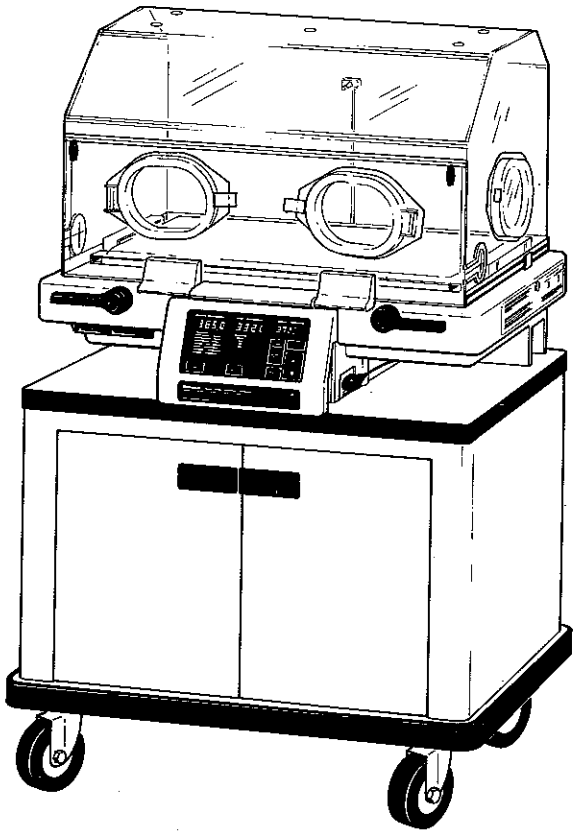
Ohmeda

Care Plus® Incubator
Service Manual



Ohmeda
Service Manual

Care Plus Incubator

6/28/88

Important

The information contained in this service manual pertains only to those models of products which are marketed by Ohmeda as of the effective date of this manual or the latest revision thereof. This service manual was prepared for exclusive use by Ohmeda service personnel in light of their training and experience as well as the availability to them of parts, proper tools and test equipment. Consequently, Ohmeda provides this service manual to its customers purely as a business convenience and for the customer's general information only without warranty of the results with respect to any application of such information. Furthermore, because of the wide variety of circumstances under which maintenance and repair activities may be performed and the unique nature of each individual's own experience, capacity, and qualifications, the fact that customer has received such information from Ohmeda does not imply in anyway that Ohmeda deems said individual to be qualified to perform any such maintenance or repair service. Moreover, it should not be assumed that every acceptable test and safety procedure or method, precaution, tool, equipment or device is referred to within, or that abnormal or unusual circumstances, may not warrant or suggest different or additional procedures or requirements.

This manual is subject to periodic review, update and revision. Customers are cautioned to obtain and consult the latest revision before undertaking any service of the equipment. Comments and suggestions on this manual are invited from our customers. Send your comments and suggestions to the Manager of Service Education, Ohmeda, Ohmeda Drive, Madison, Wisconsin 53707.

CAUTION: Servicing of this product in accordance with this service manual should never be undertaken in the absence of proper tools, test equipment and the most recent revision to this service manual which is clearly and thoroughly understood.

This static control precaution symbol appears throughout this manual. When this symbol appears next to a procedure in this manual, static control precautions MUST be observed. Use the static control work station (Stock No. 0175-2311-000) to help ensure that static charges are safely conducted to ground and not through static sensitive devices.

Technical Competence

The procedures described in this service manual should be performed by trained and authorized personnel only. Maintenance should only be undertaken by competent individuals who have a general knowledge of and experience with devices of this nature. No repairs should ever be undertaken or attempted by anyone not having such qualifications.

Genuine replacement parts manufactured or sold by Ohmeda must be used for all repairs.

Read completely through each step in every procedure before starting the procedure; any exceptions may result in a failure to properly and safely complete the attempted procedure.

Definitions

Note: A note provides additional information to clarify a point in the text.

Important: An Important statement is similar to a note, but is used for greater emphasis.

CAUTION: A CAUTION statement is used when the possibility of damage to the equipment exists.

WARNING: A WARNING statement is used when the possibility of injury to the patient or the operator exists.

Air Control Mode: Manual mode of operation. The interior incubator temperature is maintained at the air control temperature.

Desired Environmental Temperature (DET): The air temperature required to maintain the infant's temperature at the patient control temperature (patient control mode).

Incubator Temperature: The air temperature measured at a point 10 cm above the mattress.

Patient Control Mode: Servo mode of operation. The incubator changes the DET to maintain the desired patient skin temperature.

Patient Probe: The Ohio patient temperature probe, model LA003.

Temperature Rise Time: The time required for the incubator temperature to rise 10 C at ambient temperatures without water in the humidifier.

Temperature Equilibrium: The condition where the average incubator temperature does not vary by more than 0.2 C in a one hour period.

Temperature Variability: The maximum difference between the incubator temperature and the average incubator temperature at equilibrium.

Temperature Overshoot: The number of degrees by which the average incubator temperature exceeds the average incubator temperature at temperature equilibrium following a change in the air control temperature (air control mode).

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⚠ Warnings

Two people are required to lift the Care Plus Incubator. Follow safe lifting techniques to avoid injury.

If the mounting knobs that attach the incubator to the cabinet are not securely fastened, the incubator could tip off of the cabinet when the hood is opened.

After completing any portion of the calibration and adjustment procedures for the Care Plus Incubator, perform the Checkout Procedure to make sure that the unit is operating correctly. In addition a final electrical safety check and leakage current test must be performed. Record the information for future reference.

Disconnect the power to the incubator for the mechanical portion of the Checkout Procedure.

Use extreme care while performing calibration and adjustment procedures, or while working on the Care Plus Incubator with power connected. An electrical shock hazard does exist; be certain to observe all standard safety precautions.

Before any disassembly or repair, disconnect the electrical supply and any gas supply connections. Also remove any accessories. Do not perform any service or maintenance with the power applied unless specifically told to do so in the procedure.

After completing a repair of the Care Plus, the appropriate calibration procedure must be performed to make sure the Care Plus is in proper operating condition. In addition, a final electrical safety check and leakage current test must be performed. Record the information for future reference.

If a system failure alarm occurs, the unit must be removed from use until it has been serviced.

Disconnect power to the incubator and allow the heater to cool for at least 15 minutes before servicing or cleaning to avoid the danger of a burn.

Never oil or grease oxygen equipment unless a lubricant that is made and approved for this type of service is used. Oils and grease oxidize readily, and in the presence of oxygen, will burn violently. Vac Kote (R) is the oxygen service lubricant recommended (Stock No. 0220-0091-300).

Two people are required to safely replace a caster. Remove the incubator and all accessory equipment from the cabinet before replacing a caster.

(R) Vac Kote is a Registered trademark of Ball Brothers Corp.

⚠ Cautions

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Use the Static Control Work Station (Stock No. 0175-2311-000) to help ensure that static charges are safely conducted to ground. The Velostat material is conductive. Do not place electrically powered circuit boards on it.

When handling the controller, avoid bumping the fan or the heater. If these items are knocked out of alignment, the fan can grate against either the heater or the base.

Insulation on the electrical wiring can deteriorate with age. When performing the Checkout Procedure, check for brittle or deteriorated insulation on the power cord.

Inner wall fasteners are permanently attached to the inner wall and cannot be removed without damaging them.

Make sure the control board connectors are properly aligned before applying power.

If early model heaters are not installed with the nuts on the inside of the controller and the screws on the outside, water can leak in during cleaning and damage the electronics.

If gaskets are not installed properly, water can leak in during cleaning and damage the electronics.

The incubator control circuitry is located inside the removable controller. The controller interfaces with the operator through the LEDs and switches on the display board, mounted behind the control panel.

The major portion of the control logic, switch interpretation, and power supply generation occurs on the control board. Three external thermistor assemblies supply a total of five temperature signals to the control board.

The patient temperature probe attaches to the patient and plugs into the jack located on the left side of the controller. It contains one thermistor and outputs the patient temperature signal, which is used to generate the patient temperature display and to adjust heater output in the patient control mode.

The air temperature sensor mounts on the hood inside the infant compartment and attaches with the air temperature sensor connector, located on the left side of the controller. It contains two separate thermistor circuits: the air control thermistor signal is used by the control circuitry to adjust heater output and to trigger alarms; the air display thermistor signal is used by the control circuitry to generate the front panel air temperature display. The air display signal is also input to an independent air safety circuit, which shuts down the heater if the signal exceeds preset temperature safety limits.

The air flow sensor is mounted on the rear bulkhead of the controller and is used to verify that the heater fan is working. The air flow sensor contains two thermistor circuits, one of which is heated by a resistor inside the sensor assembly. Normally, the fan cools the heated thermistor to within several degrees of the unheated thermistor. If the fan fails to operate properly, the temperature difference between the unheated and the heated thermistors increases and triggers the air circulation alarm.

Note: Comparing the two thermistor readings cancels out any changes in room temperature. This means that air flow sensor operation is independent of ambient temperature within the operational range.

A separate thermal switch, mounted on the rear of the controller, shuts down the heater if the heater temperature (monitored at the thermal switch) exceeds 76.7 C (170 F).

1.1 Control Board

The control board contains the incubator logic circuitry, diagramed in Figure 1-1, page 1-3, as well as the power supply and distribution circuitry, diagramed in Figure 1-2, page 1-4.

The board centers around U19, the 8032 microcontroller. The microcontroller interfaces with its peripherals through three I/O expanders on the data bus. Analog signals are multiplexed to the Analog to Digital Converter (ADC), and the results of the conversion are read in through I/O expander U15. The microcontroller communicates with the air safety circuit, the watchdog timer, and the alarm tone generator through a second I/O expander, U17. A third I/O

expander, located on the display board (U2), interfaces with the control panel touch switches and displays. As indicated in Figure 1-1, the heater control, the air safety, the watchdog timer, and the alarm circuits generate feedback signals to the microcontroller.

The program memory is stored in EPROM U16. A transparent octal latch connected to the EPROM address lines (A_0 through A_7) allows the microcontroller's bi-directional data bus port to both address the EPROM and then read out programmed data.

The power supply circuitry produces regulated low voltage dc supplies for the control circuitry and the display board. It also generates two monitoring signals used to compensate heater output for fluctuations in line voltage and to detect power failure. In the event of a power failure, a NI-CAD battery inside the controller supplies the power failure alarm and maintains the standby control memory for up to 10 minutes (with the battery fully charged).

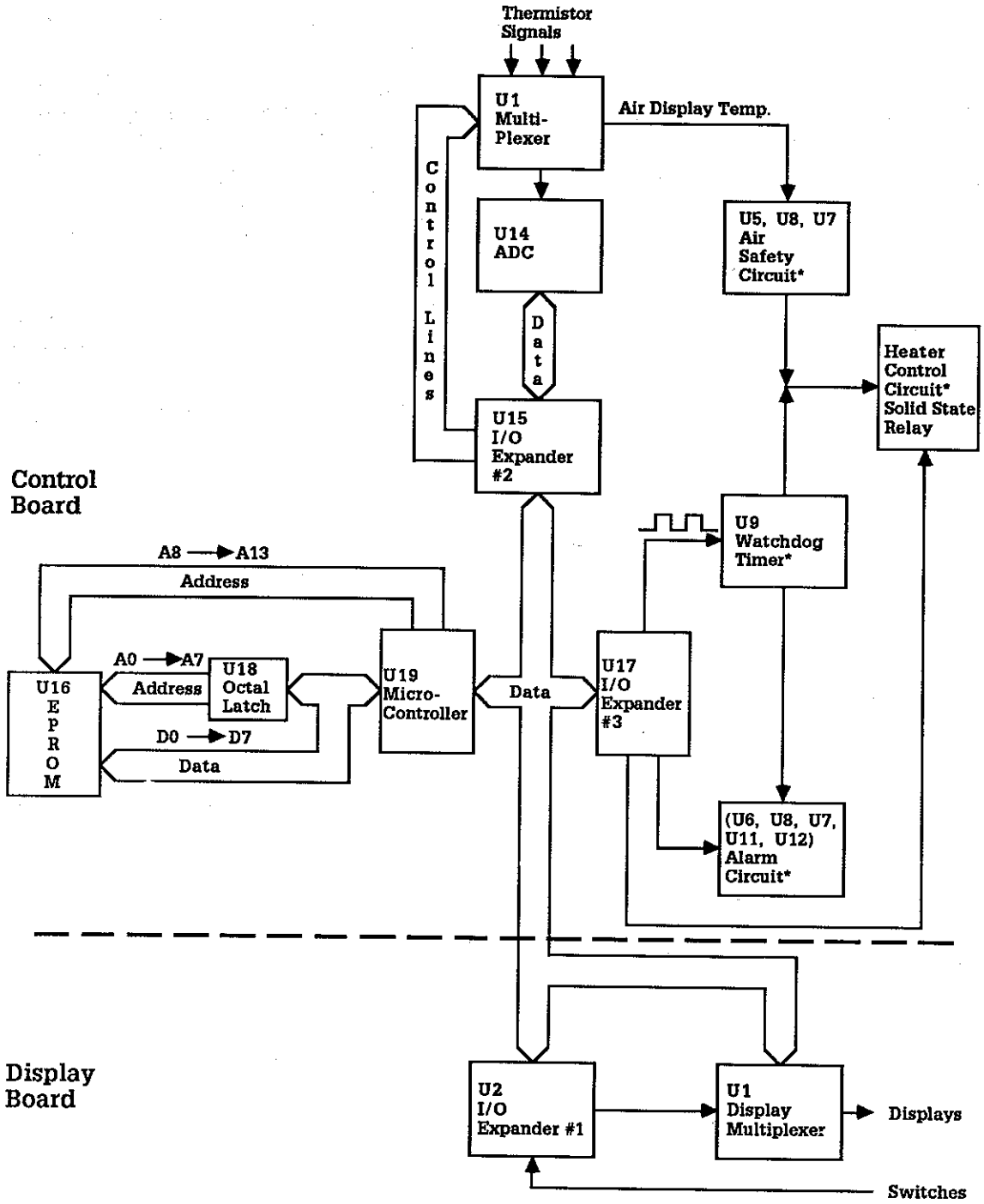


Figure 1-1 Control Circuitry Block Diagram

*** Circuit produces feedback signal to microcontroller.**

A. Power Supply Circuitry

The power supplies and power monitoring signals are generated as shown in Figure 1-2. The line frequency signal pulse that detects power failures, the +8 V unregulated supply to the heater control circuit safety relay, and the +5 V display supply to the display board are derived from the 8 Vac transformer secondaries. The line voltage signal, which adjusts the number of heater power cycles to compensate for voltage fluctuations; the 9.8 Vdc supply, used to heat the heated air flow sensor thermistor and to charge the battery; and the +5 V standby supply, used to power control board circuitry are derived from the 11 Vac transformer secondaries. Signals that can be adjusted as part of the calibration procedure are indicated in Figure 1-2.

During a power failure a NI-CAD battery supplies two voltage levels (+5 V STBY and +9 VSTBY). The +9 VSTBY supply (actual voltage approximately 7 Vdc) activates the alarms, and the 5 volt supply powers the microcontroller and the associated integrated circuits.

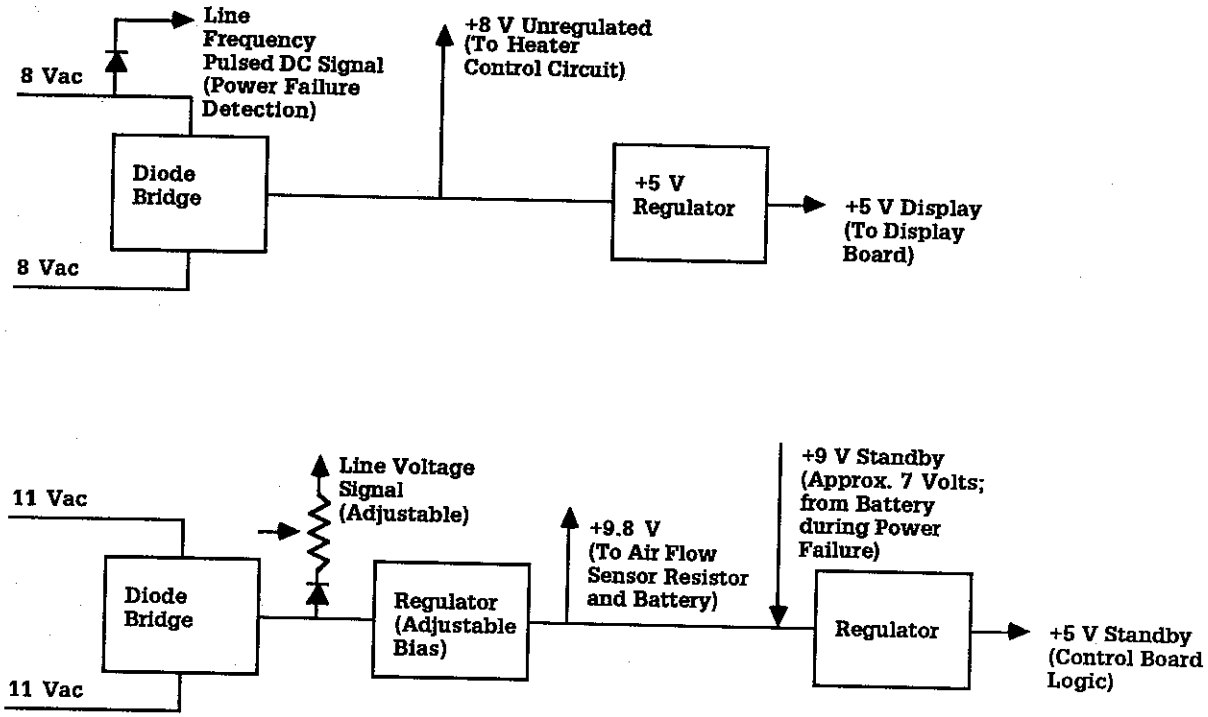


Figure 1-2 Power Supply Circuitry

1. Line Frequency, +8 Volt Unregulated and +5 Volt Display Supplies

A nominal 8 Vac from the line voltage transformer secondary is input to the power supply board at J2 pins 2 and 3.

This signal is conditioned by CR1 and R14, and fed through a 1K resistor to a Schmitt trigger NAND gate, U7B. The other gate input is tied high, so the gate acts as an inverter. The gate will not respond until the input exceeds 1.9 Vdc minimally. The resulting signal pulse, INT0, is input to the microcontroller on P3.2. Absence of this signal is interpreted as a power failure.

Bridge rectifier CR2 and capacitor C3 provide a filtered, unregulated +8 Vdc, which supplies the opto-isolator controlling the heater control circuit's safety relay, and the +5 volt regulator (VR2). The unregulated +8 volt supply can be measured at TP1-5.

Regulator VR2 outputs a nominal +5 Vdc to power the display board LEDs. This output can be measured at J3 pin 12, 13 or TP1-3. When the line voltage is within 10% of the nominal voltage, the regulator output should range between 4.8 and 5.2 Vdc with a load of 500 ma. The maximum allowable ripple voltage is 150 mV.

2. Line Voltage Signal, +9.8 Volt, and +9 Volt and +5 Volt Standby Supplies

A nominal 11 Vac from the transformer secondary is input to the control board at J2 pins 4 and 5. Bridge rectifier CR3 and capacitor C4 provide a full wave, unregulated voltage of approximately +12 Vdc.

This voltage is applied to resistor R19 to produce the line voltage monitoring signal. The line voltage signal is input to the ADC through the multiplexer (U1). The digital output is sent to the microcontroller where it adjusts heater power cycling to compensate for line voltage changes. When the incubator is operating at the rated voltage and R19 is properly adjusted, a reading of approximately 700 mV can be measured at U1 pin 15 (TP1-2).

The nominal +12 volt supply is also applied to regulator VR1 to produce the 9.8 volt supply. Regulator output can be calibrated using R20. When R20 is properly adjusted, a reading of 9.8 +/- 0.1 Vdc can be measured at TP1-1. This voltage is used for charging the NI-CAD battery through R18, and for supplying the resistor used to heat the heated air flow sensor thermistor. It also supplies +5 volt standby regulator, VR3.

When line voltage is available, current flows from the output of VR1 through CR10 to supply 9.0 volts at the input of VR3, (TP1-6). In turn, regulator VR3 outputs a voltage of 5.0 +/- 0.2 Vdc to the control circuitry (TP1-4). The maximum allowable ripple voltage is 150 mV.

When power loss occurs, the 7.2 volt NI-CAD battery maintains power to control board regulator VR3 through CR11. The output of VR3 powers the incubator logic circuits and will remain at +5.0 +/- 0.2 Vdc until the input to the regulator drops below +7.0 Vdc. When the input voltage falls below +7.0 Vdc,

the regulator output (+5 Vdc supply) may not be within the allowed tolerance (+/-0.2 Vdc). The battery's + 9 standby output also supplies approximately +7 Vdc to the alarm speaker.

B. Analog to Digital Converter

The analog to digital conversion circuit shown in the Figure 1-1 block diagram, page 1-3, has three separate sections: the Analog to Digital Converter (ADC); a multiplexer used to select converter input; and a reference voltage generator.

1. Analog to Digital Converter (ADC)

The ADC, U14, operates asynchronously, continuously converting analog voltage inputs into a number of counts between 0 and 3999 (BCD format). The conversion rate is set by an internal oscillator whose frequency is determined by the external components R67 and C37. The exact oscillator frequency is not critical and may vary by +/- 15% from the nominal 400 kHz. The oscillator frequency can be measured on pin 18 of U14. With a nominal 400 kHz clock frequency, conversions within the ADC 3711 will take place at an approximate rate of three per second.

The ADC communicates with the microcontroller through I/O expander U15. The ADC data latch is permanently enabled by tying pin 19 (DLE) low. The start conversion and the conversion complete signals synchronize the data conversion, which proceeds as follows:

1. The microcontroller's start conversion pulse triggers a new conversion, prematurely ending any conversion in progress.

2. The conversion complete output goes low on the falling edge of the start conversion pulse. It returns to a high level when the ADC completes the conversion. The low to high transition prompts the microcontroller to read the ADC output.

3. The first set of data, from the prematurely terminated cycle, is discarded since there is no way to determine if it represents an entire conversion.

4. The microcontroller waits until the new conversion cycle has been completed.

5. The data is read by the microcontroller, converted to temperatures or voltage percentages, and stored in RAM.

The BCD data is output on binary data lines, (bit 1 to bit 8, pins 23, 24, 3, and 4 respectively) in accordance with the coded digit select signals applied to the ADC digit select inputs (D0 and D1, pins 20 and 21 respectively). The digit select codes are summarized below:

D0	D1	Selected Digit
L	L	Digit 0 (LSD)
L	H	Digit 1
H	L	Digit 2
H	H	Digit 3 (MSD)

2. Analog Inputs

Important: The information on voltage input levels given in this section and in the appendices is approximate. It is based on an offset voltage of 1.99 Vdc measured at TP2-4 and will vary with the actual offset voltage.

Analog voltage signals are directed to the ADC inputs through an eight channel analog multiplexer, U1. Multiplexer switch selection is software controlled by the microcontroller, which toggles the A, B, and C input lines of the multiplexer through I/O expander U15.

CONTROL INPUT					
A	B	C	SWITCH	PIN NO.	SIGNAL
0	0	0	X0	13	CAL LOW
0	0	1	X1	14	CAL HIGH
0	1	0	X2	15	LINE COMP
0	1	1	X3	12	AIR FLOW UNHEATED
1	0	0	X4	01	PATIENT
1	0	1	X5	05	AIR DISPLAY
1	1	0	X6	02	AIR CONTROL
1	1	1	X7	04	AIR FLOW HEATED

Note: The MUX inhibit terminal (pin 6) is connected to I/O expander #2, U15, and is used to disable U1 in favor of a second 4051B analog switch. The second switch is not currently installed, but may be added for future applications.

The ADC has three separate input ranges. The first input range involves the line voltage monitoring signal produced by the power circuitry and used to compensate for fluctuations in line voltage. R19 adjusts the signal level, which ranges from approximately 630 to 770 mV for line voltages between 90% and 110% of the nominal input.

≅ADC Input	≅ADC Counts	Percent of Nominal Voltage
630 mV	1600	90% (Lowest voltage that can be compensated)
700 mV	2000	100%
770 mV	2400	110% (Highest voltage that can be compensated)

≅ ADC input voltages and counts are approximate values for general reference only.

The second input range includes: the patient temperature, the air control temperature, the air display temperature, and the ADC high and low calibration test signals. All five channels have a 5.76 kOhm resistor in series between the signal and a 1 volt reference supply. On the three temperature channels, the signal source is a thermistor that produces ADC inputs of between 920 and 410 mV for temperatures between 0 and 50 C. A partial list of approximate ADC inputs follows:

Thermistor Temperature	Equivalent Resistance	≅ ADC Counts	≅ ADC Input Voltage
20 C	12,526 Ohm	2240	740 mV
25 C	10,000 Ohm	1920	690 mV
30 C	8,036 Ohm	1590	640 mV
35 C	6,500 Ohm	1260	580 mV
40 C	5,289 Ohm	930	520 mV

≅ ADC input voltages and counts are approximate values for general reference only.

The remaining two channels use precision resistors to produce ADC input signals of approximately 690 mV for cal low, and approximately 540 mV for cal high. When the ADC is properly calibrated, these readings correspond to temperatures of 25.05 C +/- 0.3 C for cal low and 37.96 +/- 0.3 C for cal high.

Signal	Resistor	≅ Voltage	≅ ADC Counts	Temperature
Cal Low	R8, 10 kOhm	690 mV	1922	25 C
Cal High	R5, 5.76 kOhm	540 mV	1059	38 C

≅ ADC input voltages and counts are approximate values for general reference only.

The third input range is used for the two air flow thermistors. A 750 Ohm resistor in series between each thermistor and the 1 volt supply produces ADC inputs between 1,040 mV and 360 mV for temperatures between 12 and 120 C. A partial list of approximate ADC inputs follows:

Thermistor Temperature	Equivalent Resistance	≅ ADC Counts	≅ ADC Input Voltage
20 C	12,526 Ohms	3892	1020 mV
50 C	3,563 Ohms	3143	890 mV
100 C	662 Ohms	868	510 mV

≅ ADC input voltages and counts are approximate values for general reference only.

3. Reference Voltage

The LM-10 combination op-amp and voltage reference circuit (U13A and B) uses its 200 mV internal reference source to supply two reference voltages. The buffer portion of the LM-10, U13B, supplies a fixed, nominal 1 volt reference to the ADC input circuits. This is amplified by the op-amp portion of the LM-10 to provide an adjustable, nominal 2 volt reference to the ADC. During ADC calibration, the level of the 2 volt reference is adjusted using R25.

The nominal 1 volt supply should give a reading of about 1.1 Vdc at TP2-3. The nominal 2 volt ADC reference should give a reading of about 2.2 Vdc at TP2-4. The exact readings may vary between units.

C. Microcontroller

The heart of the control system is the 8032 microcontroller U19. It has been configured to operate from external memory by grounding the EA line, pin 31. The clock speed is 6 MHz and can be verified by measuring a frequency of 1 MHz at the Address Latch Enable (ALE), pin 30, (ON = 0.33 usec and OFF = 0.67 usec).

1. EPROM Read

Port 0 and port 2 are used to to read instructions from EPROM U16 (27128A). Port 2 outputs the high level address bits (8 bits) directly to U16, while port 0 serves as a multiplexed lower level address (8 bits) and data bus.

At the start of the read, all address bits are output simultaneously. On the falling edge of the ALE signal, the lower eight address bits are latched into a transparent octal data latch, U18, and port 0 is set to input mode. Then, the program store enable signal (PSEN) goes low to enable data transfer from the EPROM.

2. Peripheral Interface

Port 1 goes directly to three 8243 I/O expanders. Bits 5-7 are connected to the chip select lines of display board expander U2 (bit 5), and control board expanders U15 (bit 6) and U17 (bit 7). Only one of the I/O expanders can be enabled at a time. Bits 0-3 hold the instructions to be carried out by the enabled integrated circuit when bit 4 goes from a high to a low logic level.

3. Miscellaneous Functions

Port 3 performs several miscellaneous tasks required by the control system: it provides a serial interface for manufacturing testing; monitors the presence or absence of line power; checks the status of the watchdog timer; and sends data and clock signals to the display board driver.

The serial interface consists of the microcontroller transmit line (TXD/P3.1), the receive line (RXD/P3.0), a +5 Volt Standby connection and a connection to logic ground. These lines are all connected to J6 to allow factory testing.

$\overline{\text{INT0}}$/P3.2 is the line frequency signal pulse, which is derived from the +8 Vac nominal supply (discussed in Section A, Power Supply Circuitry). Absence of the line frequency signal pulse is used to detect a power failure.

$\overline{\text{INT1}}$/P3.3 monitors the status of the watchdog timer and the two unused address bits.

T0/P3.4 sends serial data to the display driver, U1 (display board), while T1/P3.5 clocks the driver.

D. Heater Control

The heater control algorithm ensures that line voltage variations will not affect the heater output so long as the voltage remains between 90 and 110% of the nominal voltage (115 volts for 120 volt units). For voltages outside this range, the line voltage is assumed to be either 90 or 110% depending on the violated limit.

Heater output is controlled by varying the number of ac cycles delivered to the heater. Depending on the line voltage and the percentage of the maximum heater output necessary to maintain the required temperature, between 0 and 60 cycles will be delivered to the heater every second. When the line voltage is within 10% (90% to 110%) of the nominal voltage, the number of heater power cycles is calculated proportionately:

$$\text{Number of cycles} = 50 \times \frac{(\text{rated voltage})^2}{(\text{line voltage})^2} \times (\text{required \% max. heater output})$$

If the line voltage is less than or equal to 90% of the nominal voltage, the number of cycles is calculated by multiplying the percentage of the maximum heater output required by 60. For example, at 90% of the nominal voltage, the heater would be on for 60 cycles out of 60 when 100% of the maximum heater output

was required. Above 110% of the rated voltage, the number of cycles is calculated by multiplying the percentage of maximum heater output by 40.

The heater control routine is independent of line frequency.

1. Heater Control Circuit

As shown in Figure 1-3, the heater control circuit consists of a safety relay, a solid state relay, and a thermal switch wired in series. The heater is normally switched ON and OFF by closing or opening the heater neutral.

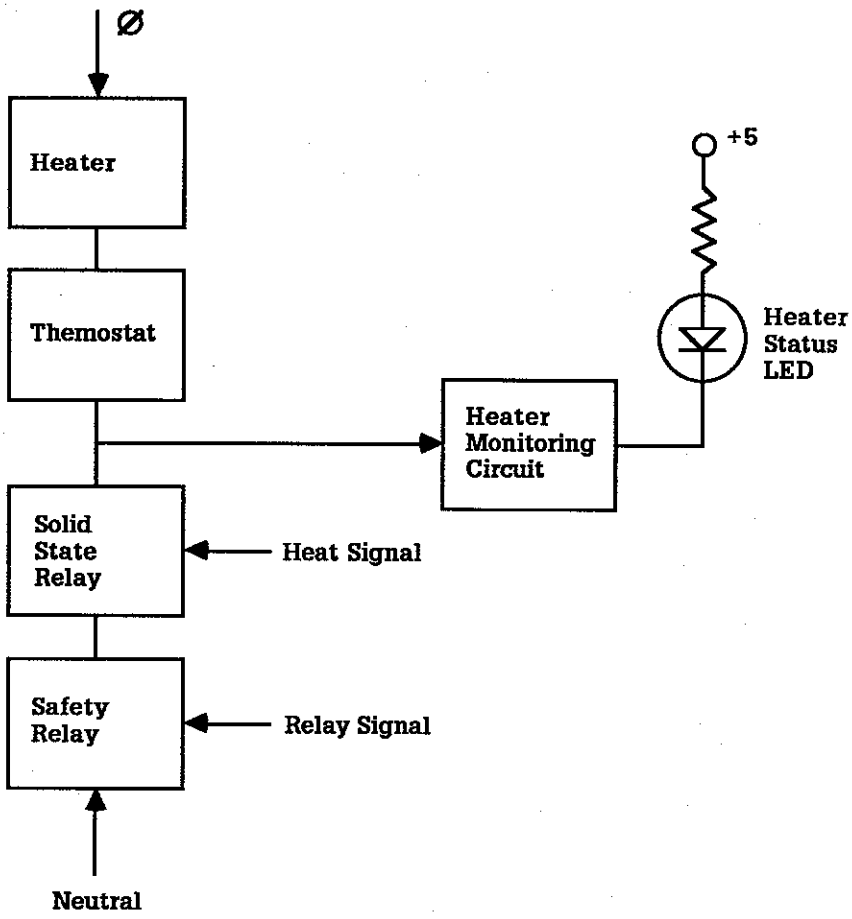


Figure 1-3 Heater Control and Monitoring Circuits

Safety Relay

The safety relay, K1, is controlled by the Relay signal, which is produced by gating the outputs of the air safety circuit and the watchdog timer circuit. The safety relay shuts down the heater if the watchdog timer fails to receive clock pulses, if the air probe shorts or opens, or if the air temperature exceeds the preset limit. An opto-isolator triac driver, U4, isolates the low voltage and the line voltage circuits.

Under normal conditions, the Relay signal is high (+2.4 Vdc minimum). This switches ON FET U12B, causing the relay coil to energize and close the contacts.

Note: This requires a minimum 7.32 Vdc from the unregulated +8 volt supply (TP1-5).

If the air safety circuit or the watchdog timer trigger an alarm, the Relay signal goes low (0.5 Vdc Maximum), switching OFF the FET and opening the safety relay contacts.

Solid State Relay

When the safety relay is closed, the solid state relay switches the heater ON and OFF under microcontroller control.

The microcontroller switches ON the heater by setting the Heat signal (U15 pin 21; P5.3) high. This switches ON U12A connecting the solid state relay neutral line to neutral and activating the zero crossing detection circuit inside the relay. Because this circuit switches ON or OFF only at zero voltage there may, in practice, be up to a half cycle switching delay.

Thermal Switch

The thermal switch is mounted on the rear of the controller, near the heating element, and is set to open if its temperature exceeds 76.7 C (170 F). The thermal switch self resets (closes) when it has cooled.

2. Heater Monitoring Circuit

Note: Heater status is monitored before the thermal switch. Hence when the thermal switch is open, the feedback from the monitoring circuit still indicates that the heater is ON.

The heater monitoring circuit outputs the heater status signal to the microcontroller through I/O expander U17. When the heater is ON, the heater status signal is low. As a diagnostic aid, a heater status LED on the control board illuminates whenever the heater is ON.

The heater status signal is derived from a portion of the heater ac signal input to CR13. When the heater is OFF, the dc output from CR13 powers opto-isolator U3 and sets the U7A NAND gate input low. The NAND gate output goes high, and the heater status LED goes out.

When the heater is ON, there is no voltage potential across CR13, and the opto-isolator is not powered. The second NAND gate input is tied high, so the gate output goes low, and the heater status LED illuminates.

Note: Every half cycle the output U3 pin 4 will show small glitches caused by the charge/discharge of capacitor C20. These glitches do not affect circuit performance unless they exceed U7's (74LS132) trigger voltage of 1.4 Vdc.

E. Watchdog Timer

A watchdog timer circuit checks that the microcontroller is working properly. After every cycle through the system software, the microcontroller sends a low pulse to the A input of U9A, a retriggerable monostable timer (74LS123). This causes the output (Q) to go high and the inverted output ($\overline{Q}$) to go low for a period of time determined by the time constant of the RC network on the RxCx and Cx pins (Tau = 0.45 x R x C = 0.23 Sec). If another pulse from the microcontroller is not received at the A input before the time constant expires, both outputs change logic levels. The output,(Q), goes low and is gated by NAND gate U7D and NOR gate U8 to produce a logic low Relay signal. This de-energizes the safety relay and shuts down the heater. The inverted output,($\overline{Q}$), sets the Reset pin on timer U6A high, triggering the high priority audio alarm. The inverted output, ($\overline{Q}$), is also gated through NOR gate U8C to produce the logic low interrupt signal that begins the microcontroller software recovery routine ($\overline{INT1}$).

F. Alarm Tone Generator

The alarm circuit consists of an alarm tone generator and control circuitry for high or low priority alarm conditions. Frequencies for the tone generator are produced by two timer circuits, U6A and U6B. If no alarm is present, the reset pins on both timers are held low and no signal is produced.

1. High Priority Alarms

Two timers are cascaded to generate the high priority audio alarm. They can be triggered either by the microcontroller through I/O expander U17 or by the watchdog timer. NOR gate U8B checks the output of both circuits. If either signal goes high, the reset pins for both timers go high. This causes U6B to generate a 2 kHz signal. A 1 Hz signal from the second timer (U6A) pulses the control line of the first timer through R35. This alters the frequency of the first timer (U6B) to produce a warbling effect (two tone alternating alarm).

U7C gates the output of NOR gate U8B with the low priority alarm line. This ensures that the high priority alarm will override the low priority alarm when both are active.

2. Low Priority Alarms

The low priority alarm is triggered by a 1 Hz pulse from the microcontroller through I/O expander U17. Before the command is executed, NAND gate U7C checks the low priority alarm signal against the output of NOR gate U8B to make sure that a high priority alarm is not already in effect. If no high priority alarm is active, (U7C pin 5 high), the reset line on timer U6B is pulsed once a second, producing a pulsed, 2 kHz signal (TP2-1). This results in a one second on, one second off (i.e. 2 kHz) audio alarm. The 2 kHz signal is adjusted to +/-100 Hz by

R36. The volume of the audio alarm is adjusted by R37. For maximum volume, R37 should be adjusted fully counterclockwise.

G. Air Safety Circuit

The air safety circuit opens the safety relay to shut down the heater if the air temperature exceeds the preset safety limit, or if a short or open circuit is detected in the air temperature sensor. The air safety circuit is completely independent of the microcontroller and has two subcircuits: the air probe test circuit, which monitors the air display signal to detect a short or open circuit; and the high air temperature circuit, which monitors the air display signal to detect high temperatures.

1. Air Probe Test Circuit

Important: The information on voltage input levels given in this section and in the appendices is approximate. It is based on an offset voltage of 1.99 Vdc measured at TP2-4 and will vary with the actual offset voltage.

The $\overline{SO}$ signal output by this circuit goes low when the air display thermistor circuit is open or shorted. Air display signals that exceed 880 mV (approximately equivalent to 25.69 kOhm, or 5 C) are interpreted as open circuits. Signals that fall below 410 mV (approximately equivalent to 35.63 kOhm, or 50 C) are interpreted as short circuits.

The air display signal is input in parallel to two open collector comparators U5B and U5C, which feature high impedance output under normal conditions. If the air display thermistor opens, comparator U5C's output pulls $\overline{SO}$ low. If the air display thermistor shorts, comparator U5B's output pulls $\overline{SO}$ low.

The $\overline{SO}$ signal is gated by the relay circuit to produce the Relay signal. A logic low $\overline{SO}$ signal causes the Relay signal to go low, opening the safety relay to shut down the heater. The $\overline{SO}$ signal (TP2-5) is also fed back to the microcontroller through I/O expander U17, pin 1 (P5.0) for alarm generation.

2. High Air Temperature Circuit

Important: The information on voltage input levels given in this section and in the appendices is approximate. It is based on an offset voltage of 1.99 Vdc measured at TP2-4 and will vary with the actual offset voltage.

Comparator U5A compares the air display signal to a reference voltage supplied by one of five resistor networks. Each network corresponds to a different temperature limit. They are connected to the comparator through multiplexer U10. Microcontroller signals applied through I/O expander U17 select the appropriate network based on the mode of operation and the control temperature. If the air display thermistor voltage signal is less than the reference voltage, comparator output, OT (TP2-6), floats high and is gated through U8A to produce a logic low Relay signal, which opens the safety relay to shut down the heater.

The OT signal (TP2-6) is also fed back to the microcontroller through I/O expander U17, pin 23 (P5.1).

Maximum temperatures and the corresponding voltages are shown below.

Mode	Control Temperature	Alarm Temperature	Approx. Voltage	Resistance
Air Control	< 37 C	38 C	540 mV	5,731 Ohm
Air Control	> 37 C	40 C	520 mV	5,270 Ohm
Patient	All	40 C	520 mV	5,270 Ohm

Important: Control board dip switches 1 and 2 must both be set to OFF for the high air temperature circuit to function.

Note: The alarm has about 1 C hysteresis before resetting.

H. Relay Circuit

The relay circuit produces the Relay signal, which directly controls the heater safety relay. The relay circuit and all the signals used by the circuit are independent of the microcontroller.

The relay circuit consists of two gates: NAND gate U7D gates the output of the watchdog timer and the air probe test circuit signal ($\overline{SO}$); NOR gate U8A gates the NAND output with the OT signal to produce the Relay signal. The Relay signal goes low, opening the safety relay to shut down the heater if: the $\overline{SO}$ signal goes low; the OT signal goes high; or the watchdog timer output goes low.

1.2 Display Board

The display board is the interface between the operator and the control system. It informs the operator about the incubator and patient status. The operator controls the system by depressing the various switches on the front display. Two integrated circuits simplify display board operation: the 8243 I/O expander, used in conjunction with the switches; and the MM5451 LED driver for the displays.

A. Switch Decoding

Signals pass between the microcontroller and the display board through I/O expander U2, at a rate of approximately 1 MHz. The I/O port is activated by a logic low on the chip select line ($\overline{CS1}$). Command words are latched into port 2 on the high to low transition of the PROG line and decoded to set a high impedance on the selected port lines. Ports 6 and 7 are connected to the front panel switches. When a switch is depressed, the corresponding line is pulled low and loaded into the I/O expander's input buffer. The data in the buffer is transferred to the microcontroller on the low to high transition of the Prog line.

B. LED Displays

The LED display driver, U1, controls the LED displays. Data is input to pin 22 synchronously with the clock signal (pin 21). The first bit activates the driver, and 35 data bits follow. After the 35th bit is loaded, data is latched to provide direct output. Because the output is inverted, a logical 1 switches ON the appropriate LED at the output.

Display brightness is factory preset, but can be adjusted using R11.

C. Multiplexing of Displays

To minimize the number of driver lines required, displays are multiplexed through U1. Displays are divided into four groups: control temperature LEDs, air temperature LEDs, patient temperature LEDs and miscellaneous LEDs (mode, alarm and heater power). Port 4 of I/O expander U2 turns on a Darlington transistor to select the active display channel. The large gain of the Darlington allows a small current to sustain the load current from the LEDs.

Bits 1-32 supply the necessary information to each section. Bit 33 is unused. Bit 34 is tied to a 221 ohm +/-1% resistor, used for calibration. After each of the four display groups have been serviced, a string of 35 zeroes is sent on the data line to reset the driver for the next string of data; the driver operates with serial input and does not have a master reset.

The basic display circuit (one LED) includes: the +5 V DISP supply from the control board routed through the 1N4001 diode, the collector emitter junction of the enabled Darlington transistor, the LED, and the MM5451 decoder.

1.3 Specifications

See Section 6, Illustrated Parts for a complete listing of incubator stock numbers.

A. Electrical Specifications

1. Power Requirements

Domestic (Designed to UL 544 and CSA 22.2 specifications)
120 Vac 60 Hz Models (115 Vac +/- 10%, 5.7 Amps)

Export (Designed to IEC 601-1 and IEC 601-2 specifications)
100 Vac 50/60 Hz Models (100 Vac +/- 10%, 6.6 Amps)
120 Vac 50/60 Hz Model (115 Vac +/- 10%, 5.7 amps)
220 Vac 50/60 Hz Models (220 Vac +/- 10%, 3.0 Amps)
240 Vac 50/60 Hz Models (240 Vac +/- 10%, 2.7 Amps)

Nominal Power Consumption 450 watts at maximum heater output

2. Line Voltage Compensation

Heat output compensated for line voltage fluctuations up to 10% of nominal line voltage.

3. Circuit Breaker

Rated Current: 7 Amps
Trip Point: 9.45 Amps Minimum
Type: Manual Resetting
Model: Airpax Snapak

B. Performance Specifications

1. Patient Temperature Measurement

Range Displayed: 22 to 42 C (71.6 to 107.6 F)
Accuracy: +/- 0.3 C (+/- 0.5 F) within range
Resolution: +/- 0.1 C or F

Probe Model Number LA003
Probe Interchangeability +/- 0.1 C (+/- 0.2 F)

2. Air Temperature Measurement
Range Displayed: 5 to 50 C (41.0 to 122.0 F)
Resolution: +/- 0.1 C or F
Accuracy: Varies over temperature range

Temperature Range	Accuracy
5 to 22 C (41 to 71.6 F)	+/- 0.5 C (0.9 F)
22 to 42 C (71.6 to 107.6 F)	+/- 0.3 C (0.5 F)
42 to 50 C (107.6 to 122.0 F)	+/- 0.5 C (0.9 F)

3. Control Temperature Ranges
Patient Control Mode: 35.0 to 37.0 C (95.0 to 98.6 F)
Up to 37.5 C (99.5 F) with internal dipswitch (Section 3.3.K)
Air Control Mode: 20.0 to 37.0 C (73.4 to 98.6 F)
Up to 39.0 C (102.2 F) with control panel Override switch.

4. Thermal Performance
*Temperature Rise Time: 25 - 30 min per 10 C (18 F)
*Temperature Variability: 0.2 C (0.4 F)
*Temperature Overshoot: Less than 0.5 C (0.9 F)

***Note:** Terms are defined in the Definition Section.

5. Alarms

Indicator and Nonsilenceable Audio Alarm
Power Failure

Indicator and Silenceable Single Tone Alarm
Difference between patient temperature and patient control temperature exceeds 1.0 C (patient control mode; adjustable to 0.5 C, Section 3.3.J.)

Air temperature is 1.5 C above or 3.0 C below air control temperature (air control mode; Disabled for 30 minutes after power up and for 15 minutes after control temperature change).

Indicator, Silenceable Two Tone Alarm and Heater Shutdown
Air temperature sensor disconnected (both modes)

Patient probe disconnected or malfunctioning (patient control mode)

Air circulation system failure

Patient temperature > 42.0 C or < 30.0 C

Air temperature > 38.0 C (air control mode w/o Override); Air temperature > 40.0 C (patient control mode or control mode w/ Override)

Indicator, Nonsilenceable Two Tone Alarm, Heater Shutdown and Possible Error Code
System failure

6. Operator Prompt Tone
An intermittent audio tone sounds when the unit is first switched ON, and when the patient control mode is first selected. The tone is silenced when control temperature is entered. The heater will not operate until a control temperature has been entered.

7. Proportional Heat Control
Features zero voltage switching to minimize radiated and conducted EMI. Heater power is compensated for line voltage fluctuations up to 10% from the nominal voltage.

C. Safety Specifications

1. Isolation Voltage
2500 Vrms @ 60 Hz from the patient probe tip to the ac phase and neutral lines for one minute.


Type B IEC Isolation

2. Leakage Current
From enclosure to ground with ground wire open and with UL, CSA, or AAMI test load attached:

a. Less than 50 microamperes measured at the metal tip of the patient probe; less than 100 microamperes measured at any exposed metal surface for equipment rated at 120 Vac, 50/60 Hz.

b. Less than 100 microamperes measured at the metal tip of the patient probe; less than 200 microamperes measured at any exposed metal surface for equipment rated at 220 Vac, 50/60 Hz or 240 Vac, 50/60 Hz.

3. Self Test
The microcontroller performs self test and software verification functions when the power is first switched ON.

D. Environmental Specifications

Operating Temperature Range:	20 to 30 C (68 to 86 F)
Storage Temperature Range:	-25 to 60 C (-13 to 140 F)
Operating Humidity Range:	0 to 95%
Air Velocity Over Mattress:	Less than 10 cm/sec (double walled units)
	Less than 35 cm/sec (single walled units)
Noise Level Within Unit:	Less than 60 Decibels, A weighted

Humidity Within Unit (when using built in humidifier):	50% +/- 10%, depending on operating conditions
Oxygen Concentration Within Unit:	25 to 45% with 5 L/min oxygen input 35 to 65% with 10 L/min oxygen input 45 to 70% with 15 L/min oxygen input

E. Mechanical Specifications (without accessories)

Dimensions with cabinet
Weight: 185 lbs (84.04 kg)
Height: 53.5 inches (135.9 cm)
Depth: 25.5 inches (64.8 cm)
Width: 35.0 inches (88.9 cm)

Incubator only
Height: 24.5 inches (62.2 cm)
Depth: 24.2 inches (61.5 cm)
Width: 32.7 inches (83.1 cm)

Mattress: 13.7 x 25.6 inches (34.8 x 65.0 cm)
Tilt Positions: +/- 8 degrees in 4 degree angular increments
Casters: 5 inch diameter, 2 locking, 2 non-locking

WARNING: Two people are required to lift the Care Plus Incubator. Follow safe lifting techniques to avoid injury.

2.1 Receiving

Refer to the setup instructions shipped with the Care Plus Incubator for initial unpacking and setup of the unit after shipment.

WARNING: If the mounting knobs that attach the incubator to the cabinet are not securely fastened, the incubator could tip off of the cabinet when the hood is opened.

Inspect the Care Plus Incubator and all accessory items for any signs of damage that may have occurred during shipment. File a damage claim with the shipping carrier if damage has occurred. Also confirm the presence of all accessory items as listed on the packing slip.

2.2 Checkout Procedure

WARNING: After completing any portion of the calibration and adjustment procedures for the Care Plus Incubator, perform the Checkout Procedure to make sure that the unit is operating correctly. In addition a final electrical safety check and leakage current test must be performed. Record the information for future reference.

Note: Refer to Section 3.3, Calibration, if the results of the Checkout Procedure indicate that the display brightness, the alarm volume, the alarm frequency, the air safety circuit trip point, or the ADC reference voltage need adjustment.

A. Mechanical Checks

WARNING: Disconnect the power to the incubator for the mechanical portion of the Checkout Procedure.

Important : See Figure 2-1, page 2-4, for the location of mechanical controls and other incubator components.

1. Disconnect the power cord for the Care Plus Incubator for the mechanical portion of the Checkout Procedure.

2. Examine the power cord for damage. Replace the power cord if damage is evident.

3. Examine the incubator for obvious signs of damage.

4. Lock the two front casters and check that the unit is held in place.

5. Open the cabinet and verify that the four incubator mounting knobs, which attach the incubator to the cabinet, are secured tightly in place.

6. Check the front door seals. With the door closed, check that the clear plastic seals on the upper and lower edges fit tightly.

7. Rotate both front door latches toward the center of the incubator and lower the door. Make sure that the inner wall is securely fastened to the door and that the deflector panel (Figure 2-1) is installed on the inner wall.

8. Make sure that the front door is securely fastened to the incubator. Opening the door exposes the two spring-loaded metal hinge pins that slide into holes in the base platform. If the door is not properly attached, pull both pins out towards the sides of the incubator and line them up with the hinge. Release the pins and verify that they snap into position.

9. Check that the mattress and the mattress tray are properly installed. Verify that you must lift the tray slightly to slide it out of the hood. This prevents the tray from sliding out accidentally. Slide the mattress tray back into the hood.

10. Check the portholes. Open the portholes by pressing on the clear plastic latch. The cover should swing open. If arm cuffs are installed, the elastic cuff band should fit into the groove around the porthole without obstructing the cover. Close the porthole and verify that the latch holds it in place.

11. If the optional inner walls are installed, check that they are securely attached to the outer walls. To attach the inner wall, align the inner wall fasteners with the mounting posts on the outer hood and push in on the plunger portion of the fastener. Also verify that the deflector panel is attached to the rear inner wall.

12. If the upper inner wall is not used, make sure that hole plugs are inserted into the unused top mounting holes.

13. Check the hood seals. Examine the seals at the bottom of the left, right and back sides of the hood. They should seal tightly when the hood is closed.

14. Check that the tubing access covers are also installed on either side of the hood.

15. Check the hood tilt latch. To open the front door, depress the hood tilt release and rotate the hood back approximately 30 degrees, until it locks into position with an audible click. Push against the hood and make sure that it is held in place. To close the hood, support the hood and press the hood tilt release. Gently lower the hood.

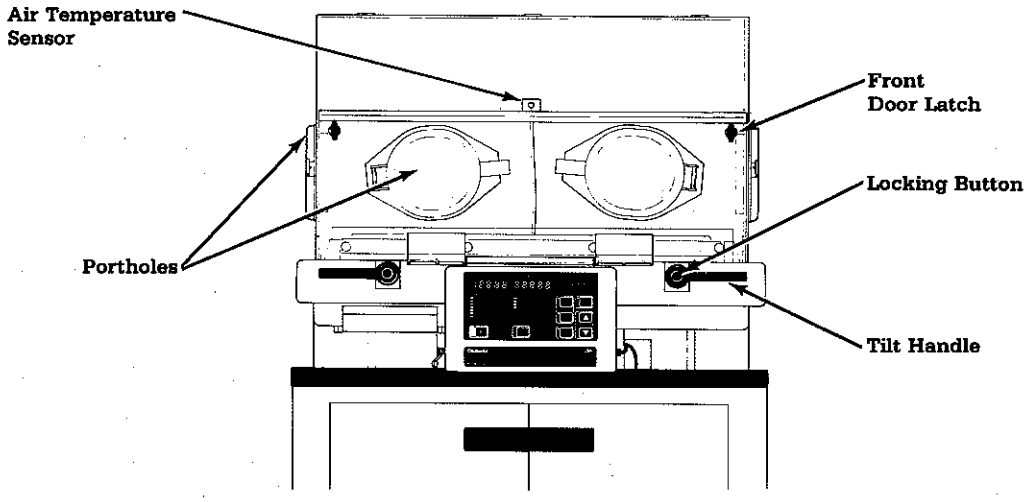
Note: The hood tilt release must be depressed while raising or lowering the hood.

16. Check the operation of the tilt mechanism. Press in the locking button in the center of the tilt handle and push down on the handle. Release the locking button and verify that the mechanism locks in the four degree position. Press the locking button again and rotate the handle downwards. Release the locking button and verify that the mechanism locks in the eight degree position. Depress the locking button and lift up on the tilt handle to return to the horizontal position. Repeat this step for the second tilt handle.

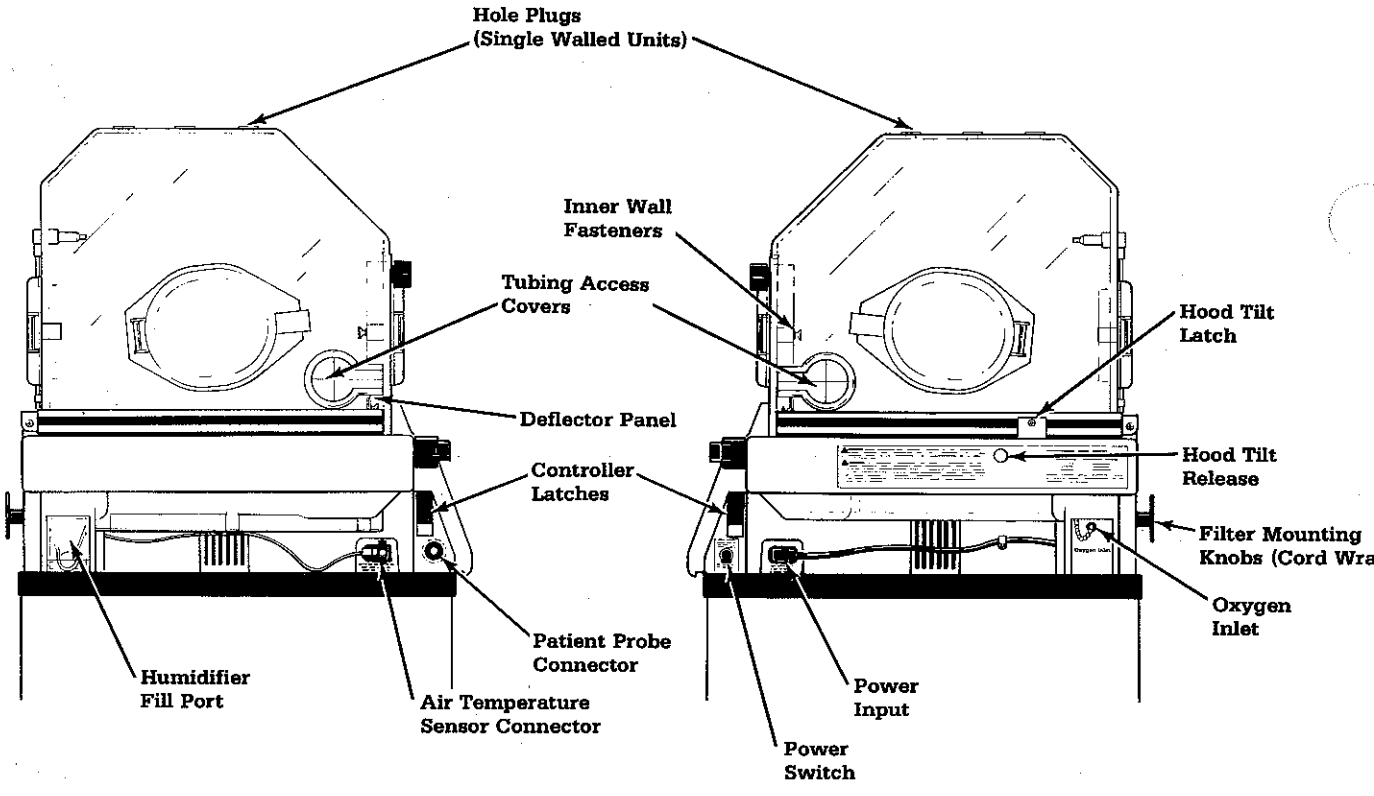
17. Check that the controller is latched in position. The controller latches should be all the way down, parallel with the sides of the controller.

18. Locate the humidifier fill port, on the left side of the unit. Grasp the handle on the lower edge of the fill port and pull it out into the open position. Make sure that it does not come out all the way unless you rotate it clockwise. Rotate it counterclockwise into the drain position. Rotate the fill port back into the upright position and push it back into the lower unit.

19. Unscrew the two filter mounting knobs on the rear of the incubator, lift off the vented filter cover panel, and check the condition of the filter. If the filter is dirty, has been used with an infectious patient, or has been in use for three months it must be replaced. When you replace the filter, mark the date on the label supplied with the replacement filter. Affix the label to the exterior of the filter cover panel.



Front View



Left Side View

Right Side View

Figure 2-1 Operating Controls, Indicators and Connectors

Item (Figure 2-1)	Function
Hood tilt latch and hood tilt release	Prevents hood from opening accidently. Also secures hood in the tilted position; You must press and hold the hood tilt release button while raising or lowering the hood.
Door hinge pins (not shown)	Spring loaded metal pins inside the front door hinges. Open door and pull hinge pins toward the sides of the incubator to remove the door.
Tilt handles and locking buttons	Depress locking button in center of handle and rotate handle for Trendelenburg and Fowler positioning.
Portholes	Press the clear plastic latch to open the porthole.
Tubing access covers	Route cables and tubes into or out of the unit through the tubing access covers.
Door latches	Turn door latches toward the center of the incubator to open the front door.
Humidifier and fill port	To use humidifier, pull port out, add water up to the fill line only, push port back in. Pull port out and rotate counterclockwise to drain. Pull port out and rotate clockwise to remove.
Oxygen inlet	Connect tubing between flowmeter outlet and oxygen inlet to raise hood oxygen concentration.
Patient probe connection	Push probe connector firmly into socket until it clicks. Grasp the connector and pull to disconnect.
Air temperature sensor connection	Keyed connector for air temperature sensor; to connect the air temperature sensor, align the connectors and push them together. Disconnect the sensor by pressing in the back of the connector while pulling back on the "T" handle.
Controller latches	Pull latches up (perpendicular to controller sides) to slide out the controller. Push down to secure controller.
Filter cover	Vented panel on rear of unit. Remove knobs and panel to access filter.
Power switch and circuit breaker	Combination power switch and circuit breaker. Set the switch to ON to reset circuit breaker.
Inner wall fastener	Used to secure inner walls. Line up with mating mounting posts in outer hood and press in plunger to snap in place. Pull out the plunger to release.
Hole plugs	Used to plug the holes in the top of the hood on single walled units.

B. Accessory Checks

1. Check that all accessories are securely mounted.

2. Check the operation of any accessories with reference to the appropriate operation and maintenance manuals.

3. If an Ohmeda manometer will be used, verify that it reads 0 Kpa at atmospheric pressure. If it is necessary to zero the manometer, unscrew the plastic bezel over the plastic cover. Adjust the zeroing screw located on top of the manometer, above the 4 Kpa marking.

4. Set up any required suction or gas supply systems. Check them for leaks as outlined in the appropriate operation and maintenance manuals.

C. Controller Checks

Important: Figure 2-2, page 2-7, identifies the individual control panel switches.

Important: The Enable switch must be pressed to activate the temperature adjustment, the Override, or the control mode switches. These switches remain active as long as the enable indicator is illuminated (approximately 12 seconds after the last time one of these switches is pressed).

Note: When the patient probe is initially plugged in for checkout, LLLL will be displayed in place of the patient temperature, if its reading is below 22.0 C, (71.6 F).

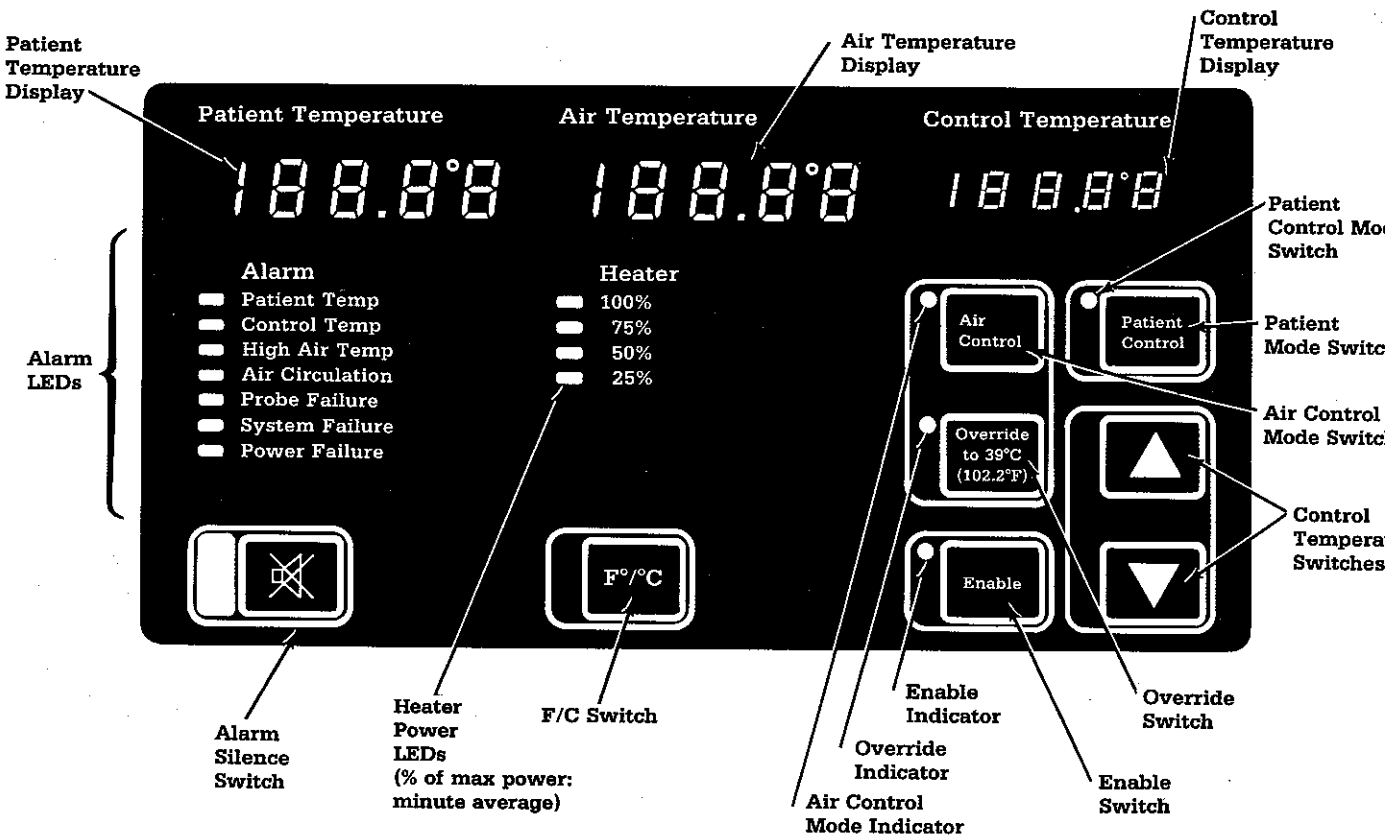


Figure 2-2 Control Panel

1. Make sure the power cord is connected to the socket on the right side of the controller.

2. Plug the patient probe into the labeled connection on the left side of the controller.

3. Line up the air temperature sensor connectors. Plug the air temperature sensor into the labeled connection on the left side of the controller.

4. Route the patient probe cord through the tubing access cover and place the patient probe inside the incubator.

5. Plug the power cord into an appropriately rated power source (see rating plate for proper voltage etc.).

6. Switch the power ON and verify the following sequence:

   a. An alternating two tone audible alarm sounds for approximately five seconds, all the indicators illuminate and 188.88 appears in the three temperature displays.

   b. All indicators are extinguished except for the air control and the enable indicators. The temperature displays change to show from left to right:

Patient Temperature	Air Temperature	Control Temperature
XX.XX (software version no. for example 01.01)	60.H (AC freq. 50 Hz for 50 Hz models)	39.0 C (max. manual control temp.)

   c. An operator prompt tone sounds, and the control temperature display flashes 33.0 C. The operator prompt tone will sound every two seconds until a control temperature is entered by pressing either the ↑ or ↓ switch.

7. Adjust the control temperature to silence the prompt tone.

8. Check display illumination and the audible alarm by depressing and holding the Alarm Silence switch until all of the indicator LEDs illuminate, and 188.8 appears in the three temperature displays (approximately five seconds). The alternating two tone alarm should sound.

9. Check the Enable switch. Press the Enable switch. The enable indicator should illuminate and go out after approximately 12 seconds. Verify that pressing the ↑ and ↓ switches has no effect when the enable indicator is extinguished.

10. Check the analog to digital calibration and the line voltage. Depress and hold the Enable switch until the following values appear in the temperature displays (approximately five seconds):

Patient Temperature	Air Temperature	Control Temperature
25.05 C (+/- 0.2 C) (low calibration point)	37.95 C (+/- 0.2 C) (high calibration point)	From 09.00 to 11.00 (Service use only)

Note: An alternating two tone alarm will sound to indicate that the actual temperatures are not displayed.

11. Check the patient probe. Warm the patient probe by placing it between your fingers. Verify that the displayed patient temperature increases. If an AAMI approved thermometer is available, place both the thermometer and the patient probe in a glass of warm water. Stir the water and wait several

minutes until the thermometer reading stabilizes. Verify that the patient temperature shown on the control panel is within 1 C of that shown on the thermometer. Replace the probe and repeat the check if the reading is outside the 1 C range.

12. Check the normal range of air control temperatures. Press the Enable switch to activate the ↑ and ↓ switches. The enable indicator will illuminate. Press and hold the ↓ switch. Verify that the lowest control temperature attainable is 20.0 C. If the enable indicator has gone out, press the Enable switch again. Depress the ↑ switch and verify that the air control temperature cannot be set above 37.0 C.

13. Check the extended range of air control temperatures. With the control temperature set to 37.0 C, sequentially press the Enable and Override switches. Both the enable and the override indicators should illuminate. Depress the ↑ switch and verify that the maximum air control temperature is now 39.0 C. The override indicator will remain illuminated as long as the control temperature setting remains at, or above, 37.0 C.

14. Check the the F/C switch. Adjust the control temperature to 36.0 C and press the F/C switch. Verify that the control temperature is now displayed as 96.8 F. Press the switch a second time to return to a Celsius display.

15. Switch to the patient control mode of operation. Press the Enable and the Patient Control switches. Then, verify the following sequence:

    a. The enable and the patient control indicators illuminate.

    b. The control temperature display flashes 36.5 C and an operator prompt tone sounds every two seconds. Adjust the control temperature to silence the prompt tone. The enable indicator will be extinguished approximately 12 seconds after the last time the ↑ or ↓ switch is pressed.

Note: A patient temperature alarm will be triggered if the patient probe temperature differs from the control temperature by more than 1.0 C. If the probe temperature is below 30.0 C or above 42.0 C the heater will not switch ON.

16. Change the range of patient control temperatures. Press the Enable switch to activate the ↑ and ↓ switches. The enable indicator will illuminate. Press and hold the ↓ switch. Verify that the lowest control temperature attainable is 35.0 C. If the enable indicator goes out, press the Enable switch again. Then depress the ↑ switch. Verify that the patient control temperature cannot be set above 37 C.

Note: The maximum patient control temperature can be raised to 37.5 C by placing control board dipswitch 3 in the ON position. (Section 3.3.K)

17. Check the patient temperature alarm. Press the Enable switch and adjust the patient control temperature until it exceeds the patient temperature by more than 1.0 C. An intermittent single tone alarm should sound, the patient

temperature should flash, and the patient temperature alarm indicator should illuminate. Press the Enable switch and adjust the patient control temperature until it is within 0.8 C of the patient temperature. The alarm should cancel.

Note: Service personnel can configure the alarm to trigger if the difference exceeds 0.5 C, and to reset when the difference is less than 0.3 C. See Section 3.3 J, Setting the Patient Temperature Alarm.

18. Check the probe failure alarm.

    a. Unplug the patient probe from the controller. Verify that an alternating two tone alarm sounds, the probe failure LED illuminates, HHHH flashes in the patient temperature display, and the heater power LEDs are extinguished. Plug the probe back in and verify that the alarm cancels.

    b. Unplug the air temperature sensor from the controller. Verify that an alternating two tone alarm sounds, 00.0 C flashes in the air temperature display, the probe failure LED illuminates, and the heater power LEDs are extinguished. Align the connectors and plug the air temperature sensor back into the controller. Verify that the alarm cancels.

19. Check the power failure alarm and the battery backed memory. First verify that you are still in the patient control mode. Then adjust the patient control temperature to 36.0 C. Switch to the air control mode and adjust the control temperature to 35.0 C. Unplug the incubator. An intermittent, nonsilencable alarm should sound, and the power failure LED should illuminate. All other displays and indicators will be extinguished. Wait two minutes and plug the incubator back in. Verify that the alarm cancels and that the unit returns to the air control mode of operation with a control temperature of 35.0 C. Switch to the patient control mode and verify a control temperature of 36.0 C.

Note: A fully charged battery should supply the power failure alarm for approximately 10 minutes. If the alarm is tested for the full 10 minutes, the incubator must be run for at least two hours to recharge the battery before it is used with a patient. Total recharge time is 8 to 10 hours.

20. Check the Alarm Silence switch. Unplug the air temperature sensor and press the Alarm Silence switch. Verify that the alarm is silenced for one minute. Reconnect the air temperature sensor.

D. Operational Checks

1. Make sure that the incubator is in the air control mode.

2. Verify that the front door, the portholes, and the hood are closed.

3. Set the control temperature as close to the air temperature as possible. Allow the air temperature reading to stabilize. Verify that the air temperature remains within 0.5 C of the control temperature for five minutes after stabilization.

WARNING: Use extreme care while performing calibration and adjustment procedures, or while working on the Care Plus Incubator with power connected. An electrical shock hazard does exist; be certain to observe all standard safety precautions.

3.1 Special Tools and Equipment

The following tools (or their functional equivalents) are required to complete the recommended service procedures. If you do not already have these items, they can be ordered from Ohmeda.

Description	Stock Number
Digital Multimeter, 3 1/2 digit	0175-2379-000
Leakage Current Tester with AAMI Test Load	0175-2284-000
Static Control Work Station (recommended)	0175-2311-000
0.1% Accuracy Variable Resistance Box	
Soldering Iron	

Optional items include:

Description	Stock Number
Oscilloscope, 15 MHz, dual trace	0175-2302-000
Ohmeda Temperature Simulator Box (variable resistance box with switches preset to various temperatures)	0271-2788-800
Hair dryer (1000 watts), or heat gun (glass of hot water, >45 C, can be used as substitute)	

Note: Connecting a variable resistance box to the incubator requires a special cable, which can be constructed as shown in Figure 3-1. This cable is not supplied by Ohmeda, because there is no one connector that will accommodate all types of variable resistance boxes.

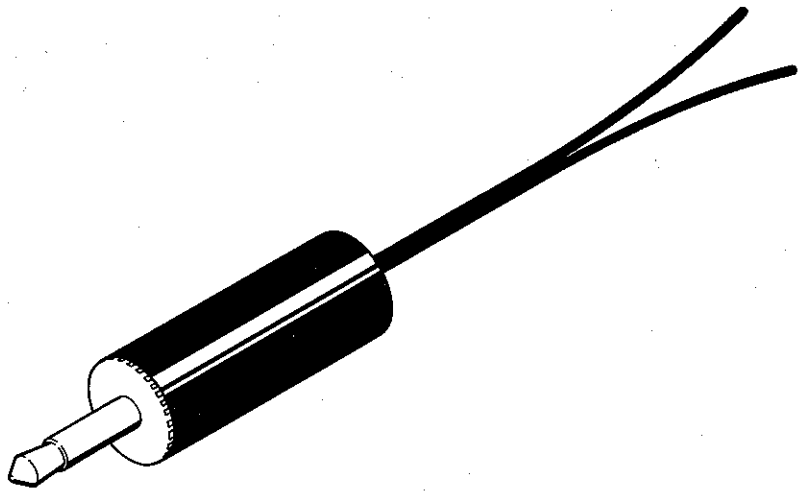


Figure 3-1 Cable for Variable Resistance Box

3.2 Calibration Loop (background information)

Note: The audible alarm sounds continuously in this loop, although the normal incubator alarms are disabled during the calibration loop.

This loop is used to adjust ADC converter calibration, the 2 kHz alarm frequency, the line voltage compensation, and display brightness. To enter the calibration loop, hold down the Enable switch during power up until a continuous alarm sounds. During the calibration loop:

1. The 2 kHz audio alarm sounds continuously. This allows frequency adjustments.

2. A four place (XX.XX C) patient probe reading appears in the patient temperature display.

Note: This display appears even if the patient temperature is outside the normal display range.

3. The percent of rated line voltage at which the unit is operating appears in the control temperature display (XX.XX = XXX.X%). When the correct percentage is displayed, the line voltage compensation is properly adjusted.

4. Output 34 on the display driver is activated. This allows the display brightness voltage to be read and adjusted.

3.3 Calibration Procedures

WARNING: After completing any portion of the calibration and adjustment procedures for the Care Plus Incubator, perform the Checkout Procedure to make sure that the unit is operating correctly. In addition a final electrical safety check and leakage current test must be performed. Record the information for future reference.

WARNING: Before any disassembly or repair, disconnect the electrical supply and any gas supply connections. Also remove any accessories. Do not perform any service or maintenance with the power applied unless specifically told to do so in the procedure.

WARNING: After completing a repair of the Care Plus, the appropriate calibration procedure must be performed to make sure the Care Plus is in proper operating condition. In addition a final electrical safety check and leakage current test must be performed. Record the information for future reference.

CAUTION: Use the Static Control Work Station (Stock No. 0175-2311-000) to help ensure that static charges are safely conducted to ground. The Velostat material is conductive. Do not place electrically powered circuit boards on it.

Important: Reference Figure 3-2, page 3-4, for the location of control board potentiometers and test points.

A. Preparation

1. Set up an anti-static work station on a flat surface near the incubator. Use a conductive wrist strap to dissipate any static from yourself to the anti-static mat.

2. Remove the controller from the incubator. First unplug the patient probe, the air temperature sensor, and the power supply cord from the controller. Then lift up the controller latches and slide it forward, out of the incubator. Place the controller on the anti-static mat.

CAUTION: When handling the controller, avoid bumping the fan or the heater. If these items are knocked out of alignment, the fan can grate against either the heater or the base.

3. Remove the six screws and lock washers used to attach the controller cover.

4. Reconnect the power cord and the air temperature sensor to the controller.

5. Verify that control board switches 1, 2, 7 and 8 are in the OFF (open) position.

Note: Leave switch 4, which selects either a 0.5 C or a 1.0 C limit for the patient temperature alarm, in its original position.

Note: Leave switch 3, which selects a maximum patient control temperature (patient control mode), in its original position.

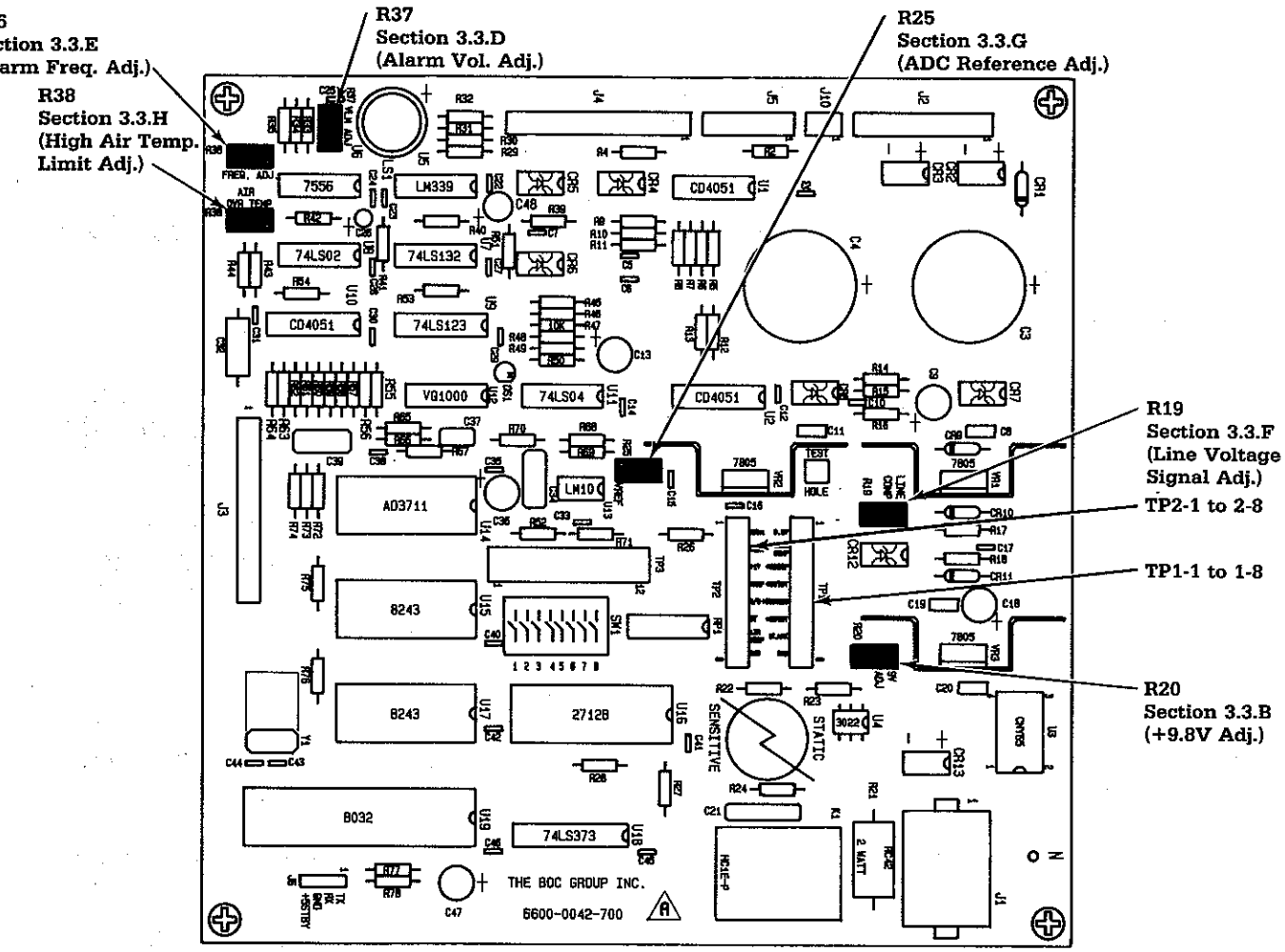


Figure 3-2 Control Board Test Points and Potentiometers

B. Check Voltage Supplies

1. Switch ON the incubator. It will proceed through the normal power up tests. Enter a control temperature to silence the prompt tone.

2. Adjust control board potentiometer R20 until TP1-1 measures 9.8 +/- 0.05 Vdc with respect to GND (TP1-8).

3. Verify the following voltages on the control board with respect to GND (TP1-8):

Test Point	Voltage
TP1-3	5.0 +/- 0.3 Vdc
TP1-4	5.0 +/- 0.3 Vdc
TP1-5	8.0 +/- 1.5 Vdc
TP1-6	9.0 +/- 0.3 Vdc

Note: These voltages cannot be adjusted. The control board must be replaced when they are not within the specified range.

C. Display Brightness

Note: Because display brightness is factory calibrated for both replacement boards and complete controllers, brightness adjustments are only required if the LEDs appear to be dim.

1. Hold down the Alarm Silence switch until all the displays illuminate (approximately five seconds). Check that all displays are illuminated and of uniform brightness. If the displays are acceptable, proceed to Section D. Otherwise, continue with this adjustment procedure.

2. Switch OFF the power and remove the front controller panel.

   a. Turn the controller upside down and remove the lower three front panel mounting screws, shown in Figure 3-3.

   b. Turn the controller right side up and remove the remaining front panel mounting screws, shown in Figure 3-3.

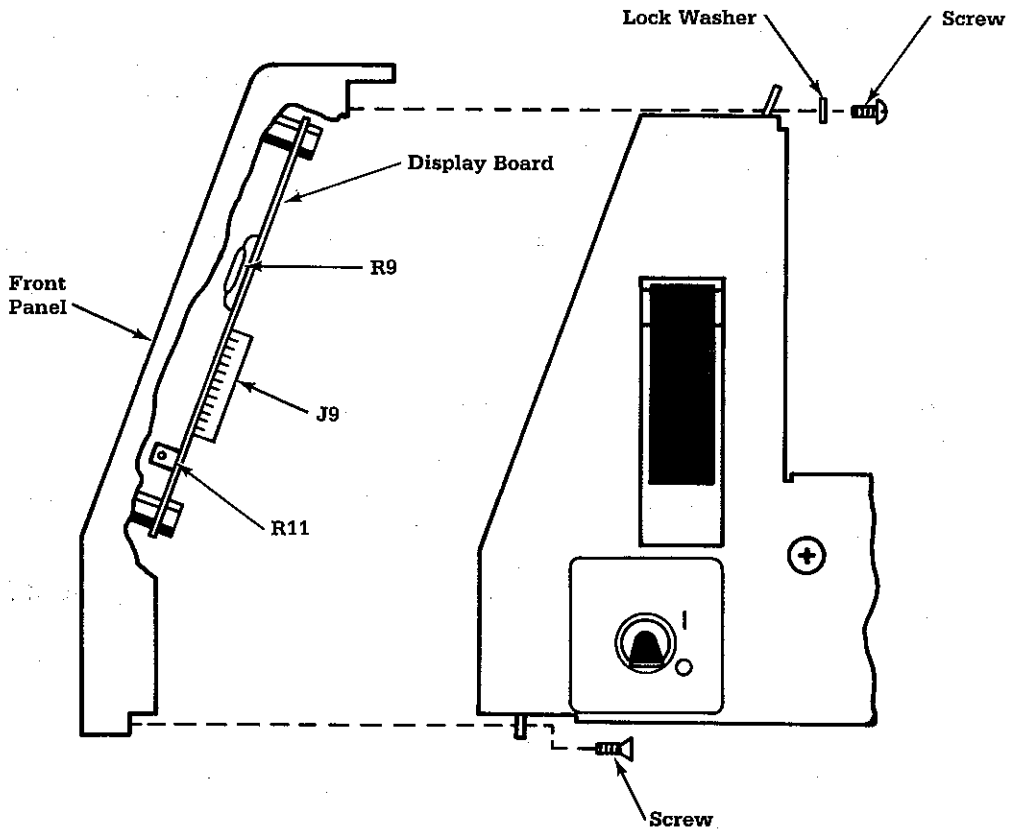


Figure 3-3 Display Brightness Adjustment

Note: Complete disassembly of the front panel is not required. Voltage measurements can be made between pins 11 and 12 of J9, the connector on the back of the display board.

3. Reconnect the power cord.

4. Enter the calibration loop by switching the unit ON while holding down the Enable switch. Continue to hold the Enable switch until a continuous single tone alarm sounds, indicating that the calibration loop is active.

5. Monitor the voltage between pins 11 and 12 of J9, the connector on the rear of the display board. Adjust display board potentiometer R11 (accessible from the edge of the board) to obtain a reading of 3.30 +/- 0.2 Vdc.

Note: This voltage corresponds to the voltage drop across R9.

Important: The voltage measured across R9 will differ if the calibration loop is not used.

6. Replace the display board if an acceptable level of brightness cannot be achieved.

D. Alarm Volume

Verify that control board potentiometer R37 is adjusted fully counterclockwise for maximum volume.

E. Alarm Frequency

Note: Because the alarm frequency is precalibrated at the factory for both replacement boards and complete controllers, frequency adjustments are only required when replacing a control board component that is part of the alarm circuit.

1. Verify that the incubator is in the calibration loop.

2. Verify that the frequency output at TP2-1 is 2 kHz +/- 0.1 kHz. Adjust R36 on the control board as required.

Note: If test equipment is not available to check the frequency, adjust R36 for maximum sound level.

F. Line Voltage Compensation

1. Verify that the incubator is in the calibration loop. In this loop the control temperature display continuously shows the percent of nominal input voltage at which the unit is operating.

Note: Multiply the displayed value by ten to get the actual percentage (XX.XX = XXX.X%).

2. Determine the rated heater voltage of your unit from the serial number sticker on the back of the base platform.

3. Measure the line voltage between the appropriate transformer primaries (pins 4 and 2 on 120 volt units):

Rated Input Voltage (from serial number sticker)	Nominal Input Voltage	Measure Between Pins
240 volts	240 volts	6 and 2
220 volts	220 volts	5 and 2
120 volts	115 volts	4 and 2
100 volts	95 volts	3 and 2

4. Calculate the percent of the nominal input voltage by dividing the measured voltage by the nominal input voltage and multiplying by 100%.

$$\% \text{ of line voltage} = \frac{\text{(Measured Voltage)}}{\text{(Nominal Input Voltage)}} \times 100\%$$

5. Adjust control board potentiometer R19 until the control temperature display shows the percentage calculated in the previous step +/- 2%.

Note: The control temperature reading appears in the format XX.XX, which must be multiplied by ten to give the actual percentage, XXX.X%.

G. Analog to Digital Converter (ADC)

1. Verify that the incubator is in the calibration loop.

2. Attach 0.1% accuracy resistance box to the patient probe jack. Adjust the box settings for a resistance of 5900 ohms +/- 0.1% (Ohmeda temperature simulator box setting I7).

Note: The Ohmeda temperature simulator box (Stock No. 0220-1114-800) is a variable resistance box with switch settings corresponding to predetermined temperatures.

3. Adjust control board potentiometer R25 until 37.3 +/- 0.05 C appears in the patient temperature display.

4. Switch OFF the power to exit the calibration loop.

5. Switch the incubator ON. After the normal power up sequence, enter a control temperature to silence the prompt tone.

6. Check the readings from the calibration resistors. Depress and hold the Enable switch until the proper calibration readings appear in the patient and air temperature displays (approximately five seconds):

Patient Temperature	25.05 +/- 0.2 C
Air Temperature	37.97 +/- 0.2 C

7. Adjust the resistance box settings for the following resistances. Verify that the corresponding temperature appears in the patient temperature display.

Resistance Input	Ohmeda Temp. Simulator Box Setting	Patient Temperature
7060 ohms +/- 0.1%	I3	33.0 +/- 0.1 C
6190 ohms +/- 0.1%	I11	36.2 +/- 0.1 C
5496 ohms +/- 0.1%	I2	39.0 +/- 0.1 C

8. Disconnect the resistance box from the patient probe jack.

9. Switch OFF the controller.

H. Air Safety Circuit Calibration (High Air Temperature Alarm)

This procedure requires a hot air source. Either a hair dryer (approximately 1000 watts), or a heat gun , or a glass of hot water (>45 C) can be used for this purpose.

1. Switch the controller ON.
2. In the air mode, adjust the control temperature to 36.9 C.
3. The heater should switch ON. Verify that the heater power LEDs on the display panel and the heater status LED on the control board are both illuminated. The heater status LED may flicker.
4. If you are using a glass of hot water (>45 C) as the heat source:
   a. Unscrew the two mounting screws that attach the air temperature sensor to the hood. Remove the sensor mounting blocks and pull the sensor out of the hood.
   b. Place the air temperature sensor in the glass of hot water (>45 C). The rate of temperature increase should not exceed 0.05 C per second.
5. If you are using a heat gun or blow dryer, switch it on and point it at the air temperature sensor. Observe how quickly the displayed air temperature increases. If necessary, reposition the heat gun (dryer) so that the rate of increase does not exceed 0.05 C per second.
6. Monitor the air temperature display. When the high air temperature alarm illuminates, verify an air temperature display of 38.0 +/- 0.3 C. Also verify that the safety relay opens (audible click; heater status LED extinguished).
7. Press the alarm silence switch and remove the air temperature sensor from the glass of water or switch OFF the blow dryer.

Important: This alarm will not reset unless the alarm silence switch is pressed.

8. Monitor the air temperature display and verify that the alarm resets.
9. If the alarm is triggered at an air temperature other than 38.0 +/- 0.3 C, adjust R38 on the control board and repeat this procedure.
10. If necessary, remount the air temperature sensor on the hood.

Important : This alarm will not reset unless the alarm silence switch is pressed.

I. Thermal Switch Operation

1. Hold a hot soldering iron (minimum temperature 76.7 C) against the thermal switch on the rear of the controller.

2. Listen for an audible click, indicating that the switch has opened. The click should occur within a few seconds. When the thermal switch has opened the heater indicator light on the control board should be constantly illuminated.

Note: An open thermal switch makes it appear as if the heater is continuously enabled. This may trigger error code E13. Switch the unit OFF and continue with step 3.

3. Remove the soldering iron and allow the switch to cool.

4. Listen for a second click indicating that the switch has closed. When the thermal switch closes, the heater indicator LED may flicker depending on the status of the heater.

5. If the thermal switch fails these tests, it must be replaced.

J. Setting the Patient Temperature Alarm Threshold

If desired, reset the patient temperature alarm to trigger when the difference between the patient control temperature and the monitored patient temperature exceeds 0.5 C. This is done by setting dipswitch 4 to the ON position.

K. Setting the Maximum Patient Control Temperature

If desired, the maximum patient control temperature (patient control mode) can be set at 37.5 C instead of 37.0 C. This is done by setting dipswitch 3 to the ON position.

L. Closure

1. Switch OFF the controller.

2. Verify that the power cord, the air temperature sensor, and the patient probe are disconnected from the controller.

3. Make sure that the dipswitches are configured for normal operation. Switches 1, 2, 7 and 8 must be OFF. The position of switches 3 and 4 will vary depending on the maximum patient control temperature and the tolerance selected for the patient temperature alarm.

Note: If dipswitches 1 and 2 are not OFF, error code E09 (incorrect dipswitch setting) will be triggered.

4. Replace the controller cover. Use the six screws and lock washers removed in Section A to secure the cover.

CAUTION: When handling the controller, avoid bumping the fan or the heater. If these items are knocked out of alignment, the fan can grate against either the heater or the base.

5. With the controller release latches in the release position (perpendicular to the controller sides), carefully slide the controller back into the incubator.

6. Push the controller latches down into the locked position.

7. Connect the air temperature sensor and the power cord to the controller.

8. Turn the unit ON. Verify that the fan is circulating air and that the fan is not rubbing against the base platform. Repeat steps 5 through 8, if there is rubbing.

9. Complete the leakage current test in Section 3.4.

10. Perform the Checkout Procedure in Section 2.2.

3.4 Leakage Current

Use approved equipment and techniques to test the unit's leakage current and ground continuity. Follow the directions supplied by the test equipment manufacturer to verify the following:

a. Less than 50 microamperes measured at the metal tip of the patient probe; less than 100 microamperes measured at any exposed metal surface for equipment rated at 120 Vac, 50/60 Hz.

b. Less than 100 microamperes measured at the metal tip of the patient probe; less than 200 microamperes measured at any exposed metal surface for equipment rated at 220 Vac, 50/60 Hz or 240 Vac, 50/60 Hz.

WARNING: Use extreme care while performing calibration and adjustment procedures, or while working on the Care Plus Incubator with power connected. An electrical shock hazard does exist; be certain to observe all standard safety precautions.

CAUTION: When handling the controller, avoid bumping the fan or the heater. If these items are knocked out of alignment, the fan can grate against either the heater or the base.

CAUTION: Use the Static Control Work Station (Stock No. 0175-2311-00) to help ensure that static charges are safely conducted to ground. The Velostat material is conductive. Do not place electrically powered circuit boards on it.

Note: Self test programs stop when a system error code is detected. Therefore a second error code will not be displayed for another failure. The same failure can trigger more than one error code. The actual code that appears is determined by the point in the test loop where the fault occurs.

The Care Plus features three levels of testing for maximum reliability and ease of troubleshooting. Self tests are performed on power up to check microcontroller, EPROM, and RAM function. They are performed continuously during operation to verify proper ADC, heater control, safety circuit, temperature sensor, alarm, RAM, and software operation.

Control panel switches activate on demand tests that can be used to assess error codes. Specifically you can compare the readings from both air flow or air temperature thermistors to verify a sensor failure; verify ADC calibration and check for drift; check the individual ADC channels; monitor the occurrence of any software upsets and check the line voltage. A separate RAM memory test loop continuously repeats the power up tests.

When required, you can operate the controller outside the incubator to directly measure control board signals. During controller testing, it is important to remember that the alarm criteria discussed in this section apply regardless of whether or not the controller is installed in the unit. Failure to connect the patient probe (or an equivalent load) in patient control mode, or the air temperature sensor in either operational mode will trigger the probe failure alarm. Air or patient temperature readings outside the alarm limits will still activate the corresponding alarms. In patient control mode the heater will not switch ON unless the patient temperature reading is within the 30 to 42 C range.

4.1 Alarms and Error Codes

There are two types of alarms on the Care Plus incubator. The first group of alarms are indicated by the alarm LEDs on the control panel. When one of these alarms is active the corresponding LED illuminates and an audible alarm sounds.

Error codes are a subset of the system failure alarm. When the system failure alarm illuminates for anything other than a gross microcontroller failure, the corresponding error code appears in the control temperature display.

A. Front Panel Alarms

1. Patient Temperature Alarm
(active in the patient mode only)

This alarm is active only in the patient control mode. It is triggered when the difference between the patient temperature and the control temperature exceeds 1 C. The alarm self resets when the patient temperature returns to within 0.8 C of the control temperature.

Note: The patient temperature alarm can be adjusted to trigger if the temperature difference exceeds 0.5 C and reset when the difference is less than 0.3 C (Refer to Section 3.3.J.).

Note: If the patient temperature is outside the 22 to 42 C range either LLLL or HHHH, respectively, will appear in the patient temperature display.

Audio Signal: Intermittent single tone if patient temperature within the 30 to 42 C range. Outside this range an alternating two tone alarm sounds.

Alarm Silence: 15 minutes if temperature difference is < 2 C
5 minutes if temperature difference is 2 C or higher.
1 minute if patient temperature < 30 C or > 42 C.

Heater Status: Heater is automatically shut off if the patient temperature is not between 30 and 42 C.

2. Control Temperature Alarm
(active in air control mode only)

The control temperature alarm is active only in the air control mode. It is suppressed for 30 minutes when power is first applied and for 15 minutes after each mode or control temperature change. The alarm is triggered when the reading from the air control thermistor exceeds the control temperature by more than 1.5 C or falls more than 3 C below the control temperature. The alarm self resets with a hysteresis of 0.2 C.

Audio Signal: Intermittent single tone

Alarm Silence: 15 minutes

Heater Status: Normal heater operation, dependent on selected control temperature and air temperature.

3. High Air Temperature Alarm

This alarm is triggered if the air display temperature exceeds the maximum control temperature (air control mode) or the maximum DET (the temperature required to maintain the infant at the selected control temperature in patient control mode) by more than 1 C. This alarm is not self resetting; you must press the alarm silence switch before the alarm will reset.

To display the DET in patient control mode, depress and hold the Air Control switch until the DET appears in the air temperature display (approximately five seconds).

A transient alarm may be triggered if you change from a mode with a 40 C alarm limit to a mode that has a 38 C alarm limit.

Control Mode	Temp. Range	Alarm Limit
Patient Control	35.0 to 37.0 C (Max. DET 39.0 C)	40.0 C
	35.0 to 37.5 C (Dipswitch 3 ON; Section 3.3.K; Max. DET still 39.0 C)	40.0 C
Air Control	20.0 to 37.0 C (Normal Range)	38.0 C
	37.0 to 39.0 C (Override switch)	40.0 C

Audio Signal: Alternating two tone

Alarm Silence: 5 minutes

Heater Status: Heater is automatically shut off.

4. Air Circulation Alarm

This alarm triggers when the flow of cooling air over the air flow sensor stops. The air flow sensor contains a heated and an unheated thermistor. During normal operation, the air flow over the sensor cools the heated thermistor. If the air flow stops, the heated thermistor is no longer cooled and the temperature difference between the two thermistors increases. When the difference reaches 21 C, the air circulation alarm is triggered. The alarm resets when the difference drops below 19 C.

To display the temperature of both thermistors, depress and hold the F/C switch until the temperature of the heated thermistor appears in the air temperature display and the temperature of the unheated thermistor appears in the control temperature display (approximately five seconds). These displays do not have a decimal point so the readings must be divided by ten to convert to degrees C.

The air circulation alarm is most commonly triggered by a blower motor failure or a missing fan blade.

Audio Signal: Alternating two tone

Alarm Silence: 5 minutes

Heater Status: Heater is automatically shut off

5. Probe Failure Alarm
In the air control mode, the probe failure alarm is triggered by a disconnected air temperature sensor. In the patient control mode, the probe failure alarm is triggered by either a disconnected or faulty patient temperature probe (short or open) or a disconnected air temperature sensor. The alarm self resets when the condition is remedied.

The patient temperature probe is judged to be disconnected or faulty if its signal is outside the 5 to 50 C range (approximately 880 to 410 mV). The air temperature sensor is assumed to be disconnected if both the air control and the air display signals are outside this range. This means that the probe failure alarm will be triggered instead of error codes 10 or 11 if both circuits in the air temperature sensor are open or shorted.

If neither the probe (patient control mode only) or the sensor are disconnected, one or the other is faulty. Check the patient temperature probe (patient control mode only) by observing the patient temperature display and verifying that it is consistent with the temperature of the probe. If LLLL or HHHH appear in the display, check the actual probe reading by depressing and holding the Air Control switch until a value appears in the patient temperature display (approximately five seconds). If the temperature is outside the 5 to 50 C range, replace the patient temperature probe.

Check the air temperature sensor by depressing and holding the Override switch until the air control thermistor reading appears in the patient temperature display and the air display thermistor reading appears in the air temperature display (approximately five seconds). If both readings are outside the 5 to 50 C range, replace the air temperature sensor.

Audio Signal: Alternating two tone

Alarm Silence: 1 minute

Heater Status: Heater is automatically shut off

6. System Failure Alarm
The system failure alarm is triggered if one, or more, of the system parameters monitored by the microcontroller self tests fail. This section describes the actual tests and gives a list of probable causes for each code.

If the microcontroller fails, there may be some cases where the only indication is a continuous, nonsilenceable audio alarm (i.e. no alarm indicator illuminates and no error code appears). This occurs because the microprocessor controls the display indicators. To ensue patient safety, an microprocessor independent safety relay will switch off the heater if the temperature exceeds preset safety limits.

WARNING: If a system failure alarm occurs, the unit must be removed from use until it has been serviced.

Audio Signal: Alternating two tone

Alarm Silence: Cannot be silenced

Heater Status: Heater is automatically shut off

7. Power Failure Alarm
The power failure alarm is triggered when the line frequency signal pulse is not input to the microcontroller (U16 INT0 P3.2). During a power failure alarm the NI-CAD battery powers the control logic and RAM circuits for up to 10 minutes. If power is restored within this time, the unit will return to the mode of operation and the control temperature in effect before the power loss.

The power failure alarm can be caused by a disconnected plug , faulty wiring or a faulty transformer.

Note: The power failure alarm is not triggered by an open circuit breaker.

Audio Signal: Intermittent single tone

Alarm Silence: Cannot be silenced

Heater Status: There is no power to the heater

B. Error Codes

Important: The recommended service policy is to limit repair procedures to sensor or board replacement, or in some cases the replacement of socketed integrated circuits. Additional information is provided for the purpose of identifying the faulty assembly.

Error codes are a subset of the system failure alarm. When an error code is triggered, an alternating two tone alarm sounds, the heater is automatically shut off, and normal incubator operation stops. However, the patient and air temperature displays will continue to update, and the various on demand test functions are still available.

This section individually discusses each error code, specifically covering the triggering conditions, any applicable on demand tests, and test points.

1. E01, Instruction Test Failure
A software routine executes selected instructions from the 8032 microcontroller. The results are then checked, and if any mistakes are found this error is triggered.

There are no related test points, however the RAM memory test loop cycles repeatedly through this test. To begin the loop, switch off the unit. Then turn it

back on while depressing the Override switch until a continuous alarm sounds (approximately five seconds). If the error recurs, replace the microcontroller (U19) and repeat the test. Replace the control board if the problem persists.

2. E02, ADC High Calibration Failure
The reading from the ADC calibrate high resistor (R5, 5.76 kOhm) has exceeded the limits of 37.96 +/-0.3 C for two consecutive ADC readings. This corresponds to a voltage of approximately 540 mV at the ADC input (U1 pin 14).

To see if the ADC requires calibration, depress the Enable switch until the low calibration test point (25.05 +/-0.3 C) appears in the patient temperature display, and the high calibration reading (37.96 +/-0.3 C) appears in the air temperature display (approximately five seconds). If both readings exceed or nearly exceed the limits, calibration is required. The second possibility is that resistor R5 may be out of tolerance. If the problem persists, replace the control board.

3. E03, ADC Low Calibration Failure
The reading from the ADC calibrate low resistor (R8, 10 kOhm), has exceeded the limits of 25.05 +/-0.3 C for two consecutive ADC readings. This corresponds to a voltage of approximately 690 mV at the ADC input (U1 pin 13).

To see if the ADC requires calibration, depress the Enable switch until the low calibration test point (25.05 +/-0.3 C) appears in the patient temperature display and the high calibration reading (37.96 +/-0.3 C) appears in the air temperature display (approximately five seconds). If both readings exceed or nearly exceed the limits, calibration is required. The second possibility is that resistor R8 may be out of tolerance. If the problem persists, replace the control board.

4. E04, EPROM Checksum Failure
The results of the EPROM memory checksum differ from the correct result stored at memory locations 3FFE and 3FFF on U16.

There are no related test points, however the RAM memory test loop cycles repeatedly through this test. To begin the loop, switch off the unit. Then turn it back on while depressing the Override switch until a continuous alarm sounds. If the error recurs, replace the EPROM (U16), and repeat the RAM test loop. If the error still recurs, replace the control board.

5. E05, RAM Test Failure
The data read out of a RAM memory location differs from the test pattern written to it.

There are no related test points, however the RAM memory test loop cycles repeatedly through this test. To begin the loop, switch off the unit. Then turn it back on while depressing the Override switch until a continuous alarm sounds. If the error recurs replace the control board.

6. E07, ADC Converter Failure
This alarm is triggered if the Conversion Complete Signal from the ADC does not occur within two seconds of the Start Conversion signal from I/O expander #2.

Do not attempt to monitor these signals; the Start Conversion and the Conversion Complete pulses are extremely narrow with durations of only a few nano seconds. Verify that no conversions are being completed by heating or cooling either the air temperature sensor or the patient temperature probe and observing that the temperature displays do not update.

Replace the ADC (U14) and restart the unit. If the error still recurs, replace the control board.

7. E08, S/0 Circuit Not Working
The logic level of the safety circuit $\overline{SO}$ signal does not agree with the level that would be expected based on the air display temperature. The $\overline{SO}$ signal (TP2-5) should be low only when the air display temperature is outside the 5 to 50 C range, approximately 0.884 to 410 mV at TP2-7.

If the air display temperature were actually outside this range, error code E10 would be triggered.

The most probable cause is a faulty comparator circuit (U5) in the S/O circuit. Since this is not a socketed chip, control board replacement is recommended.

8. E09, Incorrect Dip Switch Setting
The signals from dipswitches 1 and 2 are logic high (corresponds to logic low inputs at U17 for the inverted signals). The most probable cause is that dipswitches 1 and 2 are improperly configured. Set both dipswitches to the OFF (open) position.

If the dipswitches are correctly configured, either the dipswitch or an inverter (U11B or U11C) may be faulty. Board replacement is recommended, since these circuits are not socketed.

9. E10, Air Display Sensor Bad
The air display signal is outside the 5 to 50 C range (approximately 880 to 410 mV at TP2-7) for two consecutive ADC readings during which time the air control signal remains within the 5 to 50 C range.

Observe the displayed air temperature. If it is outside the 5 to 50 C range, replace the air temperature sensor. Alternatively, perform a continuity check on the sensor by measuring the resistance between pins 4 and 5 on the sensor connector (Figure 4-1), or between pins 10 and 11 on the control board J4 connector. Replace the sensor if you do not obtain a reading between 25.7 and 3.6 kOhms (20 C = 12.5 kOhms).

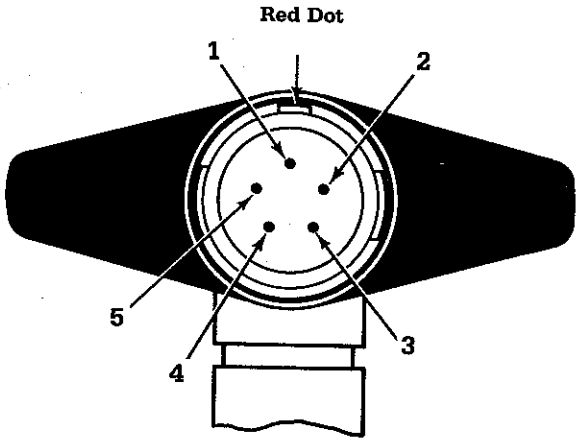


Figure 4-1 Air Temperature Sensor Connector (end view)

If the problem persists, check that the J4 connector is properly mated to the control board and then, replace the control board.

10. E11, Air Control Sensor Bad
The air control signal is outside the 5 to 50 C range (approximately 880 to 410 mV at TP2-7) for two consecutive ADC readings during which time the air display signal remains within the 5 to 50 C range.

Depress and hold the Override switch until the air control temperature appears in the air temperature display (approximately five seconds). If the displayed air control temperature is outside the 5 to 50 C range, replace the air temperature sensor. Alternatively, perform a continuity check on the sensor by measuring the resistance between pins 1 and 2 (Figure 4-1) on the sensor connector or between pins 6 and 7 on the control board J4 connector. Replace the sensor if you do not obtain a reading between 25.7 and 3.6 kOhms (20 C = 12.5 kOhms).

If the problem persists, check that the J4 connector is properly mated to the control board and then, replace the control board.

11. E12, Heater Not Switching On
The microcontroller has commanded the heater to switch on ($\overline{\text{Heat}}$ TP2-2 low), but the heater status signal from U7A pin 11 remains high, indicating that the heater is off.

This is a difficult code to troubleshoot, since the control signals and the continuity across the solid state relay change from those required to power the heater to those that shut down the heater as soon as this failure is detected.

The most probable cause of this failure is a faulty solid state relay. If the problem persists after relay replacement, replace the control board.

12. E13, Heater Not Switching Off

The microcontroller has commanded the heater to switch off ($\overline{\text{Heat}}$ TP2-2 high). However, the heater status signal from U7A pin 11 remains low, indicating that the heater is on.

This error code can be triggered without an actual failure having occurred, because of a thermal switch in the heater neutral that opens at a temperature of 76.7 C. When the thermal switch opens, it causes a logic low heater status signal, which illuminates the heater status LED and signals the microprocessor that the heater is on.

The thermal switch normally opens for a few minutes when a hot incubator is switched off because of residual radiant heat and the lack of a cooling air flow. If the incubator is restarted before the thermal switch has cooled, E13 may appear as soon as this alarm is enabled (approximately three and a half minutes after power up; normally, a period of three and a half minutes is sufficient to cool the incubator).

Check to see if the thermal switch has opened as soon as the error occurs, before it has had time to cool down. The thermal switch opens at a temperature of 76.7 C and is located on the back of the controller, adjacent to the air flow thermistors. Check the temperatures of the air flow thermistors to see if they are near this range by depressing and holding the F/C switch until the temperature of the unheated air flow thermistor appears in the air temperature display and the temperature of the heated thermistor appears in the control temperature display (approximately five seconds). Because the decimal point is not illuminated, you must divide the readings by 10 to obtain the temperature.

The second possibility is that the thermal switch has failed in an open position. Disconnect the power cord and do a continuity check between solid state relay pin 1 and the transformer phase (pin 2 on 120 volt units). If the resistance is not between 20 and 100 Ohms, replace the thermal switch.

The third possibility is a shorted solid state relay. Replace the relay. If the problem persists, replace the control board.

13. E14, Alarm Oscillator Failure

An alternating two tone alarm signal has been activated, but the 2 kHz signal at TP2-1 is not toggling.

To troubleshoot this failure, an alternating two tone alarm must be active. If there is no error code displayed, trigger an alarm by disconnecting the patient temperature probe while in the patient control mode.

If you hear the alarm (i.e. the 2 kHz signal is present), replace the I/O expander (U15), followed by the microcontroller (U19). If the problem persists replace the control board.

If you do not hear the alarm (i.e. the 2 kHz signal is missing), the timing circuit (U6B) or one of the circuits that gate the timing circuit inputs may be faulty. Since these chips are not socketed, control board replacement is recommended.

14. E15, Software Upset
A software upset has caused the watchdog timer to time out and the system is unable to recover because critical parameters (e.g. control temperature) stored in the RAM may have been altered.

This error does not necessarily indicate a hardware failure. Power the incubator up. If the error does not recur, allow the unit to run for half an hour. Then check the number of recoverable software upsets that have occurred by depressing and holding the Override switch until a new value appears in the control temperature display (approximately five seconds). If FF appears in the control temperature display, no software upsets have occurred. Complete the Checkout Procedure and return the unit to service.

If another value appears in the control display, replace the control board .

15. E17, Software Upset
The software is not cycling through all of the routines and is unable to recover.

Power the incubator up. If the error does not recur, allow the unit to run for half an hour. Then check the number of recoverable software upsets that have occurred by depressing and holding the Override switch until a new value appears in the control temperature display (approximately five seconds). If FF appears in the control temperature display, no software upsets have occurred. Complete the Checkout Procedure and return the unit to service.

If another value appears in the control display, replace the control board .

16. E18, Air Temperature Sensor Out of Tolerance
This failure is normally caused by a faulty air temperature sensor. Power the unit up from a cold start with an air control temperature of 39 C. When the error occurs, observe the difference between the air control and air display thermistor readings by pressing and holding the the Override switch until the air control temperature appears in the patient temperature display (approximately five seconds). Compare this temperature to the air display temperature. If the difference exceeds 0.5 C, replace the air temperature sensor and repeat the test. If the error persists, replace the control board.

17. E19, Software Upset
The watchdog timer has timed out 256 times since power up. This error can be caused by a software upset and does not necessarily indicate a hardware failure.

Power the incubator up. If the error does not recur, allow the unit to run for half an hour. Then check the number of recoverable software upsets that have occurred by depressing and holding the Override switch until a new value appears in the control temperature display (approximately five seconds). If FF appears in the control temperature display, no software upsets have occurred. Complete the Checkout Procedure and return the unit to service.

If another value appears in the control display, replace the control board.

18. E20, Air Flow Sensor Failure
The temperatures of the heated and the unheated air flow sensor thermistors differ by less than 5 C for two minutes.

Depress and hold the F/C switch until new values appear in the air temperature and control temperature displays (approximately five seconds). The heated thermistor signal appears in the air temperature display and the unheated thermistor signal appears in the control temperature display. Divide both values by 10 to convert them to degrees centigrade. If the resulting temperatures differ by less than 5 C, replace the air flow sensor. Check continuity across the sensor resistor (J5 pins 6 and 5) to verify that it contains a bad circuit. If the resistor has not opened or the problem persists, replace the control board.

19. E21, Air Flow Sensor Open or Shorted
Note: This failure can be triggered if a very cold incubator (<12 C) is put into service without being allowed to warm up.

The temperature of either thermistor in the air flow sensor is outside the 12 to 120 C range, indicating a short or open circuit.

Depress and hold the F/C switch until the heated thermistor signal appears in the air temperature display and the unheated thermistor signal appears in the control temperature display (approximately five seconds). If the readings are outside the specified range, replace the air flow sensor. Perform a continuity check on the thermistors in the old sensor to verify that it indeed contains a bad circuit. If the resistance indicates either an open or a short between J5, pins 8 and 7 or pins 4 and 3, discard the sensor. If the sensor tests out as good or the problem persists, replace the control board.

4.2 Power Up Tests

When power is first applied, the following self tests are performed. Specific test information for troubleshooting purposes is given in Section 4.1.B.

1. Instruction Test (E01)
2. EPROM Checksum Test (E04)
3. RAM Test (E05)

The power up test sequence is accompanied by a series of power up displays:

1. An alternating two tone audible alarm sounds for approximately five seconds, all the indicators illuminate and 188.88 appears in the temperature displays.
2. All indicators go out except the air control and the enable indicators. The temperature displays change to show from left to right:

Patient Temperature	**Air Temperature**	**Control Temperature**
XX.XX (software revision 01.01 etc.)	60.H (AC frequency 50.H for 50 Hz models)	39.0C (max. manual control temp.)

3. An operator prompt tone sounds and the control temperature display flashes 33.0 C. The operator prompt tone will sound every two seconds until a control temperature is entered.

4.3 On Line Testing

The incubator continuously performs the following tests during normal operation. An error in any of the tests triggers the system failure alarm. The corresponding error code will appear in place of the control temperature. Specific test information for troubleshooting purposes is given in Section 4.1.B.

1. ADC Calibration Test (E02 and E03)
2. ADC Failure (E07)
3. S/O Circuit Not Working (E08)
4. Incorrect Dipswitch Setting (E09)
5. Air Display Sensor Bad (E10)
6. Air Control Sensor Bad (E11)
7. Heater Not Switching On or Off (E12 or E13)

8. Alarm Oscillator Test (E14)
9. Software Upset, Watchdog Timer (E15)
10. Software Upset, Not Cycling Through All Routines (E17)
11. Air Temperature Sensor Out of Tolerance (E18)
12. Software Upset, Excessive Watchdog Resets (E19)
13. Air Flow Sensor Failure (E20)
14. Air Flow Sensor Open or Shorted (E21)

4.4 On Demand Testing

There are two types of on demand testing: a combination RAM Memory display loop that cycles through the power up tests and checks display board functions; and special switch activated displays, which display various parameters to aid in diagnosing problems. The specific troubleshooting applications of individual on demand tests are discussed in Section 4.1.B.

A. RAM Memory Display Loop

1. Self Tests
To enter this loop depress and hold the Override switch while powering up the unit. Release the switch when a continuous alarm sounds. The microcontroller cycles through a series of self tests, including:

All of the power up tests
- Instruction Test (E01)
- EPROM Checksum Test(E04)
- RAM Test (E05)

The following on line self tests
- ADC High Calibration Failure (E02)
- ADC Low Calibration Failure (E03)
- ADC Failure (E07)
- Air Display Sensor Bad (E10)
- Air Control Sensor Bad (E11)
- Heater Not Switching On (E12)
- Heater Not Switching Off (E13)
- Alarm Oscillator Failure (E14)

Important : Unless you specifically want to repeat the power up tests, troubleshooting should be performed in the normal operational modes.

2. Displays

The display loop runs simultaneously with the self tests, displaying frames of data and testing for proper LED operation. Frames are cycled as follows:

	Temperature Displays		
Frame	**Patient Temp.**	**Air Temp.**	**Control Temp.**
1.	------- All displays blank; Alternating two tone alarm -------		
2.	Patient Temp.	Air Display Temp.	Air Control Temp.
3	Low Cal. Point	High Cal. Point	%Nom. Voltage x .1
4	------- All displays read 188.88 and all LEDs illuminate ------		

B. Switch Activated Displays

In normal operation, the Alarm Silence, the Enable, the Override, the F/C, the Patient Control, and the Air Control switches activate service displays when held down for more than five seconds. The high priority alarm also sounds to indicate that actual patient and air temperatures are not displayed. The normal display reappears when you release the switch.

The following table summarizes the data that will be displayed when each switch is depressed and held for at least five seconds. It is intended as a quick reference. Switch applications for troubleshooting are discussed in Section 4.1.B under the individual error codes.

Important: Continue to hold down the switch for as long as you wish to view the special, service display. The normal display reappears when you release the switch.

Switch	Patient Temperature	Air Temperature	Control Temperature
Alarm * Silence	188.88	188.88	188.88
Enable	Low cal. point (25.05+/-0.3 C)	High cal point (37.96+/-0.3 C)	% of nominal voltage XX.XX = XXX.X%; 100 +/- 2% at 115 VAC Ok if between 90 & 110%)
Override	Air control temp (XX.XX C Format)	Air display temp (XX.XX C Format)	FF - # software upsets (hexadecimal down counter)
Air Control	Patient temp (XX.XX C Format; includes temps outside normal range)	Air control temp or DET (updated every 10 min)	XX.YY (XX = avg. power, YY =% max. power)
F/C	Patient temp XX.XXC Format; includes temps outside normal range)	Heated air flow. sensor therm-istor (Decimal point not shown Divide by 10 to obtain degrees C.	Temp of reference air flow sensor thermistor (decimal point not shown. Divide by 10 to obtain degrees C.
Patient Control	ADC counts for patient temperature thermistor.	ADC counts for unheated air flow sensor thermistor	ADC counts for line voltage

*** All display board LEDs illuminate to test proper operation.**

4.5 Test Points

Control board test points are accessible when the controller is removed from the unit. Specific application of test point readings to various error codes is discussed in Section 4.1.B. Individual test points and their expected readings are as follows:

Important: The 1.0 reference voltage varies by up to 20 percent between units. Hence thermistor resistance rather than signal voltage should be used to check temperature measurements.

Reference the appendix tables for summaries of the resistance versus temperature or percent of nominal voltage for the various ADC inputs.

Test Point	Description & Reading
TP1-1	9.8 +/- 0.05 Vdc *
TP1-2	Line Compensation (0.7 Vdc) *
TP1-3	+ 5 Volts Disp (5 +/- 0.3 Vdc)
TP1-4	+ 5 Volts Stby (5 +/- 0.3 Vdc)
TP1-5	+ 8 Volts Unregulated (8 +/- 1.5 Vdc)
TP1-6	+ 9 Volts Stby (9 +/- 0.3 Vdc)
TP1-7	(not used)
TP1-8	Logic Ground
TP2-1	2 kHz Frequency (2 kHz +/- 100 Hz) * (measure during calibration loop)
TP2-2	Heater Control Signal (Low = Heater ON)
TP2-3	+ 1 Volt Thermistor Reference (1.0 +/- 0.2 Vdc)
TP2-4	+ 2 Volt A/D Reference Signal (about 2.0 Vdc)#
TP2-5	$\overline{SO}$ Air Display Sensor Short or OPEN SIGNAL (low = sensor circuit shorted or open)
TP2-6	OT Air Display Over Temperature Signal (high = high temp. alarm active)
TP2-7	Air Display Signal
TP2-8	Logic Ground
TP3-1	SW1-1 (U17, P6.0)
TP3-2	SW1-2 (U17, P6.1)
TP3-3	SW1-3 (U17, P6.2)
TP3-4	SW1-4 (U17, P6.3, not used)
TP3-5	SW1-5 (U17, P7.0, not used)
TP3-6	SW1-6 (U17, P7.1, not used)
TP3-7	SW1-7 (U17, P7.2)
TP3-8	SW1-8 (U17, P7.3)
TP3-9	+ 5 Volts Stby (5 +/- 0.2 Vdc)
TP3-10 to TP3-12 (not used)	

* Refer to calibration section for adjustment procedure.

Nominal value, adjusted as part of ADC calibration.

WARNING: Before any disassembly or repair, disconnect the electrical supply and any gas supply connections. Also remove any accessories. Do not perform any service or maintenance with the power applied unless specifically told to do so in the procedure.

WARNING: Disconnect power to the incubator and allow the heater to cool for at least 15 minutes before servicing or cleaning to avoid the danger of a burn.

WARNING: Never oil or grease oxygen equipment unless a lubricant that is made and approved for this type of service is used. Oils and grease oxidize readily, and in the presence of oxygen, will burn violently. Vac Kote is the oxygen service lubricant recommended (Stock No. 0220-0091-300).

CAUTION: Insulation on the electrical wiring can deteriorate with age. When performing the Checkout Procedure, check for brittle or deteriorated insulation on the power cord.

CAUTION: Use the Static Control Work Station (Stock No. 0175-2311-00) to help ensure that static charges are safely conducted to ground. The Velostat material is conductive. Do not place electrically powered circuit boards on it.

5.1 Hood Repair

Important: In cases where total disassembly is not required, replacing an end porthole for example, perform only the necessary steps.

Note: You must depress the hood tilt button while opening or closing the hood.

Refer to Figures 5-1, 5-2 and 5-3.

1. Turn the power switch OFF and unplug the unit.
2. If the incubator was previously on, allow it to cool for at least 15 minutes.
3. Remove the front door by opening it to reveal the two spring loaded hinge pins that attach the door to the lower unit. Pull both pins out towards the sides of the hood and lift off the door.
4 Remove the inner wall as shown in Figure 5-1:

CAUTION: Inner wall fasteners are permanently attached to the inner wall and cannot be removed without damaging them.

a. Remove the rear inner wall by pulling out the plunger portion of the inner wall fasteners

b. To remove the upper inner wall, open the hood and pull out the plunger portion of the inner wall fasteners while supporting the wall.

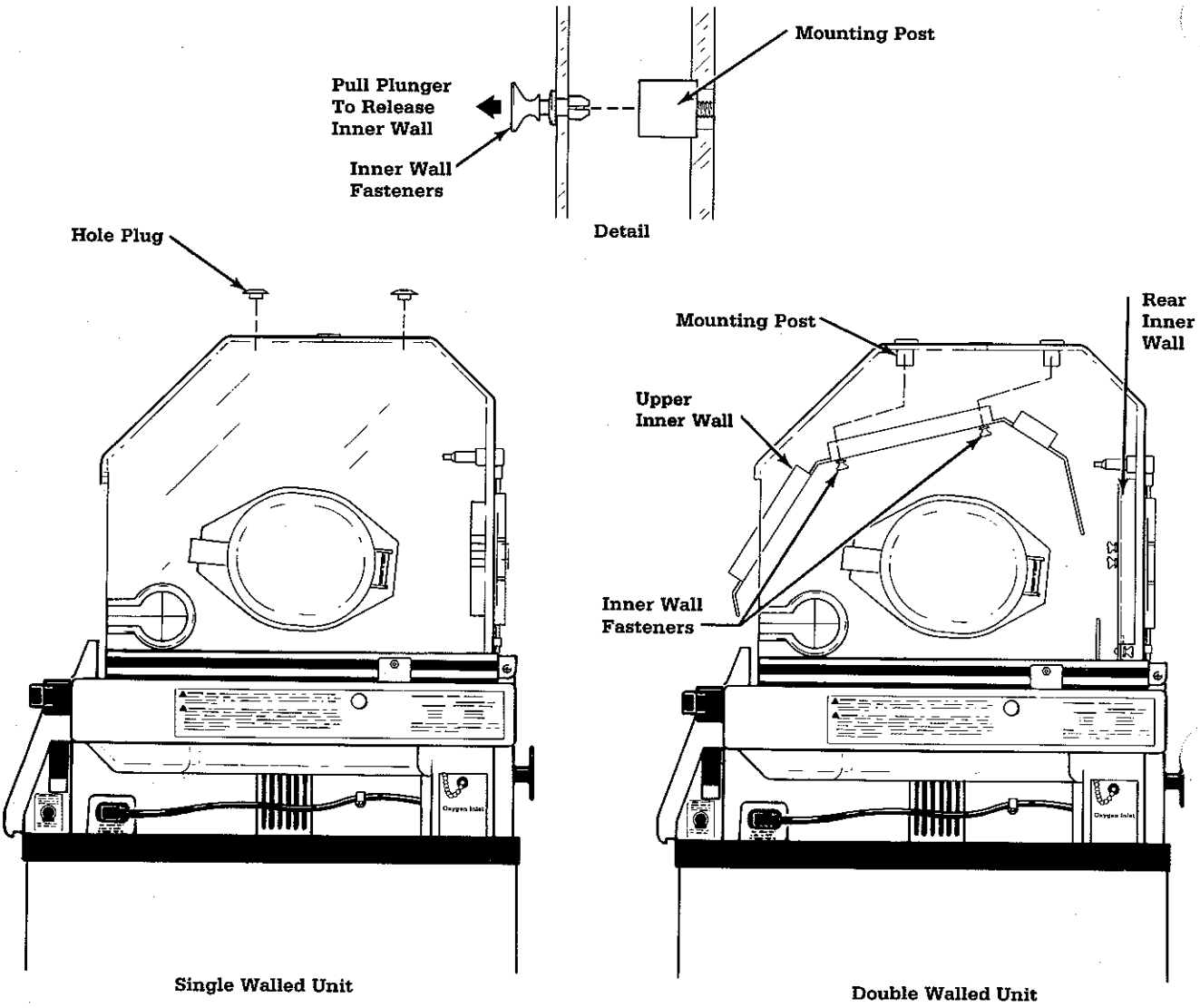


Figure 5-1 Remove the Inner Wall

5. To remove the outer hood (Figure 5-2):

   a. Lower the outer hood.

   b. Remove the air temperature sensor from the hood by: unscrewing the nut and screw that anchors the sensor cable; removing the two Phillips head screws that hold the sensor mounting blocks and spacers in position; and then sliding the air temperature sensor out of the hood.

   c. Remove the nut and screw that attach the hood to the hood tilt latch (rear, right hand corner of the incubator).

d. Remove the two Phillips head screws used to secure the back of the hood to the base hinges.

Note: When you replace the outer hood, fully tighten the hinge screws, then loosen one half turn.

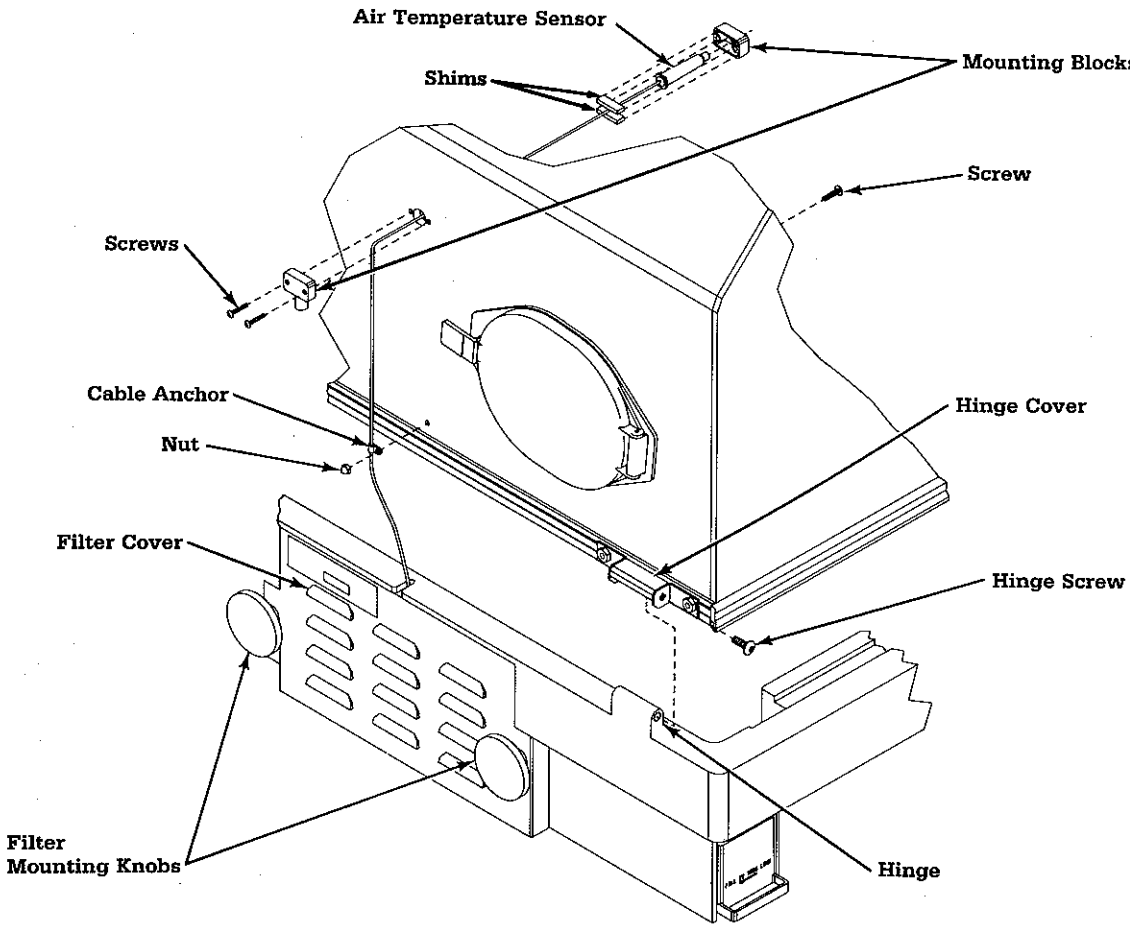


Figure 5-2 Remove the Outer Hood

6. Remove hood hardware as follows (Figure 5-3):

a. To remove the portholes, unscrew the mounting posts on either side of the port. On double-walled units this means you may have to remove the inner wall.

b. To remove the side or rear seals, first remove the outer hood. Then remove the hinge covers, the nut and screw that secure the hood tilt latch, and the Phillips head screws that hold the lower bars in position.

Note: When you replace the outer hood, fully tighten the hinge screws, then loosen one half turn.

Note: Since this is a lengthy procedure it is recommended that all seals be replaced at the same time.

c. Inner wall fasteners should not be removed. To install a new fastener, insert the socket portion into the proper hole and push the plunger in.

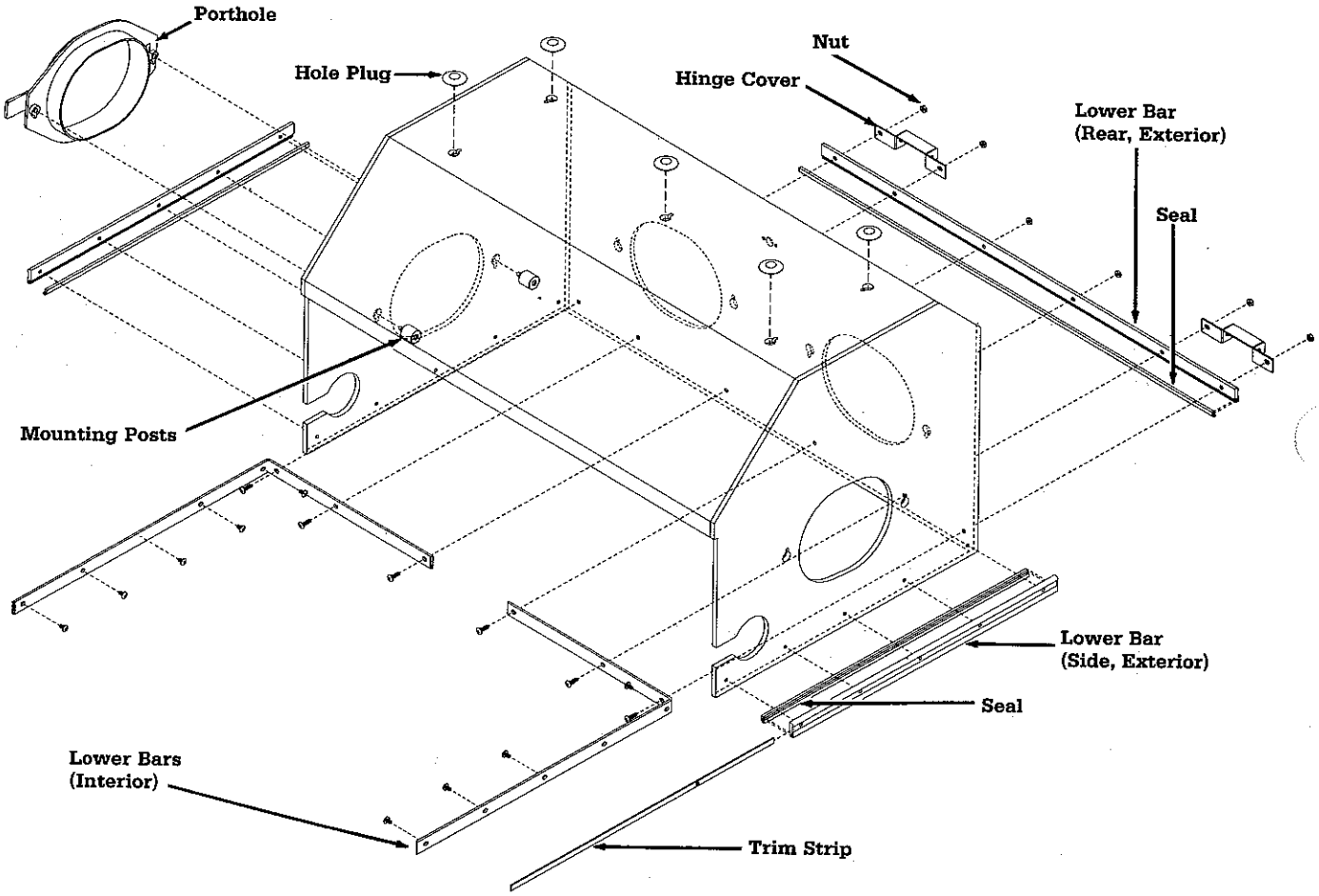


Figure 5-3 Remove Hood Hardware

d. To remove the disposable cuffs, open the porthole and slip the elastic band out from under the outer ring on the porthole housing.

Reverse the steps for assembly. To install new arm cuffs, slip the larger elastic ring over the outer ring of the porthole housing. To reattach the inner wall fasteners, line up the fasteners with the mating mounting posts and push in the

plunger portion of the fastener. When reattaching the hood tilt latch, do not over tighten the nut as this may inhibit the up and down movement of the hood.

5.2 Front Door Repair

Important: The front door seals are permanently attached and cannot be replaced individually. If they are damaged, a new outer front door must be installed.

1. Remove the front door by opening it to reveal the two spring loaded hinge pins that attach the door to the base. Pull both pins toward the sides of the hood and lift off the door.

2. Pull out the plunger portion of the inner wall fasteners to remove the inner wall.

CAUTION: Inner wall fasteners are permanently attached to the inner wall and cannot be removed without damaging them.

3. To remove the hinge pin and hinge pin assembly, remove the three Phillips head screws that secure it to the front door.

4. To remove a front door latch, loosen the set screw that secures the external knob. The curved washer and the internal latch will then slide off as shown in Figure 5-4.

5. To remove the portholes, unscrew the mounting posts on either side of the port.

6. Inner wall fasteners should not be removed. To install a new fastener, insert the socket portion into the proper hole and push the plunger in.

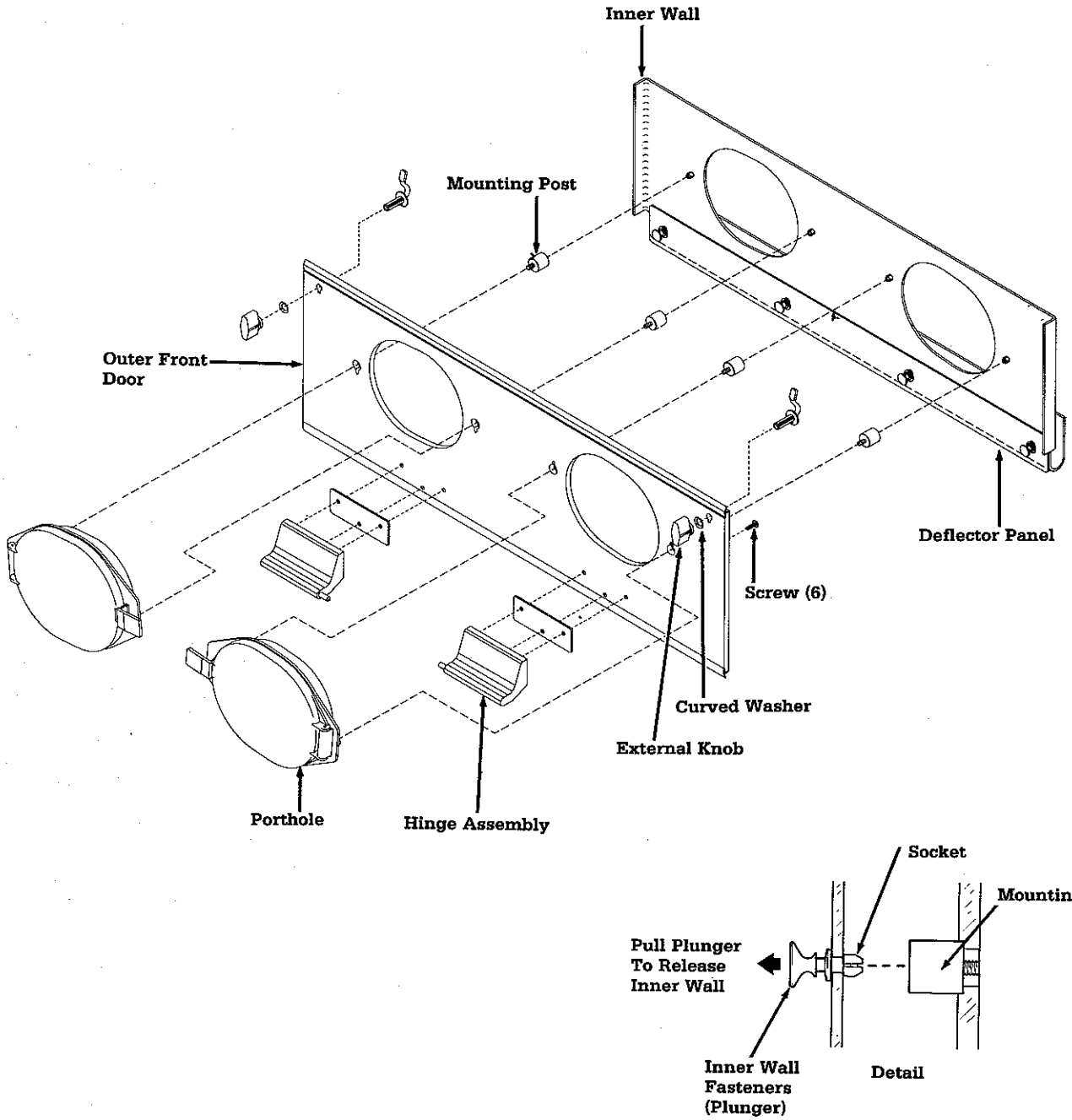


Figure 5-4 Front Door Disassembly

5.3 Air Temperature Sensor Replacement

(Figure 5-2)

WARNING: Two people are required to lift the Care Plus Incubator. Follow safe lifting techniques to avoid injury.

Note: The air temperature sensor is located inside the infant compartment and should not be confused with the air flow sensor on the rear of the controller.

1. Remove the inner walls on double walled units.

2. Lower the outer hood and close the front door.

3. Slip the sensor cable out of the retaining clip on the underside of the incubator.

Note: Early units use a screw and cable anchor to secure the cable. This requires that you unscrew the mounting knobs securing the incubator to the cabinet and lay the unit down on its side to remove the screw.

4. Remove the two Phillips head screws and shims that attach the air temperature sensor mounting blocks to the outer hood. Then slide the air temperature sensor out of the hood (Figure 5-2).

5. Unscrew the filter mounting knobs. Remove the filter cover and filter.

6. Unplug the air temperature sensor from the controller.

7. Pull the old air temperature sensor assembly out of the incubator.

8. Connect the new air temperature sensor to the controller.

9. Slip the new cable into the retaining clip. In older units, replace the screw and cable anchor with one of the new clips (Stock No. 6600-0145-400) and remount the incubator.

10. Route the cable out the rear of the base, through the hole near the air filter, and around the filter. Refer to Figure 6-8, page 6-13, for cable routing.

11. Replace the filter. Secure the filter cover with the filter mounting knobs. The hole on the top of the filter cover should line up with the cable.

12. Open the front door and rotate the hood to the open position.

13. Insert the air temperature sensor through the hole in the outer hood. Slide the symmetrical mounting block, backed by the two shims, over the sensor from the inside of the hood. Align the cable guard on the other block with the sensor cable on the outside of the hood. Secure the blocks with the two remaining Phillips head screws.

14. Anchor the sensor cable to the outer hood.

15. On double walled units, replace the inner wall.

5.4 Base Platform Disassembly

1. Remove the front door by opening it to reveal the two spring loaded hinge pins that attach the door to the base. Pull both pins toward the sides of the hood and lift off the door.

2. Depress the hood tilt release button and rotate the hood back into the locked position.

3. Remove the mattress and the mattress tray.

4. Remove each tilt assembly by pulling up on the tilt handle. The assemblies will slide out of their retaining sockets.

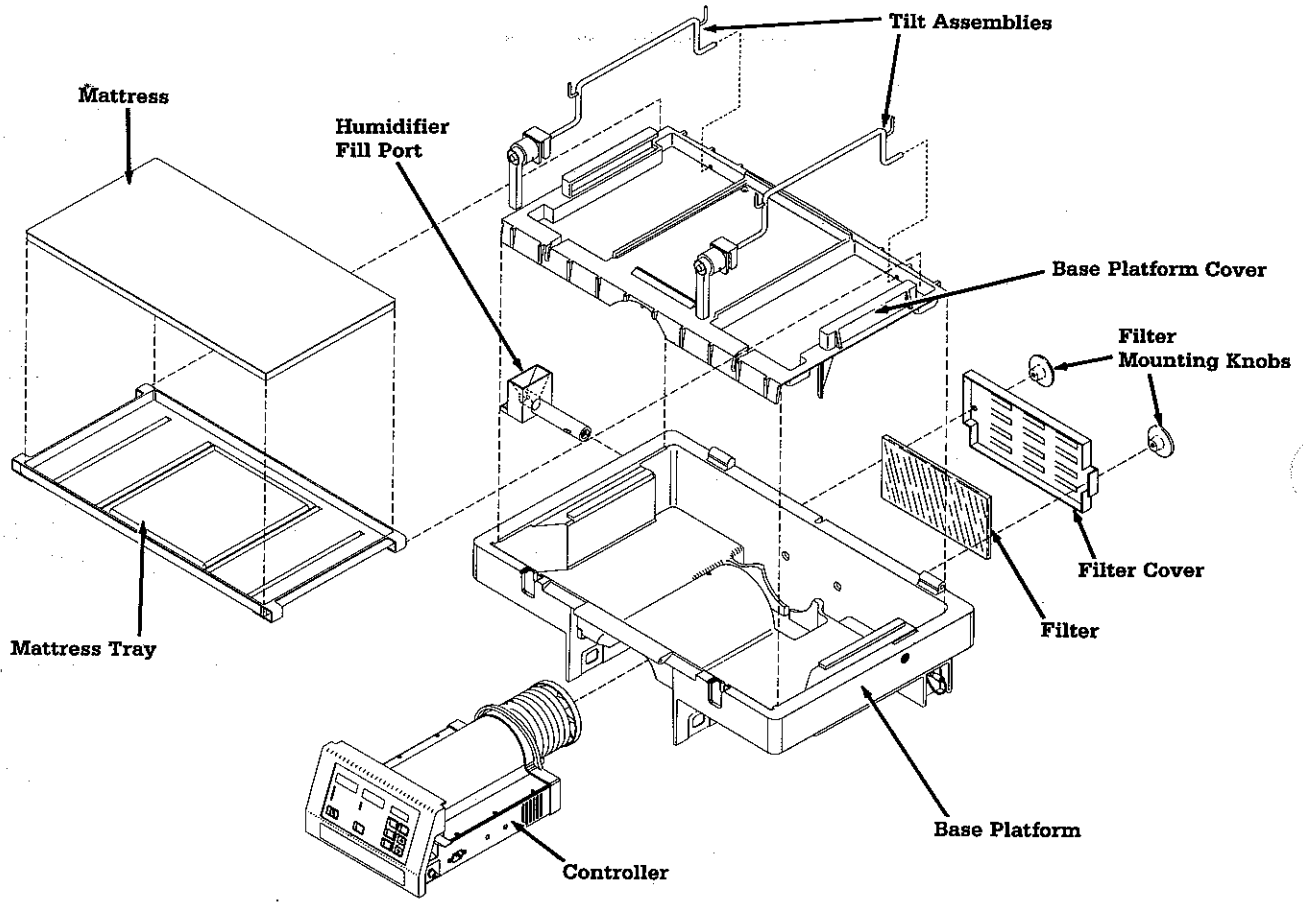


Figure 5-5 Base Platform Disassembly

5. Lift out the base platform cover.

6. Remove the humidifier fill port: pull it out to the fill position; rotate the spout clockwise about 45 degrees; and pull it out.

5.5 Controller Access

1. Disconnect the power cord, the patient probe, and the air temperature sensor from the controller.

2. Lift up the controller latches and slide the controller forward, out of the incubator.

CAUTION: When handling the controller, avoid bumping the fan or the heater. If these items are knocked out of alignment, the fan can grate against either the heater or the base.

3. Remove the six Phillips head screws and lock washers used to attach the controller cover.

4. Lift off the controller cover.

5.6 Control Board Replacement

CAUTION: Make sure the control board connectors are properly aligned before applying power.

1. Access the controller as described in Section 5.5.

2. Disconnect control board connectors J1, J2, J3, and J4.

3. Undo the four lock nuts that secure the control board.

4. Lift the board out of the controller.

5. Position the new control board so that J3 is at the front of the controller. Replace the four lock nuts to secure the board to its mounting standoffs (Figure 5-6).

6. Reconnect J1, J2, J3, and J4. Connector pins are numbered for proper alignment.

Note: Connectors J3 and J4 are identical except for the number of wires. J4 has 8 wires, J3 has 16 wires.

7. Make sure that switches 1, 2, 7 and 8 are set to OFF (open position). This selects a maximum control temperature of 39 C and disables the calibration and service loops. Make sure that dipswitches 3 and 4 are in the same position as on the previous board.

8. Perform the Calibration Procedure in Section 3.3.

9. Reattach the controller cover, using the six Phillips head screws and lock washers previously removed.

10. Pull up on the controller latches. Carefully slide the controller back into the incubator. Push down on the latches to secure the controller.

11. Perform the Checkout Procedure in Section 2.2. Listen for any grating sound caused by the fan rubbing against the base platform. Adjust the heater and fan position if rubbing is present.

12. Perform the resistance and leakage current tests in Section 3.4.

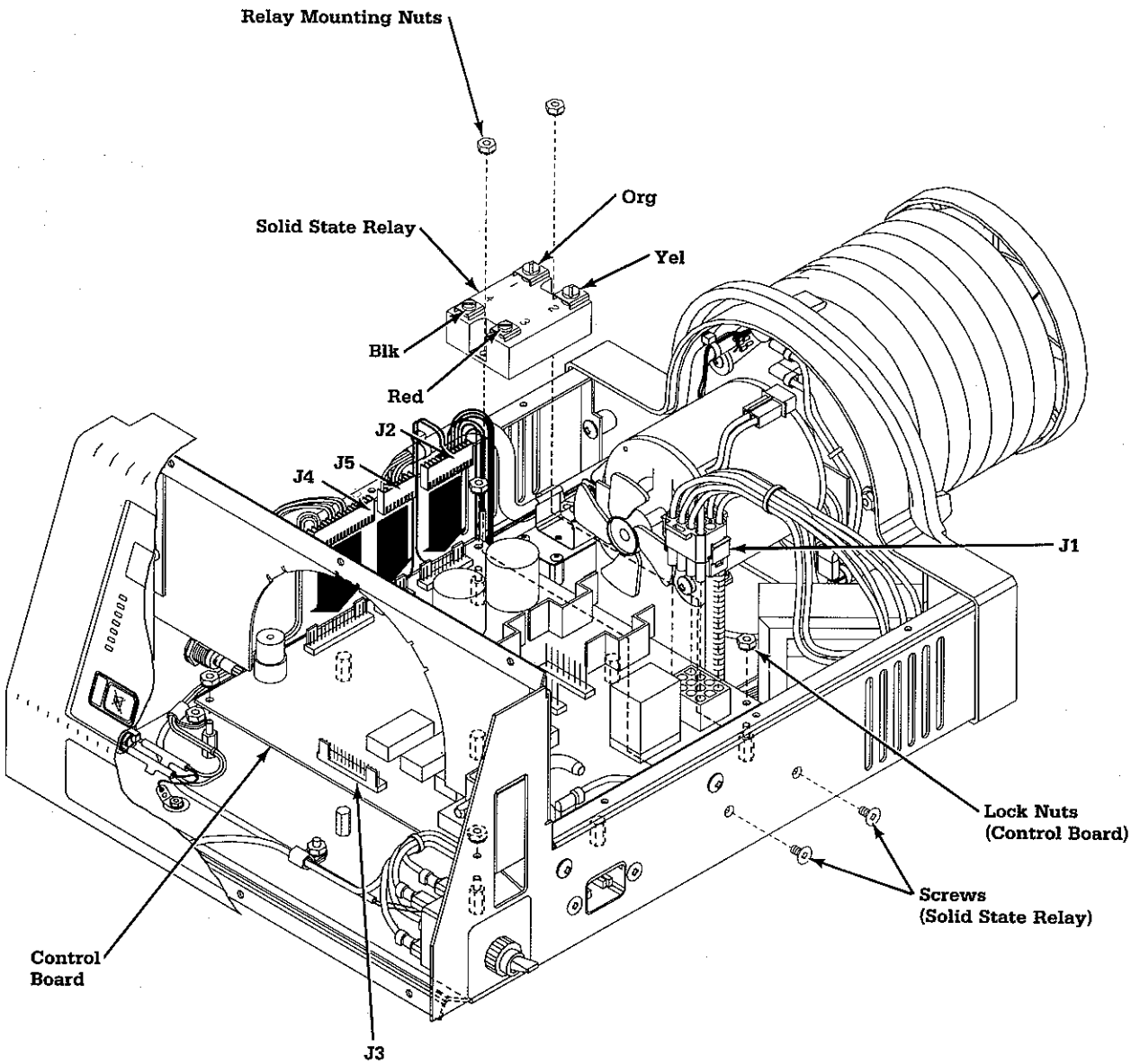


Figure 5-6 Controller Interior

5.7 Display Board Replacement

1. Access the controller as described in Section 5.5.

2. Disconnect J3 from the control board.

3 Remove the screw anchoring the controller plate ground wire to the controller front panel.

4. Turn the controller upside down and remove the lower three front panel mounting screws, shown in Figure 5-7.

5. Turn the controller right side up and remove the remaining front panel mounting screws, shown in Figure 5-7.

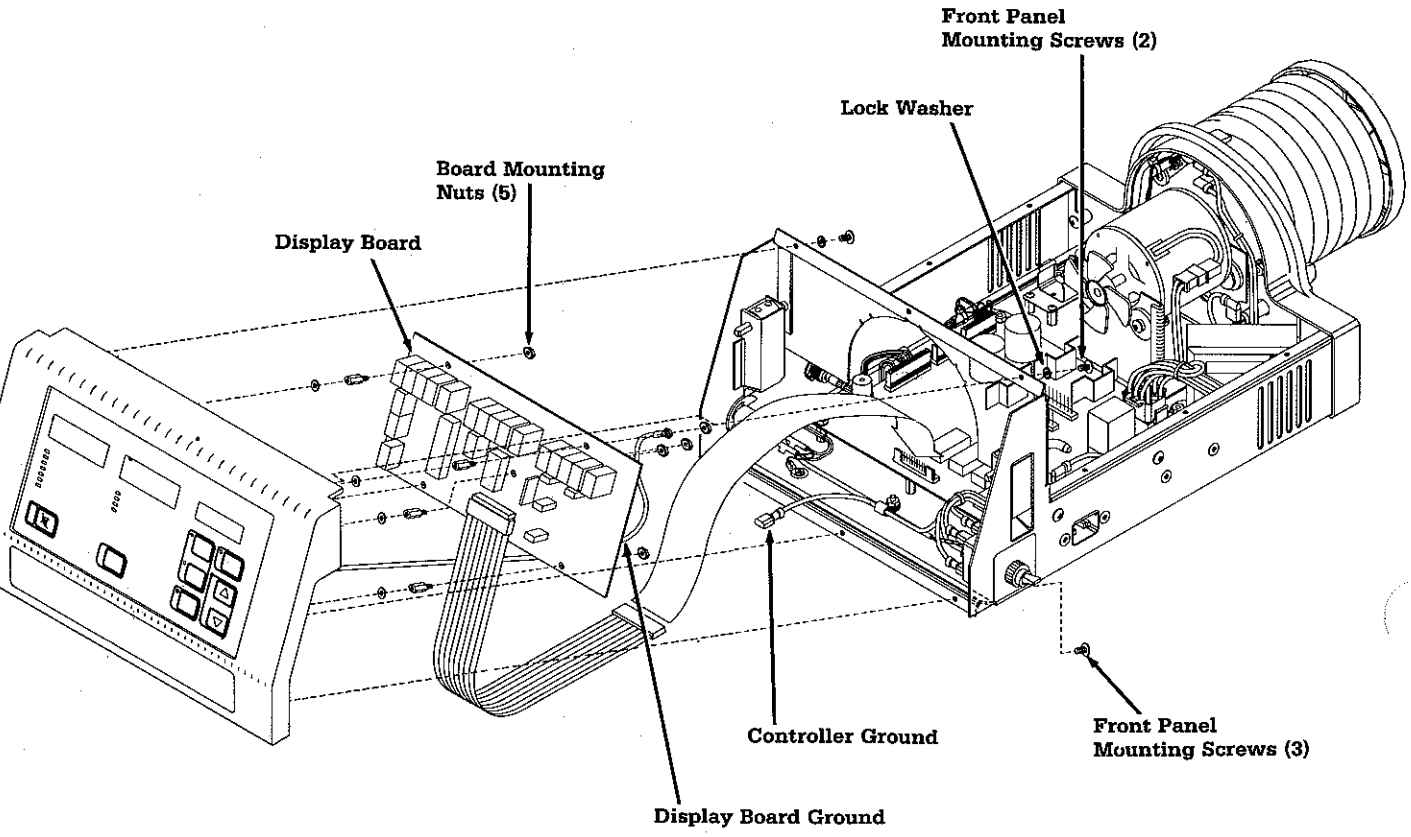


Figure 5-7 Replace the Display Board

6. Lift off the front panel.
7. Remove the five lock nuts used to mount the display board.
8. Remove the old display board.
9. Disconnect cable J8 from the old display board.

10. Connect J8 to the new display board.

11. Place the new board component side down on the board standoffs with J8 pointing toward the bottom of the controller.

12. Replace the five lock nuts to anchor the board. Use the upper left hand nut to anchor one end of the short (display board) ground wire (Figure 5-8).

13. Reattach the free ends of both ground wires to the metal bar below the display board (Figure 5-8).

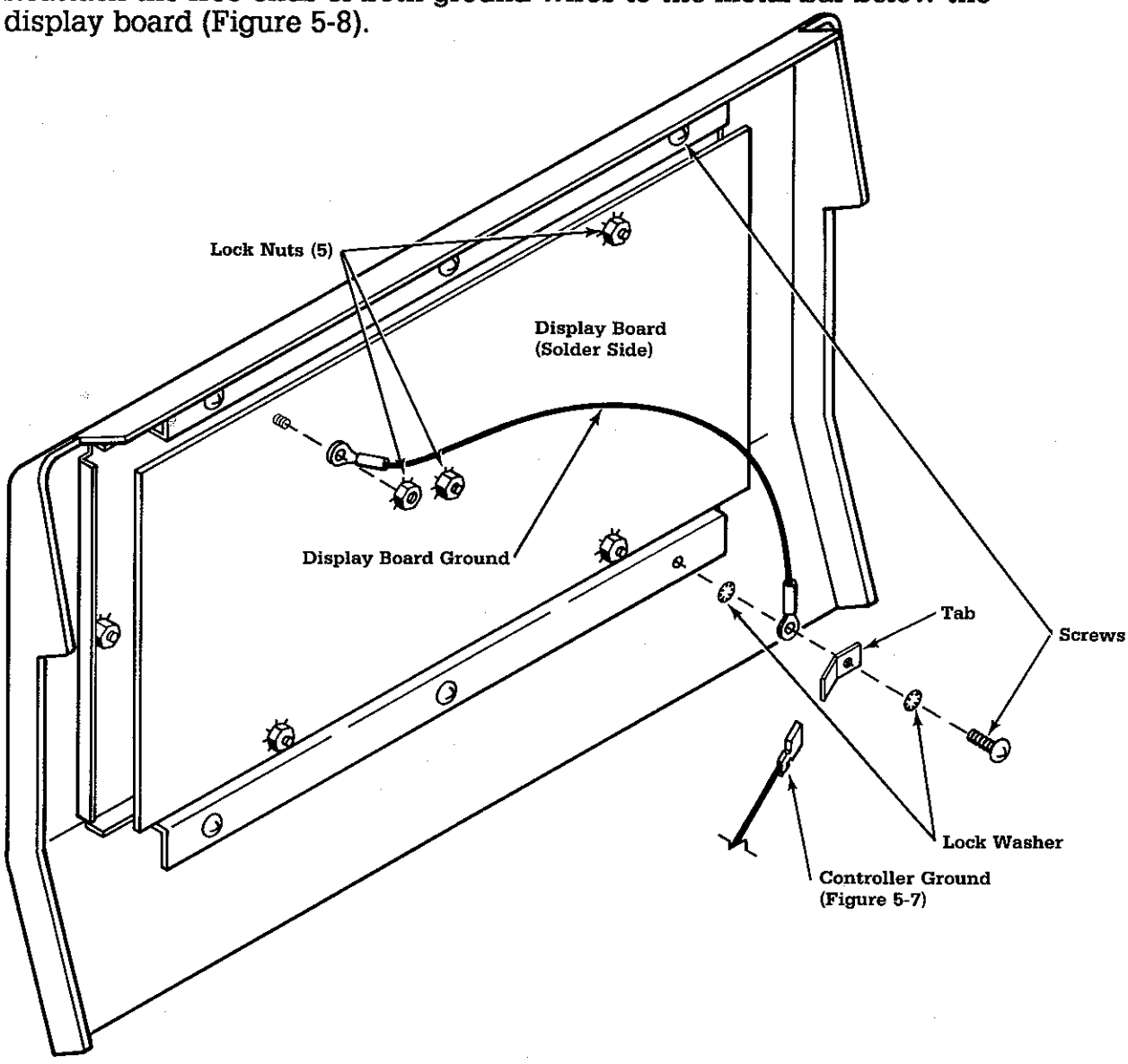


Figure 5-8- Display Panel Grounds

14. Connect the cable from J8 to control board connector J3.

15. Connect the air temperature sensor and the power cord to the controller. Plug the power cord into a power outlet and switch the controller ON.

16. If the display is too dim, complete Section 3.3.C to adjust the brightness.

17. Switch the controller OFF and reattach the front panel as shown in Figure 5-7.

18. Reattach the controller cover, using the six Phillips head screws and lock washers previously removed.

19. Pull up on the controller latches. Carefully slide the controller back into the incubator. Push down on the latches to secure the controller.

20. Perform the Checkout Procedure in Section 2.2. Listen for any grating sound caused by the fan rubbing against the base platform. Adjust the heater and fan position if rubbing is present.

21. Perform the resistance and leakage current tests in Section 3.4.

5.8 Solid State Relay Replacement

(Figure 5-6)

The solid state relay is located on the same side of the controller as the power socket. It is attached to the controller with two Phillips screws and two lock nuts.

1. Access the controller as described in Section 5.5.

2. Remove the two Phillips screws used to mount the relay.

3. Lift the relay out of the controller.

4. Remove the screws that attach the wires to the solid state relay.

5. Connect the wires to the new solid state relay as follows:

Wire Color	Pin
Orange	1
Yellow	2
Red	3
Black	4

6. Use the two Phillips screws and the two lock nuts to attach the new relay to the side of the controller. Pins 3 and 4 should be toward the front of the controller.

7. Reattach the controller cover, using the six Phillips head screws and lock washers previously removed.

8. Pull up on the controller latches. Carefully slide the controller back into the incubator. Push down on the latches to secure the controller.

9. Perform the Checkout Procedure in Section 2.2. Listen for any grating sound caused by the fan rubbing against the base platform. Adjust the heater and fan position if rubbing is present.

10. Perform the resistance and leakage current tests in Section 3.4.

5.9 Heater and/or Heater Gasket Replacement

CAUTION: If early model heaters are not installed with the nuts on the inside of the controller and the screws on the outside, water can leak in during cleaning and damage the electronics.

CAUTION: If gaskets are not installed properly, water can leak in during cleaning and damage the electronics.

1. Access the controller as described in Section 5.5.

2. Unscrew the fan mounting knob at the end of the fan shaft. Remove the fan.

3. Remove the top two heater mounting nuts on the back of the controller.

4. Disconnect the white wires from the heater.

Note: On some very early models, the heater wires are terminated with ring terminals. If you are replacing one of these heaters, remove the ring terminals from the wires and replace them with Faston 250 terminals.

5. Remove the lower heater mounting nut. The nut is accessed through a hole in the motor mounting bracket.

Note: On early units you must remove the control board and the motor bracket to install a new heater.

6. Pull off the old heater.

Note: The heater gasket will also come off.

7. Align the heater gasket with the new heater and slide the new heater into the back of the controller.

8. Secure the heater to the rear of the controller as shown in Figure 5-9.

9. If necessary, remount the motor bracket and the control board.

10. Reattach the white wires to the heater.

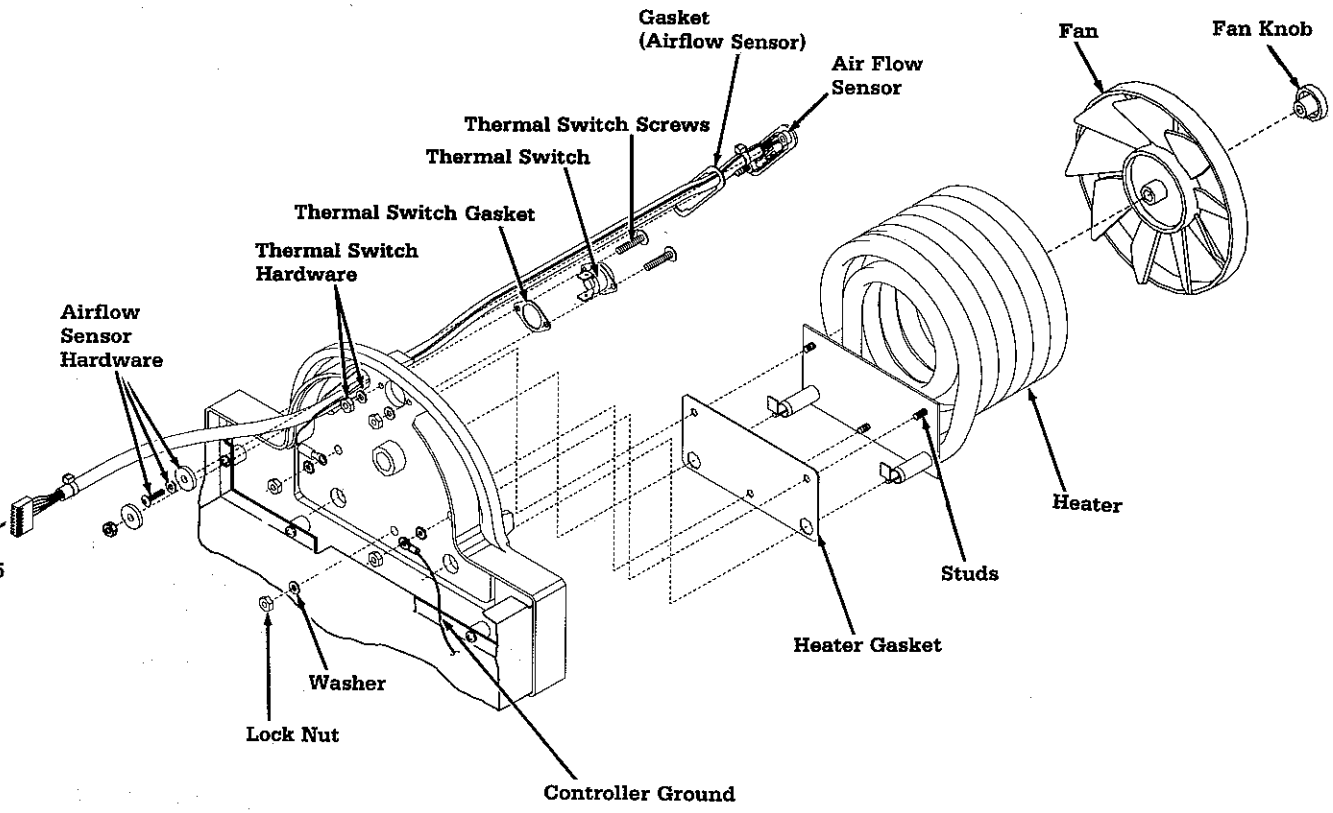


Figure 5-9 Heater, Thermal Switch and Air Flow Sensor Replacement

11. The fan is keyed to fit the shaft. Slide the fan back onto the shaft so that the collar points toward the heater.

12. Replace and tighten the fan mounting knob to secure the fan.

13. Reattach the controller cover, using the six Phillips head screws and lock washers previously removed.

14. Pull up on the controller latches. Carefully slide the controller back into the incubator. Push down on the latches to secure the controller.

15. Perform the Checkout Procedure in Section 2.2. Listen for any grating sound caused by the fan rubbing against the base platform. Adjust the heater and fan position if rubbing is present.

16. Perform the resistance and leakage current tests in Section 3.4.

5.10 Thermal Switch Replacement

CAUTION: If gaskets are not installed properly, water can leak in during cleaning and damage the electronics.

Note: It is not necessary to remove the heater.

1. Access the controller as described in Section 5.5.
2. Unscrew the fan mounting knob and remove the fan.
3. Disconnect the wires attached to the thermal switch.
4. Remove the screws securing the thermal switch and pull the thermal switch out of the controller. Position your hand inside the controller to catch the mounting nuts and lock washers when you remove the screws. Retain the gasket for use with the new thermal switch.
5. Align the gasket with the new thermal switch and replace the mounting hardware as shown in Figure 5-9.
6. Reconnect the thermal switch to the wires from J1 pin 2 and the heater.
7. Perform Section 3.3.I of the calibration procedures.
8. Reattach the controller cover, using the six Phillips head screws and lock washers previously removed.
9. Pull up on the controller latches. Carefully slide the controller back into the incubator. Push down on the latches to secure the controller.
10. Perform the Checkout Procedure in Section 2.2. Listen for any grating sound caused by the fan rubbing against the base platform. Adjust the heater and fan position if rubbing is present.
11. Perform the resistance and leakage current tests in Section 3.4.

5.11 Air Flow Sensor Replacement

CAUTION: If the gaskets are not properly installed, water can leak in during cleaning and damage the electronics.

Note: It is not necessary to remove the heater.

1. Access the controller as described in Section 5.5.
2. Remove all screws, (nuts on some units) and harness clips that hold the sensor in place.

3. Disconnect the air flow sensor cable from the control board.

4. Install the new sensor and gasket, making sure that the sensor is oriented as shown in Figure 5-10.

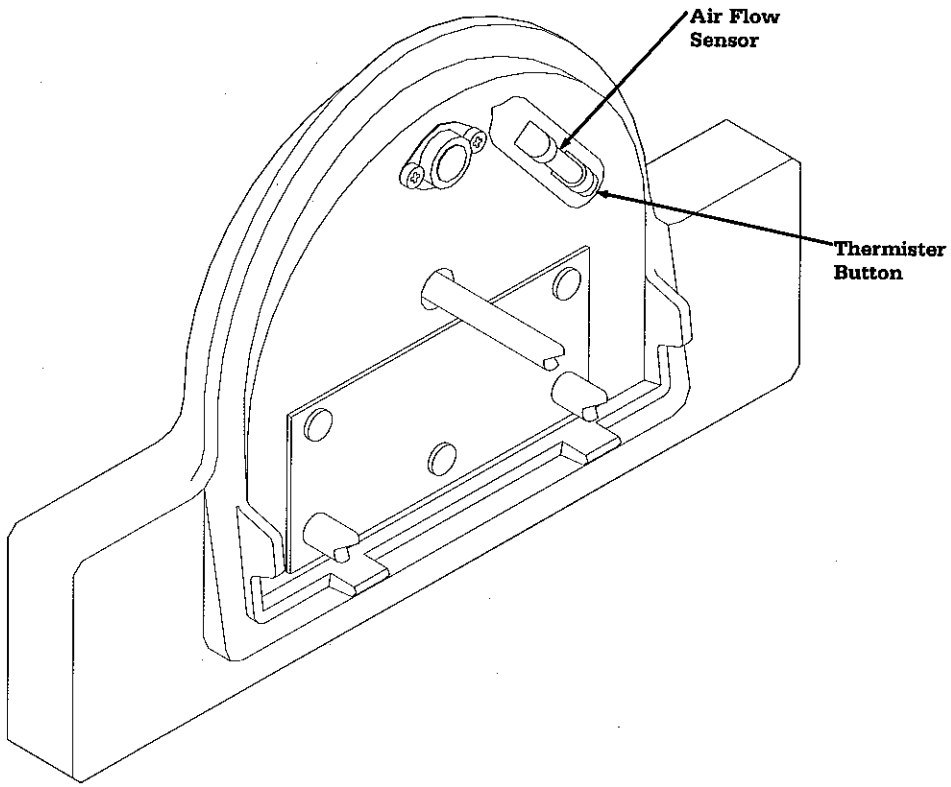


Figure 5-10 Air Flow Sensor Installation

5. Connect the air flow sensor cable to the control board and replace the controller cover.

6. Verify that the air flow sensor works as follows:

   a. Remove the controller from the rear of the unit and remove the fan. Replace the controller in the incubator and make sure that the air temperature sensor and the power cord are plugged in.

   b. Switch the incubator ON. The operator prompt tone will sound. **Do not adjust the control temperature;** running the incubator with the heater OFF provides a more thorough test of the air flow sensor.

   c. Allow the unit to run for 10 minutes. The front panel air circulation alarm indicator should illuminate and an alternating two tone alarm should sound.

d. Depress the F/C switch until a different pair of numbers appear in the air temperature and control temperature displays (approximately five seconds). Continue pressing the F/C button and record the numbers that appear in the air and control temperature displays.

e. Subtract the two numbers. The difference must be greater than 230.

f. Switch the unit OFF. Remove the controller and replace the fan. Slide the controller back into the incubator and reconnect the power cord and air temperature sensor.

g. Switch the unit ON and adjust the control temperature to 39 C. Allow the incubator to run for 10 minutes.

h. Again depress the F/C switch until a different pair of numbers appears in the air and control temperature displays (approximately five seconds). Continue pressing the F/C button and record the numbers that appear in the air and control temperature displays.

i. Subtract the two numbers. The difference must be less than 190.

7. If the conditions of steps "e" and "i" are not met, the air flow sensor must be replaced.

8. Perform the Checkout Procedure in Section 2.2. Listen for any grating sound caused by the fan rubbing against the base platform. Adjust the heater and fan position if rubbing is present.

9. Perform the resistance and leakage current tests in Section 3.4.

5.12 Fan Motor Replacement

1. Access the controller as described in Section 5.5.

2. Unscrew the fan mounting knob and remove the fan.

3. Turn the controller on its side and remove the four screws, standard washers and lock nuts used to attach the fan motor bracket to the controller.

4. Disconnect the fan motor connector from J1.

5. Remove the control board.

6. Slide the assembly toward the front of the controller, until the shaft clears the back of the controller. Then lift the assembly out of the controller.

7. Remove the four motor mounting screws and slide the motor out of the bracket.

8. Pull the small cooling fan off of the short motor shaft.

9. Attach the new motor to the bracket as shown in Figure 5-11.

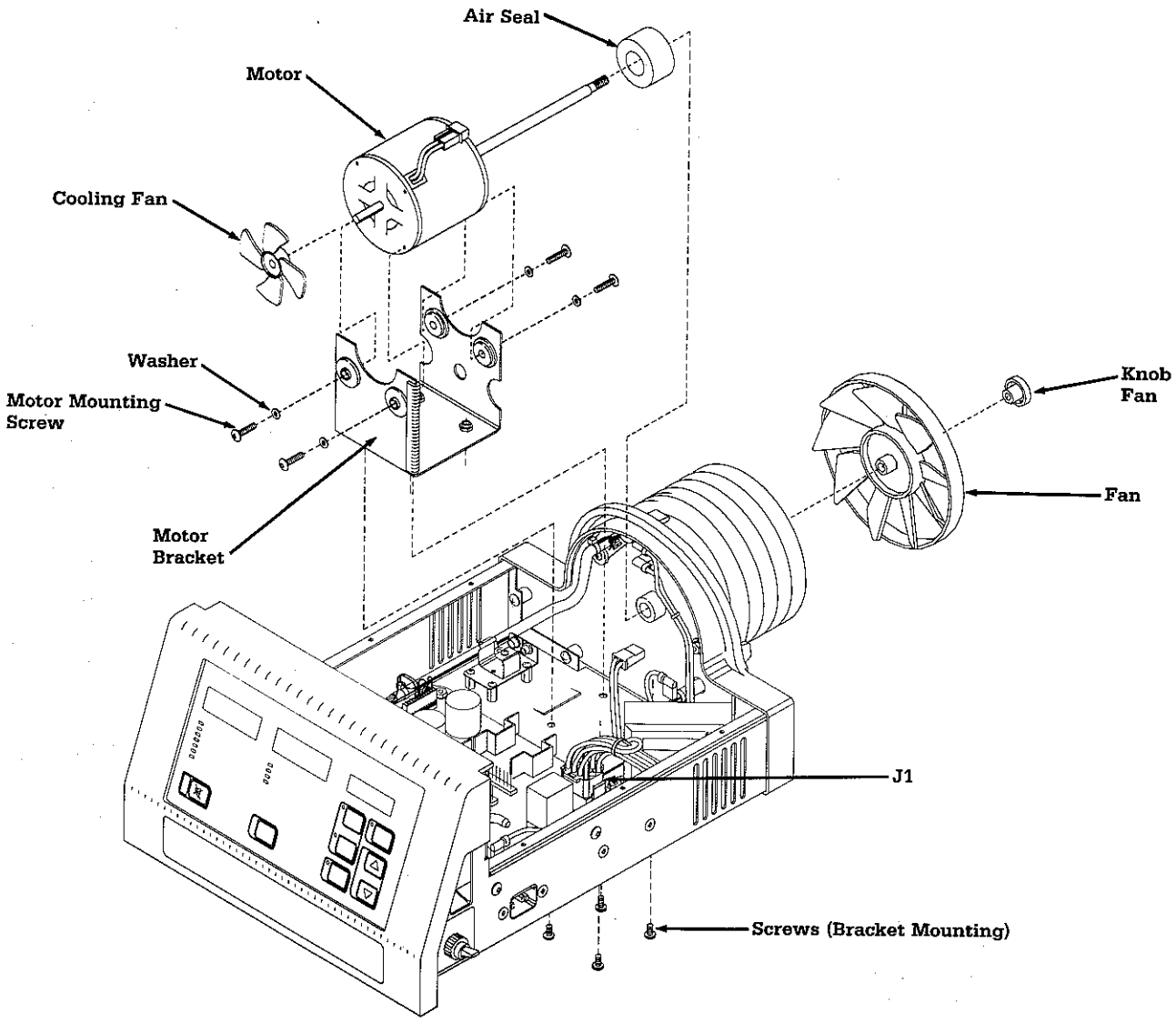


Figure 5-11 Fan Motor Replacement

10. Push the cooling fan onto the shorter motor shaft.

11. Slide the long motor shaft through the air seal and into the hole in the rear of the controller.

12. Secure the motor bracket to the controller with the four bracket mounting screws, shown in Figure 5-11.

13. The fan is keyed to slide onto the motor shaft. Slide the fan onto the shaft so the collar on the fan points toward the motor.

14. Replace the fan mounting knob. Fully tighten the knob.

15. Replace the control board.

16. Connect the motor connector to the connector from J1 on the control board.

17. Reattach the controller cover, using the six Phillips head screws and lock washers previously removed.

18. Pull up on the controller latches. Carefully slide the controller back into the incubator. Push down on the latches to secure the controller.

19. Perform the Checkout Procedure in Section 2.2. Listen for any grating sound caused by the fan rubbing against the base platform. Adjust the heater and fan position if rubbing is present.

20. Complete the resistance and leakage current tests in Section 3.4.

5.12 Battery Replacement

1. Access the controller as described in section 5.5.

2. Remove the battery by sliding the battery away from the contacts.

3. Install the new battery by lining the terminals up with the contacts and sliding the battery into the bracket.

4. Reattach the controller cover, using the six Phillips head screws and lock washers previously removed.

5. Pull up on the controller latches. Carefully slide the controller back into the incubator. Push down on the latches to secure the controller.

6. Perform the Checkout Procedure in Section 2.2. Listen for any grating sound caused by the fan rubbing against the base platform. Adjust the heater and fan position if rubbing is present.

7. Perform the resistance and leakage current tests in Section 3.4.

5.13 Caster Replacement

WARNING: Two people are required to safely replace a caster. Remove the incubator and all accessory equipment from the cabinet before replacing a caster.

1. Remove all accessories from the incubator.

2. Remove the incubator mounting knobs (located inside the cabinet), which attach the incubator to the cabinet.

3. Lift the incubator off of the cabinet

4. Lay the cabinet on its side.

5. Remove the four lock nuts that attach the caster to the cabinet.
6. Remove the old caster.
7. Slide the new caster over the mounting studs.
8. Replace and tighten the lock nuts to secure the caster. Torque to 75 in/lbs.
9. Turn the cabinet right side up.
10. Attach the incubator to the cabinet with the incubator mounting knobs.

6.1 Hood Components

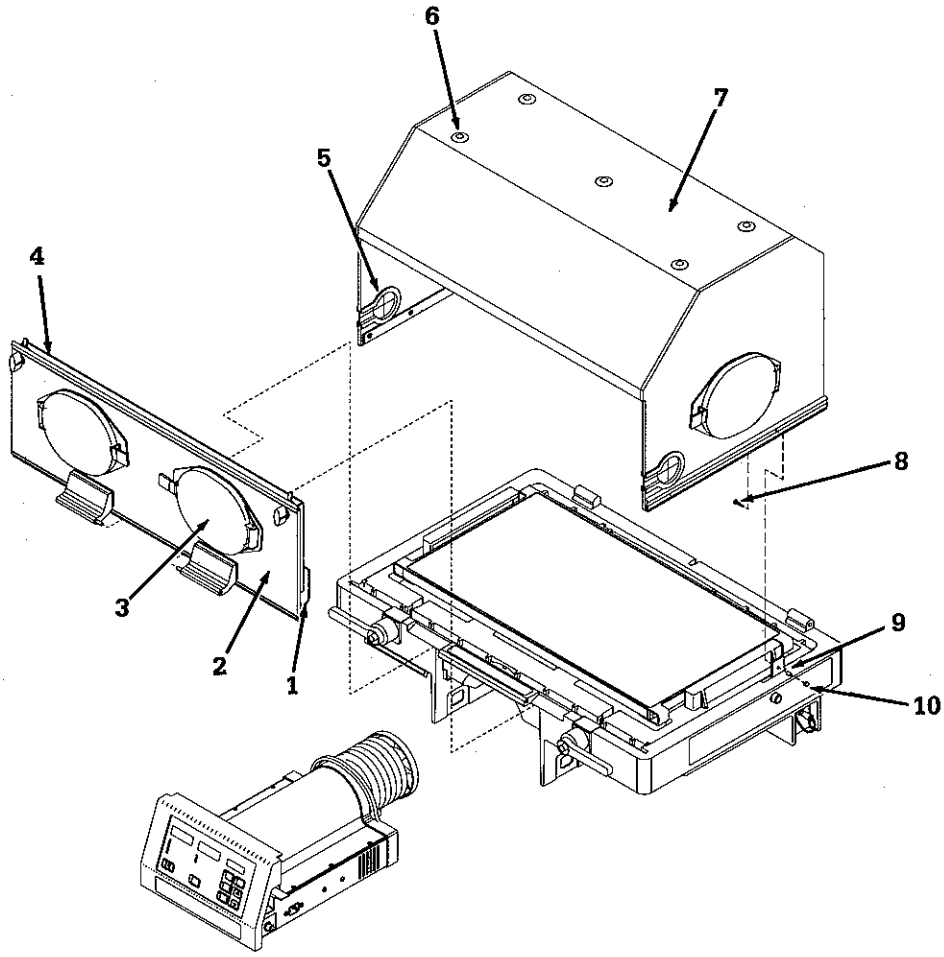


Figure 6-1 Incubator Assembly, Front View

	Item	Stock Number
1.	Deflector panel w/ fasteners	6600-0155-700
2	Front door replacement kit (outer door w/o hardware)	6600-0086-400
3.	Porthole assembly	6600-0051-400
4	Lower wall (front or rear w/ deflector panel)	6600-0106-800
5.	Tubing access cover	6600-0156-500
6	Hole plug	6600-0174-500
7	Hood replacement kit (outer hood with hardware)	6600-0038-810
8.	Screw, 10-24 x 1.000	6600-0118-400
9.	Nylon washer, 0.192 in ID	6600-0103-400
10.	Nut, ESN, 10-24, SST	6600-0088-400

	Misc. Hood Hardware	Stock Number
	Inner wall fastener (12/pkg)	6600-0102-800
	Mounting post	6600-0161-700

	Item	Stock Number
1.	Humidifier fill port kit (w/ o-ring)	6600-0070-800
2.	Filter cover	6600-0070-500
3.	Knob, filter cover mounting	6600-0068-500
4.	Nut, Hex, 8-32, FL MC	0144-3127-113
5.	Cable clamp	6600-0144-400
6.	Compartment probe kit, air temperature sensor (includes mounting blocks and screws)@	6600-0071-800
7.	Shim	6600-0222-500
8.	Screw, 8-32 x 5/8, TRS, P	0140-6627-110
9.	Screw, 1/4-20 x .500, R *	6600-0078-400

Not Shown	Stock Number
Humidifier o-ring	6600-0065-400
Filter w/ replacement date label	6600-0043-800
Probe pull, "T" handle air temperature sensor	6600-0240-500

*** Fully tighten, then loosen one turn.**

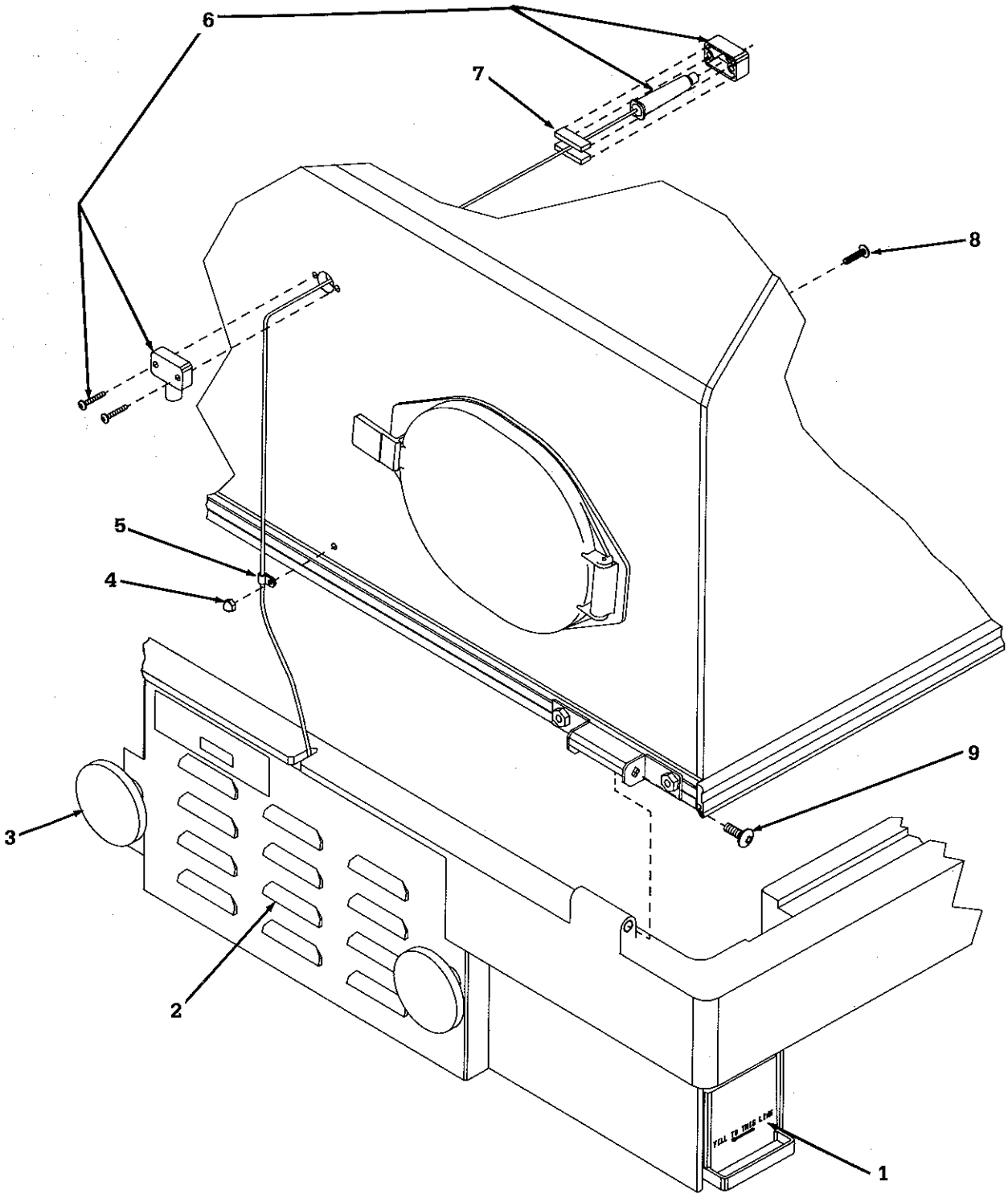


Figure 6-2 Incubator Assembly, Rear View

	Item	Stock Number
1.	Inner frame, hood (left or right half)	6600-0227-500
2.	Screw, 10-24 x .875	6600-0087-400
3.	Screw 10-24 x 1.00	6600-0118-400
4.	Screw, 10-24 x 1/2	0140-6630-108
5.	Hood seal (3 ft strip)	6600-0143-500
6.	Outer frame, left side	6600-0049-400
7.	Hole plug	6600-0174-500
8.	Hood replacement kit (all items shown above)	6600-0038-810
9.	Nut, ESN, 10-24, SST	6600-0088-400
10.	Hood hinge cover	6600-0165-500
11.	Outer frame, rear	6600-0048-400
12.	Outer frame, right side	6600-0050-400
13.	Trim, outer frame (3 ft strip)	6600-0166-500

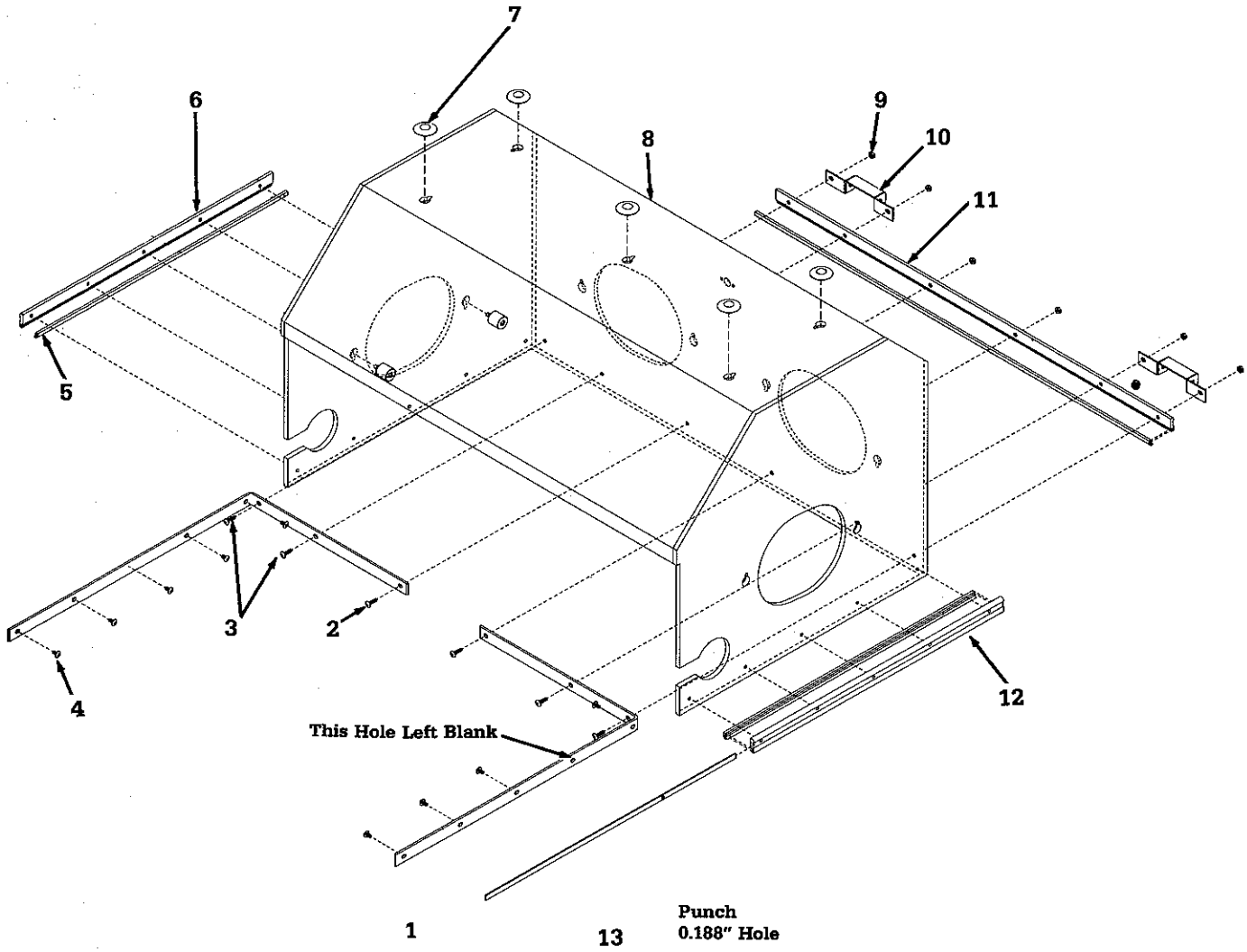


Figure 6-3 Hood Seals and Related Hardware

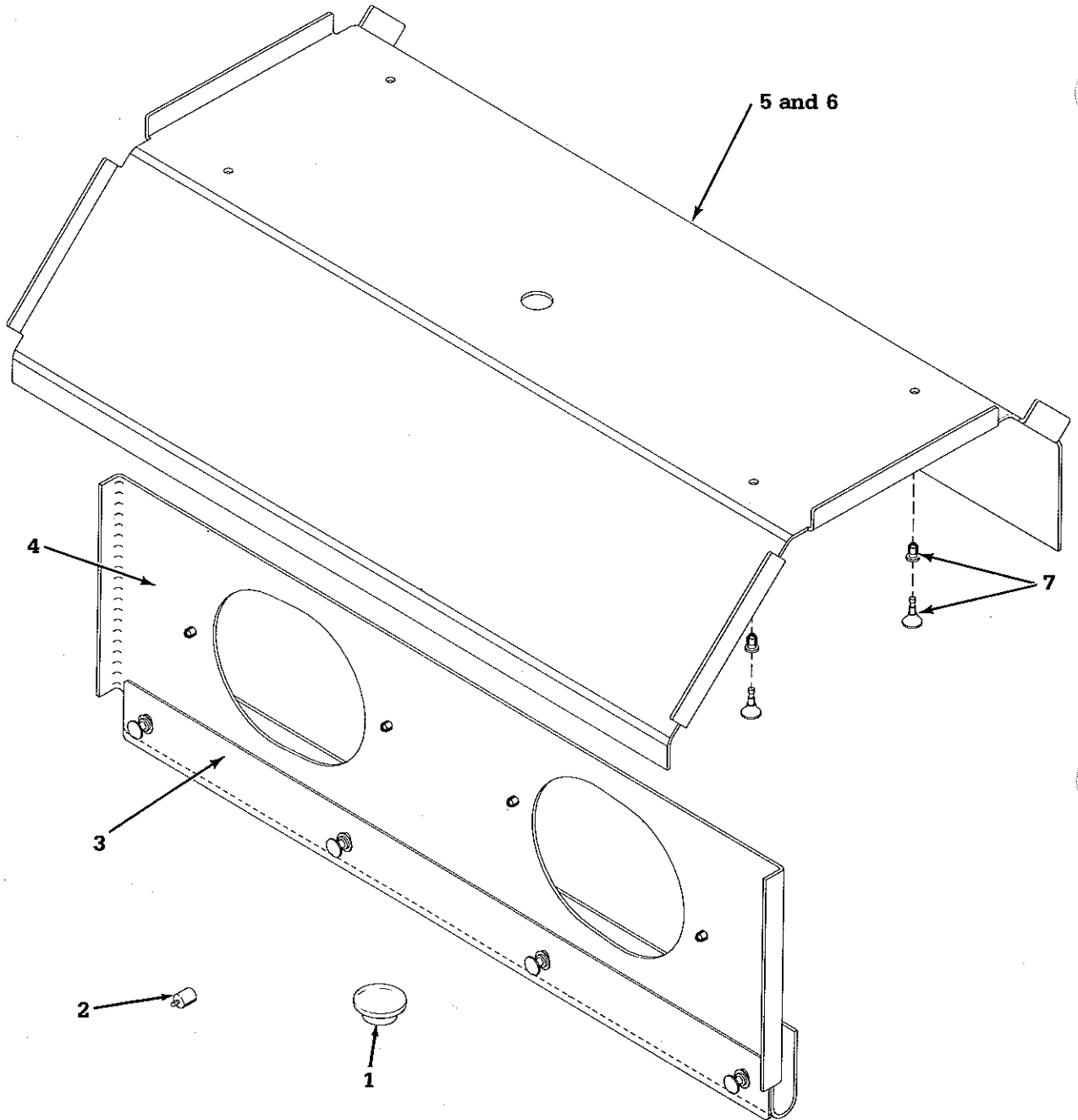


Figure 6-4 Inner Wall Assembly, Hood

	Item	Stock Number
1.	Upper wall retainer (requires post and fastener)	6600-0148-500
2.	Mounting post	6600-0161-700
3.	Deflector panel w/ fasteners	6600-0155-700
4.	Lower wall (front or rear w/ deflector panel)	6600-0106-800
5.	Inner wall, hood (includes all items shown)	6600-0040-800
6.	Upper inner wall w/ fasteners	6600-0116-800
7.	Inner wall fastener (12/pkg)	6600-0102-800

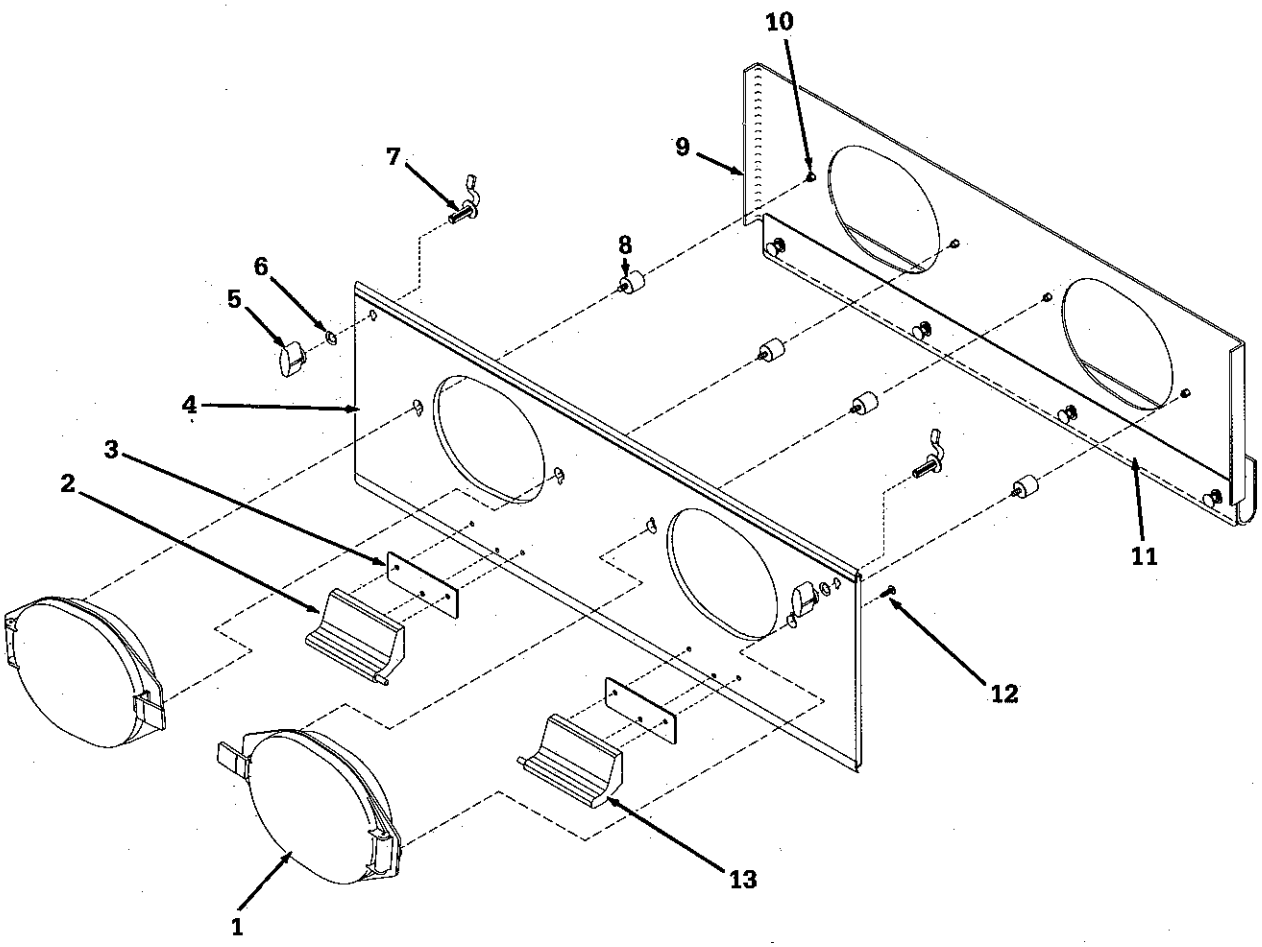


Figure 6-5 Front Door and Related Hardware

	Item	Stock Number
1.	Porthole	6600-0051-400
2.	Left hinge housing	6600-0036-400
3.	Gasket, hinge	6600-0069-500
4.	Front door replacement kit (outer door w/o hardware)	6600-0086-400
5.	Front door knob	6600-0168-500
6.	Washer, curved spring	6600-0077-400
7.	Inner latch, front door	6600-0157-500
8.	Mounting post	6600-0161-700
9.	Lower wall (front or rear w/ deflector panel)	6600-0106-800
10.	Inner wall fastener (12/pkg) *	6600-0102-800
11.	Deflector panel w/ fasteners	6600-0155-700
12.	Screw, 10-32 x .75, TR	6600-0089-400
13.	Right door hinge housing	6600-0035-400

*** Insert the socket into the proper hole in the inner wall and then push in the plunger.**

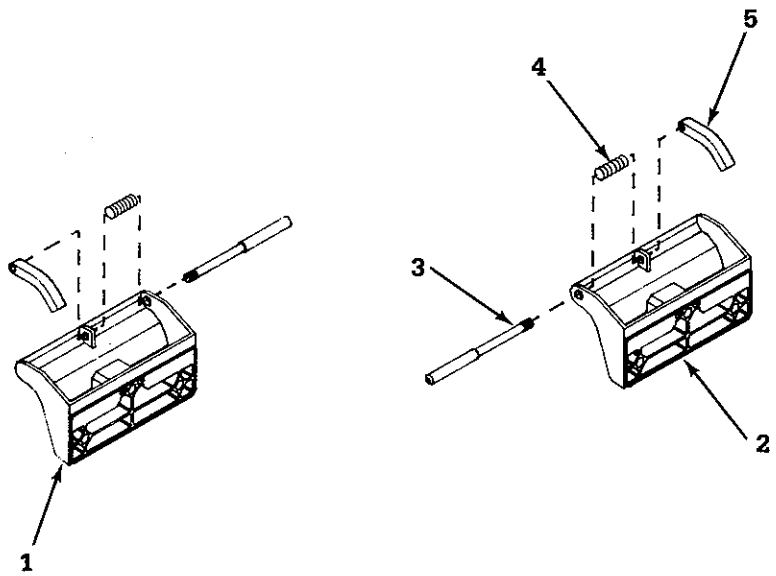


Figure 6-6 Hinge Detail

Item		Stock Number
1.	Left door hinge housing	6600-0036-400
2.	Right door hinge housing	6600-0035-400
3.	Hinge pin rod *	6600-0140-500
4.	Hinge pin spring, CPRSN	6600-0059-400
5.	Hinge pin release	6600-0141-500

*** Apply Loctite 27741 , Stock No. 0220-5025-300**

New Hood Components/Part Number Changes:

6.2 Base Platform Components

	Item	Stock Number
1.	Mattress tray	6600-0175-500
2.	Mattress w/cover	6600-0152-500
3.	Tilt handle assembly	6600-0078-800
4.	Base platform cover service kit	6600-0111-800
5.	Hood tilt latch	6600-0123-500
6.	Base platform service kit w/ hardware ^	6600-0107-800
7.	Spring, hood tilt release, CPRSN	6600-0061-400
8.	Plunger, hood tilt release	6600-0125-500
9.	Hair pin clip *	6600-0104-400

^ Includes items 5 through 10 from Figure 6-7 and items 20 through 31 from Figure 6-8.

*** Clip on after plunger is installed.**

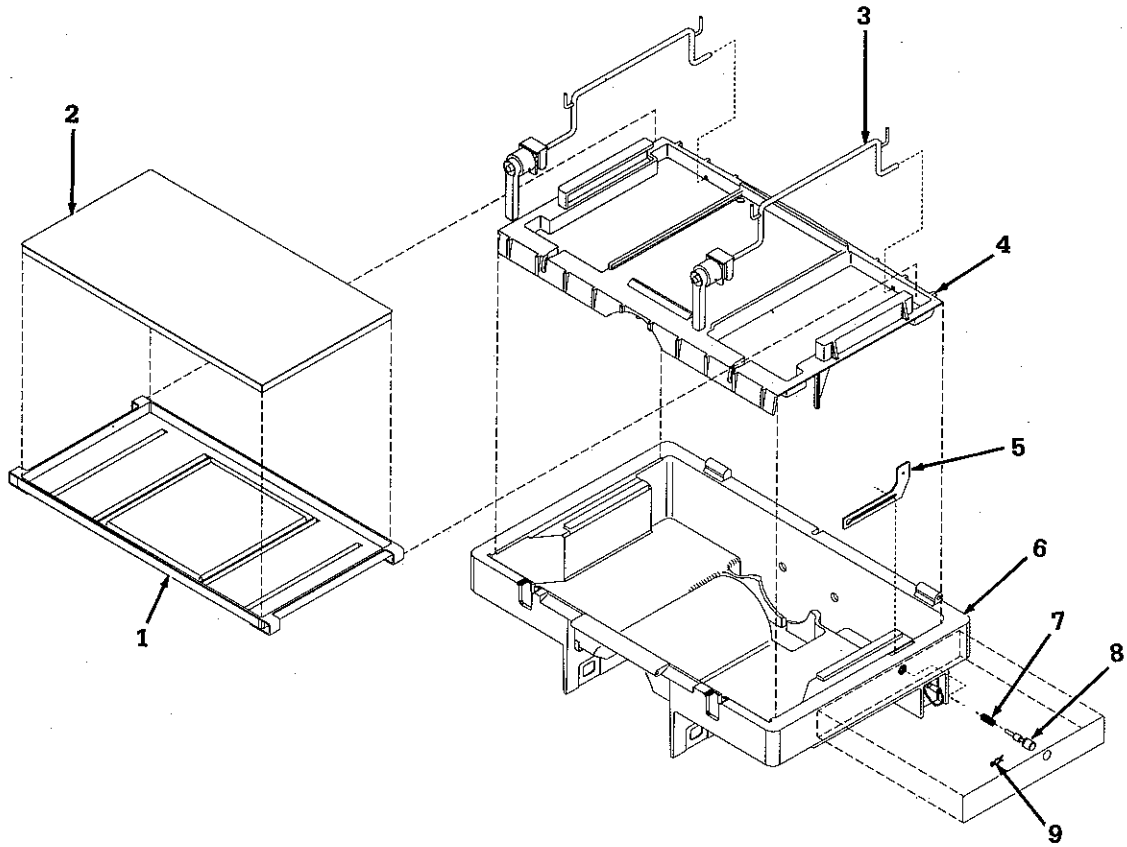


Figure 6-7 Base Platform and Cover Assembly

	Item	Stock Number
1.	Filter & replacement date sticker	6600-0043-800
2.	Knob, filter cover mounting	6600-0068-500
3.	Filter cover	6600-0070-500
4.	Humidifier fill port kit (port & o-ring)	6600-0070-800
5.	Humidifier o-ring	6600-0065-400
6.	Compartment probe kit, air temperature sensor ^	6600-0071-800
7.	Washer, Int. Lock #8	0144-1108-131
8.	Screw, 8-32 x 1/4	0140-6627-104
9.	Cover plate, base platform	6600-0160-500
10.	Cable clamp	6600-0145-400
11.	Screw, 8-32 x 3/8, TRS, P	0140-6627-106
12.	Stop clip, sliding tray	6600-0162-500
13.	Nut, elastic 4-40, ST	0202-1013-300
14.	Screw, 4-40 x 1/4, TRS, P	6600-0125-400
15.	Sliding tray	6600-0163-500
16.	Instruction booklet, English #	6600-0022-000
17.	Retainer, sliding tray	6600-0161-500
18.	Nut, KEP, 4-40 W/E	6600-0073-400
19.	Screw, 8-32 x 3/8	0140-6127-106
20.	Washer, Int. Lock #8	0144-1108-131
21.	Controller latch brackets (order separately)	
A.	Controller latch bracket (left)	6600-0225-500
B.	Controller latch bracket (right)	6600-0226-500
22.	Screw 6-32 x 3/8	0142-4163-106
23.	Cable clamp	0208-0335-300
24.	Screw, #8 x 3/8, TR, PH	0142-2164-206
25.	Base platform service kit @	6600-0107-800
26.	Cap and chain	0217-3785-700
27.	Nipple, 1/8 NPT x 3/16 hose	6600-0102-400
28.	Nut, 1/8 NPT x .125	6600-0176-500
29.	Power cord	0208-0950-300

^ Includes mounting blocks and hardware.

 # Stock Number varies with language , and/or frequency , and/or voltage. See Section 6-7 to obtain numbers for non domestic units.

@ Includes items 5 through 10 from Figure 6-7 and items 20 through 31 from Figure 6-8..

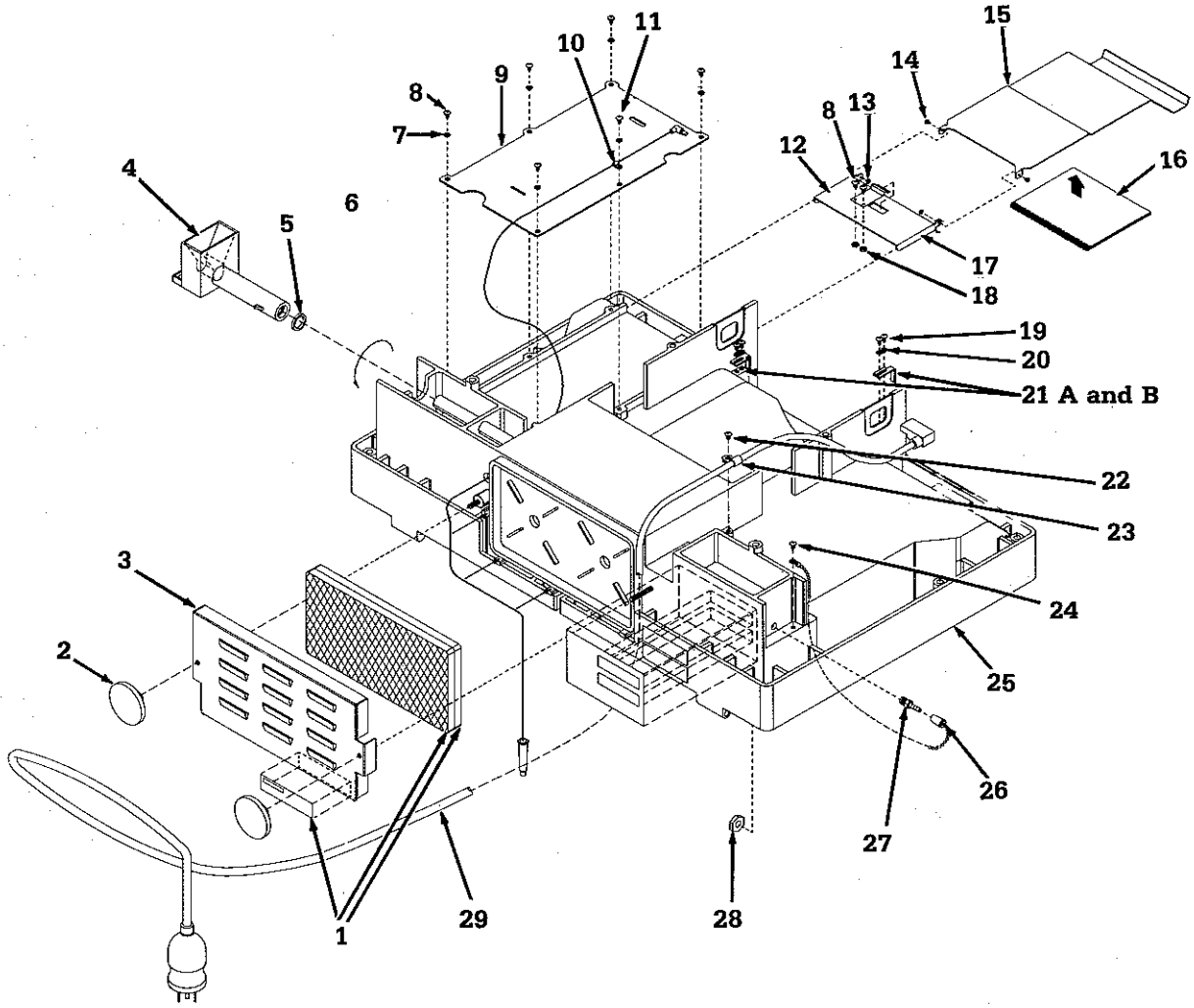


Figure 6-8 Base Platform Hardware (bottom view of platform)

6.3 Controller Components

Service Controller 120 V, 60 Hz, 6600-0084-810 #

	Item	Stock Number
1.	Screw, 4-40 x 1/4, TRS, P	6600-0125-400
2	Washer, int lock, #4, ST, N	0202-3407-340
3	Washer	6600-0151-400
4.	Nut, ext. lock, 6-32 x .31	0202-1130-300
5	Washer, #6, FL, SST	0144-1006-131
6	Gasket, thermal switch	6600-0209-500
7.	Thermal switch (170 F)	6600-0073-600
8.	Screw, 6-32, RD, PH	0140-6124-106
9.	Gasket, air flow sensor	6600-0208-500
10.	Air flow sensor, replacement kit*@	6600-0162-700
11.	Heater, 115 V # &	6600-0199-500
12.	Gasket, heater	6600-0142-500
13.	Washer, int. lock, #10	0144-1110-131
14.	Washer 0.219 ID x 0.500 OD	6600-0067-400
15.	Nut, KEP, 10-32, W/E	6600-0066-400
16.	Nut, KEP, 4-40, w/ext. lock washer	6600-0073-400

*** Install with thermistor button on the bottom.**

 # Stock Number varies with language , and/or frequency , and/or voltage. See Section 6-7 to obtain numbers for non domestic units.

& This version of the heater comes with mounting studs (as shown). Earlier versions mount with three, 10-32 x 5/8, TRS, screws (Stock No 0140-6631-110).

@ The air flow sensor is mounted on the back of the controller and should not be confused with the air temperature sensor located inside the infant compartment.

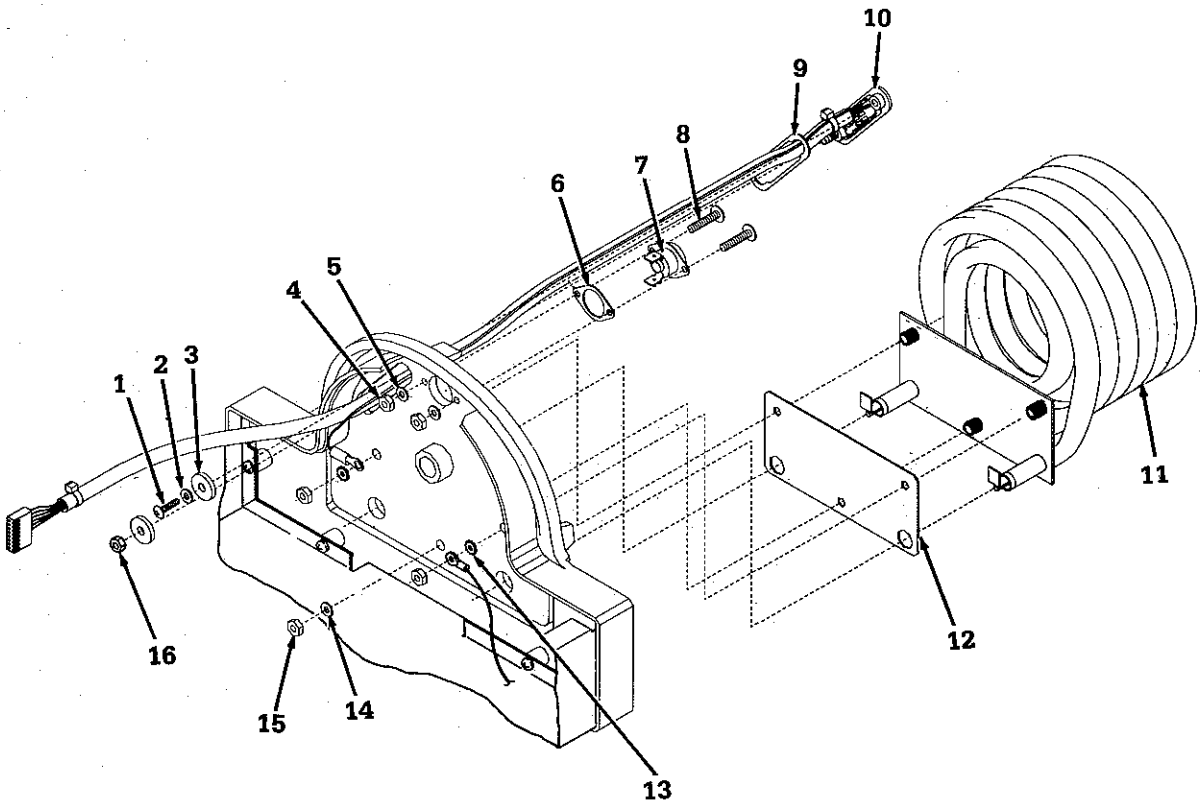


Figure 6-9 Controller Back Panel

Service Controller 120 V, 60 Hz, 6600-0084-810 #

Item		Stock Number
1.	Screw, 6-32 x 7/8, TRS, PH*	6600-0150-400
2.	Washer, #6, FL, SST	0144-1006-131
3.	Shock mount	6600-0105-400
4.	Bushing, shock mount	0217-2897-535
5.	Motor bracket, 60 Hz #	6600-0084-500
6.	Motor, 115 V, 60 Hz (includes shock mount and bushing) #	6600-0054-800
7.	Edge protector (specify 3 inches)	6600-0123-400
8.	Nut, ext. lock, 6-32 x 0.31	0202-1130-300
9.	Spacer, 6-32 x 1/2	0402-0233-300
10.	Spacer, threaded, 0.5	6600-0046-600
11.	Screw, 8-32 x 3/8, TRS, P	0140-6627-106
12.	Slide rail	6600-0167-500
13.	Screw, #6, FL, PH	0400-3103-300
14.	Screw, 6-32 x 1/4, TRS, P	0140-6624-104
15.	Washer, int. lock, #6	0144-1106-131

*** Use Loctite 24231 (Stock No. 0220-5016-300)**

 # Stock Number varies with language , and/or frequency , and/or voltage. See Section 6-7 to obtain numbers for non domestic units.

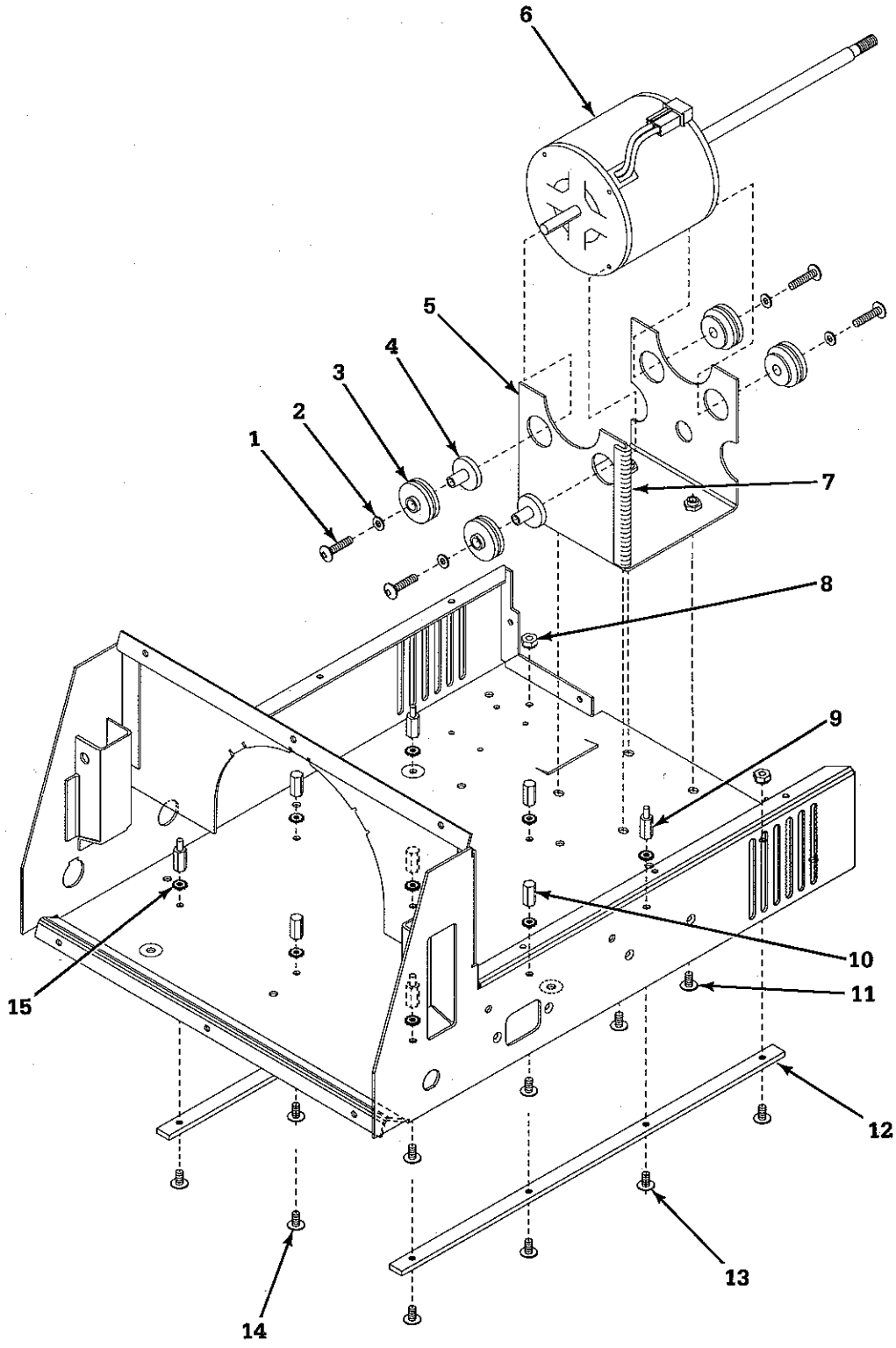


Figure 6-10 Controller Plate and Motor Mounting Hardware

Service Controller 120 V, 60 Hz, 6600-0084-810 #

Item		Stock Number
1.	Cooling fan (CCW rotation)	6600-0056-400
2.	Screw, 6-32 x 3/8, TRS, P	0140-6624-106
3.	Washer, int. lock, #6	0144-1106-131
4.	Blower fan (CW rotation)	6600-0141-400
5.	Fan knob, 1/4 x 20, THD	0402-1717-535
6.	Air seal, motor shaft *	0210-6566-300
7.	Controller latch kit (1/pkg)	6600-0108-800

*** Press Adhesive side against rear of controller.**

 # Stock Number varies with language , and/or frequency , and/or voltage. See Section 6-7 to obtain numbers for non domestic units.

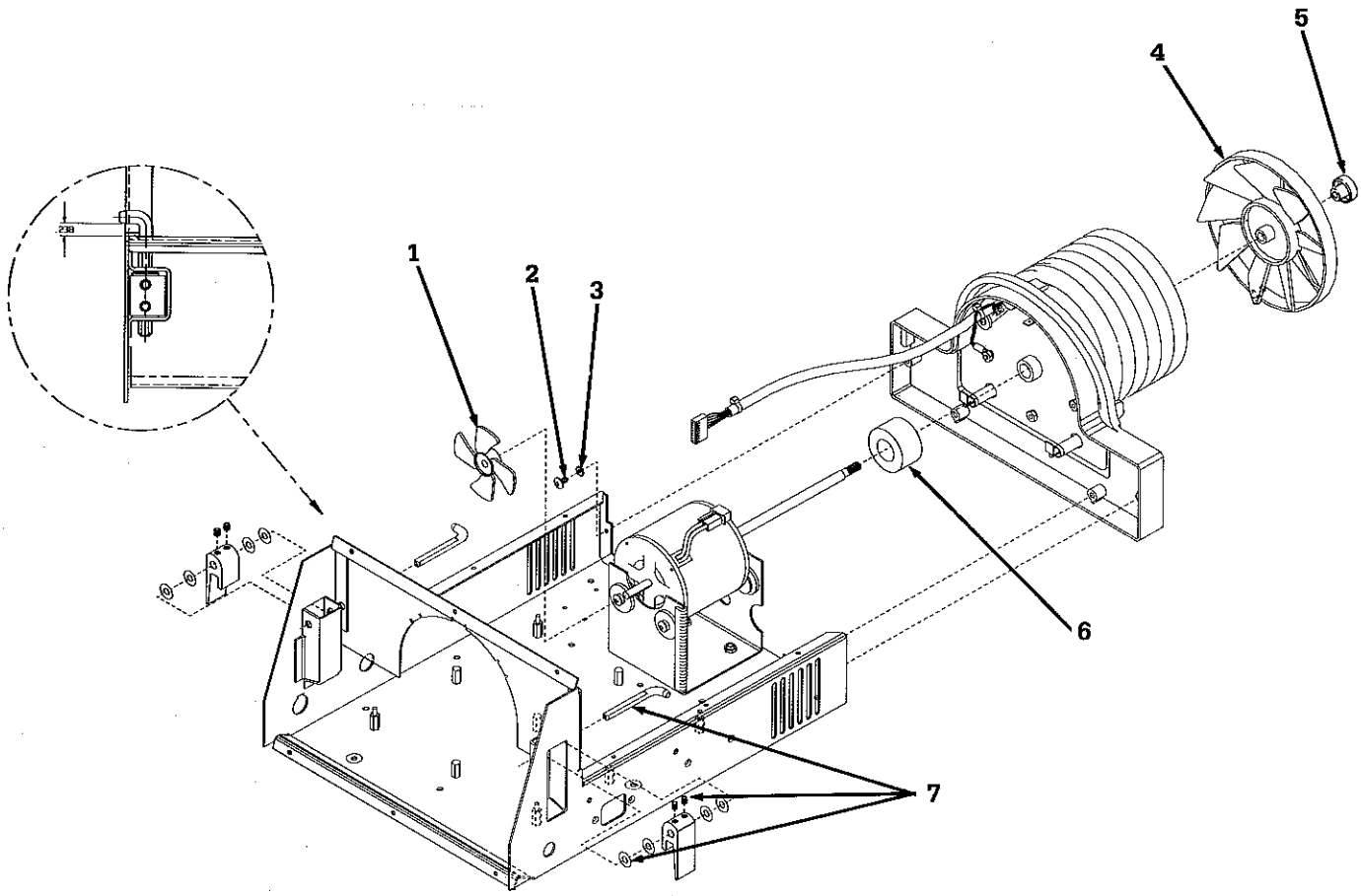


Figure 6-11 Controller Latch and Fan Assemblies

Service Controller 120 V, 60 Hz, 6600-0084-810 #

	Item	Stock Number
1.	Circuit breaker (On/Off) switch w/ bezel (DPST)	0690-2500-365
2.	Retaining ring	6600-0075-400
3.	Bezel, patient temp. probe connector	6600-0071-500
4.	Nut, ext. lock, 6-32 x 0.31	0202-1130-300
5.	Line filter, 6 amp (AC entrance)	6600-0094-700
6.	Solid state relay	6600-0096-600
7.	Nut, ext. lock, 8-32 x 0.34	0202-1131-300
8.	Spacer, threaded, #4-40 x 1/2	6600-0108-400
9.	Washer, int. lock, #4, ST, N	0202-3407-340
10.	Transformer (95, 115, 220, 240 V)	0208-7580-300
11.	Washer, int. lock, #8	0144-1108-131
12.	Screw, 8-32 x 3/8, TRS, P	0140-6627-106
13.	Screw, 8-32 x 0.375, F	6600-0071-400
14.	Screw, 6-32 x 3/8, 0V, PH	0400-3135-300
15.	Screw, 4-40 x 1/4	0140-6517-104

 # Stock Number varies with language , and/or frequency , and/or voltage. See Section 6-7 to obtain numbers for non domestic units.

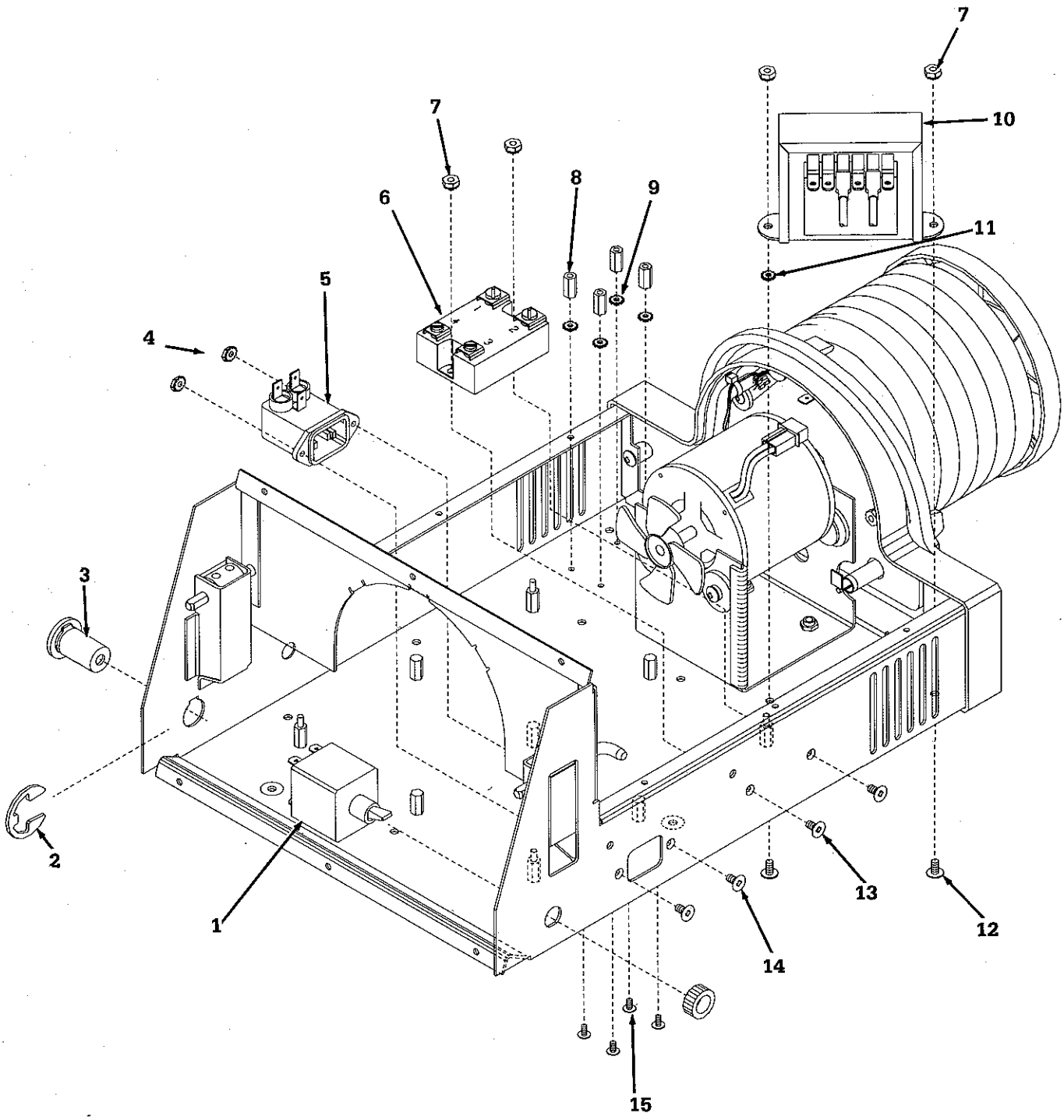


Figure 6-12 Battery and Side Mounted Controller Components

Service Controller 120 V, 60 Hz, 6600-0084-810 #

	Item	Stock Number
1.	Washer, int. lock, #6	0144-1106-131
2.	Screw, 6-32 x 1/4, RD, PH	0140-6124-104
3.	Battery, rechargeable	0690-1000-310
4.	Controller cover	6600-0066-500
5.	Screw, 6-32 x 3/8, RD, PH	0140-6624-106
6.	Rear seal controller (external) *	6600-0067-500
7.	Screw, #6, FL, PH	0440-3103-300
8	High voltage harness (terminated AC entrance and solid state relay wires, J1 and J2)	6600-0102-700
9	Display board ground wire	6600-0118-700
10.	Control board, 120/100 V # (tested)	6600-0106-710
11.	Patient temp. probe/air temp. sensor harness (Includes probe jack, J4 and related wires)	6600-0122-700
12.	Intermediate harness (display/control board cable)	6600-0101-700

Not Show:

Item	Stock Number
Connector for air temp. sensor	6600-0091-700

*** Press Adhesive side against rear of controller.**

 # Stock Number varies with language , and/or frequency , and/or voltage. See Section 6-7 to obtain numbers for non domestic units.

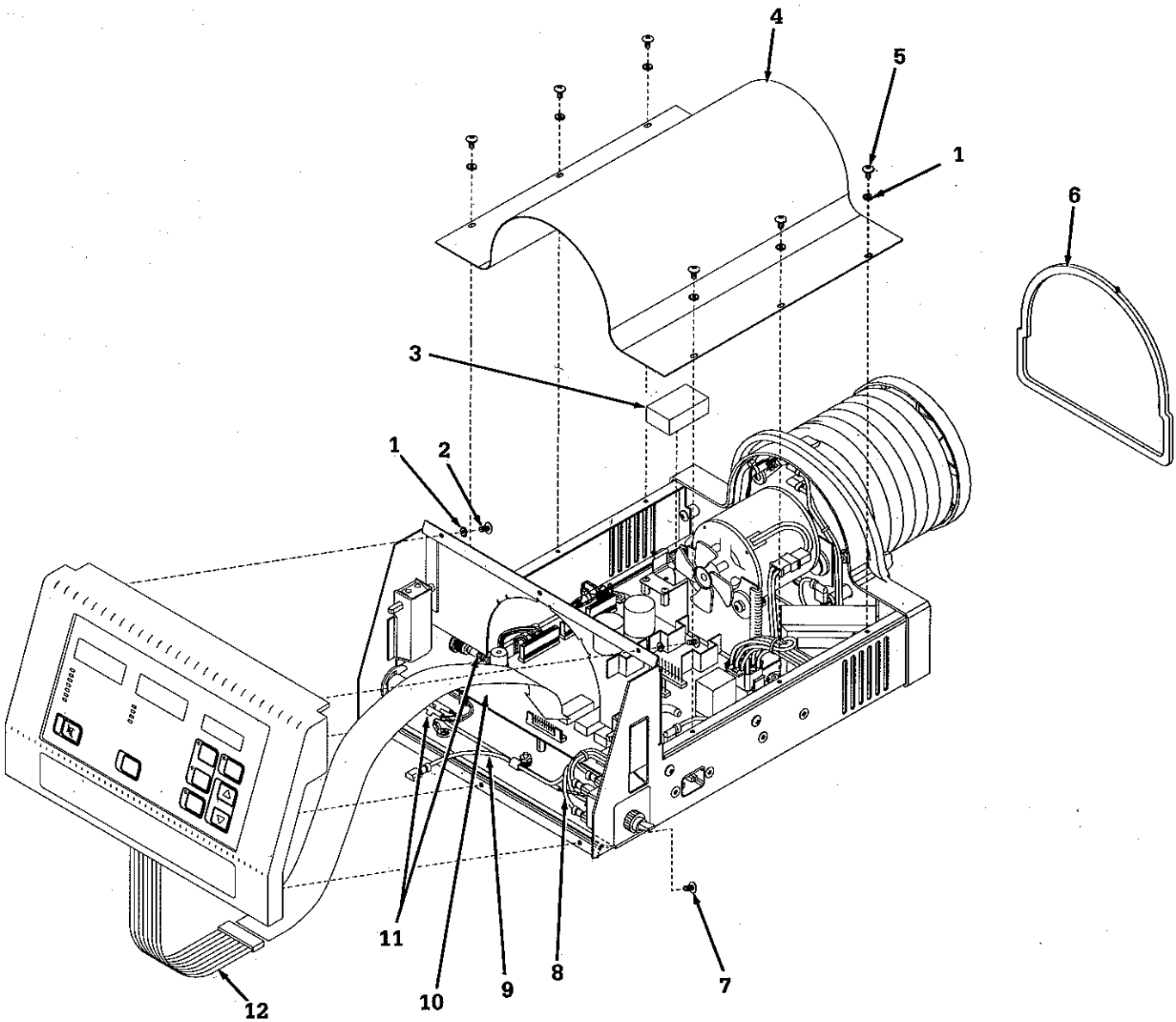


Figure 6-13 Wire Harnesses and Additional Controller Components

Service Controller 120 V, 60 Hz, 6600-0084-810 #

	Item	Stock Number
1.	Front cover, controller	6600-0064-500
2.	Display label, English #	6600-0053-100
3.	Switch panel	6600-0044-700
4.	Gasket, alarm LED *	6600-0210-500
5.	Support panel, display board	6600-0147-500
6.	Washer, int. lock, #6	0144-1106-131
7.	Screw, 6-32 x 3/8, TRS, P	0140-6624-106
8.	Display board (tested)	6600-0105-710
9.	Wire ground, display board	6600-0118-700
10.	Nut, ext. lock, 6-32 x 0.31	0202-1130-300
11.	Intermediate harness (display/control board cable)	6600-0101-700
12.	Spacer, 6-32 x 1/2	0402-0233-300
13.	Washer, 0.147 ID, 0.028 T	0202-4510-340
14.	Tab, faston	0208-0439-300

 # Stock Number varies with language , and/or frequency , and/or voltage. See Section 6-7 to obtain numbers for non domestic units.

*** Press Adhesive side against switch panel.**

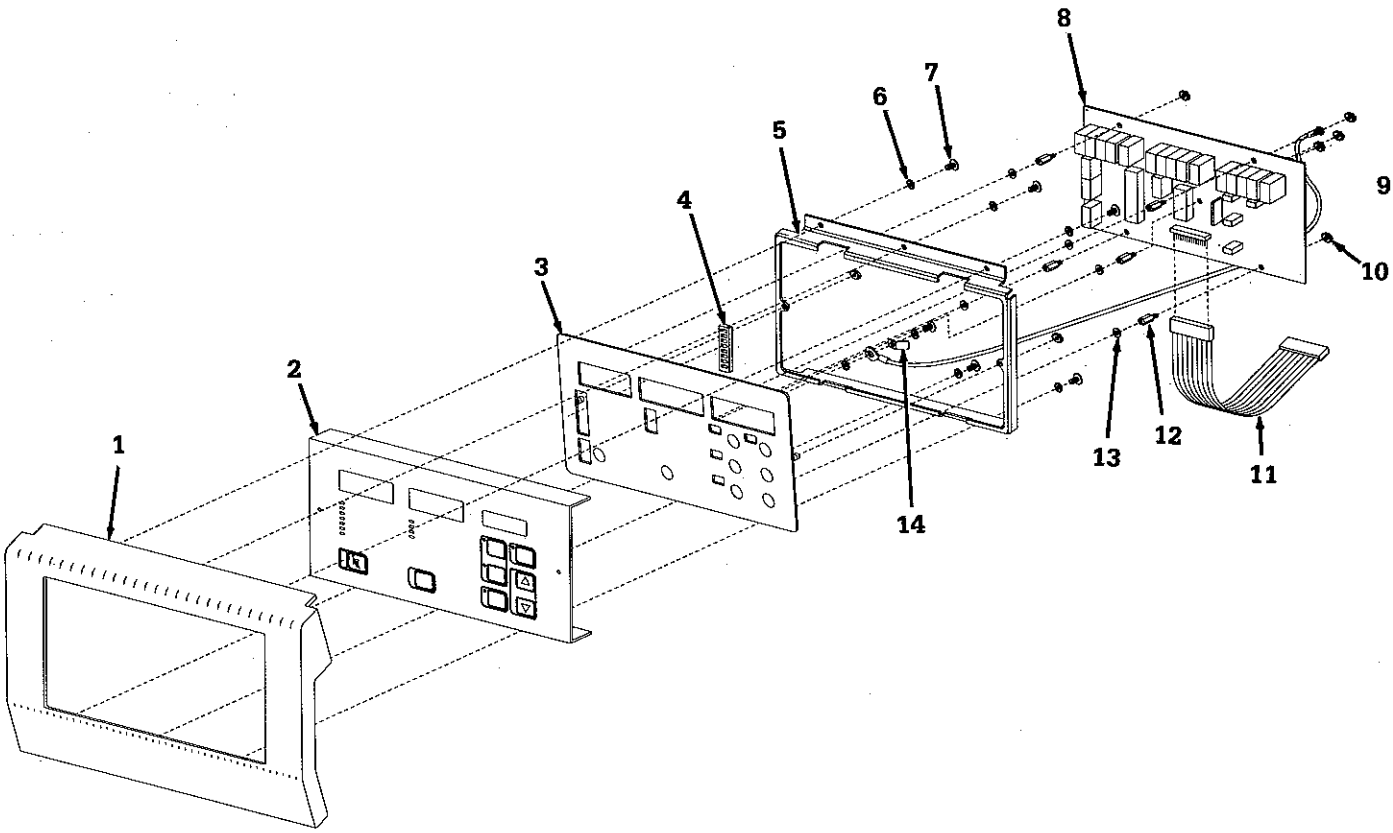


Figure 6-14 Control Panel Assembly

6.4 Board Components

Control Board
120/100 V board Stock No. 6600-0106-710
240/240 V board Stock No. 6600-0126-710

STOCK NO.	DESCRIPTION	QTY	SYMBOL
6600-0054-600	PC BOARD BLANK	1	FOR ASSEMBLY 6600-0042-700
6600-0022-600	HEADER 4 PIN	1	J6
6600-0098-700	HEADER 8 PIN	2	TP1, TP2
6600-0097-700	HEADER 16 PIN	2	J3, J4
6600-0096-700	HEADER 12 PIN	1	J2
6600-0081-700	HEADER 12 PIN AMP	1	J1
6600-0020-600	HEADER 12 PIN	1	TP3
6600-0085-600	HEADER 8 PIN POLARIZED	1	J5
0686-9000-406	SOCKET 24 PIN	3	FOR U14, U15, U17
0686-9000-408	SOCKET 40 PIN	1	FOR U19
0686-9000-407	SOCKET 28 PIN	1	FOR U16
0608-3023-300	HEAT SINK	3	H2
0202-1013-300	NO.4-40 ELASTIC NUT	3	H1
6600-0080-700	8 POS. DIP SWITCH	1	SW1
0690-1100-306	ALARM QMB-06A	1	LS1
0683-9015-301	LED HLMP-3366	1	DS1
0684-0400-031	IC 4051B	2	U1, U10
0684-0600-010	IC LM339	1	U5
0684-1000-023	IC CNY65	1	U3
0684-0400-023	IC VQ1000	1	U12
0684-0300-123	IC 74LS123	1	U9
6600-0042-600	IC 27128 PROGRAMMED	1	U16
0684-0300-373	IC 74LS373	1	U18
0684-0800-002	IC 8243	2	U15, U17
6600-0038-600	IC 8032	1	U19
0684-1000-021	IC ADC3711	1	U14
0684-0600-025	IC LM10	1	U13
0684-0400-025	IC 7556	1	U6
0684-0300-132	IC 74LS132	1	U7
6600-0056-600	IC 74LS04	1	U11
6600-0045-600	IC 74LS02	1	U8
0684-1000-022	IC 3022	1	U4

TABLE A

SYMBOL	CONTROL BOARD ASSY 100 / 120V	CONTROL BOARD ASSY 220 / 240V	
K1	0690-2350-325 HCIE-P115VAC	0690-2350-327 HCIE-P240VAC	

STOCK NO.	DESCRIPTION
0686-0025-004	CRYSTAL 6.0 MHZ
SEE TABLE A	RELAY
0684-0600-008	VOLTAGE REGULATOR 7805
0683-0500-000	BRIDGE VM08
0683-0035-300	DIODE IN4001
0683-0100-302	DIODE VSK120
6600-0084-600	CAPACITOR 3.3 MFD
0682-1122-303	CAPACITOR 33 PF
0682-1136-300	CAPACITOR 220PF
0682-1189-313	CAPACITOR 0.1 MFD
0682-1170-311	CAPACITOR 0.01 MFD 1KV
0682-4196-301	CAPACITOR .27 MFD
0682-1196-300	CAPACITOR .33 MFD
0682-1181-302	CAPACITOR .47 MFD
0682-2595-302	CAPACITOR 10 MFD 10%
0682-2600-300	CAPACITOR 15 MFD 16V
0682-7171-300	CAPACITOR 4700 MFD 16V
0682-1170-313	CAPACITOR 0.01 MFD 10%
6600-0027-600	RESISTOR, VAR 10K
6600-0028-600	RESISTOR, VAR 500
6600-0039-600	RESISTOR PACK 1K
6600-0087-600	RESISTOR 301 0.1%
6600-0030-600	RESISTOR 1K 0.1%
0680-2334-300	RESISTOR 2.21K 0.1%
6600-0029-600	RESISTOR 4.70K 0.1%
6600-0031-600	RESISTOR 4.87K 0.1%
6600-0034-600	RESISTOR 5.05K 0.1%
6600-0033-600	RESISTOR 5.30K 0.1%
6600-0032-600	RESISTOR 5.42K 0.1%
0680-2373-300	RESISTOR 5.76K 0.1%
6600-0089-600	RESISTOR 10 0.1%
0680-2564-300	RESISTOR 453K 0.1%
0680-3915-300	RESISTOR 5.9K 0.1%
0680-2902-300	RESISTOR 10K 0.1%
6600-0086-600	RESISTOR 750 0.1%
0680-0250-321	RESISTOR 100K 1%
0680-3485-300	RESISTOR 75K 1%
6600-0088-600	RESISTOR 1.2 MEG 1%
0680-1101-300	RESISTOR 47K 2W 5%
0680-0449-300	RESISTOR 100 5%
0680-0497-300	RESISTOR 10K 5%
0680-0544-300	RESISTOR 1.0 MEG 5%
0680-0509-300	RESISTOR 33K 5%
0680-0457-300	RESISTOR 220 5%
0680-0465-300	RESISTOR 470 5%
0680-0380-301	RESISTOR 22 5%
0680-0442-300	RESISTOR 51 5%
0680-0466-300	RESISTOR 510 5%
0680-0473-300	RESISTOR 1K 5%

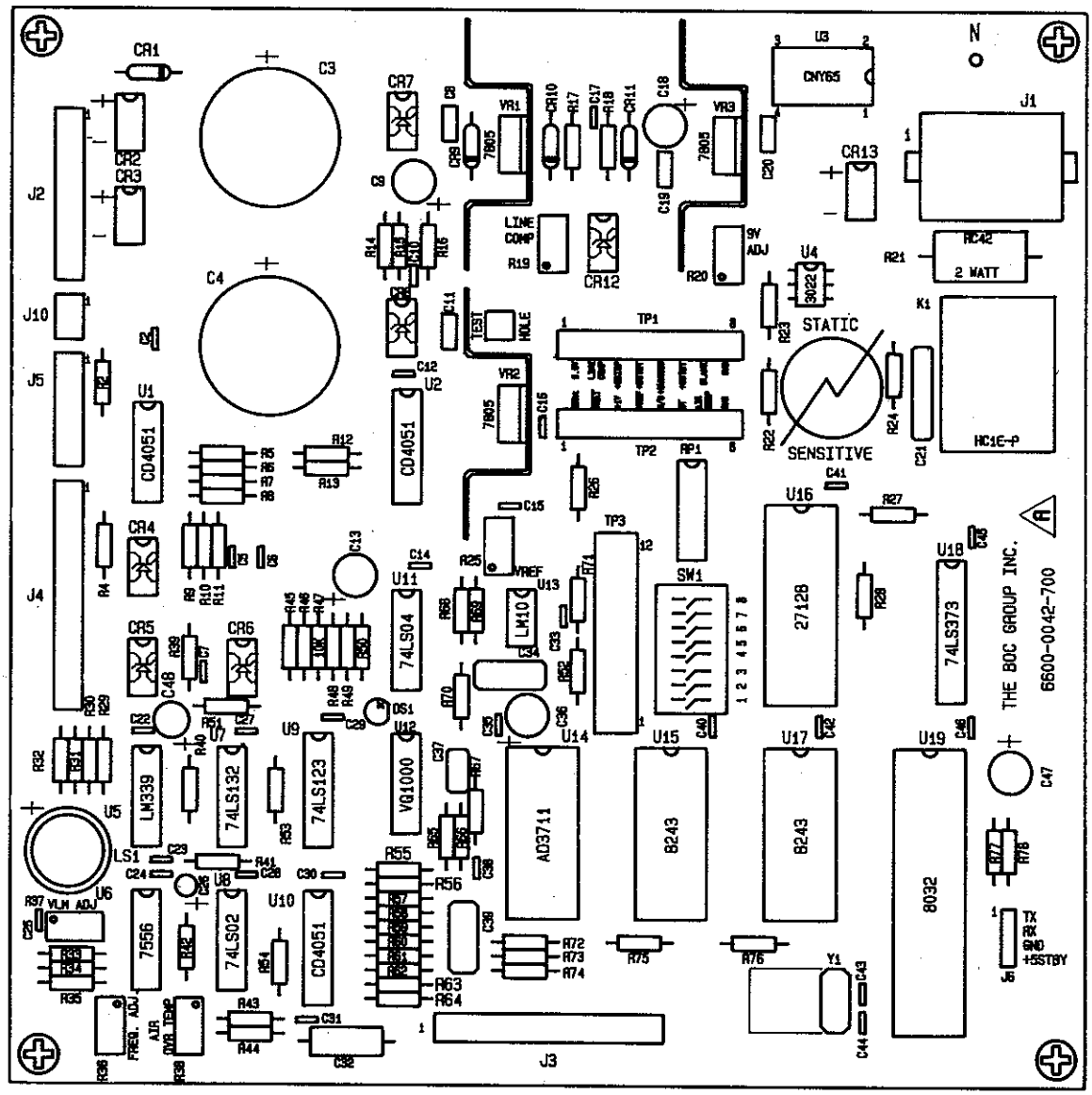


Figure 6-15 Control Board (tested and packaged)

Display Board
Tested and Packaged, Stock No. 6600-0105-710

STOCK NO.	DESCRIPTION	QTY	SYMBOL
6600-0043-600	PC BOARD BLANK	1	FOR ASSEMBLY 6600-0043-700
0690-1560-451	HEADER 12 PIN, RIGHT ANGLE	1	J9
0690-1560-452	HEADER 16 PIN, RIGHT ANGLE	1	J8
6600-0074-700	SOCKET 20 PIN	4	FOR DS-1-4, 6-9
6600-0073-700	SOCKET 16 PIN	2	FOR DS16, 17
6600-0076-700	SOCKET 8 PIN	4	FOR DS18, 19
0690-2400-316	SOCKET 4 PIN	4	FOR DS20-23
6600-0075-700	SOCKET 5 PIN	4	FOR DS5, DS10
6600-0072-700	SOCKET 9 PIN	1	J7
0690-2400-312	SOCKET 14 PIN	5	FOR DS11-15
0686-9000-408	SOCKET 40 PIN	1	FOR U1
0686-9000-406	SOCKET 24 PIN	1	FOR U2
6600-0070-700	DISPLAY HLMP-2685	1	DS-18
6600-0069-700	DISPLAY HLMP-2720	1	DS-19
0683-9020-304	DISPLAY HLMP-2400	4	DS20-23
0683-9020-303	DISPLAY HLMP-2620	2	DS16, 17
0690-2300-326	DISPLAY HDSP-5531	10	DS1-10
0690-2300-325	DISPLAY 5082-7611	5	DS11-15
0684-0800-002	IC 8243	1	U2
0684-0900-001	IC MM5451	1	U1
0685-0050-300	TRANSISTOR MPSA63	4	Q1-4
0683-0035-300	DIODE IN4001	1	CR1
0682-1189-313	CAPACITOR 0.1 MFD 50V 20%	4	C1, C2, C5, C6
0682-2600-300	CAPACITOR 15 MFD 16V	2	C3, C4
0681-0007-300	RESISTOR, VAR 5K	1	R11
0680-9000-312	RESISTOR NETWORK 10K	1	RP1
0680-0380-303	RESISTOR 180 1/4W 5%	5	R2, 4, 6, 8, 10
0680-0489-300	RESISTOR 4.7K 1/4W 5%	4	R1, 3, 5, 7
0680-2100-300	RESISTOR 221 1/4W 1.0%	1	R9

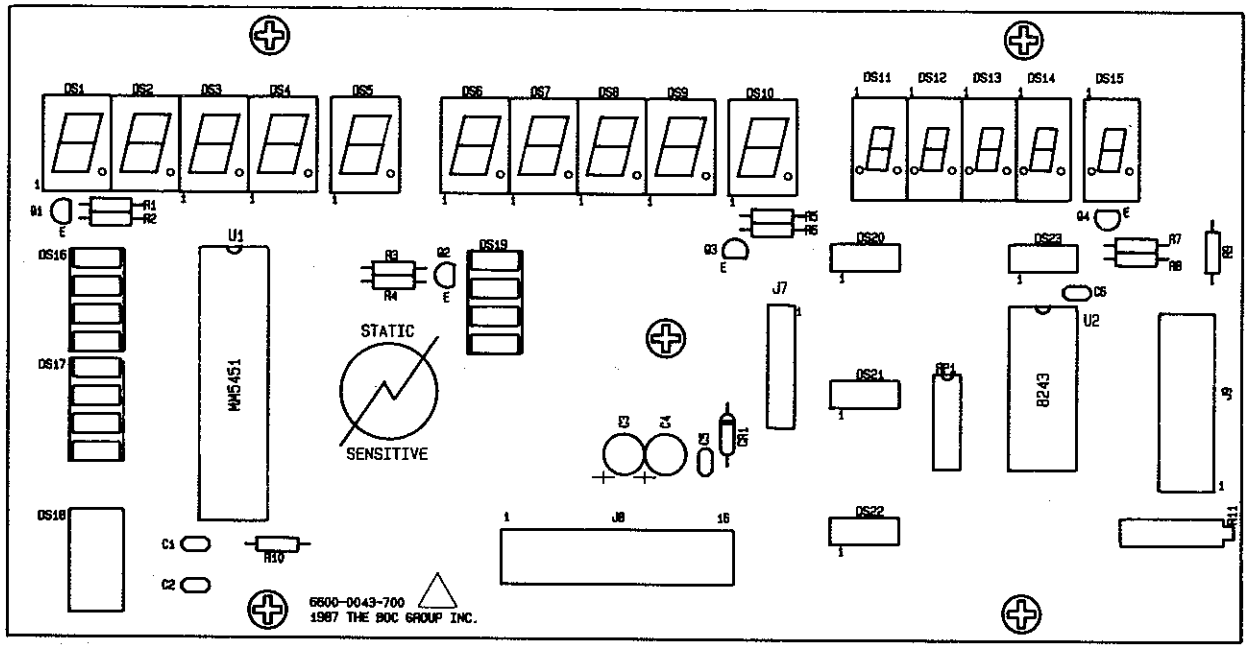


Figure 6-16 Display Board

6.5 Cabinet Components

	Item	Stock Number
1.	Screw, WD, #10 x 1 in	6600-0044-400
2.	Nut, 8-32 x .34	0202-1131-300
3.	Cabinet side, left	6600-0216-500
4.	Cabinet bottom	6600-0144-500
5.	Screw, 8-32 x 3/8	0140-6627-106
6.	Cabinet side, right	6600-0217-500

Not shown	Stock Number
Caster, locking	6600-0038-400
Caster, nonlocking	6600-0039-400

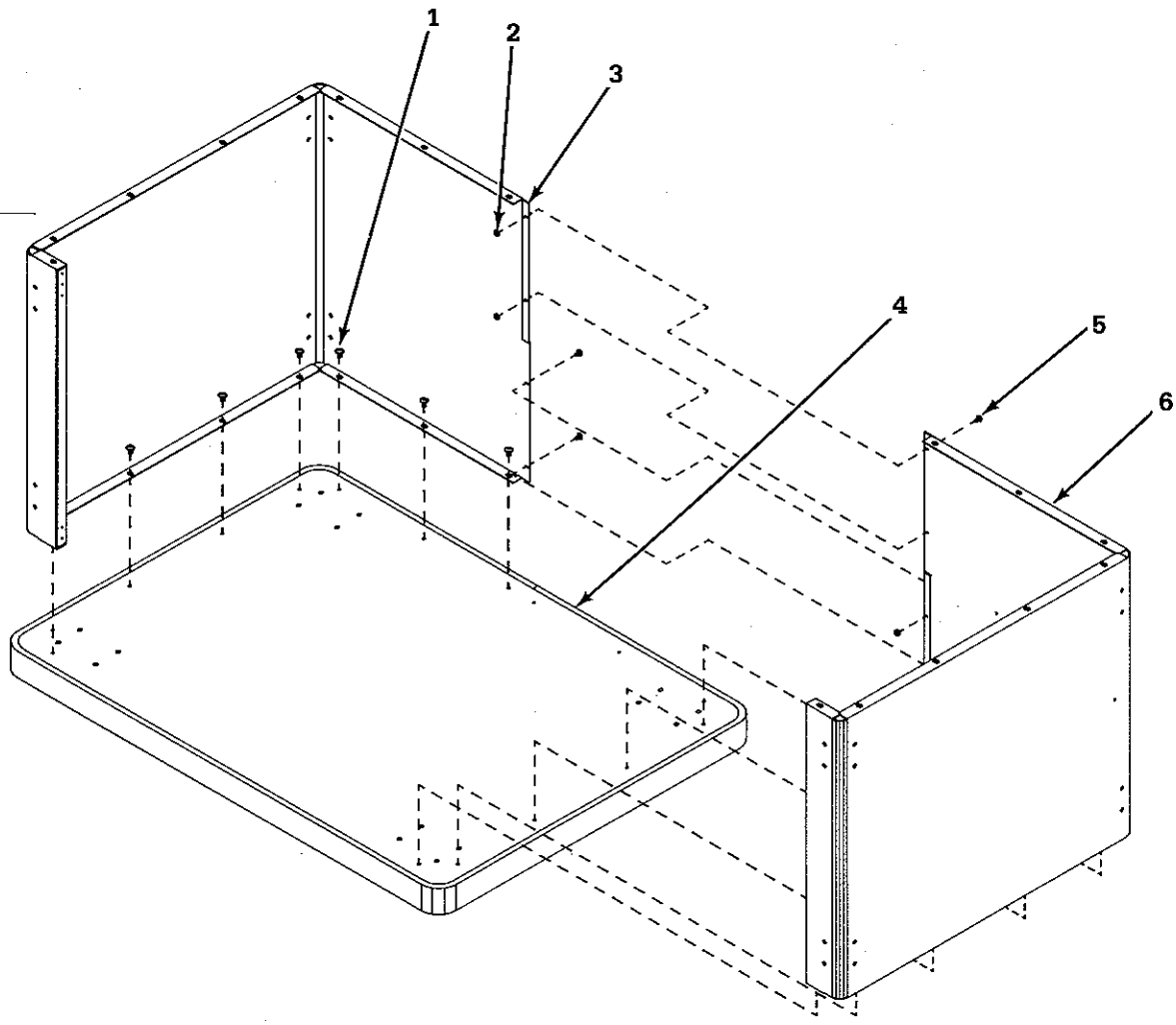


Figure 6-17 Cabinet Assembly (base and sides)

Item		Stock Number
1.	Cabinet top	6600-0145-500
2.	Incubator mounting knob (4)	6600-0154-700
3.	Screw, WD, #10 x 1 in *	6600-0044-400

*** Torque to 25 in/Lbs.**

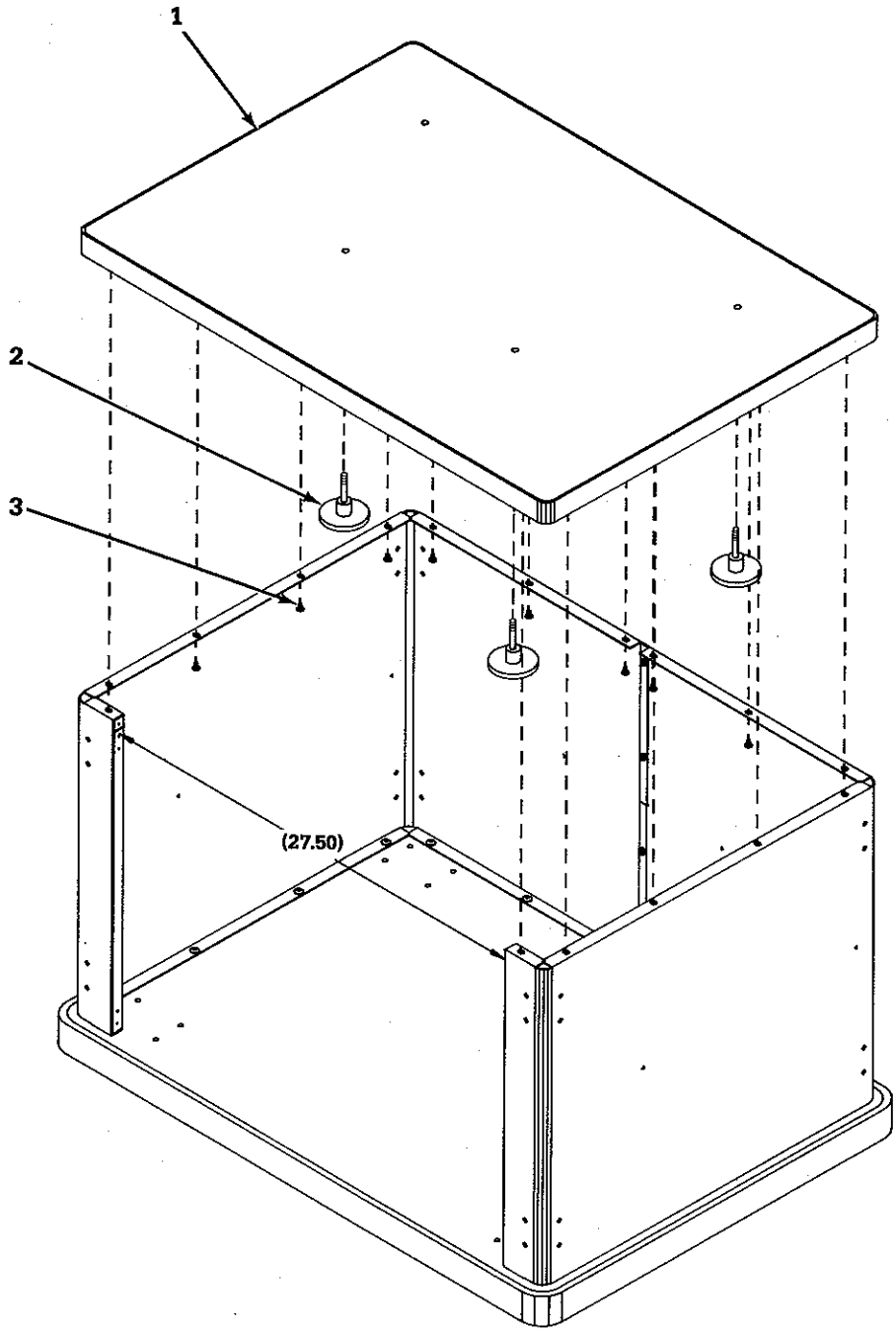


Figure 6-18 Cabinet Assembly (top)

Item		Stock Number
1.	Screw, 8-32 x 3/8, TRS, P	0140-6627-106
2.	Washer, 0.118 ID, 0.0.438 OD	6600-0080-400
3.	Nut, ext. lock, 8-32 x .34	0202-1131-300
4.	Cabinet shelf	6600-0075-500
5.	Cabinet apron	6600-0211-500
6.	Screw, WD, #10 x 1 in *	6600-0044-400
7.	Magnet	6600-0042-400
8.	Screw, #6, FL, PH **	0400-3103-300
9.	Left door	6600-0130-400
10.	Screw 8-32	6600-0045-400
11.	Screw 4-40	6600-0046-400
12.	Strike, cabinet door	6600-0043-400
13.	Plastic hole plug 0.375 in	6600-0085-400
14.	Right door	6600-0129-400
15.	Door hinge, (top right and bottom left)	6600-0128-400
16.	Door hinge, (top left and bottom right)	6600-0127-400
17.	Door handle	6600-0083-500

*** Torque to 25 in/Lbs.**

**** Apply Loctite 24231, Stock No. 0220-5016-300**

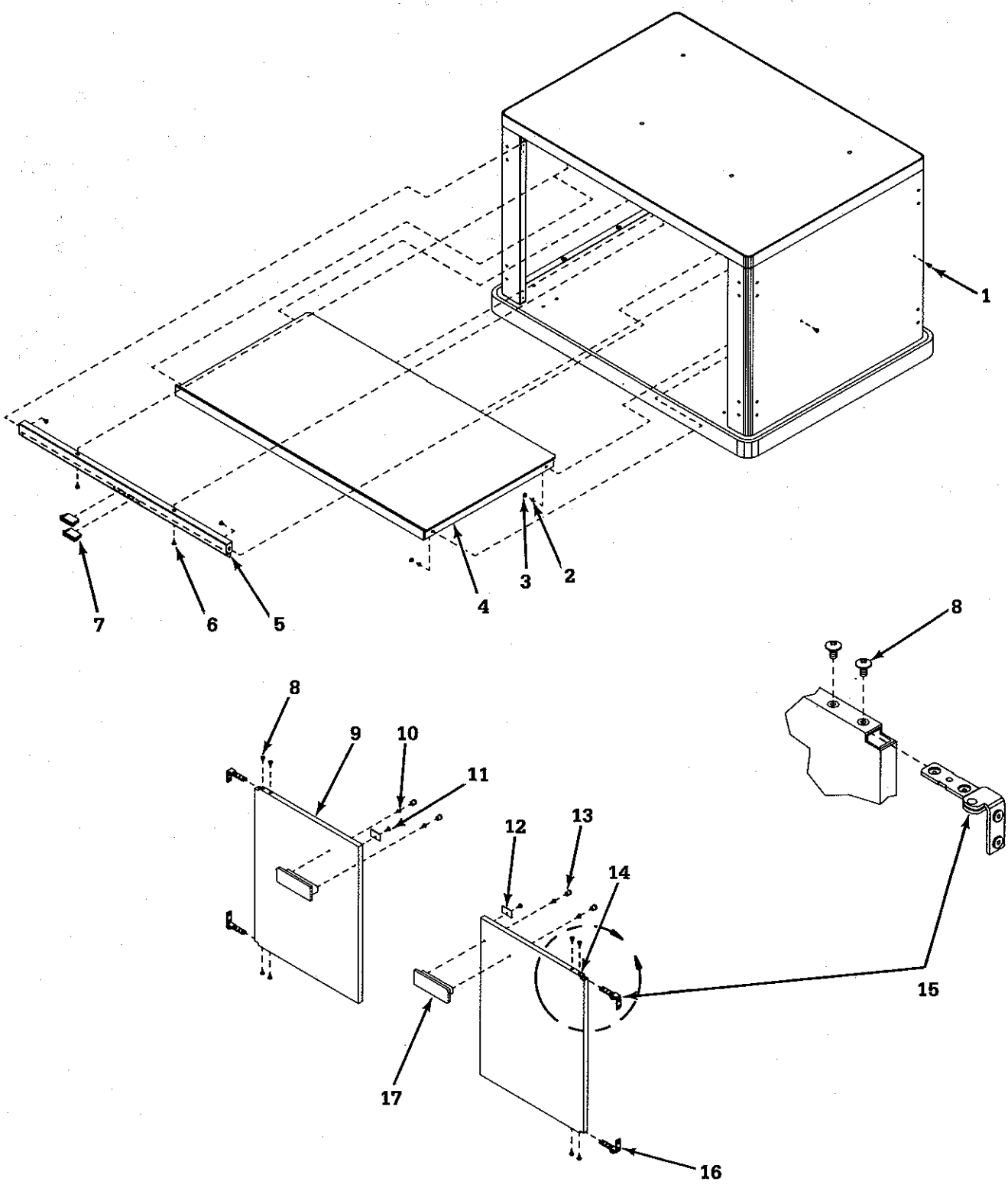


Figure 6-19 Cabinet Doors and Shelf

6.6 Accessories and Disposable Parts

	Item	Stock Number
1.	Instrument shelf	0217-5365-800
2.	Ventilator mounting post	0217-5357-800
3.	Oxygen flowmeter w/ bracket	0217-5370-800
4.	Suction regulator w/ DISS connectors & safety trap	0306-1012-810
5.	Overhead shelf & rails	6600-0042-800
6.	I.V. pole	0217-5378-800
7.	Standard M 2100 Oxygen Blender	6750-0022-900
8.	Power cord	0208-0950-300
9.	Cabinet w/ doors	6600-0036-900

Not Shown	Stock Number
Rail system	6600-0041-800
Cabinet w/o doors	6600-0037-900
Refresher instructions	6600-0022-000
Cleaning tank	6600-0202-500
Patient probe	0208-0697-700
Heat reflecting probe patch (50/pkg)	0203-1980-300
Wristlets (6/pkg)	6600-0164-500
Service Manual	6600-0017-000
Pleur-evac hanger	6600-0115-800

Note: Mounting the Standard M 2100 Oxygen Blender on the rail system requires the adapter plate (Stock No. 0217-5363-800) and the bird bracket (Stock No. 6600-0031-900).