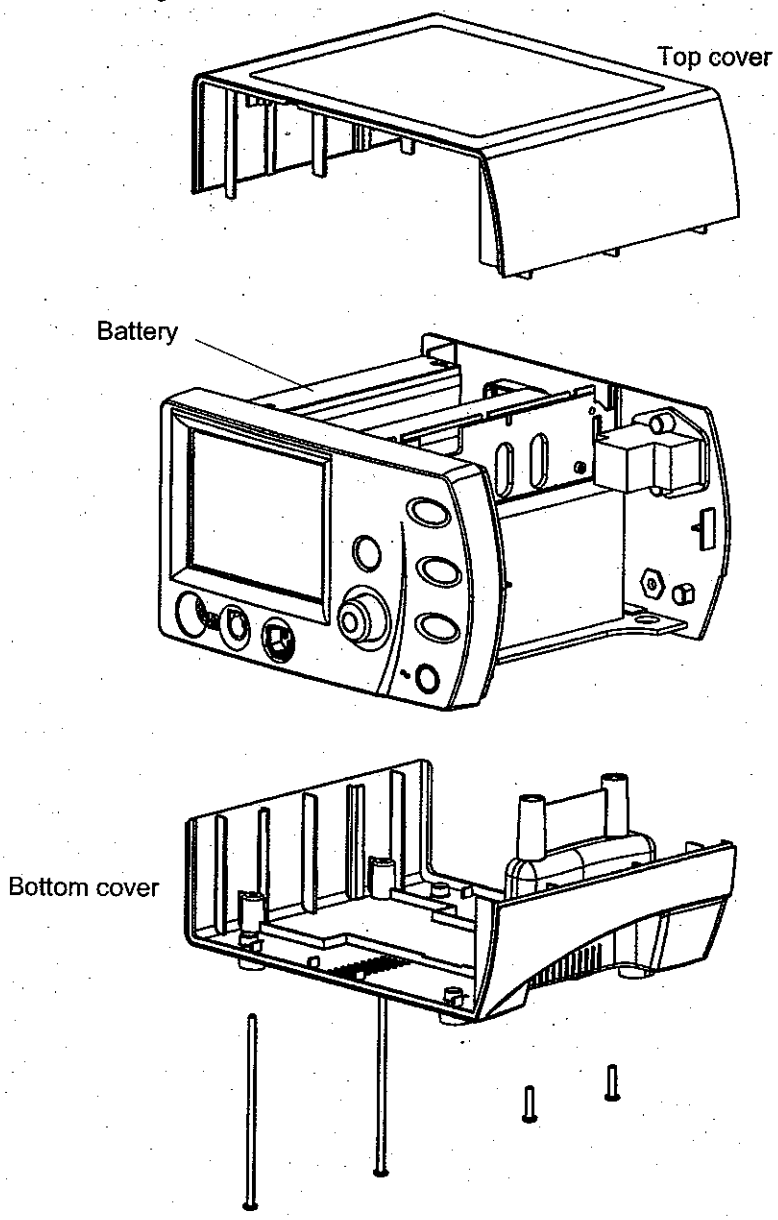
CAUTION: The Model 7600 contains static sensitive devices. Be sure to follow proper grounding procedures when handling the internal components to avoid damage from static discharge.

7.4.1 Equipment Required

- Phillips screwdriver
- Large flat-blade screwdriver
- Small flat-blade screwdriver

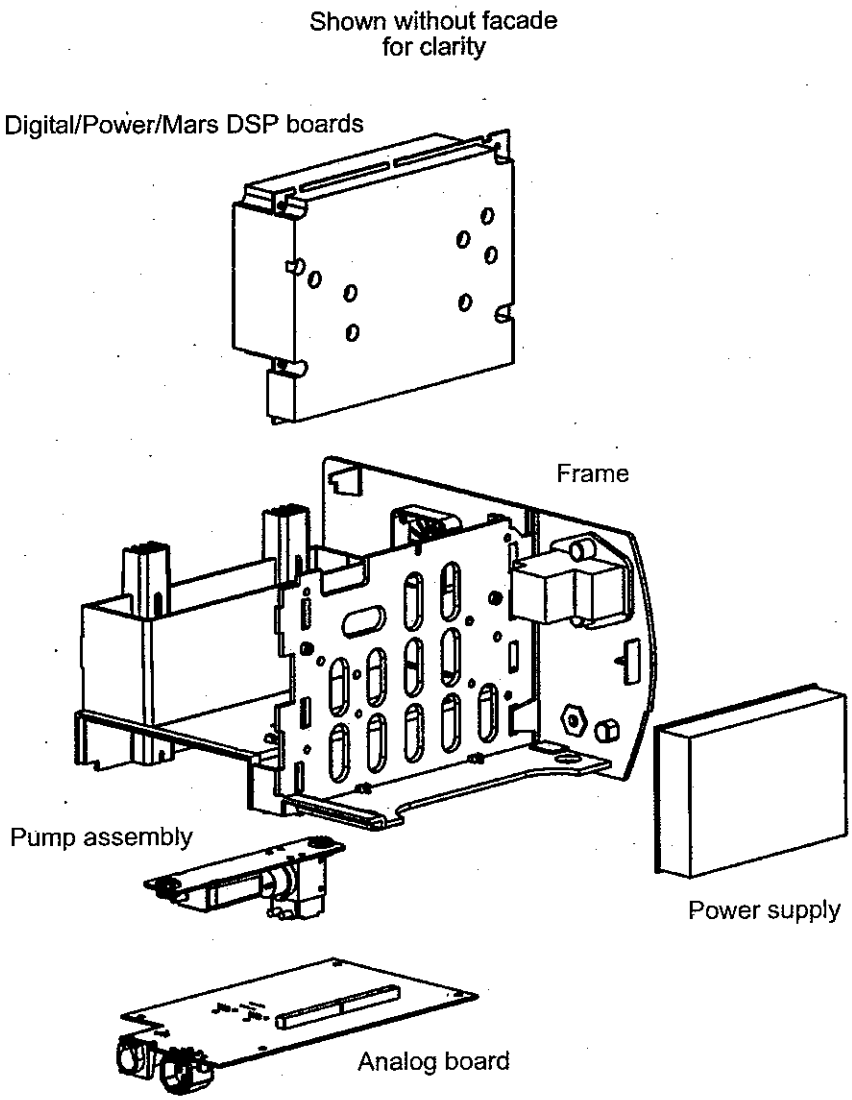
7.4.2 *Disassembling Unit*

1. Check that the monitor is OFF.
2. Set the rear panel power entry module switch to OFF ("O"). Remove the line cord from the power entry module (if connected).
3. Remove two screws from the body of the unit and two more from the handle. NOTE: Body screws are long.



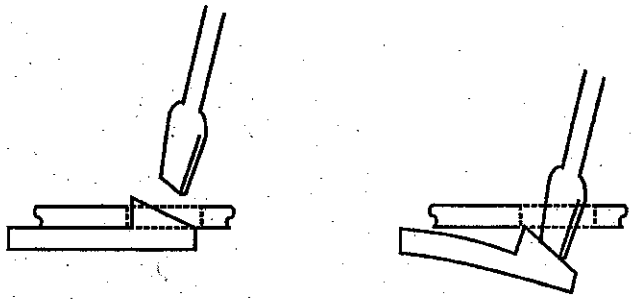
4. The top and bottom covers slide off. Place the covers and screws aside. Disconnect and remove the battery.

5. The power supply, digital, power and Mars DSP boards are accessible. To remove other assemblies further disassembly is required.

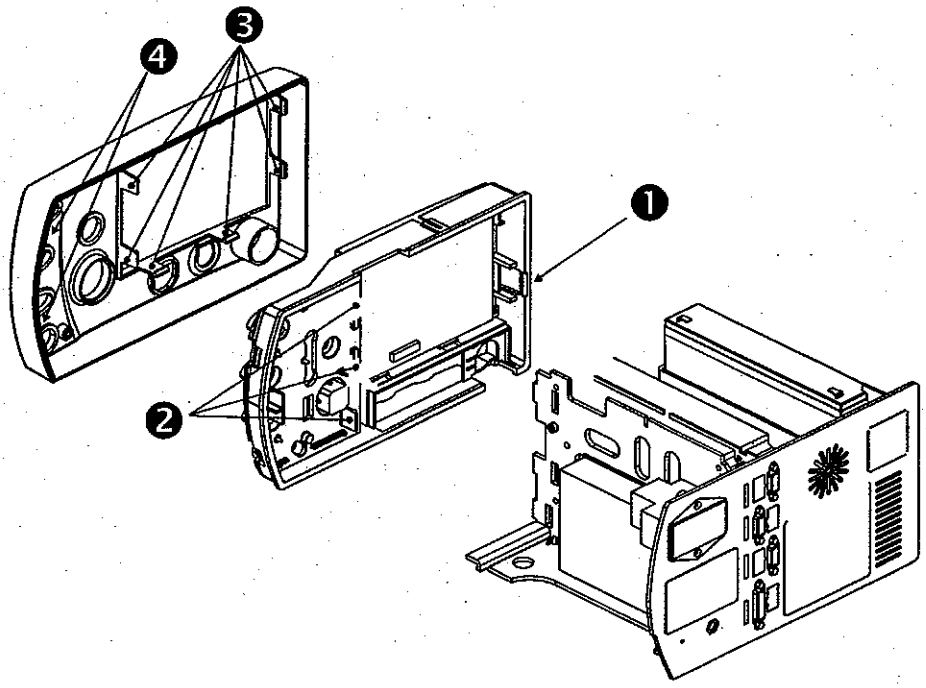


6. Disconnect the two ribbon cables from the facade assembly, J5 & J3 from the digital board and J1 & J3 from the analog board. Be sure to mark where they are connected for assembly later.
7. Disconnect the ground wires running from the CAPNOSTAT® connector and the power board to the rear panel equipotential connector.
8. The facade assembly is held together by a series of tabs. To separate the parts use a flat blade screwdriver to push the tab through its securing notch. This will release its'

hold. It is best to release all the tabs on one side (or one area), then work to the other side while keeping the tabs from reseating themselves.



9. Using the large flat-blade screwdriver, gently pry the facade assembly from the frame first at location ❶, then at ❷ starting with the top tab, the middle, then the bottom.



10. To further disassemble the facade, use both the large and small flat-blade screwdrivers. Remove the knob from the facade. Use the large flat-blade screwdriver to gently pry the black section from the white facade while using the small flat-blade screwdriver to loosen the tabs at ❸ then ❹. The prying action of the large flat-blade screwdriver will keep the tabs from reseating themselves as they are loosened. Do not use excessive force, the plastic can be damaged or marred.

7.5 Reassembling Unit

CAUTION: The Model 7600 contains static sensitive devices. Be sure to follow proper grounding procedures when handling the internal components to avoid damage from static discharge.

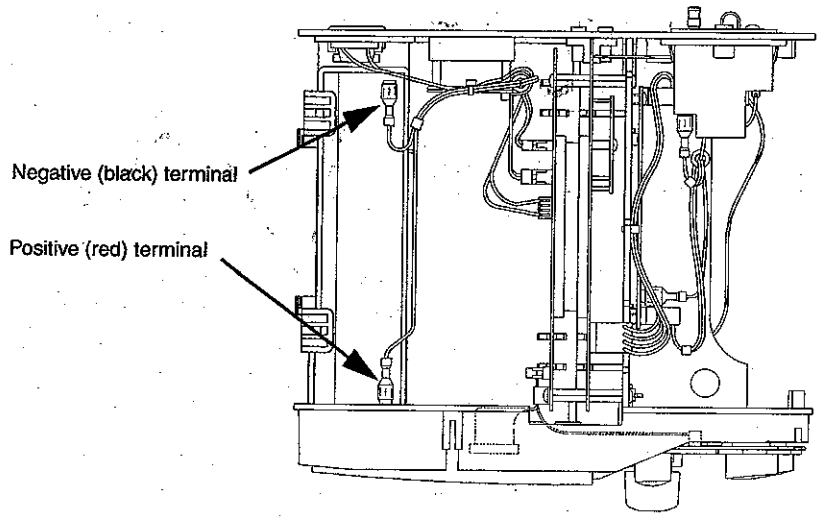
1. Refer to the 1024045DWG Main Assembly print located in section 13 for detailed assembly diagrams. Different parts of the drawing may apply depending upon the stage of disassembly of the monitor. Note locations of assemblies and routing of cables and any special notes that may apply.
2. Check that the line cord and battery are not connected. Verify no other external power sources are connected to any of the assemblies.
3. Check that there is no loose hardware or objects within the chassis assembly. Attach all board assemblies first then attach cables as necessary, verify all wires and cables are properly routed and secured.
4. When all the assemblies are secured and all cables and wire harnesses are in place connect the battery, be sure to connect wires correctly, red - positive, black - negative.
5. With the cover still off, connect the line cord and verify that the green AC Mains Power Indicator on the front panel illuminates. Press the power switch and verify the monitor powers up without any error messages (battery should be fully charged). Turn the monitor off, disconnect the line cord and reassemble the covers.

7.6 Replacing the Internal Battery

	Recyclable item. After the life cycle of the item has been met, disposal should be accomplished following national/local requirements.
	Separate collection. Appropriate steps must be taken to ensure that spent batteries are collected separately when disposed of. This symbol is found on the internal battery.
Pb	Indicates heavy metal content, specifically lead. This symbol is found on the internal battery and the monitor enclosure.

1. Unplug the line cord from the unit (if connected).

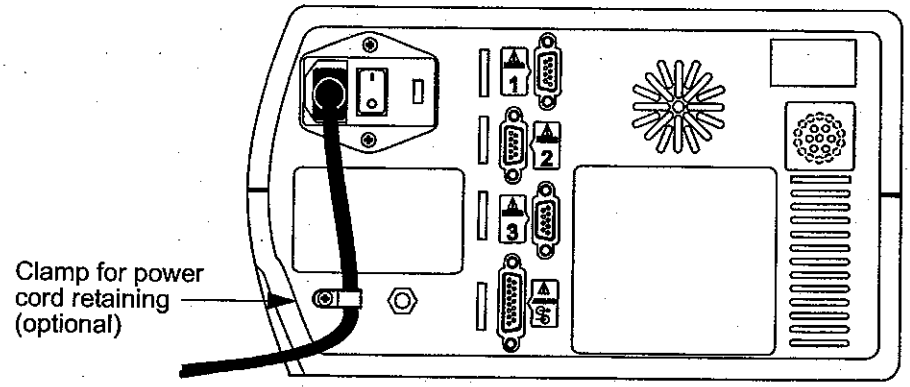
2. With the top cover removed, disconnect the positive then the negative lead from the battery terminals.



3. To remove the battery, carefully flex the tab to the left and tilt the battery to the right and pull the battery out.
4. Replace the battery and reconnect the negative lead first, being careful to connect the negative (black) lead to the negative (black) terminal on the battery.
5. Connect the positive (red) lead to the positive (red) terminal. The unit may turn on when the positive lead is connected, simply press the power key to turn the unit off. To charge the battery, connect the line cord to the power cord entry module and to an AC source, set the rear panel power switch ON (|). Check that the AC Mains Power Indicator on the front panel is illuminated (green). Allow the battery to charge for 12 hours. (Refer battery replacement to qualified service personnel.)

7.7 Mains Voltage Configuration

The Model 7600 can operate from 100-120 V~ 50/60Hz or 200-240V~ 50/60Hz with no changes to its fuse configuration.



Refer to the following section for fuse replacement.

7.7.1 Fuse Replacement

CAUTION: Replace fuses with same type and rating. Verify proper fuse value for mains voltage setting (see table below).

Mains Voltage	Fuses (Slo Blo)	Part No.
100-120 V~	T1A 250V	515005
200-240 V~		

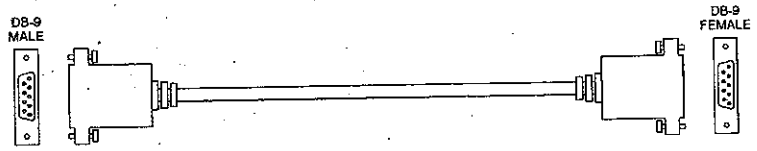
1. Check that the monitor is OFF.
2. Set the rear panel power entry module switch to OFF ("O"). Remove the line cord from the power entry module (if connected).
3. Using a flat blade screwdriver, pry the fuse access door open to expose the fuse housing and pry it out from the power entry module.
4. Replace the blown fuse(s) with the proper type and rating.
5. Re-install the fuse housing. When positioning the housing into the power entry module ensure that it is oriented correctly. Press the fuse housing back into the power entry module.
6. Close the fuse access door.

7.8 Software Update Instructions

The following procedure is for updating the monitor's software using a PC.

7.8.1 Equipment Required

1. PC computer with Windows 98, 2000, XP or later operating system and an unused serial port.
2. DB-9 male to DB-9 female serial communications cable (Null Modem Cable) Cat. No. 601012



Pin-out	
A	B
1	4
2	3
3	2
4	1
5	5
7	8
8	7
9	9

3. Update disc PN: 1015033

7.8.2 Setup

1. Connect the serial cable to the rear panel 9 pin connector marked "1" on the *NICO*$_2$® monitor (see FIG. A).

2. Connect the other end of the cable to the computer's serial communications port[1] (see FIG. A). The update software allows use of any installed serial port; the program will request which COM port to use before updating the software.

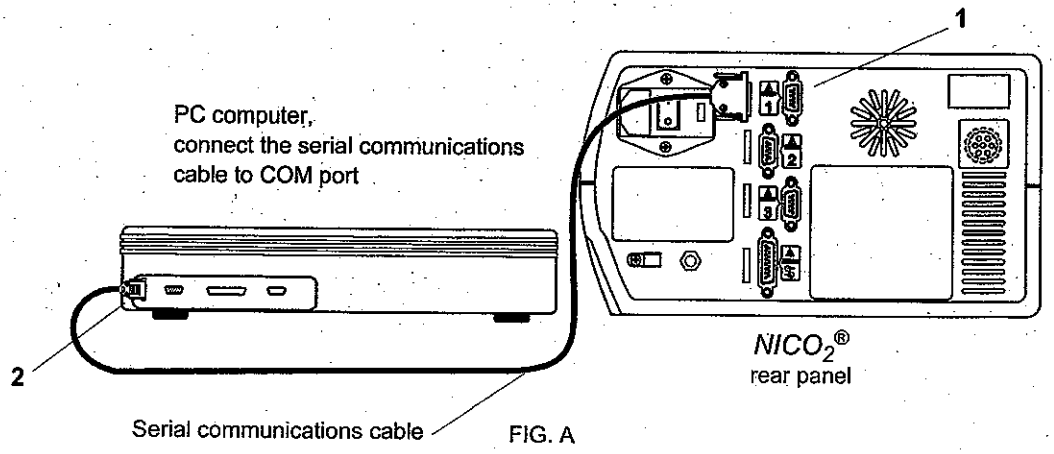
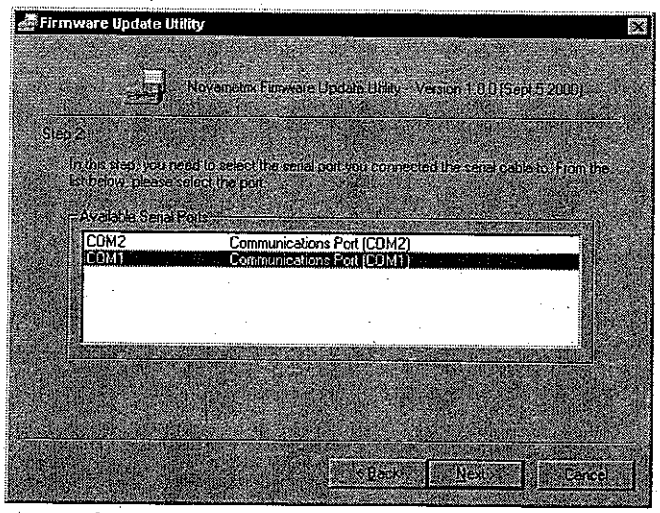


FIG. A

- Connect AC power to the monitor and turn the rear panel power switch ON (green LED on front panel lit). Turn the *NICO*$_2$® monitor on.

7.8.3 *Procedure*

1. Insert the update disc into the computer's CD-ROM drive. The update program should run automatically. If not, run the executable from the disc (example: nico7600_update_10.exe).
2. Follow the Firmware Update Utility screen instructions.
   - Click the "Next" button in Step 1.
   - Select the proper COM port in Step 2.
   - View the "Connection Status" for any instructions, "Ready to Download" should be displayed to continue. If the download does not start, try selecting the other COM port.



If you are not sure of the process, click "Cancel" button and call service.

1. The location and availability of the serial communications ports will vary from computer to computer. Refer to the computer's documentation for more information.

- When the download starts, the *NICO*$_2$® screen will blank and "DOWNLOADING FIRMWARE TO INSTRUMENT DO NOT INTERRUPT!" will appear on the Firmware Update Utility screen. The Download Status will display the progress of the download.
- The procedure is complete when "DOWNLOAD COMPLETE" is displayed. Click on "Finish" to exit the Firmware Update Utility.

3. Check that the *NICO*$_2$® restarts and returns to normal operation; if not, perform the update procedure again.
4. Remove the serial communications cable from the PC and the *NICO*$_2$® monitor. Store the update disc in a safe place.

7.9 Software Option Installation

CAUTION: An Option iButton® can be used one time only. It is not possible to use the same Option iButton® to install into multiple $NICO_2$ monitors. Use Option iButtons® designed for the $NICO_2$ monitor only.

CAUTION: It is recommended that option installation be performed with the $NICO_2$ monitor running on AC power (wall cord). If the monitor accidentally powers off during the option installation, for example due to a low battery, the Option iButton® may be rendered inoperable without the option being installed.

7.9.1 Installing a $NICO_2$ Option

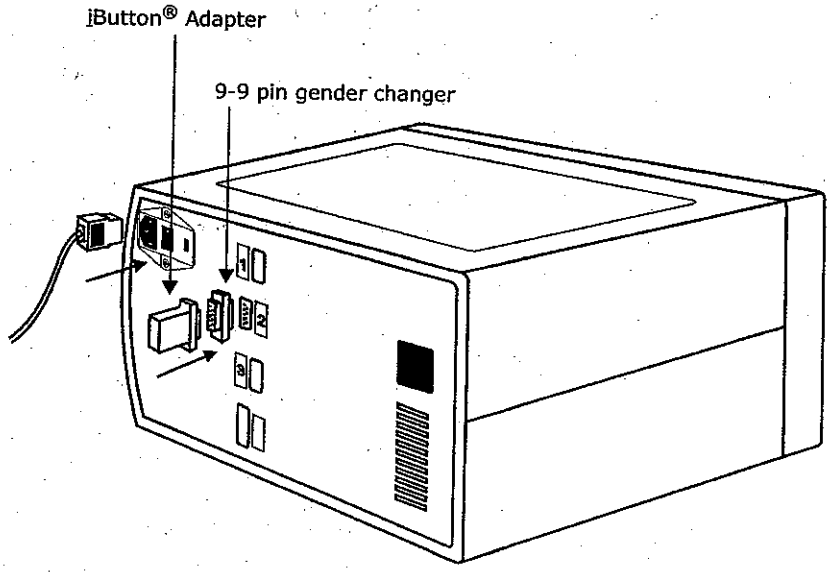
To install the option, a serial port adapter, an RS232 iButton®[2] Adapter and the Option iButton® are required. All required components are included in the option upgrade kit. Installations should be performed with a fully charged battery and on AC power (wall cord).

To install the option:

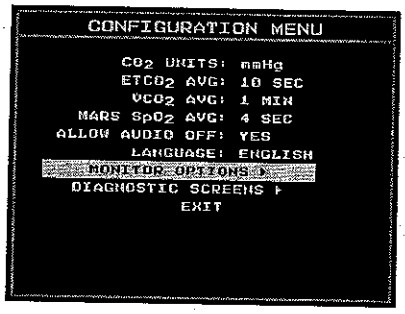
1. Insert the Option iButton® into the RS232 iButton® Adapter, label side up. The clips will click into place when the button is properly seated.
2. Connect the iButton® Adapter to the serial port adapter (9-9 pin gender changer).

2. iButton® is a registered trademark of Dallas Semiconductor / Maxim Integrated Products

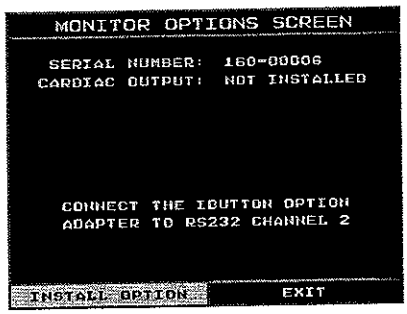
3. Connect the iButton® and adapter assembly to the RS232-2 port on the rear panel of the $NICO_2$ monitor. Only port 2 will work for option installation. Refer to the figure below.



4. Power on the $NICO_2$ monitor (on AC power). DO NOT turn the monitor off during the install process.
5. Press and hold the DATA ENTRY and MENU keys simultaneously for 3 seconds to enter the CONFIGURATION MENU. Turn and press the KNOB to select the MONITOR OPTIONS menu.



6. Turn the KNOB to highlight the INSTALL OPTION menu option and press the KNOB to begin the install.



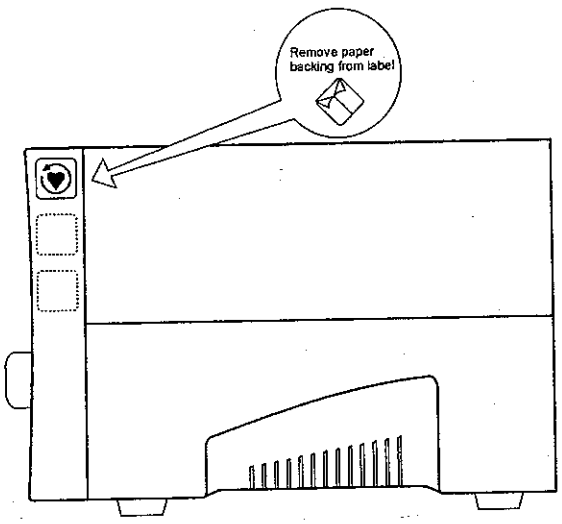
The monitor will display VERIFYING IBUTTON, followed by INSTALLING OPTION - PLEASE WAIT. See the Troubleshooting section below for error messages displayed.

> NOTE: If all available options are already installed, the **INSTALL OPTION** menu item will not be available.

7. The monitor will display MONITOR WILL RESET TO ACCEPT NEW OPTIONS, and the new option now states INSTALLED. Press the KNOB to restart the monitor.
8. Remove the iButton® and adapter assembly from the rear panel of the $NICO_2$ monitor.

7.9.2 *Option Sticker*

Option Upgrade Kits also contain a sticker to help identify which software options are installed on a particular monitor. This sticker should be affixed to the right edge of the front-panel façade. Area should be clean and dry before application of the Option sticker (see "Cleaning and Disinfection" in User's Manual). Refer to the figure below for correct sticker placement.



7.9.3 Troubleshooting Option Installation

The following error messages are displayed.

Message	Description
IBUTTON NOT RESPONDING	The option adapter is not connected to RS232-2 on the $NICO_2$ Rear Panel, or an iButton® is not inserted properly into the iButton® Adapter. Verify the option adapter is properly assembled, seated on the RS232-2 port and the clips on the Adapter are touching the metal can of the iButton®.
INVALID IBUTTON RESPONSE	An invalid iButton® is inserted into the iButton® Adapter, or there is a hardware error with the iButton® or iButton® Adapter.
INVALID BUTTON TYPE	
INVALID MONITOR CODE	
INVALID CRC	
UNRECOGNIZED ERROR	
INVALID OPTION CODE	An invalid iButton® is inserted into the iButton® Adapter, or the iButton® has previously been used to install the Option into a different $NICO_2$ monitor.
IBUTTON TIMEOUT	The iButton® did not respond within a predetermined time. There may be a hardware error with the iButton® or iButton® Adapter.

8 Troubleshooting

This section is intended as a guide in determining possible causes for monitor malfunctions. The first section lists messages that may appear on the display followed by the reason. Not all of the messages indicate a fault, but may indicate an improper operating condition or be a signal for required user interaction. The second section lists symptoms with probable causes. If checking the causes offered does not remedy the problem, contact Respironics Customer Service/Product Support.

8.1 Screen Messages

8.1.1 Message Areas - Respiratory Mechanics mode

The General Message Area messages are listed below, in alphabetical order.

(Alert Class: H-High Priority, M-Medium Priority, L-Low Priority, S-Status Message. See User's Manual for details.

General Message Area	Message Description	Alert Class
ADULT CO_2/FLOW SENSOR IDENTIFIED	An adult size CO_2/Flow sensor was just connected to the $NICO_2$ monitor.	S
ALERTS OFF	Displayed as a reminder that the default for all user selectable alerts is OFF. To cancel the message, adjust any individual limit value and activate the audible alert. Both the alert limit and audible alert must be activated.	S
AMBIENT LIGHT COVER SpO_2 PROBE	The monitor detects interference on the SpO_2 sensor from ambient light. This can be corrected by covering the SpO_2 sensor, or possibly by changing the sensor site.	M
CHECK / CHANGE AIRWAY ADAPTER	A change in the CO_2 adapter portion of the CO_2/Flow sensor is detected. Possible causes: • CAPNOSTAT® CO_2 sensor off adapter • High level of moisture and/or secretions in the adapter. Replace if needed.	S
CHECK COMMUNICATION	The monitor is unable to establish RS-232 communication with the Esprit ventilator. Displayed in NICO-Esprit Interface mode only.	S
CO_2 SENSOR FAILURE REPLACE SENSOR	A problem with the CAPNOSTAT® CO_2 sensor has been identified. Replace the CAPNOSTAT® CO_2 sensor and return it to Respironics for exchange or repair.	M
CO_2 SENSOR?	The CAPNOSTAT® CO_2 sensor has been disconnected from the $NICO_2$ monitor. Acknowledge by pressing the SILENCE key.	M

General Message Area	Message Description	Alert Class
CO_2 ZERO REQUIRED (MENU→SETUP)	The CAPNOSTAT® CO_2 sensor needs to be zeroed. Press the **MENU** key, then select **SETUP**, then **CO2 ZERO NOW**, and follow the instructions on the screen. NOTE: the CO_2 adapter provided with the CAPNOSTAT® CO_2 sensor can be used for the CO_2 zero procedure rather than a new sensor.	S
C.O. OPTION NOT INSTALLED	The optional Cardiac Output feature is not installed. Call Respironics Customer Service for more information.	M
DEMO MODE	The monitor is in demonstration mode and is not displaying patient data (all data is simulated). To exit demo mode, turn the monitor off, then back on.	S
PRODUCTION TEST MODE	The Monitor is in an operating mode with additional test and diagnostic options. This mode is enabled by internal hardware. Refer to page 36 - 5.3.1.	S
$ETCO_2$ > XX mmHg	End tidal CO_2 is greater than 60 mmHg or exceeds the high alert limit. Appears in the general message area to supplement screens that do not display the $ETCO_2$ value.	L
FLOW SENSOR?	The CO_2/Flow sensor has been disconnected. Acknowledge by pressing the **SILENCE** key.	M
GAS COMP ON	The **INSP O2** is greater than or equal to 60%, or the **INSP AGENT** is greater than 0.0%, or N_2O or He is selected as the **BALANCE** gas (press **DATA ENTRY** key to view the gas compensation settings).	S
HIGH $ETCO_2$	The displayed $ETCO_2$ value is above the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	H
HIGH PULSE	The displayed pulse rate value is above the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
HIGH RESP RATE	The displayed respiration rate value is above the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
HIGH SpO_2	The displayed SpO_2 value is above the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
HIGH VCO_2	The displayed VCO_2 value is above the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
INCOMPATIBLE CO_2 SENSOR	The wrong part number CAPNOSTAT® CO_2 sensor is connected to the $NICO_2$ monitor. Use only a CAPNOSTAT® CO_2 sensor with part number 9567-00 or 9567-37 (this can be distinguished from other CAPNOSTAT® CO_2 sensor part numbers by the yellow part number label on the sensor's electrical connector).	M
INCOMPATIBLE FLOW SENSOR	The wrong flow sensor is connected to the $NICO_2$ monitor. Use only a NICO CO_2/Flow sensor part number 9765-00, 9766-00, or 9767-00. If message persists, a hardware error is may exist. Contact qualified personnel for monitor repair or exchange.	M

General Message Area	Message Description	Alert Class
INFANT MODE ON	**INFANT MODE** is enabled in the **SETUP** menu to accommodate neonatal and smaller patients (press **MENU** key, then select **SETUP** to adjust the **INFANT MODE** setting). NOTE: This message is not displayed when a neonatal CO_2/Flow sensor is connected.	S
INSP CO_2: xx	(where xx is a numeric value with units of mmHg, kPa, or %). At least 3 mmHg, 0.1% or 0.1 kPa of CO_2 has been detected during inspiration (other than during rebreathing) for at least ten continuous seconds.	S
LOW $ETCO_2$	The displayed $ETCO_2$ value is below the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
LOW PULSE	The displayed pulse rate value is below the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	H
LOW RESP RATE	The displayed respiration rate value is below the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
LOW SpO_2	The displayed SpO_2 value is below the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	H
LOW VCO_2	The displayed VCO_2 value is below the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
MONITOR INOPERABLE AIRWAY ZERO ERROR	The $NICO_2$ monitor detected a problem with its pneumatic flow and pressure sub-system. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE BARO PRESS ERROR	The $NICO_2$ monitor detected a problem with its internal barometric pressure sensor. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE CLOCK FAILURE	The $NICO_2$ monitor detected a problem with its internal clock. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE SELF-TEST ERROR	The $NICO_2$ monitor detected a problem with its internal memory. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE FLOW ZERO ERROR	The $NICO_2$ monitor detected a problem with its flow zeroing sub-system or related pneumatic components. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE MARS HDW ERROR	The $NICO_2$ monitor detected a problem with its pulse oximetry sub-system. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE SpO_2 HDW ERROR	The $NICO_2$ monitor detected a problem with its pulse oximetry sub-system. Contact qualified personnel for monitor repair or exchange.	L
NEONATAL CO_2/FLOW SENSOR IDENTIFIED	A neonatal size CO_2/Flow sensor was just connected to the $NICO_2$ monitor.	S
NO RESP: xx:xx	The time selected in the **SET ALERTS** screen for the NO RESP (no respiration) alert was exceeded since the end of the last detected breath (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	H

General Message Area	Message Description	Alert Class
PEDIATRIC CO_2/FLOW SENSOR IDENTIFIED	A pediatric size CO_2/Flow sensor was just connected to the $NICO_2$ monitor.	S
PROBE OFF PATIENT	SpO_2 sensor disconnected from patient, improperly applied, or placed on an area too translucent for proper sensor operation. Reposition sensor. (Flashing) Acknowledge by pressing the SILENCE key. Alert Class M.	S
PULSE SEARCH	The pulse oximeter is not detecting a sufficient pulse. This could be due to: • Insufficient perfusion at the site • Tissue at the site is too thick If this condition is not corrected within 30 seconds, audible and visual alarms will occur. Alert Class M.	S
SpO_2?	The monitor is in N-395 interface mode, but SpO_2 data is not being received via the interface. An alarm is not generated.	S
SpO_2 PROBE FAILURE	The pulse oximeter sensor is faulty. Replace the sensor and contact qualified service personnel.	M
SpO_2 PROBE?	The pulse oximeter sensor has been disconnected from the $NICO_2$ monitor. Acknowledge by pressing the SILENCE key.	M
WARMUP	The CAPNOSTAT® CO_2 sensor is not at proper operating temperature yet.	S

8.1.2 *Message Areas - Cardiac Output mode (Optional)*

The General Message Area messages are listed below, in alphabetical order.

(Alert Class: H-High Priority, M-Medium Priority, L-Low Priority, S-Status Message. See User's Manual for details.)

General Message Area	Message Description	Alert Class
ALERTS OFF	Displayed as a reminder that the default for all user selectable alerts is OFF. To cancel the message, adjust any individual limit value and activate the audible alert. Both the alert limit and audible alert must be activated.	S
AMBIENT LIGHT COVER SpO_2 PROBE	The monitor detects interference on the SpO_2 sensor from ambient light. This can be corrected by covering the SpO_2 sensor, or possibly by changing the sensor site.	M
CHECK / CHANGE AIRWAY ADAPTER	A change in the CO_2 adapter portion of the NICO Sensor is detected. Possible causes: • CAPNOSTAT® CO_2 sensor off adapter • High level of moisture and/or secretions in the adapter. The moisture can be drained from the NICO Sensor and re-inserted in the circuit. Facing the pneumatic tubing upward as it exits the NICO Sensor can minimize this.	S
CHECK COMMUNICATION	The monitor is unable to establish RS-232 communication with the Esprit ventilator. Displayed in NICO-Esprit Interface mode only.	S

General Message Area	Message Description	Alert Class
CO_2 SENSOR FAILURE REPLACE SENSOR	A problem with the CAPNOSTAT® CO_2 sensor has been identified. Replace the CAPNOSTAT® CO_2 sensor and return it to Respironics for service.	M
CO_2 SENSOR?	The CAPNOSTAT® CO_2 sensor has been disconnected from the $NICO_2$ monitor. Acknowledge by pressing the **SILENCE** key.	M
CO_2 ZERO REQUIRED (MENU→SETUP)	The CAPNOSTAT® CO_2 sensor needs to be zeroed. Press the **MENU** key, then select **SETUP**, then **CO2 ZERO NOW**, and follow the instructions on the screen. NOTE: the CO_2 adapter provided with the CAPNOSTAT® CO_2 sensor can be used for the CO_2 zero procedure rather than a new NICO Sensor.	S
DEMO MODE	The monitor is in demonstration mode and is not displaying patient data (all data is simulated). To exit demo mode, turn the monitor off, then back on.	S
PRODUCTION TEST MODE	The Monitor is in an operating mode with additional test and diagnostic options. This mode is enabled by internal hardware. Refer to page 36 - 5.3.1.	S
$ETCO_2$: XX mmHg	End tidal CO_2 is greater than 60 mmHg or exceeds the high alert limit. Appears in the general message area to supplement screens that do not display the $ETCO_2$ value.	L
GAS COMP ON	The **INSP O2** is greater than or equal to 60%, or the **INSP AGENT** is greater than 0.0%, or N_2O or He is selected as the **BALANCE** gas (press **DATA ENTRY** key to view the gas compensation settings).	S
HIGH C.O.	The displayed cardiac output value is above the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
HIGH $ETCO_2$	The displayed $ETCO_2$ value is above the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	H
HIGH PULSE	The displayed pulse rate value is above the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
HIGH RESP RATE	The displayed respiration rate value is above the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
HIGH SpO_2	The displayed SpO_2 value is above the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
INCOMPATIBLE CO_2 SENSOR	The wrong part number CAPNOSTAT® CO_2 sensor is connected to the $NICO_2$ monitor. Use only a CAPNOSTAT® CO_2 sensor with part number 9567-00 or 9567-37 (this can be distinguished from other CAPNOSTAT® CO_2 sensor part numbers by the yellow part number label on the sensor's electrical connector).	M
INCOMPATIBLE FLOW SENSOR	The wrong flow sensor is connected to the $NICO_2$ monitor. Use only a NICO Sensor, part numbers 8950-00, 8951-00 or 8952-00 (the correct flow sensor is an integral part of the NICO Sensor).	M

General Message Area	Message Description	Alert Class
INFANT MODE ON	**INFANT MODE** is enabled in the **SETUP** menu to accommodate neonatal and smaller patients (press **MENU** key, then select **SETUP** to adjust the **INFANT MODE** setting). NOTE: This message is not displayed when a neonatal CO_2/Flow sensor is connected.	S
INSP CO_2: xx	(where xx is a numeric value with units of mmHg, kPa, or %). At least 3 mmHg, 0.1% or 0.1 kPa of CO_2 has been detected during inspiration (other than during rebreathing) for at least ten continuous seconds.	S
LARGE NICO SENSOR IDENTIFIED	A large size NICO Sensor was just connected to the $NICO_2$ monitor.	S
LOW C.O.	The displayed cardiac output value is below the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	H
LOW $ETCO_2$	The displayed $ETCO_2$ value is below the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
LOW PULSE	The displayed pulse rate value is below the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	H
LOW RESP RATE	The displayed respiration rate value is below the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	M
LOW SpO_2	The displayed SpO_2 value is below the set alert limit in the **SET ALERTS** screen (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	H
MONITOR INOPERABLE AIRWAY ZERO ERROR	The $NICO_2$ monitor detected a problem with its pneumatic flow and pressure sub-system. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE BARO PRESS ERROR	The $NICO_2$ monitor detected a problem with its internal barometric pressure sensor. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE CLOCK FAILURE	The $NICO_2$ monitor detected a problem with its internal clock. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE SELF-TEST ERROR	The $NICO_2$ monitor detected a problem with its internal memory. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE FLOW ZERO ERROR	The $NICO_2$ monitor detected a problem with its flow zeroing sub-system or related pneumatic components. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE MARS HDW ERROR	The $NICO_2$ monitor detected a problem with its pulse oximetry sub-system. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE NICO VALVE ZERO ERR	The $NICO_2$ monitor detected a problem with its internal rebreathing valve control circuitry or related pneumatic components. Contact qualified personnel for monitor repair or exchange.	L
MONITOR INOPERABLE SpO_2 HDW ERROR	The $NICO_2$ monitor detected a problem with its pulse oximetry sub-system. Contact qualified personnel for monitor repair or exchange.	L

General Message Area	Message Description	Alert Class
MVi-MVe MISMATCH	The $NICO_2$ monitor detected greater than 15% difference between MVi and MVe measurements. NICO cycle must be active. Check for leaks in the circuit.	S
NO RESP: xx:xx	The time selected in the **SET ALERTS** screen for the NO RESP (no respiration) alert was exceeded since the end of the last detected breath (press **MENU** key, then select **SET ALERTS** to view the alert limit settings).	H
PROBE OFF PATIENT	SpO_2 sensor disconnected from patient, improperly applied, or placed on an area too translucent for proper sensor operation. Reposition sensor. (Flashing) Acknowledge by pressing the **SILENCE** key. Alert Class M.	S
PULSE SEARCH	The pulse oximeter is not detecting a sufficient pulse. This could be due to: • Insufficient perfusion at the site • Tissue at the site is too thick If this condition is not corrected within 30 seconds, audible and visual alarms will occur. Alert Class M.	S
SMALL NICO SENSOR IDENTIFIED	A small size NICO Sensor was just connected to the $NICO_2$ monitor.	S
SpO_2?	The monitor is in N-395 interface mode, but SpO_2 data is not being received via the interface. An alarm is not generated.	S
SpO_2 PROBE FAILURE	The pulse oximeter sensor is faulty. Replace the sensor and contact qualified service personnel.	M
SpO_2 PROBE?	The pulse oximeter sensor has been disconnected from the $NICO_2$ monitor. Acknowledge by pressing the **SILENCE** key.	M
STANDARD NICO SENSOR IDENTIFIED	A standard size NICO Sensor was just connected to the $NICO_2$ monitor.	S
WARMUP	The CAPNOSTAT® CO_2 sensor is not at proper operating temperature yet.	S

8.1.3 C.O. Message Area

The C.O. Message Area messages are listed below, in alphabetical order.

(Alert Class: H-High Priority, M-Medium Priority, L-Low Priority, S-Status Message. See User's Manual for details.)

C.O. Message Area	Message Description	Alert Class
BLOOD GASES HAVE BEEN RESET	Indicates that previously entered blood gas data is no longer being used. See the Data Entry screen to re-enter the blood gas data.	S
CONSIDER USING SMALL NICO SENSOR	Resizing the NICO Loop was not effective because the ventilator set tidal volume is less than 300 ml. The $NICO_2$ monitor is suggesting a different sized sensor, with smaller loop, to correct the condition.	L

C.O. Message Area	Message Description	Alert Class
CONSIDER USING STD NICO SENSOR	If a small NICO Sensor is currently in use: Resizing the NICO Loop was not effective because the ventilator set tidal volume is greater than 500 ml. The $NICO_2$ monitor is suggesting a different sized sensor, with a larger loop, to correct the condition. If a large NICO Sensor is currently in use: Resizing the NICO Loop was not effective because the ventilator set tidal volume is less than 1000 ml. The $NICO_2$ monitor is suggesting a different sized sensor, with a smaller loop, to correct the condition.	L
CONSIDER USING LARGE NICO SENSOR	Resizing the NICO Loop was not effective because the ventilator set tidal volume is greater than 1000 ml. The $NICO_2$ monitor is suggesting a different sized sensor, with a larger loop, to correct the condition.	L
EXPAND LOOP	The NICO Loop (expandable rebreathing volume on the NICO Sensor) needs to be expanded. Expand the loop by approximately 3-6 inches or until the message is removed. Note that the message is displayed only during the rebreathing phase of the NICO cycle. If the loop is not appropriately sized by the end of the rebreathing phase, the message will be removed and displayed again during the next rebreathing phase. If this message persists with maximal expansion of the NICO Loop, the tidal volume may be too large for the ventilatory conditions for the $NICO_2$ monitor to report accurate results.	L
NEXT ↻: xx:xx	There are x:xx minutes:seconds until the beginning of the next rebreathing period (provided as an indicator as to the current state of the NICO cycle).	S
NICO SENSOR?	A NICO Sensor has been disconnected from the monitor. Acknowledge by pressing the SILENCE key.	M
NICO SENSOR? ADAPTER DISCONNECT REMOVE FROM CIRCUIT	The NICO Sensor was disconnected from the monitor after C.O. measurements had been made since the last power-up. The NICO Sensor should be removed from the breathing circuit in order to avoid leaking breathing circuit gas through the sensor connector.	S
NOISY SIGNALS	The $NICO_2$ monitor was not able to calculate an averaged cardiac output value. This can be due to: • Spontaneous breaths or efforts • Surgeon moving the lungs • Ventilator adjustments	L
↻REBREATHING	The patient is currently rebreathing a portion of his/her tidal volume in order for the $NICO_2$ monitor to calculate cardiac output (provided as an indicator of the current state of the NICO cycle). The rebreathing phase of the NICO cycle lasts for 50 seconds.	S

C.O. Message Area	Message Description	Alert Class
REBREATHING OFF	Rebreathing and therefore C.O. measurements are currently disabled. The **STOP/CONTINUE REBREATHING** key is illuminated amber while rebreathing is off, and can be pressed to enable rebreathing and C.O. measurements. Rebreathing is off when: • The monitor is first turned on until the **STOP/CONTINUE REBREATHING** key is pressed • The **STOP/CONTINUE REBREATHING** key is pressed while C.O. measurements are enabled • The monitor detected a system fault or condition which warrants automatic disabling of C.O. measurements	S
REBREATHING OFF NICO SENSOR FAILURE	A problem with the NICO Sensor was detected by the monitor. Discard the sensor and replace it. If the problem persists, contact qualified service personnel.	M
REBREATHING OFF PRESS Ø KEY TO CONTINUE	Rebreathing and therefore C.O. measurements are currently disabled and can be enabled by pressing the **STOP / CONTINUE REBREATHING** key.	S
REBREATHING PAUSED WAITING FOR $ETCO_2$ < XX	Rebreathing and therefore C.O. measurements have been temporarily paused automatically by the monitor, and will resume automatically once the indicated parameter is within the stated range (here, XX = 85 mmHg, 11.5 kPa, 11.5 %).	L
REBREATHING PAUSED WAITING FOR $ETCO_2$ > XX	Rebreathing and therefore C.O. measurements have been temporarily paused automatically by the monitor, and will resume automatically once the indicated parameter is within the stated range (here, XX = 15 mmHg, 2.0 kPa, 2.0 %).	L
REBREATHING PAUSED WAITING FOR RR < 60 br/m	Rebreathing and therefore C.O. measurements have been temporarily paused automatically by the monitor, and will resume automatically once the indicated parameter is within the stated range.	L
REBREATHING PAUSED WAITING FOR RR > 3 br/m	Rebreathing and therefore C.O. measurements have been temporarily paused automatically by the monitor, and will resume automatically once the indicated parameter is within the stated range.	L
REBREATHING PAUSED WAITING FOR VCO_2 > 20 mL/min	Rebreathing and therefore C.O. measurements have been temporarily paused automatically by the monitor, and will resume automatically once the indicated parameter is within the stated range.	L
REBREATHING PAUSED WAITING FOR Vt > 200 mL	Rebreathing and therefore C.O. measurements have been temporarily paused automatically by the monitor, and will resume automatically once the indicated parameter is within the stated range.	L

C.O. Message Area	Message Description	Alert Class
RETRACT LOOP	The NICO Loop (expandable rebreathing volume on the NICO Sensor) needs to be retracted (made smaller). Retract the loop by approximately 3-6 inches or until the message is removed. Note that the message is displayed only during the rebreathing phase of the NICO cycle. If the loop is not appropriately sized by the end of the rebreathing phase, the message will be removed and displayed again during the next rebreathing phase. If this message persists with the NICO Loop at its minimal size, the tidal volume may be too small for the ventilatory conditions for the $NICO_2$ monitor to report accurate results.	L

8.2 Additional troubleshooting

The following table lists symptoms and possible causes that may be corrected by servicing the electronic components inside the monitor.

Symptom	Explanation
Flow zero error	Check for moisture in pneumatic tubing on the analog board. Differential transducer malfunction (IC18 or 2769-01 board) on analog board. Leaking tubing or solenoids.
MONITOR INOPERABLE message	Check ribbon cable between power and analog boards.
Monitor will not turn on	Check AC input, battery and main fuses. Check front panel ribbon cable. Check crystal Y1 on digital board.
Blank display on power up	Check ribbon cable connections on front panel and display board.
Check Airway Adapter	Verify proper zeroing procedure, refer to User's Manual.
CO_2 warmup message always displayed	Case heaters in CAPNOSTAT® CO_2 sensor malfunction. Check fuse F2, F3, F4 and F6 on power board.
Flow sensor intermittent "not connected" message	Check flow input housing on sensor, verify no cracks or damage.
Software update cannot be completed	Reboot computer used for updating. Restart software upgrade procedure. Verify proper operation of COM port and that the correct cable is being used.
CO_2 Sensor Failure	Case or detector heater in the CAPNOSTAT CO_2 sensor malfunction. Check fuse F2, F3, F4 and F6 on power board. Replace CAPNOSTAT CO_2 Sensor.

Symptom	Explanation
Monitor on and front panel DATA ENTRY LED blinks with no display (other LEDs on but do not blink)	1 blink - RAM test failure. Contact qualified personnel for monitor repair or exchange. 2 blinks - bootcode ROM checksum test failure. Contact qualified personnel for monitor repair or exchange. 3 blinks - maincode ROM checksum test failure (software update may correct problem). Contact qualified personnel for monitor repair or exchange.

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9 Specifications

9.1 General

Specifications for the Respironics NICO_2® Monitor, Model 7600, are listed for informational purposes only, and are subject to change without notice.

9.2 CO_2

- Principle of Operation: Non-Dispersive Infrared (NDIR) absorption, dual wavelength ratiometric-single beam optics, mainstream sensor.
- Response Time: Less than 60 ms
- Gas composition effects: O_2, N_2O (operator selectable)
- CAPNOSTAT® CO_2 Sensor:
  - Weight: Less than 18 g without cable
  - Sensor Size: 1.3 x 1.67 x .85 inches (3.3 x 4.2 x 2.2 cm), 8 foot cable (2.44 m)
  - Construction: Durable high performance plastic, ultra-flexible cable. Shock Resistant: Sensor will withstand a 6 foot drop to a tile floor.
- End Tidal CO_2:
  - Range: 0-150 mmHg, 0-20 kPa or % at Pb 760 mmHg
  - Accuracy: ± 2 mmHg for 0-40 mmHg, ± 5% of reading for 41-70 mmHg, ± 8% of reading for 71-150 mmHg
- Respiratory Rate:
  - Range: 2-150 breaths/min
  - Accuracy: ± 1 breath/min

9.3 Flow

- Flow Range (L/min) at Pb 760 mmHg, room air, 35°C
  - Adult: 2 to 180
  - Pediatric: .5 to 100
  - Neonatal: .25 to 25
- Flow Accuracy: Greater of ± 3% reading or:
  - Adult: .5 L/min
  - Pediatric: .25 L/min
  - Neonatal: .125 L/min
- Tidal Volume Range (ml)
  - Adult: 200 to 3000
  - Pediatric: 30-400
  - Neonatal: 1-100

- Airway Pressure Range (cmH_2O): ± 120
  - Accuracy: greater of 0.5 cmH_2O or ± 2% reading
- Gas composition effects: O_2, anaesthetic agent, CO_2, N_2O, N_2, He (operator selectable)

9.4 SpO_2

- Oxygen Saturation
  - Range: 0-100%
  - Accuracy: ± 2% for 70-100%, ±3% during motion conditions, for 1 standard deviation, unspecified for 0-69%. Applies for Finger Sensor, Y-Sensor, and Single Patient Use Sensor. Use of ear clip can add an additional 1%.
  - Averaging Time selectable: none, 2, 4 or 8 seconds
  - Settling time: Display settles to within 1% of the reading less than 15 seconds after the sensor is applied.
- Pulse Rate:
  - Range: 30-250 beats per minute
  - Accuracy: ± 1% of full scale (for 1 standard deviation or approximately 68% of readings)
  - Averaging Time: 8 seconds, or selectable (based on SpO_2 setting)
  - Display Resolution: 1 bpm

9.5 Cardiac Output

- Measurement Frequency: Rebreathing cardiac output measurement made every three minutes, rebreathing period is 35 seconds.
- Cardiac Output Range: 0.5-19.9 liters/minute
- Cardiac Output Resolution: 0.1 liters/minute
- Pulmonary Capillary Blood Flow (PCBF) Range: 0.5-19.9 L/min, Resolution: 0.1 L/min
- Cardiac Index Range: 0-9.9 L/min/meter^2, Resolution: 0.1 L/min/meter^2
- Stroke Volume Range: 0-250 ml, Resolution: 1 ml
- Rebreathing Valve/sensor:
  - Valve type: dual diaphragm, pneumatically controlled
  - Return spring: automatically returns valve to normal position
  - Resistance: 3 cmH_2O/L/min maximum
  - Rebreathed volume: normal position 35 ml; rebreathing position 150-450 ml (std.)
  - CO_2/flow sensor: integrated into valve assembly
- Parameter limits for cardiac output measurements:
  - VCO_2: >20 ml/min
  - RR: >3, <60
  - Vt: >200 (small and standard), >400 (large)
  - $ETCO_2$:>15, <85 mmHg (<100 mmHg during rebreathing)
    >2.0 mmHg, <11.5 kPa or % (<13.5 kPa or % during rebreathing)

9.6 Monitor Specifications

- Classification (IEC601-1): Class I/internal power source, type BF, continuous operating mode, enclosure protection rating IPX0.
- Operating Environment: 50-104° F (10-40° C), 10-90% relative humidity (non-condensing)
- Size: Height 6.5 in., Width 10.75 in., Depth 9.5 in.
- Weight: 9 lbs, 10 oz.
- Power: 100-240 VAC, 50-60 Hz, 70VA
- Fuse Rating: 100-240 V~, T1A
- Battery: Internal, Sealed lead-acid gel-cell, 45 minute life on full charge (on-screen life indicator), 12 hours recharge time.
- Display: 4.625 x 3.5 inch EL, 320 x 240 pixels
- Electromagnetic Emissions: Conforms to EMC Directive 93/42/EEC, CISPR Class A. Tested to EN55011 (1998) and CISPR11 (1999).
- Electromagnetic Immunity: Conforms to the EMC requirements of the Medical Device Directive 93/42/EEC. Tested to IEC60601-1-2:2001, IEC61000-4-2:2001 ESD, IEC61000-4- 3:2002 RF, IEC61000-4-4:1995 EFT, IEC61000-4-5:2001 Surge, IEC61000-4-6:2001 Conducted RF, IEC61000-4-8:2001 Magnetic Fields, IEC61000-4-11:2001 Voltage Dips, Interruptions and Variations, IEC61000-3-2:2001 Harmonic Distortion, IEC61000-3-3:2002 Voltage Fluctuations and Flicker.

9.7 RS232 Communications

- RS232 Communications Ports:

Pin #	RS232-1	RS232-2	RS232-3
2	Rx	Rx	Rx
3	Tx	Tx	Tx
5	Ground	Ground	Ground
7	n/a	RTSB	n/a
8	n/a	CTSB	n/a
9	n/a	Power	n/a

9.8 Analog Specifications

- Analog Input/Output Port (selectable, 0 to 1 volt range):
  - $ETCO_2$ - 0-150 mmHg, 0-20 kPa or %, 6.67mV/mmHg
  - SpO_2 - 0-100%, 10mV/%
  - Resp Rate - 0-150 br/min, 6.67mV/br/min
  - Pulse Rate - 0-250 bpm, 4mV/bpm
  - CO_2 Waveform - 0-150 mmHg, 0-20 kPa or %, 6.67mV/mmHg
  - Pleth Waveform - auto scaled
  - Flow Waveform - -125 to +125 L/m, 4mV/L/m
  - Airway Pressure Waveform - -20 to +105 cmH_2O, 8mV/cmH_2O
  - C.O. - Cardiac Output, 0-20 L/m, 50mV/L/m (optional)

- CI - Cardiac Index, 0-20 L/m, 50mV/L/m^2 (optional)
- SV - Stroke Volume, 0-20 L/m, 50mV/mL (optional)
- PCBF - 0-20 L/m, 50 mV/L/m

Pin#	Description	Pin #	Description
1	Ground	9	Ground
2	Channel 1 - input (not enabled)	10	Ground
3	Channel 2 - input (not enabled)	11	Channel 1 - output
4	Channel 3 - input (not enabled)	12	Channel 2 - output
5	Channel 4 - input (not enabled)	13	Channel 3 - output
6	Ground	14	Channel 4 - output
7	Ground	15	Input/Output Sense
8	Ground		

10 *NICO$_2$*® Accessories

Catalog No.	Description
1024839	***NICO$_2$*® Respiratory Profile Monitor with optional Non-invasive Cardiac Output,** Model 7600 Includes: Monitor, *CAPNOSTAT*® CO_2 Sensor, SpO_2 Sensor, Power Cord and User's Manual.
8950-00	***NICO*® Sensor** (10 per box) **Small size (for tidal volumes of 200 - 500 mL)**
8951-00	***NICO*® Sensor** (10 per box) **Standard size (for tidal volumes of 400 - 1000 mL)**
8952-00	***NICO*® Sensor** (10 per box) **Large size (for tidal volumes of 750 - 1500 mL)**
9567-00	***CAPNOSTAT*® CO_2 Sensor - NICO**
6934-00	**Cable Management Straps** for use with the *CAPNOSTAT*® CO_2 Sensor. Organizes and holds multiple cables and tubings (package of 5)
8751-00	***CAPNOSTAT*® CO_2 Sensor Cable Holding Clips** (50 per box)
8776-00	***SuperBright*™ Finger Sensor** (10 ft. sensor cable) 1 yr. warranty
8791-00	***SuperBright*™ Y-Sensor** (10 ft. sensor cable) 90 day warranty
9765-00	***NICO*® CO_2/Flow Sensors** (10 per box) **Neonatal size**
9766-00	***NICO*® CO_2/Flow Sensors** (10 per box) **Pediatric size**
9767-00	***NICO*® CO_2/Flow Sensors** (10 per box) **Adult size**
6063-01	**Single Patient Use Airway Adapter** - (1 piece) Adult size
6455-00	**Single Patient Use SpO_2 Sensor (10 per box) Pediatric/Adult**
6455-25	**Single Patient Use SpO_2 Sensor (25 per box) Pediatric/Adult**
6480-00	**Single Patient Use SpO_2 Sensor (10 per box) Neonatal/Pediatric**
6480-25	**Single Patient Use SpO_2 Sensor (25 per box) Neonatal/Pediatric**
4941-00	**Saturation Sensor Extension Cable** (4 feet)
4942-00	**Saturation Sensor Extension Cable** (6 feet)
4943-00	**Saturation Sensor Extension Cable** (10 feet)
5266-00	**Saturation Sensor Extension Cable** (25 feet)
6147-00	**Saturation Sensor Extension Cable** (50 feet)
8828-00	**20mm Wrap Style Y-Strip Taping System** (100 per box) Neonatal foot and hand, pediatric toe or finger, color coded blue
8829-00	**25mm Wrap Style Y-Strip Taping System** (100 per box) Neonatal foot and hand, color coded green
8831-00	**20mm Finger Style Taping System** (100 per box) Use on pediatric finger or on small adult finger, color coded blue
8832-00	**25mm Finger Style Taping System** (100 per box) Use on adult finger, color coded green
6929-00	**Adhesive Foam Wraps**, Large (25 per box)
9168-00	**DB9 Finger Sensor**
9768-00	**DB9 Finger Sensor**
9169-00	**DB9 Y-Sensor**
9769-00	**DB9 Y-Sensor**
8933-00	**DB9 extension cable**

Catalog No.	Description
8936-00	**DB9 extension cable**
6968-00	**Adhesive Foam Wraps**, Small (25 per box)
8836-00	**Non-Adhesive Foam Wraps**, Large (25 per box)
8943-00	**Non-Adhesive Foam Wraps**, Small (25 per box)
6131-25	**Ear Clips** (25 per box)
8700-00	**Adhesive Dots** (200 per box)
9861-00	**Flow Connector Cap**, 3 port (25 per bag)
601012	***NICO® Monitor*** 9-pin to 9-pin null modem (crossover) cable
600026	**Power Cord** (120V USA)
600041	**Power Cord**, AC for UK
600042	**Power Cord**, International
1024815	***NICO2® Monitor*** User Manual
1024826	***NICO2® Monitor*** Service Manual
9960PED-00	***CAPNO$_2$mask***™ - Pediatric O_2 Delivery/CO_2 Mainstream Monitoring Mask (10 per bag)
9960STD-00	***CAPNO$_2$mask***™ - Adult Standard O_2 Delivery/CO_2 Mainstream Monitoring Mask (10 per bag)
9960LGE-00	***CAPNO$_2$mask***™ - Adult Large O_2 Delivery/CO_2 Mainstream Monitoring Mask (10 per bag)
1018292	***NICO2®*-Esprit Cable**, 9 pin male/male null modem (cross over) cable
Software Options	
1026516	**Cardiac Output** (new monitors only)
1025434	**Cardiac Output** - field installation
Field Service Kits	
1020933	**FRU, NICO Front Panel display**
1028003	**FRU, Rear Panel assembly, 7600**
1015033	**System Software Update Kit**
1015035	**Boot Software Update kit**
9488-01	**Bottom Cover assembly**
Service Test Fixtures and Equipment	
5776-00	**TB1265 CO_2 Sensor Simulator**
6081-00	**Model 1298 Gas Calibrator**
8364-00/ 8964-00	**Low point calibration gas**
5530-00	**TB500B Saturation Simulator**
1025485	**RS232 iButton DS1411 adapter**
1025486	**RS232 9 pin male to male adapter**
1038980	**NICO_2 Flow Leak Test Fixture**
1038004	**Patient Leakage Test Fixture**

11 Parts Lists

11.1 1024839 $NICO_2$® Respiratory Profile Monitor, Model 7600

Item Nbr	Part Nbr	Description	Quantity
N/A	1025197 (1025198)	LABEL, SERIAL NUMBER	1
2	1024045	MAIN ASSY, 7600	1
7	9026-32	LABEL, MANUFACTURED IN USA	1
9	1024057	TOP COVER LABEL (ENGLISH)	1
10	1024029	FACADE W PAD PRINT (ENGLISH)	1
11	1024815	USER'S MANUAL (ENGLISH)	1
12	1024049	REAR PNL LABEL SET (ENGLISH)	1
14	1217-32	REPAIR LABEL	1

11.2 1024045 Main Assy

Part Nbr	Description	Quantity
284261	SCREW, 4-40 X 5/8, PHI	4
5826-10	FOOT PAD, BOT CVR	4
284252	SCREW, 4-40 X 3/8L	2
161067	TAPE, CL CELL, POLYC	0
608128	CABLE CLAMP. .312 DI	1
608001	CABLE TIE, .094 X 3.	2
5760-16	L FOOT, KICKSTND	2
5761-16	R FOOT, KICKSTND	2
400024	BATTERY, 12VDC, 2.3A	1
515005	FUSE, 1A, 250V, SB	2
510016	SWITCH, ROTARY ENCDR	1
U2783-01	DIGITAL BD ASSY, 7600	1
600079	RIBBON CABLE, 20 PIN	1
600078	RIBBON CABLE, 24 PIN	1
600080	RIBBON CABLE, 40 PIN	2
1020933	FRONT PANEL DISPLAY FRU	1
9335-10	GASKET, PCB	1
9336-10	KICKSTAND	2
9337-10	GASKET, DISPLAY	1
1028330	REAR PANEL, 7600 FRU	1
9487-16	TOP COVER	1
9488-16	BOTTOM COVER	1
9489-16	MAIN FRAME	1
9490-11	BEZEL	1
1024041	SILICONE KEYPANEL, 7600	1

Part Nbr	Description	Quantity
U2784-01	POWER BD ASSY, 7600	1
U2765-01	ANALOG BOARD ASSY	1
2766-01	CO_2 INPUT BOARD ASSY	1
9379-01	FAN & BTRY HARN ASSY	1
9392-01	PUMP W RSVR ASSY	1
210157	PWR ENTRY MODULE	1
9419-01	CABLE ASSY, PWR ENTRY MODULE	1
9420-01	CABLE ASSY, DC PWR	1
286005	SCREW, 6-32 X 1/4L, PAN	4
286006	SCREW, 6-32 X 5/16L, PAN	7
285051	WASHER, .500 DIA X .120 ID X 0.50 THK	2
284007	SCREW, 4-24 X 1L, PAN	2
284008	SCREW, 4-24 X 5/16L, PAN	6
280244	STANDOFF, 1/4 HEX X 11/16L, FM	2
280245	STANDOFF, 1/4 HEX X 11/16L, M-F	2
280246	STANDOFF, .18DIA X 11/16L, SNAP	2
286010	SCREW, 6-32 X 4 3/4L, PAN	2
400056	PWR SUPPLY, 15 VDC	1
286011	SCREW, 6-20 X 5/16L	2
286012	SCREW, 6-32 X 3/4L	2
1024042	KNOB, 7600	1
216074	CONNECTOR, PLUG, POT	1
216077	TERMINAL LUG, RING,	2
161082	TAPE, UHMW POLYETHYL	0
216077	TERMINAL LUG, RING	2
161098	TAPE, KAPTON, 3/8 W	0
608126	TUBING, HEAT SHRINK,	0
180065	FERRITE, SPLIT CORE	4
9859-01	GROUND WIRE ASSY	1
608135	TENSION CLIP	1
2776B-01	MARS DSP BOARD ASSY	1
284200	SCREW, 4-40 X 1/4 PHILLIPS	2
285013	WASHER, NO. 4, NYLON	2
284261	SCREW, 4-40 X 5/8	4
1025197 1025198	LABEL, SERIAL NUMBER	1

11.3 2783-01 Digital Board Assy

Part Nbr	Description	Quantity	Reference Designators
154106	CAPACITOR, 22PF, 50V	4	C16, C18, C22, C23
486037	IC, 128K X 8 BIT STATIC RAM	2	IC18, IC22
180034	FERRITE FILTER, 4 LI	2	L10, L4
474222	RESISTOR, 10 OHM	2	R6, R94
486790	IC, TLE2022CD, DUAL	1	IC21
154069	CAPACITOR, 4.7UF	1	C11
180029	INDUCTOR, 50MHZ	4	L6, L8, L9, L12
180030	INDUCTOR-CAP, 4700PF	1	L1
486314	IC, MC74HC541DW, OCT	2	IC10, IC13

Part Nbr	Description	Quantity	Reference Designators
474227	RESISTOR, 1K OHM	5	R10, R11, R34, R61, R108
486042	IC, AT93C66-10SC, 4K EEPROM	1	IC8
154112	CAPACITOR, .047UF	6	C67, C15, C19, C26, C65, C66
474247	RESISTOR, 10M OHM	1	R18
482551	LED, RED, WITH LENS	1	D2
230024	CRYSTAL, 32.768 KHZ	1	Y1
486320	IC, SN74HC14D, HEX SCHMIT INV	1	IC7
474231	RESISTOR, 4.99K OHM	2	R7, R8
474240	RESISTOR, I00K OHM	8	R35, R39, R40, R2, R13, R14, R15, R16
481546	DIODE, SWITCHING	2	D1, D3
487094	IC, RTC-62423, REAL	1	IC16
180035	FERRITE FILTER,	3	L2, L3, L5
180022	INDUCTOR, 10UH, 10%	1	L11
487132	IC, TL7757CPK, SPLY	1	IC9
487114	IC, MC34119D, AUDIO AMP	1	IC23
515087	FUSE W FUSEHOLDER	1	F2
486481	IC, TLC5620CD, QUAD	1	IC20
211213	CONNECTOR, 2 PIN	1	J7
474224	RESISTOR, 100 OHM	21	R4, R5, R29, R36, R37, R38, R62, R63, R64, R65, R66, R67, R99, R100, R101, R105, R109, R110, R111, R112, R113
154072	CAPACITOR, .1UF	3	C48, C50, C69
154079	CAP, 10UF, 25V, 20%	4	C1, C40, C56, C70
216029	TEST POINT, SPRING	1	TP1
154116	CAPACITOR, 10UF	5	C25, C28, C29, C30, C31
211327	CONNECTOR, 3 PIN	1	J8
474225	RESISTOR, 499 OHM	1	R25
513010	SWITCH, SLIDE, SPDT	1	S1
474235	RESISTOR, 24.9K OHM	2	R42, R58
486323	IC, SN74HC573DW, OCT	1	IC14
487138	IC, GRAPHICS LCD CON	1	IC19
486365	IC, MICROCONTROLLER	1	IC2
154119	CAP, 6.8PF, 50V, 5%	5	C7, C20, C42, C63, C64
474313	RES PACK, 10K OHM	3	RP5, RP6, RP7
474316	RES PACK, 100K OHM	1	RP8
180062	FERRITE BEAD, 1K OHM	1	L13
486055	IC, 512K X 8 BIT STATIC RAM	2	IC3, IC6
515094	FUSE WITH FUSEHOLDER	1	F1
210156	CONNECTOR, 96 PIN	1	J2
9428-07	PROGRAM, CPLD	1	IC2

Part Nbr	Description	Quantity	Reference Designators
1024056	PRGM, B CODE & SYS	1	IC4
474233	RESISTOR, 10K OHM	29	R1, R9, R19, R20, R21, R22, R23, R24, R26, R27, R28, R30, R33, R44, R45, R49, R50, R51, R52, R53, R54, R55, R56, R60, R102, R115, R116, R117, R118
154105	CAPACITOR, 47PF	4	C56, C57, C58, C62
154108	CAPACITOR, 100PF	3	C9, C12, C55
154104	CAPACITOR, .01UF	32	C2, C3, C4, C5, C6, C8, C10, C14, C17, C21, C24, C32, C33, C34, C35, C36, C37, C38, C39, C41, C43, C45, C46, C47, C49, C51, C52, C54, C59, C60, C61, C68
474311	RES PACK, 51 OHM	10	RP1, RP2, RP3, RP4, RP9, RP10, RP11, RP12, RP13, RP14
212544	CONNECTOR, 20 PIN	1	J5
485532	TRANSISTOR, 2N7002T1	4	Q1, Q2, Q4, Q5
212611	CONNECTOR, 24 PIN	1	J3
474256	RESISTOR, ZERO OHM	1	L14
9974-32	BARCODE LABEL	1	
486821	IC, AD822AR, OPAMP	1	IC26
486828	IC, LT1460HCS3, UPOWER SERIES	1	IC27
484543	VOLTAGE REULATOR, +5 OUT	1	IC24
180074	FERRITE, DUAL T-TYPE W/100PF CAP	1	L7
211414	CONNECTOR, 4 PIN	1	J9
474243	RESISTOR, 324K OHM	1	R17

11.4 2784-01 Power Board Assy

Part Nbr	Description	Quantity	Reference Designators
474243	RESISTOR, 324K OHM, 1/16W, 1%, 0603 STYL	2	R114 R158
474227	RESISTOR, 1K OHM, 1/16W, 1%, 0603 STYLE,	20	R1 R2 R24 R25 R28 R58 R65 R70 R76 R79 R80 R89 R125 R140 R173 R174 R175 R176 R177 R180
474261	RESISTOR, 7.5K OHM, 1/16W, 1%, 0603 STYL	1	R161
471400	RESISTOR, 100M OHM, 1W, 5%, .9 PITCH	1	R205
6756-10	TRANSFORMER, MAIN BOARD,	1	T1
9330-01	WIRE ASSY	1	
9974-32	PN BAR CODE LABEL	1	
152096	CAPACITOR, 220UF, 35V, 20%, ELCTLT, 8X10	12	C2 C4 C25 C32 C78 C79 C96 C99 C101 C102 C106 C109
152097	CAPACITOR, 470UF, 16V, 20%, ELCTLT, 8X10	5	C71 C72 C76 C98 C160
153045	CAP, .47UF, 50V, 10%, X7RCER 0.2 IN. P	1	C81
154072	CAPACITOR, .1UF, 50V, 10%, X7R, CER CHIP	9	C18 C34 C48 C49 C50 C53 C54 C55 C95
154079	CAP, 10UF, 25V, 20%, TANT, L ESR .6 OHM	8	C20 C28 C30 C77 C136 C137 C156 C157
154081	CAPACITOR, 100PF, 100V, 10%, NPO, MLTILY	5	C129 C130 C131 C132 C133
154086	CAPACITOR, 4.7UF, 10VDC, 20%, TANTALUM,	3	C15 C21 C155
154093	CAPACITOR, 68UF, 16VDC, 10%, TANTALUM, S	2	C36 C37
154103	CAP, .001UF, 50VDC, 10% X7R, SURF MT	4	C9 C13 C84 C89

Part Nbr	Description	Quantity	Reference Designators
154104	CAPACITOR, .01UF, 50VDC, 10%, X7R, SURFA	58	C1 C3 C5 C6 C10 C14 C16 C17 C19 C23 C24 C26 C27 C29 C31 C33 C35 C38 C40 C42 C43 C46 C60 C62 C63 C64 C67 C68 C75 C82 C85 C47 C51 C52 C56 C87 C88 C92 C100 C103 C105 C107 C108 C111 C112 C113 C114 C116 C119 C128 C134 C143 C144 C145 C146 C147 C148 C149
154105	CAPACITOR, 47PF, 50VDC, 5%, NPO, SURFACE	3	C41 C45 C94
154106	CAP, 22PF, 50VDC, 5% NPO, SURF MT	1	C58
154108	CAP, 100PF, 50VDC, 5%, COG NPO SURF MT	5	C39 C44 C83 C158 C159
154110	CAPACITOR, 3.3NF, 50VDC, 5%, MLTILYR CER	1	C104
154111	CAPACITOR, .1uF, 16VDC, 5%, PPS FILM, 12	4	C7 C8 C11 C12
154112	CAPACITOR, .047UF, 16VDC,10%, X7R, SURFA	21	C57 C61 C65 C66 C69 C70 C73 C74 C93 C121 C123 C138 C139 C140 C141 C142 C150 C151 C152 C153 C154
154116	CAPACITOR, 10UF, 35V, 20%, LOW ESR, D SI	15	C22 C80 C86 C90 C91 C97 C115 C117 C118 C120 C124 C125 C126 C127 C135
154118	CAP, 33PF, 50V, 5%, NPO, SURF MT	1	C59
180019	INDUCTOR, 100uH, 10%, 250mA DC, 1.6 OHM,	1	L3
180022	INDUCTOR, 10UH, 10%, SURFACE MOUNT	3	L7 L13 L15
180030	INDUC-CAP, 4700PF, 50V 2A3 TERM, SURF MT	5	L6 L10 L12 L16 L20
180035	FERRITE FILTER, 8 LINE, EMI SUPPRESSION,	1	L4
180045	INDUCTOR, 220UH, 20%, .53OHMS 15% DCR, S	2	L1 L2
180047	INDUCTOR, 50 OHMS 100MHZ 3A, 1206 STYLE,	8	L5 L8 L9 L11 L14 L17 L22 L23
180057	INDUCTOR, 22UH, 20%, .05 OHMS DCR, 2.6A,	1	L18
180067	FERRITE BEAD, 600 OHM, .2A, 1206 SIZE, S	1	L24
210070	CONN, 96 PIN, RCPT, STR, .1 SP, 3 ROW, P	1	J8
211411	CONN, PLUG, 4 PIN, PC MT,LOCKING, SQ POS	1	J6
211924	CONN, 9 PIN, RCPT, D-SUB,R ANG, W TABS,	3	J1 J2 J3

Part Nbr	Description	Quantity	Reference Designators
212136	CONN, 10 PIN, HDR, BD STKR, .1 SP, .375	1	J5
212307	CONN, 15 P, D-SUBMIN, RT ANG, W TABS, SO	1	J4
213413	CONN 40 PIN HEAD DIL .078S, SF MT	2	J7 J9
216029	TEST POINT, SPRG LOAD 475 DEG C MAX	6	TP10 TP19 TP22 TP34 TP43 TP44
230028	CRYSTAL, 7.3728 MHZ, 20PF, SURFACE MOUNT	1	Y1
280089	SPACER, NYLON HEX, 4-40 X3/8 L	2	
280261	PEM STANDOFF, .219 DIA X 3/8 L, 4-40 FEM	2	
284200	SCREW, 4-40 X 1/4, PHILLIPS PAN HD, STL	2	
470109	RESISTOR, 470K OHM, 1/2W,10%	1	R206
474172	RES, 10 OHM, 1/8W, 1%, SURF MT	1	R129
474193	RESISTOR, 8.87K OHM, 1/16W, 1%, 0603, SU	1	R136
474195	RESISTOR, 511K OHM, 1/16W, 1%, SURFACE M	7	R91 R98 R119 R145 R150 R151 R181
474197	RESISTOR, 49.9K OHM, 1/16W, 1%, SURFACE	2	R132 R188
474198	RESISTOR, 2.49K OHM, 1/16W, 1%, SURFACE	1	R190
474207	RESISTOR, 6.19K OHM, 1/16W, 1%, 0603 STY	2	R55 R62
474220	RES, 0 OHM, 1/4W, 5% 1206STYLE, SURF MT	2	R182 R204
474222	RES, 10 OHM, 1/16W, 0603 STYLE, SF MT	6	R15 R16 R37 R38 R39 R88
474223	RESISTOR, 49.9 OHM, 1/16W, 1%, 0603 STYL	4	R192 R193 R194 R195
474224	RESISTOR, 100 OHM, 1/16W,1%, 0603 STYLE,	13	R31 R32 R33 R43 R48 R86 R109 R162 R179 R186 R187 R191 R202
474225	RESISTOR, 499 OHM, 1/16W,1%, 0603 STYLE,	25	R44 R49 R66 R67 R68 R69 R72 R73 R74 R75 R81 R82 R83 R85 R90 R105 R165 R166 R167 R168 R169 R170 R171 R172 R178
474228	RESISTOR, 1.21K OHM, 1/16W, 1%, 0603 STY	1	R118
474229	RESISTOR, 2.05K OHM, 1/16W, 1%, 0603 STY	3	R106 R107 R121
474230	RESISTOR, 3.32K OHM, 1/16W, 1%, 0603 STY	1	R120
474233	RESISTOR, 10K OHM, 1/16W,1%, 0603 STYLE,	31	R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R17 R19 R22 R29 R34 R35 R36 R53 R71 R112 R126 R137 R138 R141 R142 R154 R160 R183 R189
474234	RESISTOR, 20.5K OHM, 1/16W, 0603 STYLE,	2	R18 R100

Part Nbr	Description	Quantity	Reference Designators
474235	RESISTOR, 24.9K OHM, 1/16W, 1%, 0603 STY	5	R51 R54 R59 R61 R135
474236	RESISTOR, 33.2K OHM, 1/16W, 1%, 0603 STY	5	R21 R56 R63 R108 R115
474238	RESISTOR, 37.4K OHM, 1/16W, 1%, 0603 STY	2	R113 R116
474239	RESISTOR, 75K OHM, 1/16W,1%, 0603 STYLE,	2	R130 R156
474240	RESISTOR, 100K OHM, 1/16W, 1%, 0603 STYL	22	R20 R30 R40 R41 R45 R46 R52 R60 R77 R78 R84 R87 R101 R104 R110 R122 R124 R128 R133 R134 R139 R148
474241	RESISTOR, 150K OHM, 1/16W, 1%, 0603 STYL	2	R26 R111
474242	RESISTOR, 249K OHM, 1/16W, 1%, 0603 STYL	7	R92 R96 R117 R146 R152 R196 R197
474244	RESISTOR, 750K OHM, 1/16W, 1%, 0603 STYL	2	R153 R163
474245	RESISTOR, 1M OHM, 1/16W, 1%, 0603 STYLE,	6	R27 R42 R47 R102 R149 R164
474247	RESISTOR, 10M OHM, 1/16W,5%, 0603 STYLE,	1	R99
474256	RESISTOR, ZERO OHM, 0603 STYLE, SURFACE	2	R200 R201
474257	RESISTOR, 1 OHM, .5 W, 1%, 2010 SIZE, SU	1	R144
474259	RESISTOR, 15k OHM, 1/16W,1%, 0603 STYLE,	1	R131
474260	RESISTOR, 121K OHM, 1/16W, 1%, O603 STYL	2	R95 R97
474265	RES, THK FLM, 1 OHM, 1/4W1% , 1206	1	R23
474302	RES,150 OHM, .33W,5% 1210SIZE,SF MT	1	R143
474305	RES, 470 OHM, .75W,5% 2010SIZE,SF MT	2	R103 R127
474306	RES, 26.7OHM, .33W,1% 1210SIZE, SF MT	1	R50
474307	RES, 3.32 OHM, .33W,1% 1210SIZE,SF MT	1	R57
474308	RES, 5.6 OHM, .33W, 5%, 1210, SMT	1	R64
474311	RES PACK, 51 OHM, .1W, 5 %, 8 ISOL RES,	1	RP9
474312	RES PK, 1K OHM, .1W, 5%, 16 PIN, DIP SMT	2	RP3 RP4
474316	RES PK, 100K, 15 RES W 16COM 16P SMT	3	RP6 RP7 RP8
474320	RESISTOR, 221K OHM, 1/16W, 1%, 0603, SUR	1	R147
474333	RESISTOR, 210K OHM, 1/16W, 1%, 0603 SIZE	1	R155
481036	DIODE, ZENER, 1N5366B, 39V, 5W, 5%	1	D23
481051	ZENER DIODE, 1N4737A, 7.5V, 1W, 5%, PC	1	D9
481546	DIODE, SWITCHING, BD914, SOT-23, SURFACE	5	D10 D11 D24 D28 D32
481547	DIODE, SCHOTTKY, BAT54, SOT-23 PACKAGE,	6	D1 D2 D4 D34 D36 D43
481548	DIODE, RECT, SIL. SURF MT	4	D25 D27 D29 D30
481549	DIODE, SCHOTTKY RECTIFIER, 1A, 40V, SURF	5	D6 D8 D21 D26 D33
481552	DIODE,SCHOTTKY, 40V,3A SF. MT	6	D35 D37 D38 D39 D40 D42

Part Nbr	Description	Quantity	Reference Designators
481555	DIODE, MMBD7000LT1, DUAL,SWITCHING, SURF	11	D5 D7 D12 D13 D14 D15 D16 D17 D18 D19 D20
481556	DIODE, DUAL SCHOTTY, COM CATH. SF.MT	1	D3
481557	DIODE, SCHOTTKY, 1A, 100V, SURF MT	2	D22 D31
483019	TRANS, PNP, SOT-23, SURF MT	1	Q21
484061	TRANS, MMBT2222ALTI, NPN,SOT23, SMT	5	Q11 Q16 Q22 Q23 Q24
484062	TRANSISTOR, MMBT2369LT1, NPN, SOT23, SMT	1	Q17
484541	V RGLTR, LM317LDR2, 1.2- 37VDC OUT, SOP8	1	IC11
484542	VOLTAGE REGULATOR, MC79L05ACD, -5V OUT,	1	IC56
484543	VOLTAGE REGULATOR, MC78L05ACD, +5V OUT,	1	IC38
484544	VOLTAGE REGULATOR, MC79L12ACD, -12V OUT,	1	IC53
484545	VOLTAGE REGULATOR, MC78L12ACD, +12V OUT,	1	IC52
484557	VOLT RGLR, LT1117CST-5, ++5V, 800mA L DR	1	IC27
484562	IC, LT1175CS8, SW RGLTR, 4A 100kHZ 5 LD	1	IC36
484563	VOLT RGLTR, LT1117CST, POS, 800mA, ADJ,	1	IC33
484565	IC, LT1170CQ, V RGLTR, 5ASW, 5 LEAD	1	IC34
484575	V RGLTR, 1.2V-37V, 150KHZTO-263, SMT	1	IC37
484576	V RGLTR, uPWR, LO DR W SHDWN, 5 PIN SMT	1	IC39
485532	TRANSISTOR, 2N7002T1, N-CHAN ENHAN MODE,	12	Q3 Q5 Q6 Q8 Q9 Q12 Q14 Q15 Q18 Q20 Q27 Q28
485541	TRANSISTOR, SI4947DY, MOSFET, DUAL P-CH	4	Q4 Q7 Q19 Q25
485543	TRANSISTOR, MOSFET, N-CHANNEL & P-CHANNEL	2	Q1 Q2
485546	TRANSISTOR, VN0605T, N-CHAN ENHANCEMENT	2	Q10 Q13
486313	IC, MC14066BD, QUAD ANLG SW, SMT	1	IC5
486314	IC, MC74HC541DW, OCTAL BUFFER/LINE DRVR-	1	IC44
486320	IC, SN74HC14D, HEX SCHMITT-TRIGGER INV,	2	IC15 IC45
486321	IC, SN74HC138D, 3-LINE TO8-LINE DECDR, S	2	IC43 IC46
486323	IC, SN74HC573ADW, 8 D LTCH W 3ST OUT SMT	2	IC41 IC42
486325	IC, MC14093BD, 4 2-IN NAND SCHM TRIG SMT	1	IC31
486326	IC, MC14013BD, DUAL D FLIP-FLOP, SURFACE	1	IC32
486340	IC, TLC2543CDW, 12 BIT A TO D CONV, 20 P	1	IC9
486346	IC, TC7SOOFTE85L, 2-IN NAND GATE, CMOS,	2	IC25 IC47
486363	IC QAD UNV ASNCH XCVR XMT68 PN SF MT	1	IC14
486364	IC 8 BIT A TO D CNV SER CONT 4 PIN SMT	1	IC20
486369	IC LT1134ACSW 4 RS232 DRVR, 5V, 24 P SMT	1	IC13
486481	IC, TLC5620CD, QUAD 8-B D-TO-A CNVRTR, 1	1	IC22
486781	IC, TL072CD, OP AMP, JFETIN, LOW NOISE,	1	IC12
486785	IC, LP339M, QUAD VOLTAGE COMPARATOR, ULT	1	IC35
486790	IC, TLE2022CD, DUAL OP AMPLIFIER, H SPEE	2	IC3 IC28
486796	IC, TLC2272CD, DUAL OP AMP, RAIL TO RAIL	1	IC4
486805	IC, LM393, DUAL V COMPAR ATOR, LOW PWR,	2	IC6 IC40
486813	IC, TLC2274AID QUAD FET AMP SMT 14 PIN	1	IC18
486821	IC, AD822AR, FET-IN OP AMP, L POWER, 8 P	1	IC8
486825	IC, LMC7101BIM5X, OP AMP,L PWR, RAIL-RAI	2	IC24 IC29
486828	IC, LT1460HCS3-2.5, UPOWER SERIES REF, 3	2	IC19 IC30
486831	IC PREC 2.5V REF 20MA MINOUT 8 PIN SMT	1	IC7

Part Nbr	Description	Quantity	Reference Designators
487100	IC, TC1426COA, DUAL MOSFET DRVR, INVERTI	1	IC10
487103	IC, TC4405COA, DUAL OD FET DRVR, NON-INV	1	IC2
487104	IC, TC4404COA, DUAL OD FET DRVR, INV, 1.	1	IC1
487142	IC, ANALOG SWITCH, SPST, NC, 5 PIN, S MN	2	IC54 IC55
487145	IC, OPTOCPLR, DL, LGC GT,V HI-SPD, 8 PIN	7	IC21 IC23 IC26 IC48 IC49 IC50 IC51
515085	FUSE W FUSEHOLDER, 2A, 125V, SLO-BLO, SU	2	F2 F3
515088	FUSE W FUSEHOLDER, 1/16A,125V, V FAST-AC	1	F1
515094	FUSE WITH FUSEHOLDER, 3A,125V, SLO-BLO,	2	F4 F5
515098	FUSE, RESETTABLE, .75A, 13.2 VDC, MINISM	2	F6 F7
608007	TUBING, HEAT SHRINK, 1/4 (6.4) DIA, BLAC	0	

11.5 2765-01 Analog Board Assy

Part Nbr	Description	Quantity	Reference Designators
154072	CAPACITOR, .1UF, 50V, 10%, X7R, CER CHIP	14	C26 C32 C33 C38 C71 C89 C92 C96 C105 C120 C127 C177 C185 C189
154103	CAP, .001UF, 50VDC, 10% X7R, SURF MT	9	C51 C63 C102 C153 C188 C75 C79 C113 C116
154104	CAPACITOR, .01UF, 50VDC, 10%, X7R, SURFA	63	C2 C4 C6 C9 C12 C14 C19 C20 C22 C23 C35 C39 C40 C45 C46 C47 C50 C52 C53 C56 C57 C64 C65 C74 C84 C86 C87 C93 C94 C95 C97 C98 C100 C103 C106 C107 C110 C114 C117 C118 C122 C123 C124 C132 C133 C142 C143 C144 C149 C151 C155 C157 C160 C165 C166 C168 C169 C174 C178 C179 C186 C187 C191
154105	CAPACITOR, 47PF, 50VDC, 5%, NPO, SURFACE	4	C48 C59 C140 C148
154106	CAP, 22PF, 50VDC, 5% NPO, SURF MT	6	C112 C115 C128 C129 C194 C195

154112	CAPACITOR, .047UF, 16VDC,10%, X7R, SURFA	42	C11 C21 C24 C25 C27 C28 C34 C37 C43 C70 C73 C76 C77 C78 C83 C91 C101 C104 C108 C109 C111 C121 C125 C126 C130 C131 C135 C137 C138 C139 C146 C152 C154 C156 C161 C163 C175 C176 C181 C190 C82 C119
180030	INDUC-CAP, 4700PF, 50V 2A3 TERM, SURF MT	5	L4 L5 L6 L7 L10
180056	FERRITE BEAD, 120 OHMS 100MHZ, 0603 ST	4	L8 L9 L11 L12
474197	RESISTOR, 49.9K OHM, 1/16W, 1%, SURFACE	18	R23 R24 R28 R37 R39 R42 R55 R56 R58 R70 R71 R115 R149 R169 R203 R207 R225 R227
474233	RESISTOR, 10K OHM, 1/16W,1%, 0603 STYLE,	19	R1 R2 R6 R26 R27 R72 R82 R91 R92 R101 R102 R117 R120 R163 R201 R205 R218 R220 R245
474240	RESISTOR, 100K OHM, 1/16W, 1%, 0603 STYL	44	R12 R13 R18 R25 R34 R36 R40 R68 R77 R81 R93 R99 R105 R109 R114 R118 R139 R151 R158 R159 R175 R177 R180 R182 R183 R186 R187 R189 R191 R194 R196 R199 R202 R204 R206 R209 R221 R226 R228 R229 R230 R231 R232 R244
474256	RESISTOR, ZERO OHM, 0603 STYLE, SURFACE	5	R20 R237 R238 R239 R243
484061	TRANS, MMBT2222ALTI, NPN,SOT23, SMT	2	Q8 Q10
485540	MOSFET,SI9945D, DUAL N CHSO-8, SMT	3	Q4 Q5 Q6
486855	IC, LF353M, DUAL OP AMP, JFET IN, WIDE B	0	IC34 IC36
475051	POT, 10K OHM, 10%, T ADJ,M-TURN, SMT	2	VR2 VR4

474224	RESISTOR, 100 OHM, 1/16W,1%, 0603 STYLE,	27	R29 R43 R78 R79 R86 R87 R88 R95 R97 R100 R106 R107 R113 R116 R121 R126 R132 R133 R135 R140 R148 R160 R170 R171 R172 R173 R215
474227	RESISTOR, 1K OHM, 1/16W, 1%, 0603 STYLE,	23	R50 R51 R53 R59 R60 R63 R64 R65 R67 R76 R98 R103 R104 R112 R128 R147 R150 R176 R181 R188 R192 R222 R223
474225	RESISTOR, 499 OHM, 1/16W,1%, 0603 STYLE,	3	R52 R66 R131
9269-01	SPO2 CONN BRKT ASSY, 7300- NICO	1	J4
9270-16	FL CONN, RCPT, 3 PT, 7300- NICO	1	J5
9974-32	PN BAR CODE LABEL	1	
152096	CAPACITOR, 220UF, 35V, 20%, ELCTLT, 8X10	5	C164 C167 C170 C171 C180
153012	CAPACITOR, 22pF, 100V, 2%, .1 SP, METAL	4	C196 C197 C198 C199
154079	CAP, 10UF, 25V, 20%, TANT, L ESR .6 OHM	11	C13 C18 C29 C30 C58 C66 C72 C99 C172 C173 C184
154086	CAPACITOR, 4.7UF, 10VDC, 20%, TANTALUM,	2	C5 C8
154108	CAP, 100PF, 50VDC, 5%, COG NPO SURF MT	2	C44 C54
154111	CAPACITOR, .1uF, 16VDC, 5%, PPS FILM, 12	8	C49 C60 C61 C68 C81 C145 C147 C162
154116	CAPACITOR, 10UF, 35V, 20%, LOW ESR, D SI	7	C3 C10 C15 C16 C17 C31 C183
154137	CAPACITOR, .0047uF, 50VDC,5%, 1210 SIZE,	2	C36 C42
154139	CAPACITOR, .047uF, 5%, 16VDC, 1206 SIZE,	1	C85
154143	CAPACITOR, .01uF, 50VDC, 5%, 1210 STYLE,	6	C41 C55 C62 C67 C69 C182
154145	CAP, .1uF, 16V, 10%, 0603SIZE, SURF MNT	10	C1 C7 C80 C88 C134 C136 C141 C150 C158 C159
9024-10	PNEUMATIC JUNCTION BOX, FOUR-WAY	2	
9272-16	SEAL FL CONN, 7300 - NICO	1	
180034	FERRITE FILTER, 4 LIN, EMI SUPPRESSION,	1	L2
180035	FERRITE FILTER, 8 LINE, EMI SUPPRESSION,	2	L3 L1
9328-16	SUPPORT, XDUCER, 7300 - NICO	2	
211327	CONNECTOR, 3 PIN, HEADER,STR, .1 SP, FRI	1	J6

212501	CONNECTOR, 20 PIN, HEADER, DUAL ROW, STR	1	J2
213414	CONN 40 PIN HDR ELEV SHRD.078 SP SF MT	2	J1 J3
216029	TEST POINT, SPRG LOAD 475 DEG C MAX	16	TP8 TP10 TP13 TP16 TP19 TP24 TP30 TP34 TP38 TP40 TP43 TP44 TP45 TP63 TP65 TP66
250146	VALVE, SOLENOID, 5V, 0-30PSIG, 10 PSID M	4	V5 V6 V1 V2
250151	VALVE, SOLENOID, 5V, 0-30PSIG, 10 PSID M	2	V3 V4
2769-01	DIFF PRESSURE XDCR BD ASSY, 7300	1	
9779-33	ASSY PROC, EPOXY MIXING	0	
474157	RESISTOR, 511 OHM, 1/8W, 1%, SURFACE MOU	4	R178 R184 R190 R195
474175	RESISTOR, 3.92K OHM, 1/8W, 1%, SURFACE M	2	R145 R167
474194	RESISTOR, 2.2M OHM, 1/16W, 5%, SURFACE M	2	R35 R41
474195	RESISTOR, 511K OHM, 1/16W, 1%, SURFACE M	1	R153
474198	RESISTOR, 2.49K OHM, 1/16W, 1%, SURFACE	2	R110 R165
474222	RES, 10 OHM, 1/16W, 0603 STYLE, SF MT	20	R4 R5 R7 R17 R94 R136 R137 R138 R143 R146 R152 R154 R157 R162 R168 R224 R21 R233 R234 R235
474223	RESISTOR, 49.9 OHM, 1/16W, 1%, 0603 STYL	8	R3 R8 R9 R10 R11 R15 R16 R19
474228	RESISTOR, 1.21K OHM, 1/16W, 1%, 0603 STY	1	R210
474229	RESISTOR, 2.05K OHM, 1/16W, 1%, 0603 STY	1	R156
474230	RESISTOR, 3.32K OHM, 1/16W, 1%, 0603 STY	2	R47 R32
474234	RESISTOR, 20.5K OHM, 1/16W, 0603 STYLE,	2	R46 R31
474235	RESISTOR, 24.9K OHM, 1/16W, 1%, 0603 STY	8	R73 R164 R213 R214 R22 R30 R44 R45
474236	RESISTOR, 33.2K OHM, 1/16W, 1%, 0603 STY	2	R33 R38
474238	RESISTOR, 37.4K OHM, 1/16W, 1%, 0603 STY	1	R49
474239	RESISTOR, 75K OHM, 1/16W,1%, 0603 STYLE,	8	R89 R90 R123 R127 R129 R134 R216 R217
474241	RESISTOR, 150K OHM, 1/16W, 1%, 0603 STYL	9	R84 R125 R130 R141 R144 R166 R197 R211 R212
474242	RESISTOR, 249K OHM, 1/16W, 1%, 0603 STYL	5	R48 R108 R155 R161 R174
474245	RESISTOR, 1M OHM, 1/16W, 1%, 0603 STYLE,	7	R54 R69 R179 R185 R193 R198 R208
474251	RESISTOR, 61.9K OHM, 1/16W, 1%, 0603 STY	1	R142
474259	RESISTOR, 15k OHM, 1/16W,1%, 0603 STYLE,	4	R62 R75 R111 R124

474261	RESISTOR, 7.5K OHM, 1/16W, 1%, 0603 STYL	3	R57 R61 R74
474265	RES, THK FLM, 1 OHM, 1/4W1% , 1206	1	R219
474310	RES PK,10K OHM, 4 ISO RES8 PIN DIP SMT	1	RP3
474316	RES PK, 100K, 15 RES W 16COM 16P SMT	1	RP2
474331	RESISTOR, 332 OHM, 1/16W,1%, 0603, SURFA	1	R119
474342	RES, 143 OHM, 1/16W, 1% 0603, SMT	1	R83
474343	RES, 374 OHM, 1/16W, 1%, 0603 SMT	1	R85
474344	RES 715 OHM 1/16W 1% 0603 SMT	1	R122
475042	POT, 50K OHM, 10%, T ADJ,M-TURN, SMT	1	VR5
475053	POTENTIOMETER, 200 OHM, 10%, T ADJ, MLTI	2	VR1 VR3
481546	DIODE, SWITCHING, BD914, SOT-23, SURFACE	1	D25
481547	DIODE, SCHOTTKY, BAT54, SOT-23 PACKAGE,	5	D12 D14 D35 D32 D37
481548	DIODE, RECT, SIL. SURF MT	3	D1 D2 D3
481555	DIODE, MMBD7000LT1, DUAL,SWITCHING, SURF	25	D4 D5 D6 D7 D8 D9 D10 D11 D13 D15 D19 D20 D21 D22 D23 D24 D26 D27 D28 D29 D30 D31 D33 D34 D36
481556	DIODE, DUAL SCHOTTY, COM CATH. SF.MT	2	D16 D18
483019	TRANS, PNP, SOT-23, SURF MT	1	Q9
484540	VOLTAGE REGULATOR, LP2951CM, POSITIVE, A	1	IC45
484542	VOLTAGE REGULATOR, MC79L05ACD, -5V OUT,	1	IC7
484543	VOLTAGE REGULATOR, MC78L05ACD, +5V OUT,	1	IC6
484544	VOLTAGE REGULATOR, MC79L12ACD, -12V OUT,	1	IC3
484545	VOLTAGE REGULATOR, MC78L12ACD, +12V OUT,	2	IC49 IC50
485532	TRANSISTOR, 2N7002T1, N-CHAN ENHAN MODE,	3	Q1 Q2 Q3
485543	TRANSISTOR, MOSFET, N-CHANNEL & P-CHANNE	1	Q7
486042	IC, AT93C66-10SC, SERIAL 4K EEPROM, 8 PI	1	IC5
486314	IC, MC74HC541DW, OCTAL BUFFER/LINE DRVR-	1	IC51
486324	IC, DG444DY, QUAD SPST CMOS ANALOG SW, S	1	IC35
486332	IC, AD7703BR, 20-BIT A TOD CONVERTER, SU	2	IC33 IC37
486340	IC, TLC2543CDW, 12 BIT A TO D CONV, 20 P	1	IC4
486362	IC 20 BIT A TO D CONV W SER OUT 20 P SMT	1	IC25
486481	IC, TLC5620CD, QUAD 8-B D-TO-A CNVRTR, 1	1	IC26
486785	IC, LP339M, QUAD VOLTAGE COMPARATOR, ULT	2	IC40 IC10
486790	IC, TLE2022CD, DUAL OP AMPLIFIER, H SPEE	4	IC12 IC15 IC16 IC38
486796	IC, TLC2272CD, DUAL OP AMP, RAIL TO RAIL	4	IC8 IC9 IC22 IC46
486805	IC, LM393, DUAL V COMPAR ATOR, LOW PWR,	1	IC44
486807	IC, SMP04ES, QUAD SAMPLE & HOLD AMP, 16	1	IC13
486821	IC, AD822AR, FET-IN OP AMP, L POWER, 8 P	4	IC2 IC11 IC20 IC30
486825	IC, LMC7101BIM5X, OP AMP,L PWR, RAIL-RAI	1	IC48
486829	IC, LTC1590CS, DUAL 12-BIT X D TO A CONV	1	IC14
486831	IC PREC 2.5V REF 20MA MINOUT 8 PIN SMT	1	IC1
486832	IC, PREC 5V REF LOW NOISE8 PIN SMT	1	IC19
486833	IC,4-INPUT & OUTPUT OP AMP 14 PIN SMT	1	IC21

487115	IC, INSTR AMP, LOW POWER,8 PIN, SURFACE	4	IC27 IC31 IC23 IC28
487124	IC, ERT-3281, REFLECT SENSOR	4	IC39 IC41 IC42 IC43
487129	IC, CPC15AFH, ABSOLUTE PRESSURE SNSR, 15	1	IC29
487136	IC, PRESSURE XDCR, 0-5 PSIG, 1 PORT, SIP	1	IC32
605103	WIRE, 24AWG, STRANDED, BLACK	0	
160030	TUBING, .062 ID X .125 OD+/-.006, CLR, E	0	
160038	SOLVENT,50% CYCLOHEXANONE& 50% TETRAHYDR	0	
250109	FITTING, TEE, FOR 1/16 IDTUBING, WHITE,	2	
250134	FITTING, Y, FOR 1/16 ID TUBING, WHITE, N	2	
250164	FITTING, PRESS-IN PLUG, F1/16 ID TUBING,	1	
250169	FILTER, INLINE, 25 MICRON, FOR 1/8 IN. I	4	
250171	CHECK VALVE, NC, .7 OD, .825 L, .140 IN	2	
281211	SCREW, NO. 2 X 1/4 L, SELF TAPPING, TYPE	0	
284008	SCR, 4-24 X 5/16L, PAN HD, PHIL, THD FOR	0	
608129	TUBING, ESTER-BASED POLTHN, 3/16 OD X 1/	0	
606400	WIRE, BUSS, 22AWG	0	
608008	TEFLON TUBING	0	
161110	EPOXY, 2 PART (1/1), FLEXIBLE, GRAY	0	
487078	IC, AD712JR, DUAL BIFET OP AMPLIFIER, SU	2	IC34 IC36

11.6 2766-01 CO_2 Input Board Assy

Part No.	Description	Quantity	Reference Designator
600055	RIBBON CABLE ASSY, 20 PIN	1	J301
212527	CONNECTOR, 20 PIN, RECEPT	1	J302
9974-32	PN BARCODE LABEL	1	-
9822-01	GROUND WIRE ASSY	1	E1
153063	CAPACITOR, 22PF, 3KV	2	C1, C2

11.7 9392-01 Pump W Rsvr Assy

Part No.	Description	Quantity
9322-01	RESERVOIR ASSY	1
9397-10	MOUNTING PL, PUMP, 7300	1
161108	FOAM TAPE, 1/32THK x 3/4W	0
211328	CONNECTOR, 3 PIN, RCPT	1
250130	PUMP, DIAPHRAGM, 4.5V	1
250169	FILTER, INLINE, 25 MICRON	1
280192	GROMMET, RIBBED, ISODAMP	2
284009	SCREW, 4-24 X 1/4L, PAN HD	0
605001	WIRE, 28AWG, RED, TINNED	0
605007	WIRE, 28AWG, BLACK, TINNED	0
608001	CABLE TIE, .094 X 3.62L	0
608005	TUBING, HEAT SHRINK, 1/16	0
608012	CABLE TIE, SELF-LKG, .094	1
608114	TUBING, TYGON, 3/32 IN	0

11.8 1023208 Speaker Assembly

Part No.	Description	Quantity
130023	SPEAKER, 28MM DIA, 1W	1
211413	CONNECTOR, 4 PIN RECEPTACLE, 22AWG	1
605156	WIRE, #22 7/30 HOOKUP WIRE	0
608001	CABLE TIE, SELF-LKG, 0.94	2

11.9 Translations

Language	Monitor P/N	Printed Façade (10)	Rear Panel Label Set (12)	Top Cover Label (9)	User's Manual (11)
Danish	1024840	1025395	1025303	1025385	1024816
Dutch	1024841	1025396	1025304	1025386	1024817
Finnish	1024842	1025397	1025355	1025387	1024815
French	1024927	1025398	1025356	1025388	1024819
German	1024928	1025399	1025357	1025389	1024820
Italian	1024929	1025400	1025358	1025390	1024821
Norwegian	1024930	1025401	1025359	1025391	1024815
Portuguese	1024931	1025402	1025360	1025392	1024823
Spanish	1024932	1025403	1025361	1025393	1024824
Swedish	1024933	1025404	1025362	1025394	1024825

12 Test Fixtures

This section documents the test fixtures used in testing the Model 7600.

12.1 5776-48 TB1265 Adapter Cable

Purpose: Aid connection of old-style TB1265 CO_2 Test Box to the front panel receptacle on the $NICO_2$ monitor.

Parts list:

7156-10	20pin connector
7153-16	Strain relief ring
7154-16	Connector ring
7157-16	Connector housing, lower
7158-16	Connector housing, upper
2766-01	Input connector board

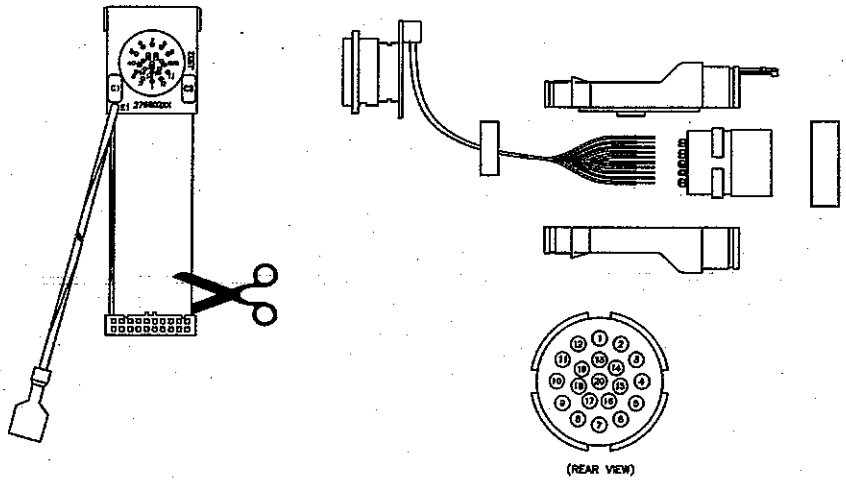
Assembly

1. Cut the header connector from the ribbon cable on the 2766-01 input connector board.
2. Separate, strip and tin each of the ribbon cable wires.
3. Slide the 7153-16 strain relief over the ribbon cable, then solder each of the ribbon cable wires to the 20 pin connector as indicated below. The stripe on the ribbon cable designates pin one. Ensure a good solder connection and no shorting between pins.

Ribbon cable	20 pin connector
1	4
2	6
3	18
4	20
5	15
6	19
7	10
8	17
9	7

Ribbon cable	20 pin connector
10	3
11	11
12	9
13	14
14	12
15	16
16	8
17	13
18	5
19	1
20	2

4. Assemble the 20 pin connector by placing the 7157-16 lower and 7158-16 upper housings together over the 20 pin connector. Snap the 7154-16 connector ring into place, and then the 7153-16 strain relief ring.



12.2 5693-48 Current Limit Test Jack

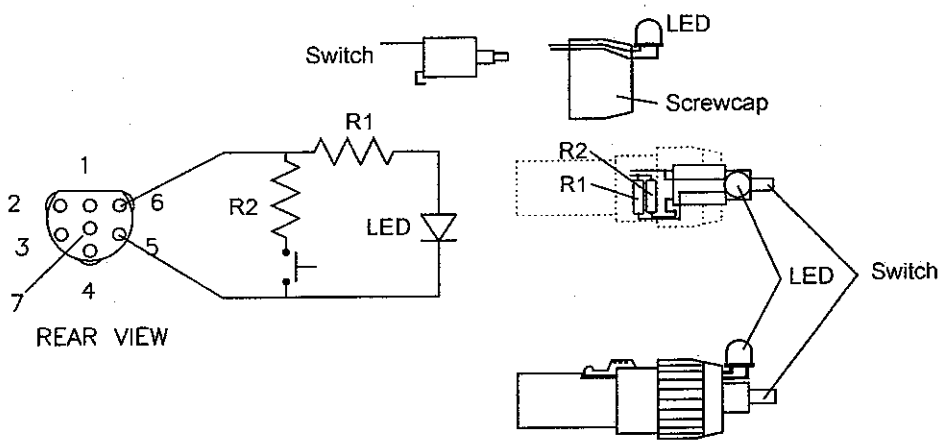
Purpose: Tests the SpO_2 LED drive safety cutoff operation.

Parts list:

472261	Resistor 33.2 ohm, 1/4 W, 1%
472028	Resistor 220 ohm, 1/4W, 1%
482500	LED, red
511031	Switch, momentary, SPST, normally open
211705	Connector assembly, 7 pin male

Assembly:

1. Bend one lead of the switch as shown. Solder the other lead of the switch to pin 5 of the connector.
2. Solder one end of R2 to the bent pin of the switch, solder the other end to pin 6 on the connector.
3. Bend the leads of the LED to match the contour of the screw cap. Place the LED leads through the screw cap. Solder one lead of R1 to pin 6 of the connector, solder the other lead to the LEDs anode. Solder the cathode of the LED to pin 5 of the connector.
4. Assemble the connector, ensure no shorts. The switch and LED should exit the rear of the connector after the screw cap is set in place. The connector collet is not needed and can be discarded.



12.3 6573-48 Shorted Saturation Test Jack

Purpose: Test the SpO_2 LED drive safety cutoff operation.

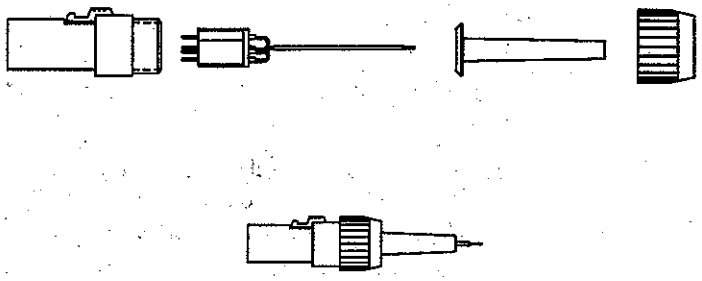
Parts list:

211705	Connector assembly
-	18 gauge stranded wire

Assembly:

1. Solder all of the pins on the connector assembly together. Strip and tin a 5" piece of wire and solder one end to the shorted pins.

2. Assemble the connector, the wire should exit the rear of the connector assembly.



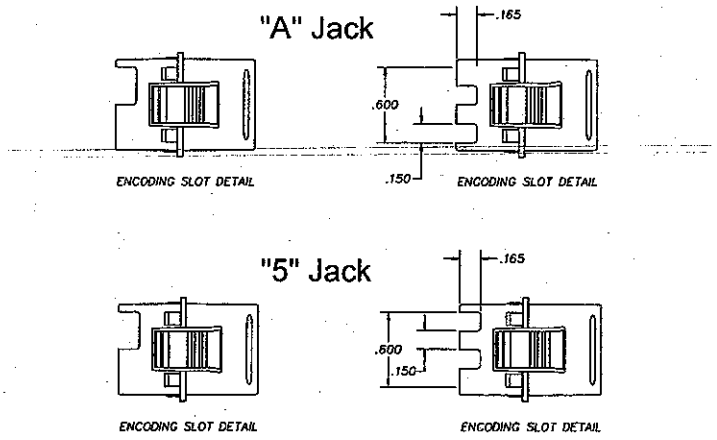
12.4 9635-14, 9635-48 Optical Encoder Test Jacks

Purpose: Verify the operation of the NICO monitor flow sensor detection hardware.

Parts list:

9271-89	3 port connector Qty: 2
Solvent 50/50/Cyclohexanone	

1. The encoding section of the connector needs to be modified by cutting a portion of the plastic from the connector and reattaching it in a specific location. The left illustration in each case is the original connector, the right illustration portrays the necessary modifications.



12.5 9637-48 Analog Loopback Test Fixture

Purpose: Connect the four analog output channels to the four analog input channels for the purpose of testing each channel.

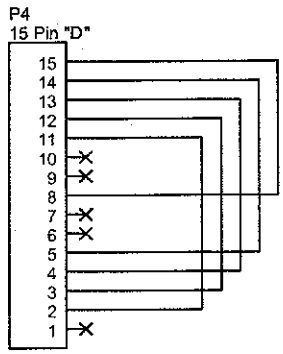
Parts List:

Part Number	Description
212306	Connector, 15 Pin, Male, 'D'

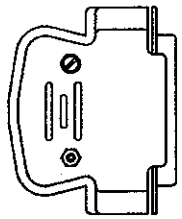
608021	Connector, 15 Pin, Shell, 'D'
606402	Wire, Buss, 26 AWG

Assembly:

1. Cut five (5) 1/2 inch lengths of the buss wire (PN: 606402)
2. Bend each of the wires so that there is an approximate 3/16 inch radius centered on the wire.
3. Using the bent wires, reference the schematic and short the appropriate 15 pin connector (PN: 212306) pins together and solder the wires in place.



4. Place the 15 pin connector into one half of the connector shell (PN: 608021).
5. Place the other half of the connector shell on top of the 15 pin connector.
6. Using the screws and hex nuts, part of the connector shell kit, secure the connector shell together. Note: Discard all remaining pieces of the connector shell kit.



12.6 9639-48 RS232 Loopback Test Fixture

Purpose: Connect the transmit data output to the receive data input on the serial port for the purposes of testing.

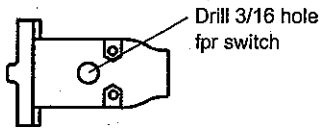
Parts List:

Part Number	Description
211907	Connector, 9 Pin, Male, 'D'
512003	Switch, SPDT, Toggle
605059	Wire, Stranded, 26 AWG, Black

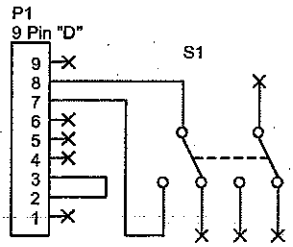
606402	Wire, Buss, 26 AWG
608082	Connector, 9 Pin, Shell, 'D'

Assembly:

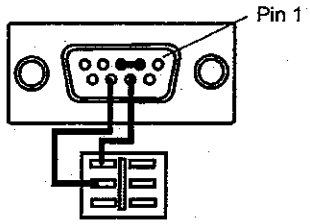
1. Cut a 1/2 inch lengths of the buss wire (PN: 606402).
2. Bend the wire so that there is an approximate 3/16 inch radius centered on the wire.
3. Cut two (2) 1-3/4 inch lengths of wire (PN: 605059).
4. Strip and tin both ends of each wire approximately 1/8 inch.
5. Drill a 3/16 inch diameter hole in one of the connector shell halves (PN: 608082). Centrally locate the center of the hole approximately 1-1/16 inch from the strain relief end.



6. Using the bent buss wire, short pin 2 and 3 on the 9 pin connector (PN: 211907). Solder the buss wire in place.

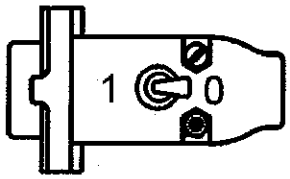


7. Solder the end of one of the stranded wires to pin 7 on the 9 pin connector.
8. Solder the end of the other stranded wire to pin 8 on the 9 pin connector.
9. Solder the other end of the stranded wire that is soldered to pin 7 on the 9 pin connector to the outer pin on the switch (PN: 512003) as shown.



10. Solder the other end of the stranded wire that is soldered to pin 8 on the 9 pin connector to the wiper (center pin) on the switch that is adjacent to the pin that the other wire is soldered to.
11. Slip the shaft of the switch through the hole that was drilled in the connector shell half.

12. Using the lock washer and hex nut that come with the switch, secure the switch to the connector shell half. Align the switch so that the soldered wires are facing the strain relief end of the connector shell.
13. Place the 9 pin connector into the shell half. Position the wires so that they are inside the shell half.
14. Place the other half of the connector shell on top of the 9 pin connector.
15. Using the screws and hex nuts, part of the connector shell kit, secure the connector shell together. Note: Discard all remaining pieces of the connector shell kit.
16. Permanently mark the part number (PN: 9639-48) on the test fixture.
17. Permanently mark the closed switch position as "1" on the test fixture.
18. Permanently mark the open switch position as "0" on the test fixture.



12.7 9633-48 Leak Test Adapter Test Fixture

Purpose: Provide an interface between the monitor and the leak tester.

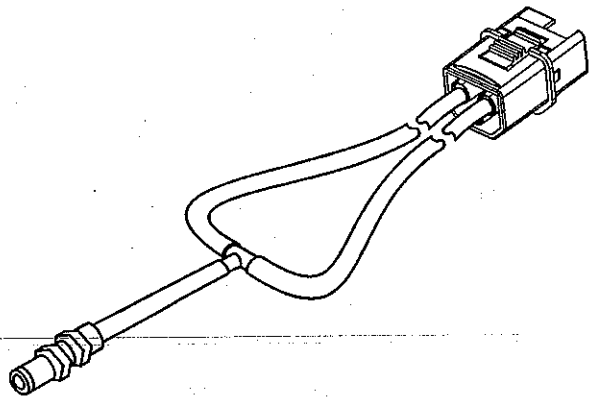
Parts List:

Part Number	Description
9156-10	Tubing, Triple Line, (2) 3/32 ID x 5/32 OD , (1) 1/16 ID x 1/8 OD
9271-89	Connector, Plug, Standard Adult, NICO Sensor
160038	Solvent, Mixture, 50% Cyclohexanone & 50% Tetrahydrofuran
250072	Pneumatic Connector, Quick Disconnect, Plug
250144	Fitting, Tee, 3/32 inch Tubing

Assembly:

1. Cut an approximate 20.0 inch length of the triple line tubing (PN: 9156-10)
2. Separate and discard the 1/16 inch ID tube from the triple line tubing.
3. Cut the 20.0 inch length in half to create two dual tube lengths that are approximately 10.0 inch long.
4. On one of the two dual tube lengths, split apart the two tubes 1 inch up from the end (both sides).
5. On the other dual tube length, separate the two tubes. Discard one of the two tubes created.

6. Dip the end of one of the two separated tubes into the 50:50 mix of THF/ Cyclohexanone (PN: 160038) to a minimum depth of 1/2 inch for 4 seconds.
7. Blot the end of the tube on an absorbent towel to draw the solvent out of the tubing bore.
8. Insert the tube into one of the NICO sensor ports on the NICO sensor connector (PN: 9271-89). Note: Hold the tubing into connector port for a minimum of 4 seconds.
9. Repeat steps 4.2.1 through 4.2.3 for the remaining tube and NICO sensor connector port.
10. Allow the solvent bond to cure for a minimum of 12 hours. Note: Do not test or excessively handle the assembly during the cure time.
11. Connect the barb on the quick disconnect plug to one end of the separate 3/32 inch tubing.
12. Connect the other end of the separate 3/32 inch tubing to the center barb on the tee.
13. Connect each of the 3/32 inch tubes that were solvent bonded to the sensor connector to one of the 3/32 inch barbs on the tee.
14. Using a permanent marker, write "9633-48" on the side of the flow sensor connector.



12.8 9634-48 Battery Charger Test Fixture

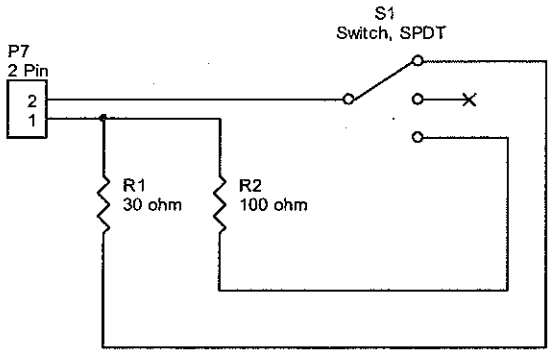
Purpose: Simulate battery load conditions for testing the battery charger circuit.

Parts List:

Part Number	Description
211215	Connector, 2 Pin, Housing, IDC
474023	Resistor, 100 Ohm, 1 Watt
474047	Resistor, 30 Ohm, 3 Watt
512005	Switch, SPDT, 3 Position
605059	Wire, 26 AWG, Black

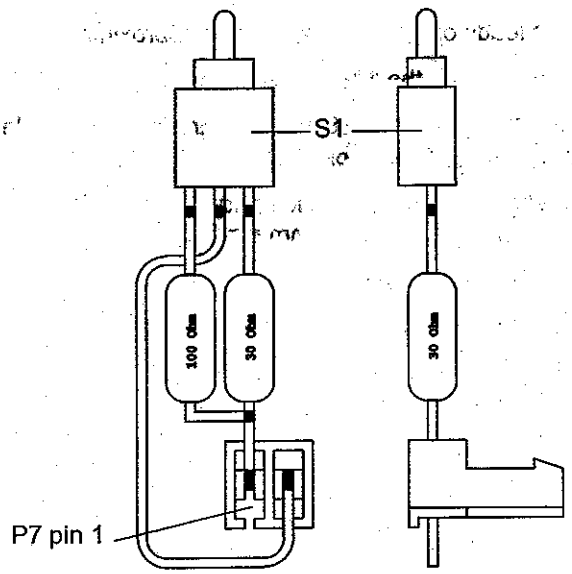
Assembly:

1. Cut a 1-1/2 inch length of the black wire (PN: 605059)
2. Strip and tin both ends of the wire approximately 1/8 inch from the end.
3. Cut the leads on the 30 ohm resistor approximately 1/4 inch from the resistor body.
4. Cut the leads on the 100 ohm resistor approximately 1/4 inch from the resistor body
5. Bend one lead on the 100 ohm resistor at a right angle. Note: Make the bend as close as possible to the resistor body
6. Place the resistors side by side and bend the right angled lead on the 100 ohm resistor around one lead of the 30 ohm resistor.
7. Solder the leads together.
8. Solder this lead to the contact for pin 2 on the IDC connector. Note: Orient the resistor so that it is on the side of the IDC connector that shows the pin numbers.



9. Solder the other lead of each resistor to the outer two contacts on the switch.
10. Solder one end of the black wire to the center contact on the switch.
11. Solder the other end of the black wire to the contact for pin 1 on the IDC connector.

12. Permanently mark the part number (PN: 9634-48) on the test fixture. Mark the switch positions on the switch to indicate which resistor is connected at each position.



13 Drawings

Number	Title
1024839DWG	$NICO_2$® Model 7600 (1 sheet)
1024045MC4	Overall Wiring Diagram (1 sheet)
1024045DWG	Main Assembly, Model 7600 (6 sheets)
2783-01	Digital Board Assy (2 sheets)
2783-03	Schematic, Digital Bd (3 sheets)
2784-01	Power Board Assy (2 sheets)
2784-03	Schematic, Power Board (6 sheets)
2765-01	Analog Board Assy (3 sheets)
2765-03	Schematic, Analog Board (5 sheets)
2766-01	CO_2 Input Board Assy (1 sheet)
2766-03	Schematic, CO_2 Input Board (1 sheet)
2776B-01	MARS DSP Board Assy (1 sheet)
2776B-03	Schematic, MARS DSP Board (2 sheet)
9488-01	Bottom Cover Assy (1 sheet)

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