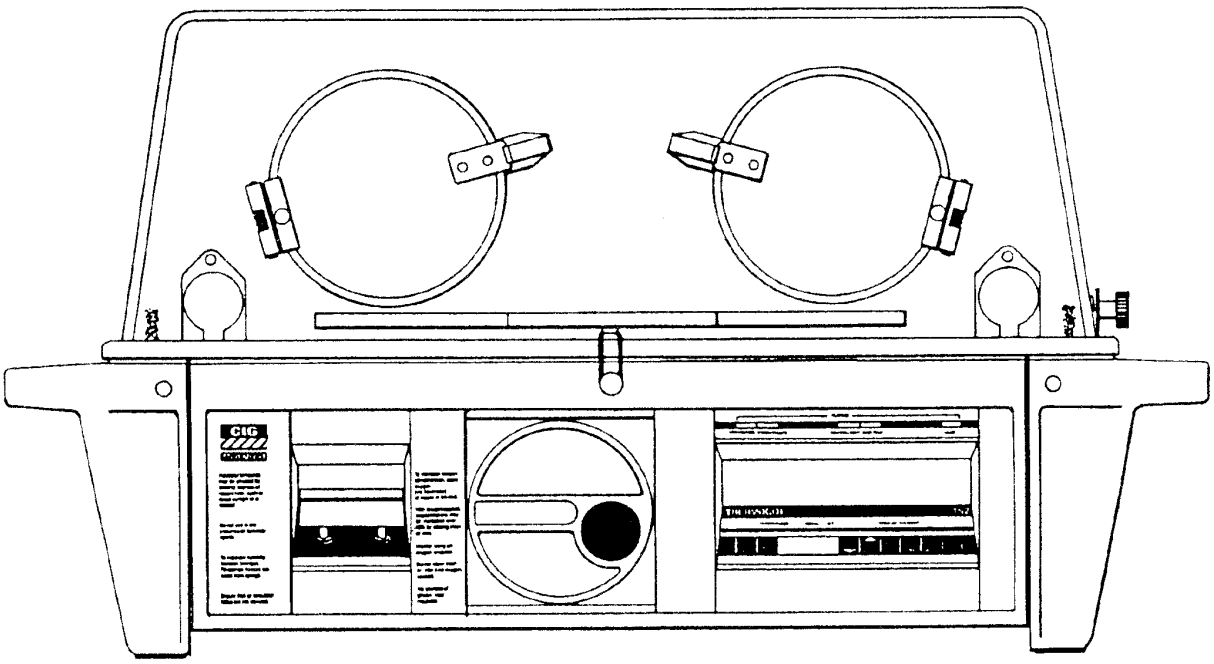
TS2 Thermocot

Service Manual



CIG Health Care

A Division of The Commonwealth Industrial Gases Ltd A.C.N. 000 029 729

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Specifications

1. Introduction

The TS2 Thermocot is an Air Controlled infant incubator which is designed to be easily transported within, or outside, a hospital. It operates from various supply voltages and features quick operation, good temperature control and a comprehensive range of automatic safety checks and alarms.

See also the Notes at the end of this section.

2. Physical Dimensions

Overall Length:	830mm (33 inch)
Overall Width:	430mm (17 inch)
Overall Height:	440mm (17 1/2 inch)
Weight:	23kg (51 lb)
Mattress Size:	305mm x 575mm (12"x 22 1/2")
Height above Mattress:	235mm (9 1/4 inch)

3. Power Requirements

Voltage	240	115	24	12
Hz	50	60	DC	DC
Max AMPS	1	2	10	20
TYPICAL AMPS HEATER ON:				
Standby	0.7	1.2	7.1	10.4
On	0.8	1.3	8.5	11.9
TYPICAL AMPS HEATER OFF:				
Standby	0.2	0.4	1.4	1.4
On	0.3	0.4	1.7	1.9

4. Control Temperature Range

30.0°C to 37.0°C (SET mode on Digital Display)
(See note C at the end of this section)

5. Warm-Up Times & Overshoot

Start	**Set Temp**	**Time**	**to Reach**	**Overshoot**
21.0°C	33.0°C	15 min	32.0°C	<2.0°C (typical)
30.0°C	34.0°C	5 min	34.0°C	<0.2°C
Standby	36.0°C	5 min	36.0°C	<0.2°C

6. Temperature Distribution:

Less than 1.0°C across mattress.
(See Note F at the end of this section.)

7. Accuracy of Indicators

Correlation to Incubator Temperature:
Digital Readout (Actual) ± 0.5°C
Canopy Thermometer ± 0.8°C
(See Notes E and H at end of this section)

8. Fresh Air Intake

(Fresh Air Inlet open) > 10 lpm
Filter: 3m "Filtrete" grade G0110
Effective area 8700mm² (13.5 inch²)

9. Carbon Dioxide Concentration

<0.25% CO_2 (See Note I at the end of this section

10. Oxygen Concentration

i. With Fresh Air Inlet open, 5 lpm Oxygen applied- maximum 40% O_2

ii. With Fresh Air Inlet closed, 8 lpm Oxygen applied, after 5 minutes from an ambient of 21% O_2 - 55% O_2 minimum (See notes B, J)

11. Air Velocity

Across mattress - <0.1 m/s (typical)

12. Sound Levels

i.	At centre of Mattress	52 dbA (max) 50 dbA (typical)
ii.	Same as (i) but with 8 lpm Oxygen applied	52dbA (typical)
iii.	Same as (i) but with 10 lpm Oxygen applied	54dbA (typical)
iv.	Same as (i) but with Alarm sounding	60dbA (typical)
v.	Alarm level 3 metres in front of incubator (See Note K)	>65dbA

13. Alarms

(See the Alarm Chart, and Note L)

SOFTWARE OVERTEMP Auto reset at 36.0°C	37.5°C
HARDWARE OVERTEMP Latch, manual reset	38.0°C

14. Humidity

Increase in humidity by adding water to sponges in holders about 20% RH. (See Note M)

NOTES:

A. This is an Air Controlled incubator; it cannot be used as a Baby Controlled incubator i.e. there is no provision for automatic control of the infant's temperature. The air temperature must be adjusted by the nursing staff to suit the requirements of the infant.

B. **OXYGEN:** The oxygen concentration level achievable within the incubator, by applying oxygen at the nipple at the left end, is dependent on the flow rate and the amount and position of leaks to the outside atmosphere.

If the Fresh Air Inlet is left open, a maximum of 40% oxygen only can be achieved. Note that even this low level may cause physiological complications with some patients.

If the Fresh Air Inlet is closed, higher levels of oxygen concentration can be obtained. Note that it is important to only close the Fresh Air Inlet when oxygen is being applied - otherwise there can be an accumulation of the patient's expired Carbon Dioxide.

As a guide, if a flow of 8 lpm of oxygen is applied, the concentration will build up to 55% within 5 minutes (i.e. 34% above ambient). Higher flows, or longer times, will give higher concentrations.

Note though, that higher flows also increase the noise level inside the incubator.

C. The Set Temperature is limited to 37.0°C. During normal operation it is not possible to exceed 37.0°C. However, a facility is available to a Biomedical Technician which will override this maximum for the purpose of testing the Overtemperature alarm points. Always check the Set Temperature when preparing to nurse an infant in the incubator.

D. When starting from cold there may be an overshoot. To avoid inadvertent operation of the Overtemperature alarms, make the Set Temperature for this first warm-up no more than 34°C, and then change the Set Temperature to a higher setting if required after about 20 minutes.

A warm-up from STANDBY will produce only minimal overshoot, and it is recommended that this mode be employed if the incubator is likely to be pressed into service at short notice.

E. All parameters specified are measured at an ambient temperature of 21°C. Temperatures are measured using calibrated thermocouples attached to the centre of black-painted brass discs having a diameter of 25mm and a thickness of 1mm. The discs are mounted horizontally 100mm above the mattress at the nominated test points.

Each disc is held in place by three 1mm diameter plastic rods protruding from a 50mm diameter base.

F. To assess the temperature distribution, the Control Temperature can be set at any temperature, and the difference between this and the temperature at each of the following 5 test points is measured. Test Point A is 100mm above the exact centre of the mattress surface; four other test points are at the same height above the mid-points of the lines drawn from the centre of the mattress to each of its corners.

G. **CONTROL TEMPERATURE**: Temperature selected at the digital display (in SET mode).

H. **INCUBATOR TEMPERATURE**: Temperature measured at point A in Note F. That is, 100mm above the exact centre of the mattress surface.

I. To evaluate the maximum CO_2 concentration which will occur, with the Fresh Air Inlet open, a 4% mixture of CO_2 in Air is administered at a rate of 750ml/min to a point 100mm above the centre of the mattress and the CO_2 concentration at a point 150mm apart from this point is monitored until stability is achieved.

J. The sound level inside the incubator increases as oxygen flow is increased. At 8 lpm the sound level is typically 52dbA, but this increases to 54dbA when 10 lpm is applied.

K. The sound level of the Audible Alarm is measured at a point which is at a distance of 3m perpendicular to the front of the incubator. Both the sound level meter and the incubator are positioned 1.5m above the floor.

L. There are two Overtemperature Alarms. One is in the microprocessor control system and monitors its own readings; if the readout goes over 37.5°C it will automatically cause the heaters to be disconnected and sound an alarm which can be muted.

However there is also a totally independent overtemperature detection circuit. This will be initiated if there is a microprocessor failure which causes the Incubator Temperature to go up to 38.0°C. At this temperature the Hardware Overtemperature Alarm will cause the heaters to be disconnected, will sound a steady Audible alarm which cannot be muted, and will latch so that it cannot be reset other than by the incubator being turned off.

Note that both Overtemperature Alarms cause the heaters to be disconnected.

M. The amount of moisture which will be added to the circulating air in the incubator by adding water to the sponges in the sponge holders is controlled by several factors:

- The relative humidity of the air being drawn in through the Fresh Air Filter.
- Whether (dry) oxygen is being applied.
- The temperature of the water added to the sponges.
- The Incubator Temperature.
- The length of time allowed for humidity to build up.

Warning Statements

(A Warning Statement is used when there is a possibility of injury to the patient or the operator.)

WARNING Do not place the incubator in the path of a source of radiant heat such as sunlight or an electric radiator. Such exposure may cause the infant to overheat.

WARNING Complete the Checkout Procedure as detailed in this Manual before placing the Incubator into service. If the incubator fails any portion of the procedure it must be withdrawn from service.

WARNING All personnel using the incubator should be thoroughly familiar with its operation and under the direction of qualified medical personnel familiar with the known risks and benefits of using the equipment.

WARNING Do not use the incubator in the presence of flammable anaesthetics; a possible explosion hazard exists under these conditions.

WARNING Do not leave the patient unattended in the incubator for long periods. Check the patient's temperature at least every 30 minutes.

WARNING The canopy should only be raised to move the infant in or out of the incubator. When it is raised there is significant heat loss.

WARNING Do not leave a patient unattended in the incubator while the canopy is raised.

WARNING The concentration of inspired oxygen does not predictably determine the partial pressure of oxygen in the blood; blood gas measurements are extremely important for the regulation of inspired oxygen concentrations when an oxygen enriched environment is necessary. High oxygen concentrations can increase the risk of retrolental fibroplasia. Even concentrations below 40% can be dangerous to some infants.

WARNING If oxygen is applied its flow should be measured with a pressure compensated flowmeter. The concentration of oxygen should be monitored at a position near the infant's head.

WARNING When a system fail alarm is activated, the incubator should be removed from service and the infant shifted to another incubator to ensure continuity of care.

WARNING If an alarm is muted closely monitor the patient.

WARNING The administration of oxygen will increase the noise level within the incubator.

WARNING Proper temperature control is dependent upon continuous unobstructed air circulation. Do not cover air circulation openings at the ends and sides of the mattress. Obstruction could lead to loss of proper air circulation, loss of heat, loss of air temperature control and carbon dioxide build-up. An air circulation alarm may be triggered.

Caution Statements

(A caution statement is used when there is a possibility of damage to the equipment.)

CAUTION Do not mount a radiant warmer or incandescent light source (including phototherapy) on or over the incubator canopy.

CAUTION Thoroughly clean the incubator at least once a week or after each patient.

CAUTION Do not use organic solvents including ether, alcohols, ketones (e.g. acetone) or scouring compounds for cleaning the incubator. These compounds may damage the surfaces to which they are applied.

CAUTION Do not autoclave the mattress or any of the plastic parts of the incubator.

CAUTION To minimise the generation of static electricity do not polish the incubator canopy with a dry cloth.

CAUTION When disassembling the incubator for cleaning disconnect the power and allow at least 10 minutes for the heating elements to cool.

CAUTION If flammable agents have been used for cleaning make sure that the incubator has been thoroughly air dried. Small amounts of agents such as alcohol or ether left in the incubator can cause a fire particularly in the presence of oxygen.

CAUTION Never oil or grease oxygen equipment with other than a substance approved for this type of service. Oils and grease oxidise readily and in the presence of oxygen will burn violently. CIG Health Care can advise on suitable lubricants.

CAUTION The voltage of the internal battery is automatically checked continually when the incubator is turned on. If the incubator is to be taken out of service for an extended period the battery should be removed to prevent possible damage due to leaking. The battery should be routinely replaced every 6 months.

CAUTION When applying water to the humidity sponge holder be careful that the level of free liquid that is not soaked up into the sponges is at least 5mm below the lip. If water is spilled mop it up immediately.

CAUTION The Thermocot weighs in excess of 20Kg. It should only be lifted by at least two people and only by the handles at either end.

CAUTION The use of oxygen increases the danger of fire. Auxiliary equipment which may produce sparks should not be placed in the incubator.

Checkout Procedure

WARNING Do not perform a checkout procedure while a patient is in the incubator.

WARNING Complete the checkout procedure before putting the incubator into use. If it fails any portion of the checkout procedure it should be removed from service and repaired.

Mechanical Checks

WARNING Disconnect the power lead from its outlet before disassembling the incubator.

1. Inspect the power lead.

2. Examine the incubator for signs of damage.

3. Tilt the canopy back so that it is possible to remove the mattress tray. Check that the hinge pins are screwed completely home.

4. Undo the four screws which secure the mattress tray. Remove the mattress tray.

5. Remove the baffle and check that the liner, the two sensors, the two heaters and the impeller are undamaged and securely in place. Verify cleanliness of all parts. Check the presence of rubber seals around the two sensors, 8 heater holes and the fan shaft hole. Check that the two liner retaining screws are firmly in place.

6. Replace all parts securely, including the Baffle and Mattress tray, securing the latter with its four screws. Sponges must be in position if extra humidity is required. Check for cleanliness of all parts.

7. Close the canopy to its mid-way position ensuring that the latch is secure and the canopy can only be moved from that position by deliberately releasing the catch.

8. Close the canopy and test the two porthole doors. They should open automatically when the catches are pressed but should otherwise withstand a force of 20N from inside the incubator without opening. Check that all screws are tight.

9. Check for smooth operation of the fresh air inlet rotor.

10. Check the condition of the fresh air inlet filter. It should be clean and securely held in place.

    In a clean environment and under normal operating conditions a new filter will remain effective for about 6 months.

    However adverse conditions, such as continuous operation in a dusty environment, will shorten the filter's effective life.

    The filter will darken in colour as it takes up dust from the incoming air. This colour can be observed through the inlet protective mesh or by removing the rotor plate. To do this peel off the blue cover strip in the centre of the rotor; underneath is a Philips head screw which retains the complete rotor and filter assembly.

    When replacing a filter make sure it is the right way round to achieve optimum efficiency. (The label must face into the incubator.) Tighten the screw so that the rotor is stiff to turn (but not too stiff) and replace the cover strip.

    Replacement filters are available in packs of 5 under part number NWT900900500. The pack includes gaskets and blue cover strips.

Operational Checks

1. Following the above mechanical checks make sure that all parts are securely in place including the mattress and the fresh air filter. Put the fresh air inlet rotor in the open position.

2. Put the main ON/OFF switch to the ON position. If the power lead is still unconnected there should be a continuous audible Power Fail alarm.

3. Turn OFF the incubator and connect the power lead.

4. Put the main ON/OFF switch to the ON position. There should be an automatic test of all displays before the incubator goes into the STANDBY mode - the Standby light should be on flashing and the heater light should be on but there should be no other lights and the digital display should be off.

   There should be an intermittent audible alarm to draw attention to the Standby Mode having been selected and this can be cancelled by pushing MUTE. No Mute light should come on.

5. There should be no alarms in the Standby mode. If there are any alarms, their cause should be investigated and the incubator should not be used until the condition has been repaired.

6. Push the ON button to enter the Operational mode. Again an automatic test of all displays should be initiated. Check that all lamps and all segments of the digital display are illuminated.

7. The digital display should show incubator air temperature, the heater light should be on, and the Actual light above the display. There should be no alarms.

8. Push the ∧ (up) button momentarily to display the Set temperature. The "Actual" light should be off and the "Set" light on. Push the button continuously to move the Set temperature up in 0.1 increments. Release the button and check the function of the ∨ (down) button.

9. Note the Set temperature you have selected. Turn off the power to the incubator at the power source, not at its ON/OFF switch. There should be a power fail alarm. Restore power after 15 seconds, and check that the incubator has resumed in the Operational mode (not Standby) and that the Set temperature is the same as was selected.

10. Push the TEST button. All lamps and displays should be briefly lit. The Audible Alarm should sound briefly.

11. Turn off the incubator at the ON/OFF switch. After 15 minutes turn it on again; it should come on in Standby mode.
    Select Operational mode and check the Set temperature - it should be the same as was selected in 9.

12. Allow the incubator to run until it has stabilised at the selected Set temperature. This will be indicated by the Heater light blinking. Run the incubator for 60 minutes at this temperature. There should be no alarms.

13. Select the maximum temperature, 37.0°C, and allow the incubator to run for another 60 minutes. Again, there should be no alarms.

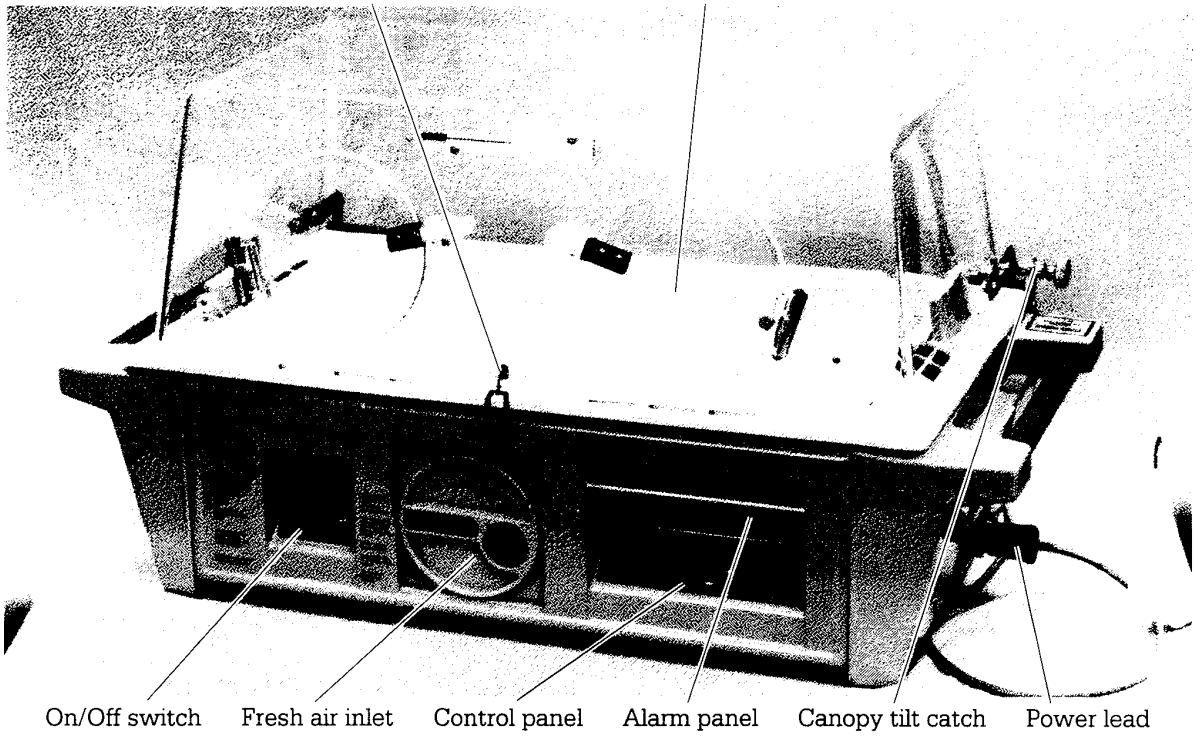
Electronics Check

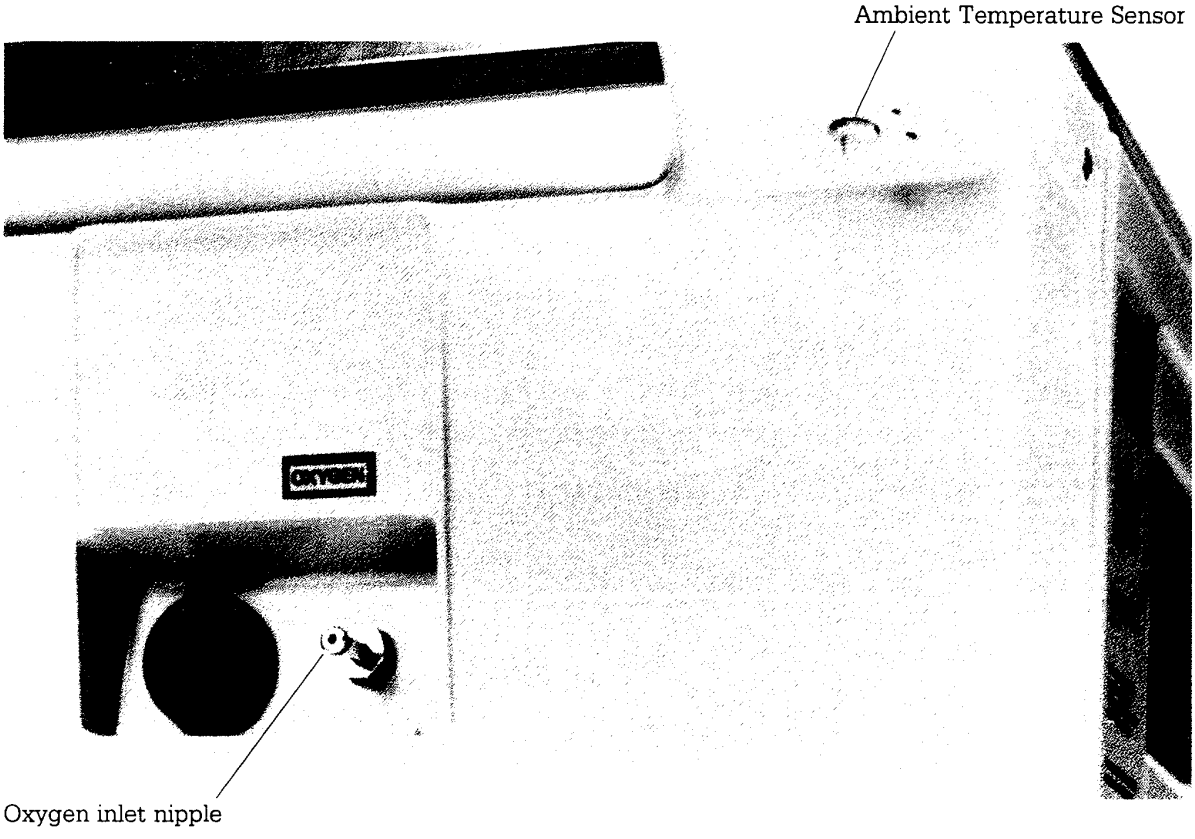
1: A technician can use the self-diagnostic facility to verify correct performance. Use the Diagnostic push-button which is accessible through the slot in the rear panel beneath the circuit breakers. The results are shown on the front panel digital display.

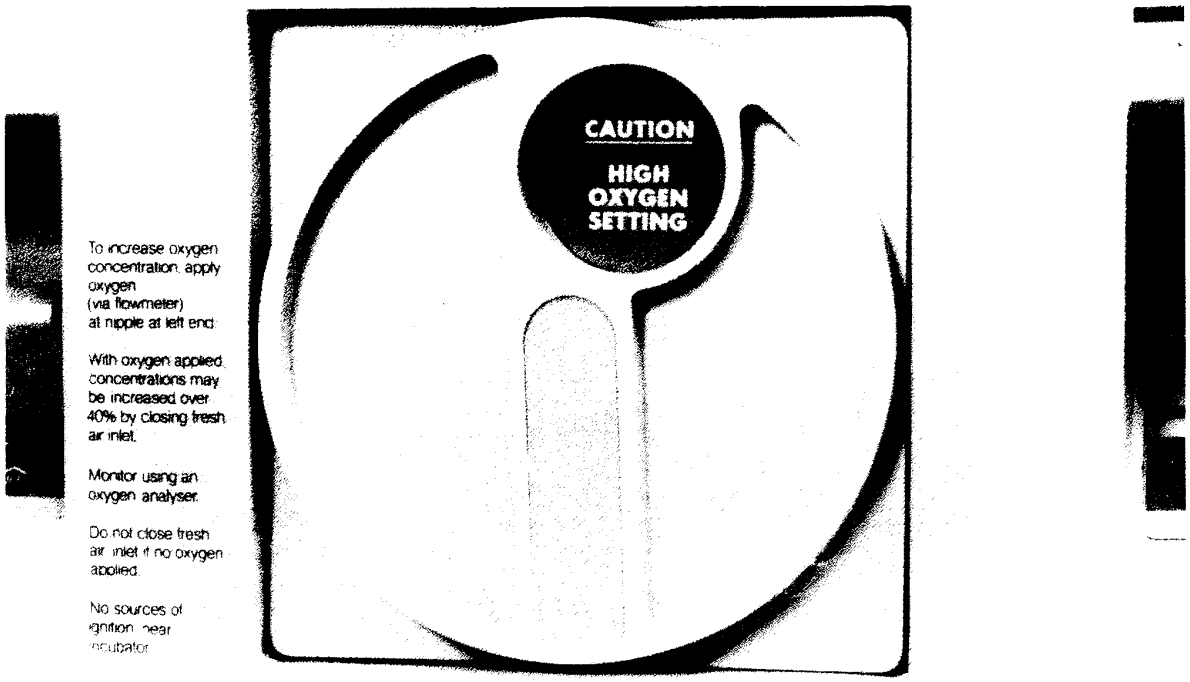
Diagnostics

	Display
For 1 push	Set temp
2	Air temp @ #1 Sensor (return air)
3	Air temp @ #5 Sensor (ambient)
4	Air temp #2 Sensor (return air)
5	Input Voltage (rectified D.C.)
6	Heater temp #3 Sensor
7	Heater temp #4 Sensor
8	Internal Battery Voltage (9 Volt nominal)
9	Fan Speed (display is 4 x revs/sec) [Acceptable range is 80 to 140 i.e. 20 rps to 35 rps or 1200 rpm to 2100 rpm]

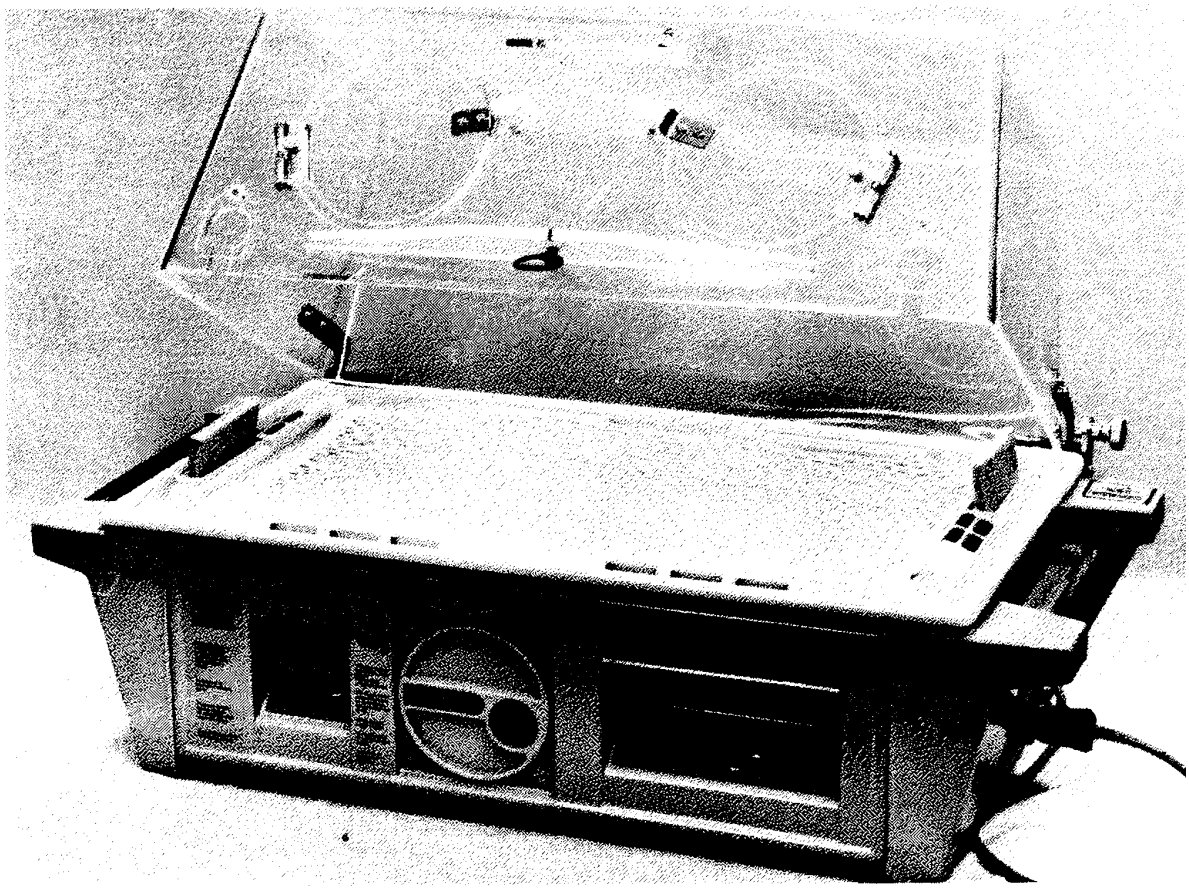
From any selection return to normal by pushing either the ∧ (up) or ∨ (down) button.


Front Canopy Catch
Infant Restraint Harness
On/Off switch
Fresh air inlet
Control panel
Alarm panel
Canopy tilt catch
Power lead


Ambient Temperature Sensor
OXYGEN
Oxygen inlet nipple



Fresh air inlet in closed position



Cleaning

WARNING Disconnect the power lead from its outlet before disassembling the incubator.

WARNING Allow at least 10 minutes after the incubator has been switched off before handling the heaters.

CAUTION Do not use organic solvents including ether, alcohols, ketones (e.g. acetone) or scouring compounds for cleaning the incubator. These compounds may damage the surfaces to which they are applied.

CAUTION To minimise the generation of static electricity do not polish the canopy with a dry cloth.

CAUTION If flammable agents have been used for cleaning, make sure that all parts have been thoroughly air dried before re-assembly.

Disassembly Procedure

1. Make sure the incubator is turned off.

2. Disconnect the power lead from the power outlet.

3. Open the canopy to its fully back position.

4. Undo the 4 screws retaining the mattress tray. Remove the tray, the screws and the mattress.

5. Remove the sponges from the mattress tray.

6. Remove the baffle.

7. Remove the impeller from the motor shaft.

8. Check that the two heaters are not too hot to touch. Remove both heaters.

9. The liner may be removed for cleaning if the two retaining screws are removed. A 7mm Nut-driver is required.

Cleaning

10. All removed parts should be cleaned using only antiseptic soap and warm water.
Do not use alcohols, ether or ketones, or coarse polish.
The mattress can be scrubbed and wiped clean. Do not immerse the mattress.
The Mattress Tray, the Baffle, the Impeller, the two heaters and the Liner can all be immersed if necessary. Scrub them and wipe clean.

11. The canopy may be scrubbed with a soft brush or cloth and wiped clean. Use only an antiseptic soap and warm water.
Do not use alcohols, ether, ketones or coarse polishes.

12. With a slightly damp cloth wipe the rubber seals on the sensors, the heaters and the fan shaft to remove any deposits.

13. Remove the Air inlet rotor, the filter panel, and the filter. Check the filter to see if it needs replacing - if it is excessively discoloured a new filter is required.
Wipe the rotor and filter panel with a slightly damp cloth.

14. With a damp cloth, wipe the area which contains the filter, and, using a bottle brush or similar technique, the air entrainment tube and its top gasket.

15. Before re-assembling the removed parts, make sure that they are quite dry and free of soap or other deposits.

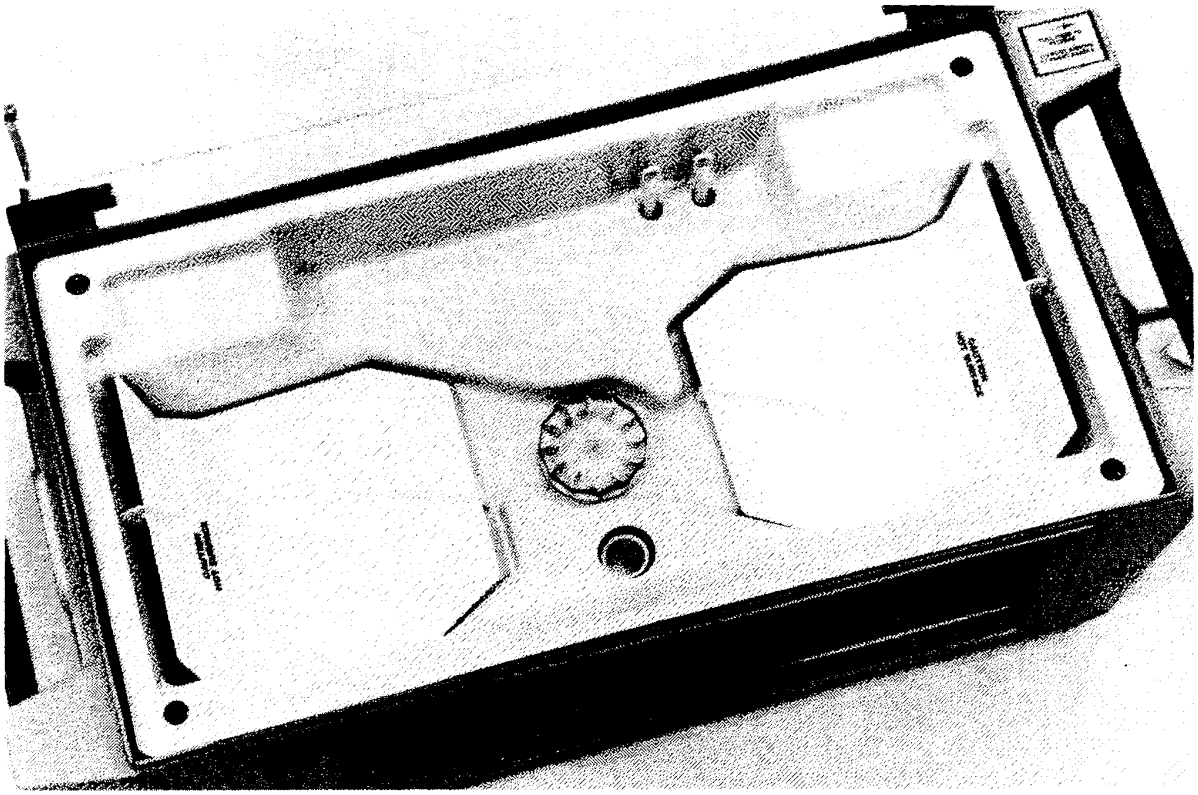
16. Replace all parts in the reverse order to that in which they were removed. Make sure that the heaters are firmly seated. Push on the impeller as far as it will go. The screws which retain the mattress tray should be firm, but not over tightened.

    Make sure the filter is installed with the clean air side towards the incubator. The rotor should be firm, but not too hard to turn. Leave the rotor in the fresh air position; the red warning label should not be showing.

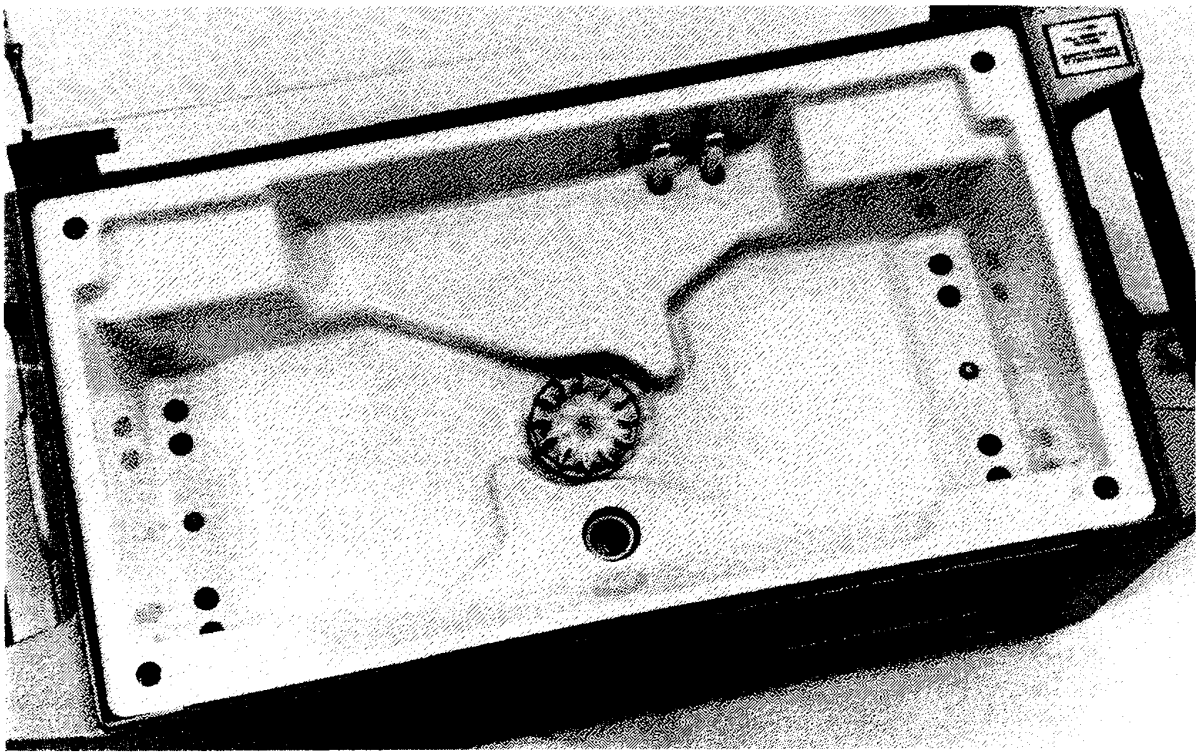
17. Replace the mattress and close the canopy.

18. Before being declared fit for service, the incubator should be briefly operated to make sure that the re-assembly has been correctly carried out.

19. With a damp cloth wipe all external surfaces to remove grime. Include the front control panel.



Canopy fully back, mattress tray removed



Heaters removed, showing impeller, 2 sensors

Alarms

	Caused by:	**Visible Alarm**	**Audible Alarm**	**Mute**	**Heaters**	**Digital display (Push Test)**
Power Failure	Removal of power when cot switched on	None	Steady	No Mute	X	None
Low Voltage	Input Voltage 12.5% below normal	Flashing	Flashing	15 min	No action	Normal
System Failure		Flashing	Flashing	15 min	No action	Normal
Fan	Fan less than 60% of normal RPM					(FAn)
Heater	Heater current or temp not correct					(HEA)
Sensor	Error in one of the five sensors					(SEn)
Internal Battery	Voltage below 7.5 volt					(bAt)
Control temp	Air temp more than 1°C from set temp	Flashing	Flashing	15 min	No action	Normal
Over Temp						
Software	Air Temp over 37.5°C	Flashing	Flashing	15 min	Cut off reset at 36°C	Normal
Hardware	Air temp over 38°C	None	Steady	N/A	Cut off Manual reset	N/A
Standby Mode Initiated	Cot turned on at Main Switch	None (Standby light flashing)	Flashing	Continuous	On	None

Technical Description

The TS2 Thermocot is a lightweight incubator which supplies warmth to an infant by circulating air around it at a temperature which is set by the nursing staff.

CAUTION
This incubator does not have Servo Control of Skin Temperature and the infant's temperature should be routinely monitored.

Underneath the mattress are a fan and two heaters. Return air from the patient vicinity passes down to the fan through the vent holes in the front and rear of the mattress. It then is passed over the two heaters and the warmed air re-enters the nursing area through the end slots.

CAUTION
Ensure that the vent holes and end slots are not blocked by blankets, sheets or any other materials.

Fresh Air

If the fresh air inlet is open, more than 10 lpm of fresh filtered air is added to the circulating air, helping to minimise the accumulation of expired carbon dioxide. The circuit thus acquires a slight positive pressure, and some air escapes through any gaps which there may be around the canopy and doors.

Oxygen

The fresh air inlet should only be closed if it is desired to apply pure oxygen and raise the patient's environment above 40% oxygen. The concentration achieved will be a factor of the input flow rate of oxygen, and time. It is important to continuously monitor the oxygen concentration, placing the sensor near the patient's head. If the fresh air inlet is closed without oxygen being fed into the incubator there is a danger of carbon dioxide build-up.

If oxygen is applied with the fresh air inlet open, the concentration achieved in the incubator is limited.

Humidity

As the recently warmed air re-enters the nursing area through the end slots, it passes over the humidity sponges. If elevated humidity is required, wet the sponges by putting a small amount of water into the holders and allowing it to soak up through the sponges. Do not overfill the holders or spill any water. Either remove and soak the sponges to add water, or leave them in place and use a syringe to add water to the holders.

Circulation

After the warmed air passes out of the end slots, it goes up along the skin of the canopy before being attracted down into the return air vents. This mode of air movement has two significant advantages - the canopy is kept warm, thereby reducing radiant heat losses from the infant; and the air velocity around the infant is relatively low, thus reducing evaporative heat losses.

CAUTION
It is important to keep clear the vent holes around the mattress - any blockage can interfere with the air circulation patterns.

Electronics

The operation of the heaters and fan is controlled electronically by a microprocessor-based system which is relatively sophisticated in the variety of functions it performs, but quite simple for the user to operate. The user is able only to adjust the Set Temperature, turn the unit ON and OFF, mute audible alarms and perform a rudimentary test procedure. The microprocessor is all the time

scanning 5 temperature sensors, a fan speed sensor, heater power, input voltage, internal battery voltage and monitoring its own correct operation. As it runs through its program, the microprocessor is constantly checking the validity of the information it is receiving, making calculations and decisions, and controlling the heater power and fan speed. If any fault conditions are detected, alarms are initiated.

Alarms

Refer to the Alarms Chart for a quick guide to the causes and effects of fault conditions. (Page 19)

In the event of a power failure while the incubator is switched on, the Power Fail audible alarm sounds. It is a steady tone, and there is no alarm light. The alarm can only be cancelled by restoration of power or turning off the incubator.

Most other alarms come on as flashing red lights accompanied by a similarly modulated audible alarm. The audible alarm can be cancelled for 15 minutes by pushing the Mute. A flashing red light indicates that the Mute mode has been selected. When the alarm condition is cleared, the Mute mode is cancelled.

There are two types of Over Temperature alarm. The first activates if the air temperature exceeds 37.5°C and if the microprocessor itself is functioning correctly - this is called the Software Over Temperature Alarm. There is also a Hardware Overtemperature Alarm which is triggered if the air temperature exceeds 38.0°C, and this is independent of the microprocessor and any other normal control circuitry.

Whereas the Software Overtemperature alarm will reset itself when the incubator cools to 36.0°C and restore power to the heaters, the Hardware Overtemperture Alarm locks out the heaters, gives a steady audible alarm and can only be reset by turning off the incubator.

Immediate attention is required for either Overtemperature Alarm.

A Low Voltage alarm indicates that the incoming supply voltage is 12.5% below its nominal value i.e. on a 12 volt supply, down to 10.5 volts.

The Control Temp alarm indicates that the Actual air temperature is more than 1.0°C away from the Set temperature, either above or below. The heaters and fan continue to run, and the incubator's control system will attempt to remedy the situation. However, nursing intervention may be required. The Audible alarm can be muted.

A System alarm indicates that there has been a failure with the incubator, outside of the control of nursing staff, which should be immediately attended to by a technician. The incubator should be withdrawn from service, and the patient transferred to another as soon as possible. The cause of a System alarm can be diagnosed by pushing the Test button, while the alarm is current, and reading the message displayed. It could be sensor failure (SEn), a heater failure (HEA), fan failure (FAn) or a flat internal battery (bAt).

If there is a total control system failure, there will be a continuous audible alarm and no displays.

Display

The digital display on the front panel normally shows the actual air temperature around the infant. Calculations performed by the microprocessor on readings from the 5 temperature sensors allow this temperature to be accurately known without having a sensor in the nursing area.

Set Temperature

To read the Set Temperature, push either the Up (∧) or the Down (∨) touch button. To change the reading, touch the appropriate button for 2 seconds and hold it until the desired Set Temperature is reached. The lights above the digital display indicate whether the reading is the Actual air temperature or the Set temperature.

Test

Pushing the Test button during normal operation causes all the displays to be activated, so that the operator can see if any are faulty. The Audible Alarm is also tested. When there is a System alarm, pushing the Test button causes an alarm diagnostic message to be displayed.

Standby

When the incubator is first switched on it goes automatically into Standby mode. In this condition the heaters are activated, and their temperature is regulated. The fan does not operate, thus saving wear on the fan motor, and air is not drawn through the inlet filter. The Standby light flashes, and there is an audible alarm which can be permanently cancelled by pushing Mute. The incubator is thus kept warm, ready for immediate use, without the wear associated with full operation. Warm up time, through use of this Standby mode, is reduced to about 15% of normal. To go to full Operational mode, push the On button. To revert to Standby it is necessary to switch off the incubator and then switch on.

Memory

When the incubator is switched off, either intentionally or by accident (e.g. the power cord is pulled out or there is a power failure), the Set Temperature and the mode of operation, Standby or Operational, are automatically stored in temporary memory for about one hour. After this time, restoration of power will set the incubator in Standby mode, with an audible alarm sounding, and the Set Temperature will be, by default, 32.0°C until it is reset by the Operator.

Power Supply

The TS2 Thermocot will operate from 4 different supply voltages; 240v a.c., 115v a.c., 24v d.c., and 12v d.c. To change from one supply to another, disconnect the power cable at the right hand end of the incubator by screwing the retaining ring anticlockwise until the connector comes away. Now attach the power cable designated for the new power supply, screwing the retaining ring clockwise until it is tight. It is not necessary to make any other adjustments.

Filter

The fresh air inlet filter should be routinely replaced every 6 months, or when it is noticeably dark, or seems to be restricting inlet fresh air flow. If the incubator is used in dusty environments, it will be necessary to change the filter more frequently.

Routine Technical Maintenance -

Every Six Months apart from cleaning (q.v.)

Mechanical

1 Change the filter.

2 Check the seals-still in place, cracked or split, or dirty.

3 Check for damage-look for chips or cracks in plastic parts, split in mattress, chips or cracks in canopy or doors.

4 Is canopy latch o.k.?

5 Listen for excessive noise.

6 Check fan speed (on diagnostics); motor should need no maintenance (do not oil).

7 Canopy door function - adjust if necessary.

8 Self test.

9 Are heaters secure?

10 Is impeller secure on shaft?

11 Measure earth leakage, operating currents.

12 Check over-temp.

13 Replace on-board battery (9 volt).

14 Carefully vacuum clean inside bottom of incubator to remove accumulated dust and fluff.

Calibration Procedure

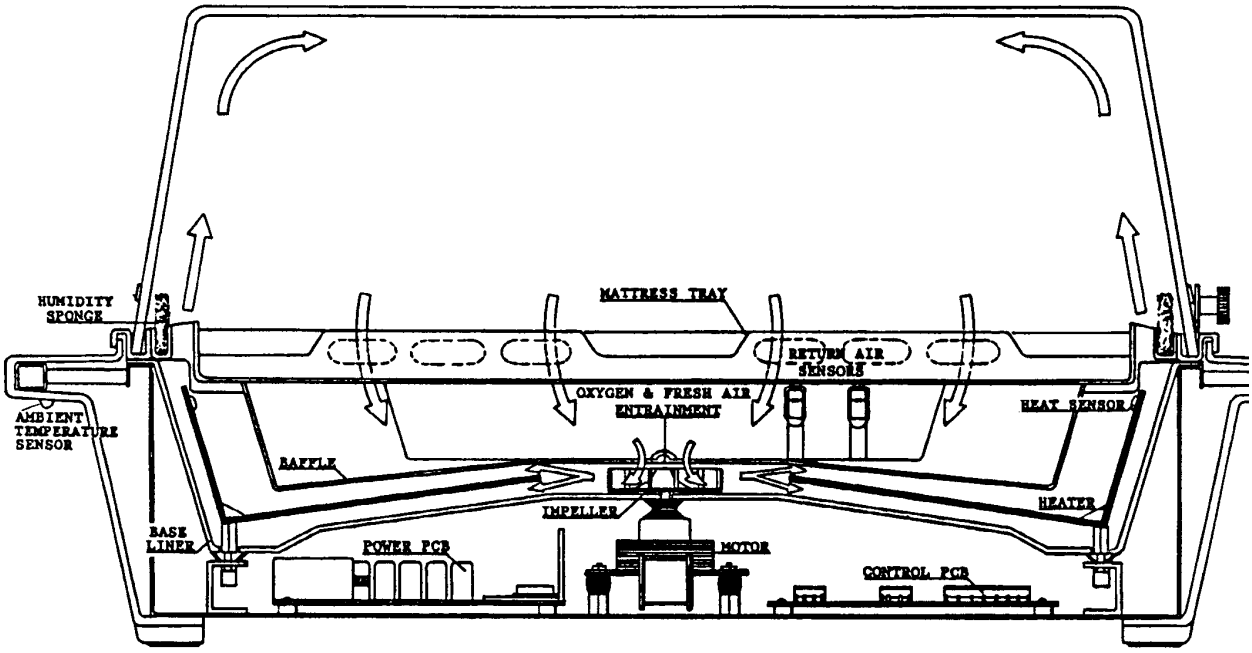
There are are only two calibration adjustments to be made- one for the Incubator Temperature to align with the digital readout, and the other for the Hardware Overtemperature alarm.

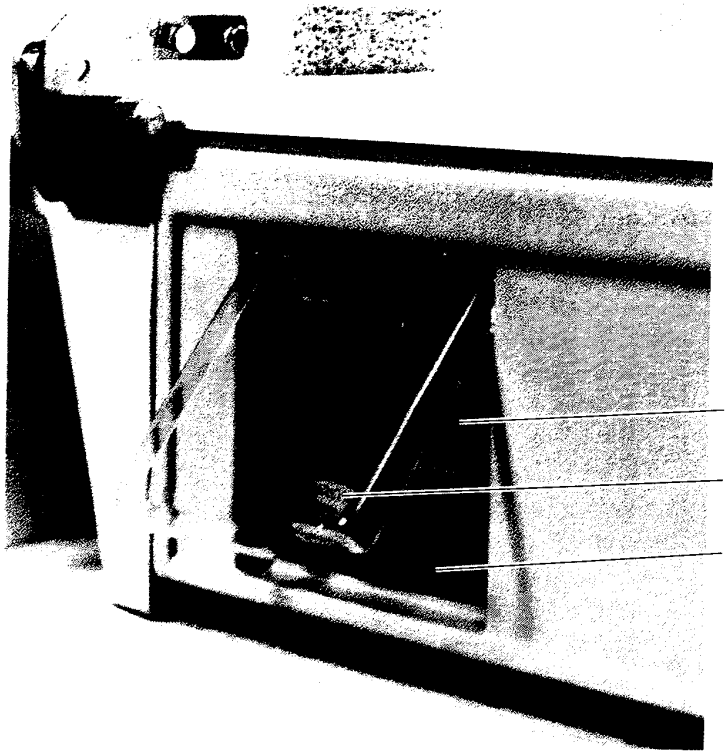
The Incubator Temperature is measured at a point 100mm above the exact centre of the mattress using a thermocouple attached to a black-painted brass disk, 25mm in diameter and 1mm thick, aligned horizontally.

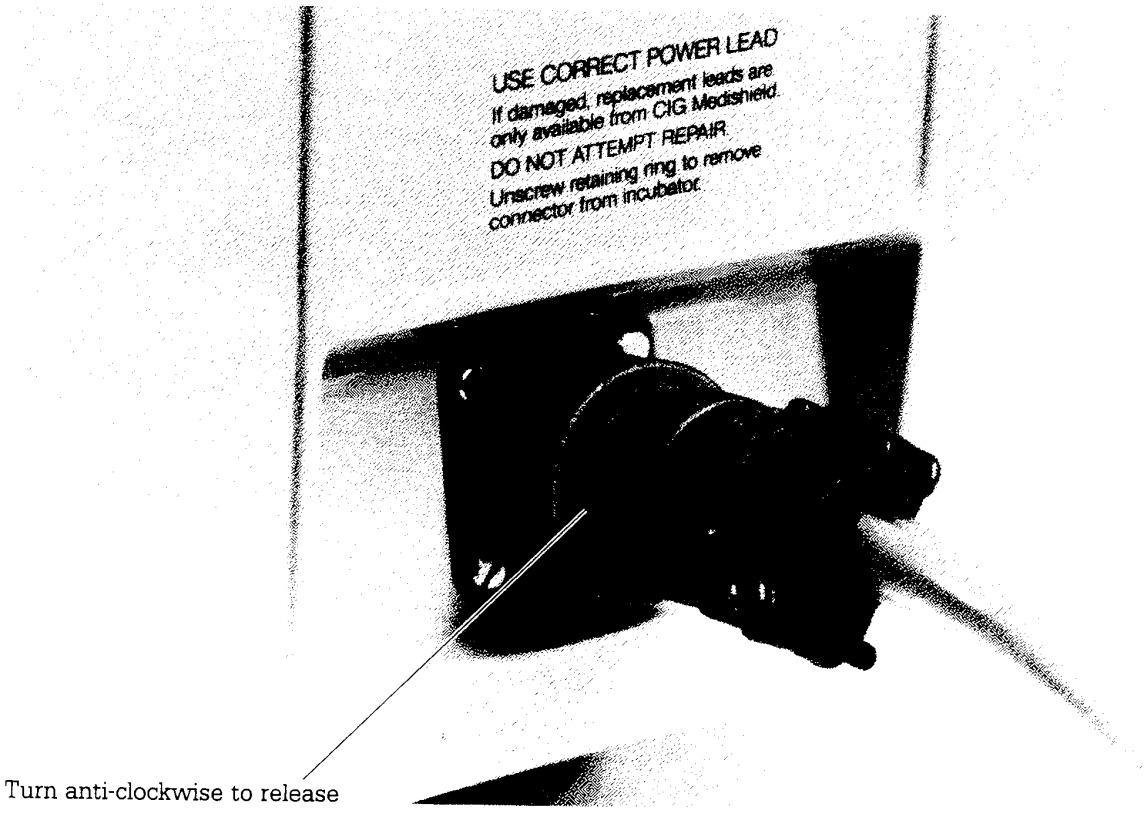
Set the incubator to run at 34.0°C. When it has stabilized, adjust the calibration pot (closest to the centre of the incubator) so that the digital readout is the same as the Incubator Temperature. Check the calibration at Set points of 37.0°C and 33.0°C and make adjustments if necessary.

To set the overtemperature alarm point, first stabilize the incubator temperature at 36.0°C. Then push the Diagnostic button 3 times followed by the Test button once- this selects a Set Temperature of 39.0°C and the temperature will commence to rise. Push one of the SET buttons so that there is a digital display of Incubator Temperature. When the Incubator Temperature- as measured by the thermocouple on the brass disc- reaches 38.0°C the alarm should have sounded; adjust the pot (left hand) so that this happens. Ideally the trigger point should be at about 37.8°C. Repeat the test until it is correct and consistent. Once the alarm has triggered, the circuit can only be reset by turning OFF. Allow the incubator to cool before trying to re-stabilize at 36.0°C.

Air Flow Diagram



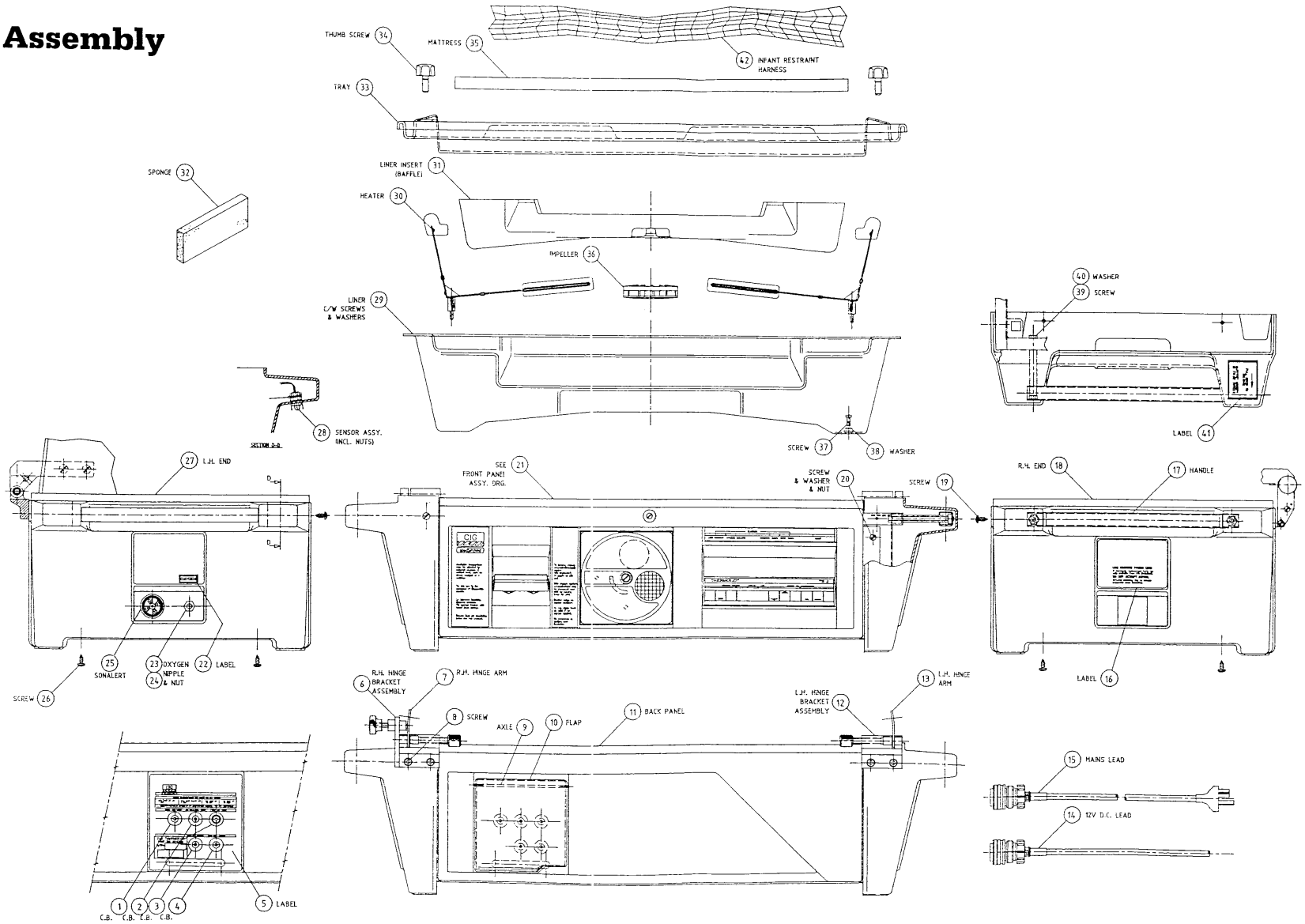

Circuit Breakers
Serial Number
Calibration Slot


USE CORRECT POWER LEAD
If damaged, replacement leads are only available from CIG Medishield.
DO NOT ATTEMPT REPAIR.
Unscrew retaining ring to remove connector from incubator.
Turn anti-clockwise to release

Parts List - General Assembly

Item	Part No.	Description	Qty
1	9012-002-00	Circuit Breaker 1.0 AMP	1
2	9012-003-00	Circuit Breaker 2.0 AMP	2
3	9012-005-00	Circuit Breaker 20.0 AMP	1
4	9012-004-00	Circuit Breaker 10.0 AMP	1
5	9012-006-00	Label, Circ. Breaker	1
6	9013-101-00	R.H. Hinge Bkt. Assy.	1
7	9027-018-00	R.H. Hinge Arm	1
8	9100-001-00	Screw, Soc. HD. Cap, M6	4
9	9012-010 -00	Axle, Hinge, C/W End Stops	1
10	9012-009-00	Cover, Circuit Breaker	1
11	9012-001-00	Panel, Back	1
12	9013-102-00	L.H. Hinge Bkt. Assy.	1
13	9027-017-00	L.H. Hinge Arm	1
14	9001-101-00	Cable Assembly, 12V	1
15	9001-102-00	Cable Assembly, 240V	1
16	9016-003-00	Label, Power Lead	1
17	9015-002-00	Handle	2
18	9016-001-00	Cover, Right Hand End	1
19	9100-002-00	Screw, Phil. HD. No.10	2
20	9100-003-00	Screw, Slotted Pan HD. M4	8
21	9006-000-00	Front Panel Assembly	1
22	9015-005-00	Label, Oxygen	1
23	9015-003-00	Nipple, Oxygen Supply Hose	1
24	9100-004-00	Nut, Hex	1
25	9015-004-00	Buzzer, Sonalert MC-07-1305	1
26	9100-005-00	Screw, Self Tap	4
27	9015-001-00	Cover, Left Hand End	1
28	9015-006-00	Sensor, Ambient Temp.	1
29	9020-001-00	Liner, C/W Screws and Washers	1
30	9022-000-00	Heater Assembly	2
31	9023-001-00	Baffle	1
32	9026-004-00	Sponge	2
33	9024-001-00	Tray	1
34	9030-000-00	Thumbscrew	4
35	9026-002-00	Mattress	1
36	9029-000-00	Impeller Assembly	1
37	9100-006-00	Screw, Slotted Pan HD. M4	2
38	9100-007-00	Washer, I.D. 4mm	2
39	9100-008-00	Screw, Hex Head, M6	4
40	9100-009-00	Washer, I.D. 6mm	4
41	9016-002-00	Label, Canopy Release	1
42	9026-005-00	Infant Restraint Harness	1

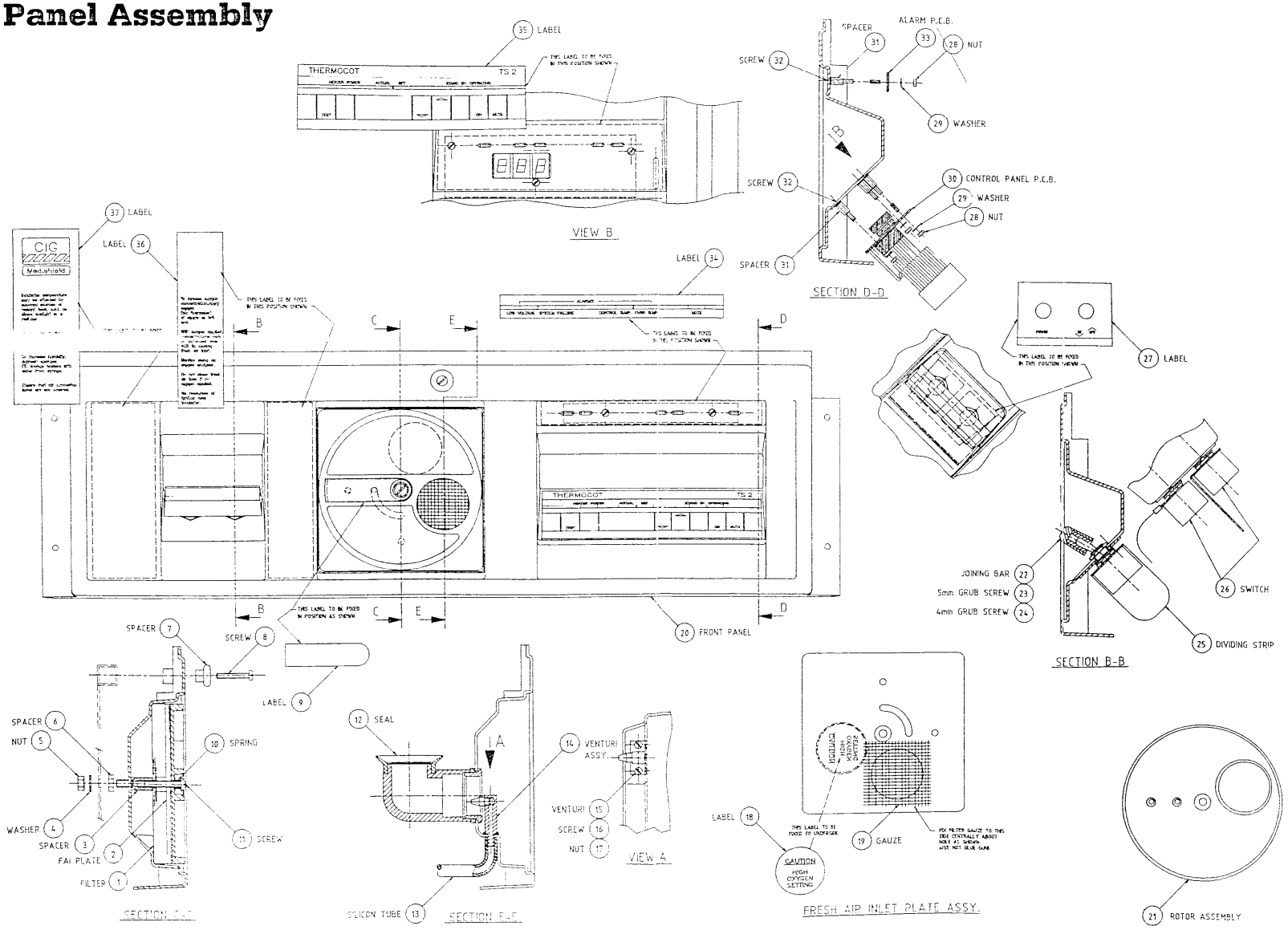
General Assembly



Parts List - Front Panel Assembly

Item	Part No.	Description	Qty
	9009-005-00	Pack of 5 Filters	
1	9009-000-00	Filter Assembly	1
2	9010-000-00	Air Inlet Plate Assembly	1
3	9011-004-00	Spacer, Air Inlet	1
4	9100-010-00	Washer, I.D. 6mm	1
5	9100-011-00	Nut, Hex. M6	1
6	9006-017-00	Spacer, Canopy/Front Panel	3
7	9006-016-00	Knob, Canopy Latch	1
8	9100-012-00	Screw, Slotted Pan HD. M5	1
9	9011-003-00	Label, Blue	1
10	9011-006-00	Spring, Compression	1
11	9100-013-00	Screw, Philips Rnd. HD. M6	1
12	9006-009-00	Seal, Air Inlet	1
13	9006-004-00	Tube, Oxygen Supply	1
14	9006-101-00	Venturi Sub-Assembly	1
15	9006-018-00	Venturi Jet	1
16	9100-014-00	Screw, Slotted Pan HD. M3	2
17	9100-015-00	Nut, Hex. M3	2
18	9010-003-00	Label, High Oxygen	1
19	9010-002-00	Steel Gauze	1
20	9006-001-00	Panel, Front	1
21	9011-101-00	Rotor	1
22	9017-011-00	Coupling, Switch (Bar), C/W Inserts and Grub Screws	1
23	9100-016-00	Screw, Grub, M5	2
24	9100-017-00	Screw, Grub, M4	2
25	9017-003-00	Insulator, Switch	1
26	9017-002-00	Switch, 3PDT Toggle	2
27	9006-014-00	Label, Power Switch	1
28	9100-018-00	Nut, Hex. M3	4
29	9100-019-00	Washer, I.D. 3mm	4
30	9008-000-00	Front Panel PCB	1
31	9006-005-00	Spacer, Threaded, M3 x 10 LG	5
32	9100-020-00	Screw, Slotted C'Sunk, M3	4
33	9007-000-00	Alarm Board Assembly	1
34	9006-010-00	Label, Alarm Panel	1
35	9006-011-00	Label, Touch Panel	1
36	9006-013-00	Label, Rotor Instruction	1
37	9006-012-00	Label, General Instruction	1

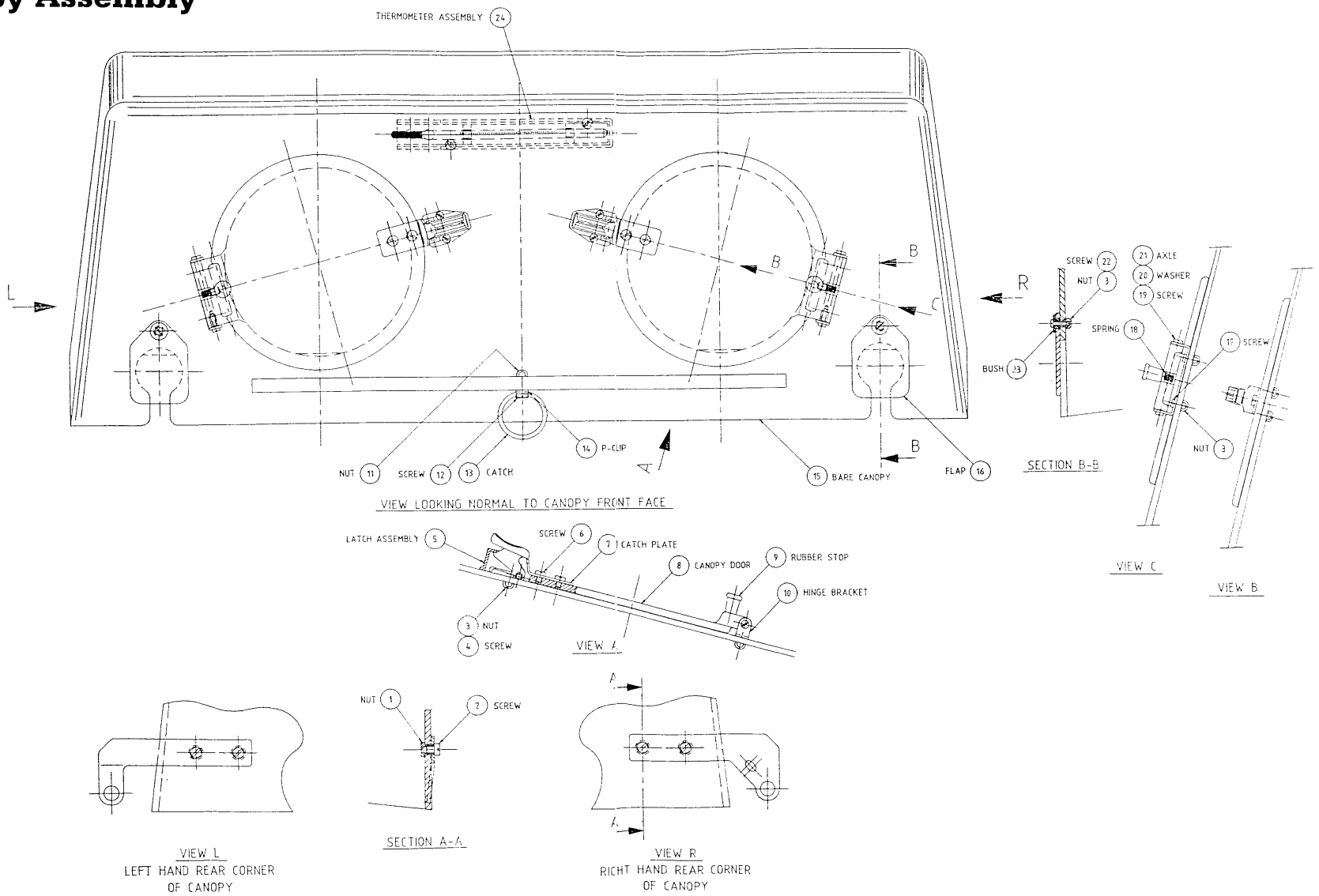
Front Panel Assembly



Parts List - Canopy Assembly

Item	Part No.	Description	Qty
1	9027-019-00	Nut, Blind, M6	4
2	9100-021-00	Screw, Slotted Cheese HD. M6	4
3	9027-005-00	Nut, Blind, Chrome	8
4	9100-022-00	Screw, Slotted Pan HD. M3	4
5	9027-101-00	Latch Assembly	2
6	9100-023-00	Screw, Slotted Pan HD. M4	4
7	9027-007-00	Plate, Door Catch	2
8	9027-006-00	Door, Canopy	2
9	9027-010-00	Stop, Door	2
10	9027-002-00	Bracket, Door Hinge	2
11	9100-024-00	Nut, M4	1
12	9100-025-00	Screw, Slotted Pan HD. M4	1
13	9027-016-00	Catch, Rubber	1
14	9027-015-00	Clamp, "P"	1
15	9027-001-00	Canopy, Bare	1
16	9027-012-00	Flap, Pivot	2
17	9027-004-00	Screw, M3 x 6 pan Pozi Taptite	8
18	9027-008-00	Spring, Canopy Door	2
19	9100-026-00	Screw, Slotted Pan HD. M3	2
20	9100-027-00	Washer, I.D. 3mm	2
21	9027-009-00	Pin, Hinge	2
22	9100-028-00	Screw, Slotted Pan HD. M3	2
23	9027-011-00	Bush, Flap	2
24	9027-102-00	Thermometer Assembly	1

Canopy Assembly

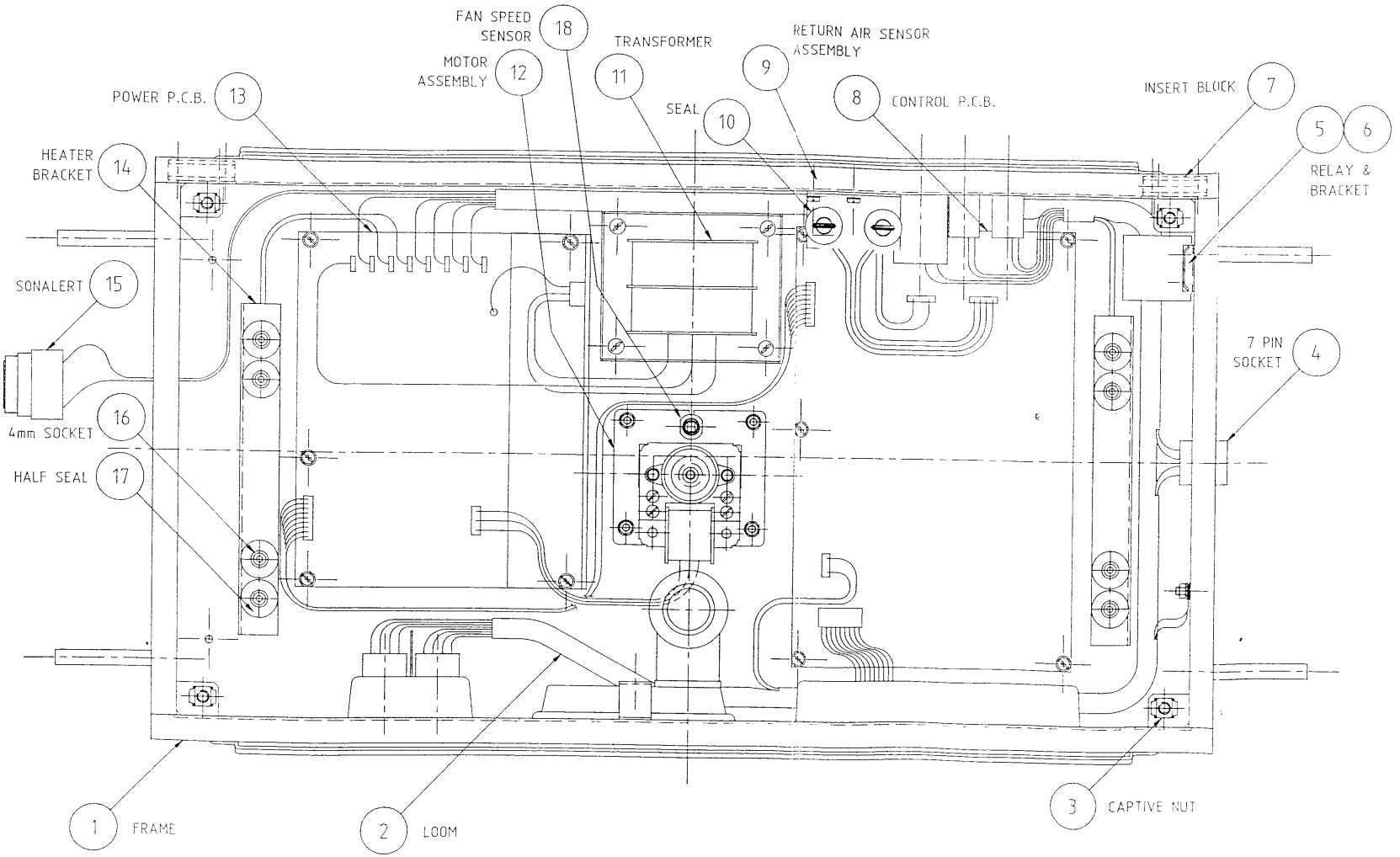


Parts List - Frame Assembly

Item	Part No.	Description	Qty
1	9001-001-00	Frame	1
2	9027-021-00	Loom Assembly †	1
3	9001-003-00	Cage Nut, M8	4
4	9001-006-00	Socket, Housing	1
5	9001-005-00	Bracket, Relay	1
6	9028-002-00	Relay	1
7	9001-004-00	Insert, Threaded	2
8	9018-000-00	Control Board Assembly	1
9	9002-000-00	Temperature Sensor Assembly	1
10	9002-007-00	Seal, Rubber	2
11	9028-001-00	Transformer	1
12	9004-000-00	Motor Assembly	1
13	9019-000-00	Power Board Assembly	1
14	9017-008-00	Channel, Heater Socket	2
15	9015-004-00	Sonalert	1
16	9017-007-00	Socket, Heater	8
17	9017-009-00	Seal, H'tr Socket	8
18	9005-001-00	Fan Speed Sensor Assembly	1

† Loom includes relay socket (9005-005-00),
7 pin socket insert (9017-018-00) and
front panel switches (9017-019-00)

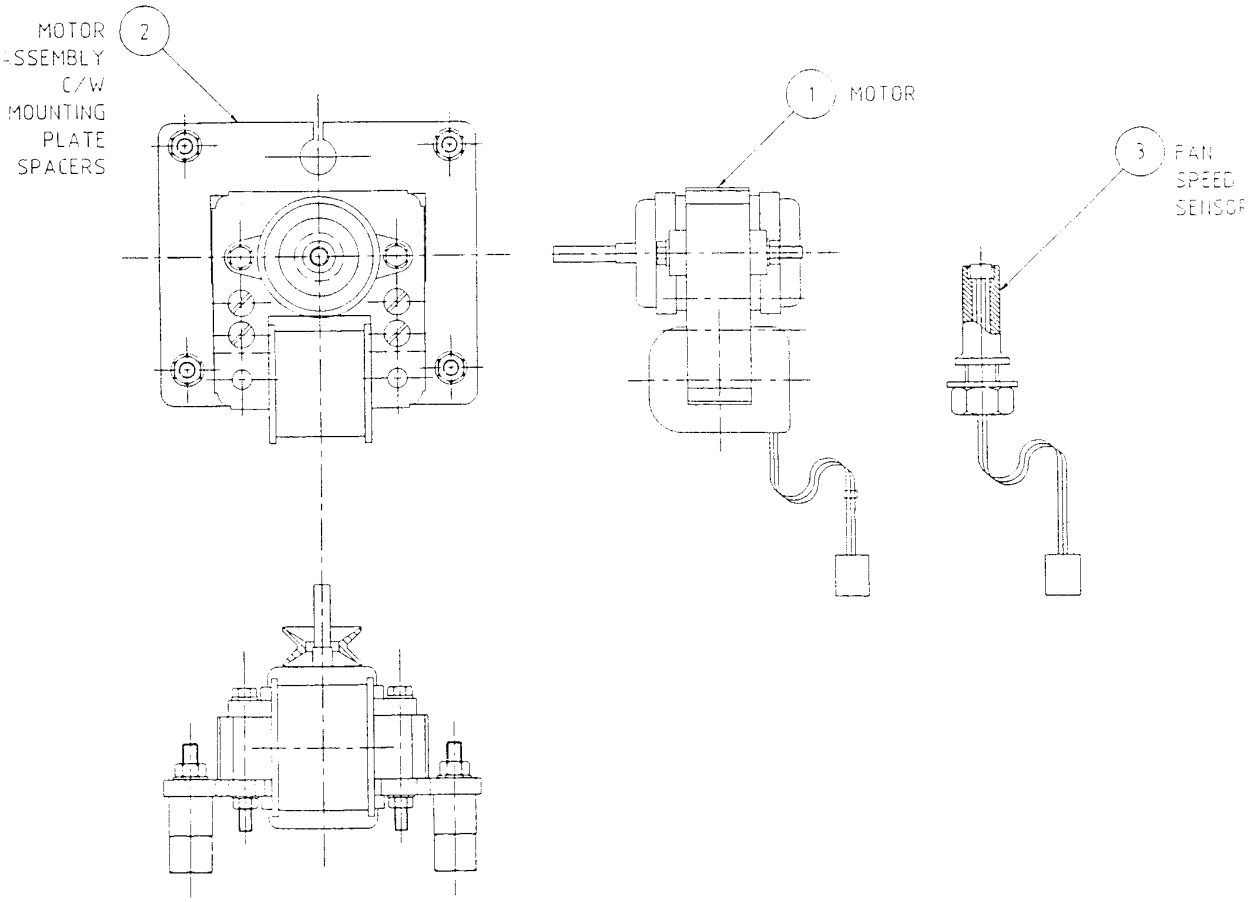
Frame Assembly



Parts List - Motor Assembly

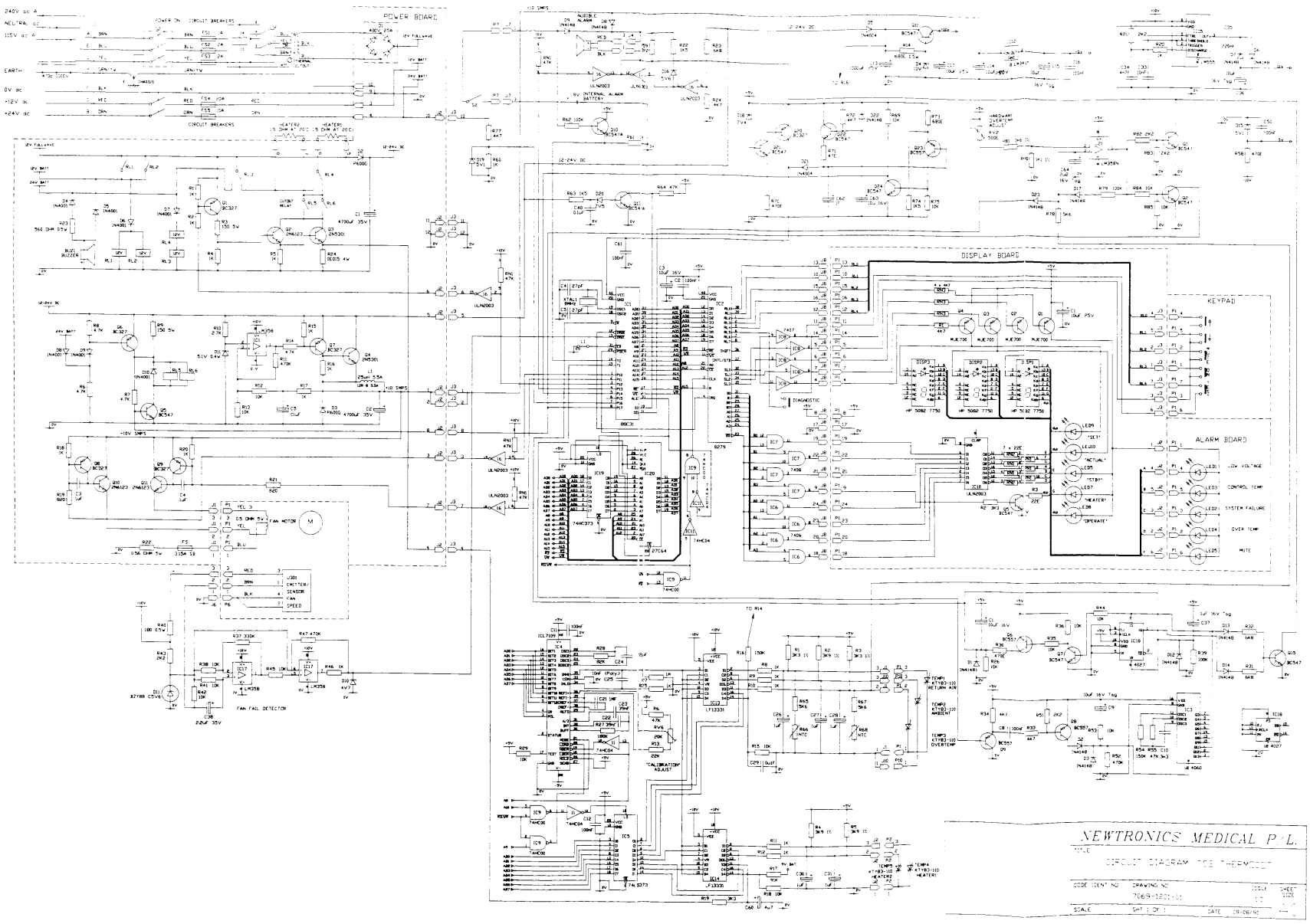
Item	Part No.	Description	Qty
1	9004-001-00	Motor	1
2	9004-000-00	Motor Assembly, C/W Mounting Plate (Without Sensor)	1
3	9005-001-00	Fan Speed Sensor Assembly	1

Motor Assembly



Circuit Diagram

TS2 Thermocot Service Manual



Circuit Description

1. Input Power Supply and Power Supply PCB:

The Thermocot will operate from supply voltages of 240V and 115Vac and of 24V and 12Vdc. Incoming alternating voltage supplies are connected via the ON/OFF switch S2 and circuit breakers FS1(1A), FS2(2A), and FS3(2A) to transformer TR1. The primary windings of TR1 are switched either in series or in parallel by means of a 240Vac relay; when 240Vac is applied the relay switches the primary coils in series. Otherwise the coils remain in parallel i.e. 115Vac input supply.

At the mains inlet three 470pF/1000V capacitors are used to suppress RF interference.

The transformer secondary provides 24Vac centre tapped, which is rectified by half of diode bridge D1 to provide a full wave rectified voltage of 12Vdc. This unsmoothed dc is used as the heater supply rail: after diode D2 it is smoothed by capacitor C1 and becomes the 12-24Vdc rail. The heaters in this ac input voltage mode are connected in parallel via the normally closed contacts of the unactivated relays RL3 and RL4.

12Vdc used as the supply to the Thermocot is applied via the ON/OFF switch S2 and circuit breaker FS4(20A) to parallel relays RL1 and RL2, (via diode D6), which connect the 12Vdc input to the supply rail. The heaters in this input voltage mode are connected in parallel via the normally closed contacts of the unactivated relays RL3 and RL4.

When 24Vdc is used as the voltage supply to the Thermocot it is applied via the ON/OFF switch S2 and circuit breaker FS5(10A) to the series connected relays RL3 and RL4 via diode D7. When the relays make, they connect the 24Vdc input to the supply rail. In this mode, the heaters are connected in series.

Accidental reversal of either dc input supply will be detected and alarmed by means of diodes D4 and D5 and BUZ1.

Switching of the heaters is controlled by a signal from the micro-processor on the Control PCB which is input to the Power Supply PCB via pin 6 of J2. This signal feeds Q1, which in turn switches the power transistors Q2 and Q3 to complete the heater circuit.

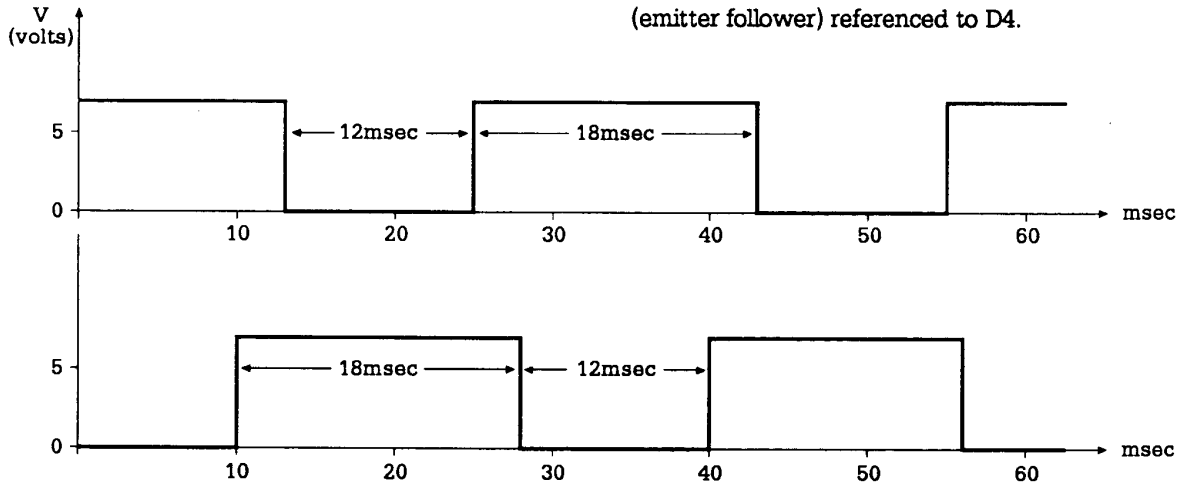
Relays RL5 and RL6 perform as an emergency cutout - they are switched by Q5 which is controlled, via pin 8 of J2, by either the Overtemperature alarm or the microcontroller (see Control Board description).

Correct heater operation is assessed by monitoring the voltage across R24 (0.015R). Typically this voltage should be between 150-220mV (12 Vdc or mains operation) or 80 - 110mV (24Vdc operation), when the heaters are switched on. This voltage is connected to the A/D converter on the Control PCB via Pin 4 of J2.

To provide an efficient 10 volt regulated supply for the fan driver circuit from a wide range of input voltages a switch mode power supply (SMPS) is used. Zener diode D11 provides a reference for the circuit in which the necessary feedback loop gain is provided by IC11, and Q5, D3, L1 and C2 are the switching transistor, flyback diode, power inductor and output capacitor respectively.

The fan driver comprises two similar switching sections which provide alternating power to the motor windings via J1 pins 2 and 3. The waveform applied to the motor is rounded off by capacitors C3 and C4 to maximise efficiency and avoid "rattle" effects. The common of the motor windings returns via pin 1 of J1 and is protected with fuse F5 (3.15A S.B). Control of the switching is from the microcontroller which supplies two individual switching pulse trains of 33Hz whose relationship to each other is show below:

GRAPH A



These pulse trains from the microcontroller are connected via pins 3 and 7 of J2.

2. CONTROL PCB:

Four power supply rails are in use on the Control PCB, namely:

+ 10Vdc
- 10Vdc
+ 5Vdc
- 5Vdc

The +5Vdc rail is derived by the linear voltage regulator IC12 (LM340T), from the +10Vdc switched mode power supply on the Power Supply PCB via J3 pins and 1 and 2.

The +10Vdc rail is derived from the 12-24Vdc rail on the Power Supply PCB via J3 pin 5 by Q11 (emitter follower) referenced to D4.

The -10Vdc (nominal - actual voltage is about -8Vdc) rail is generated by circuitry comprising IC15 (LM555), used as a square wave generator, and rectifying diodes D6 and D7. An (approximate) 53 kHz pulse train of magnitude 8Vp-p may be measured at pin 3 of IC15 with C35 acting as a dc block. C36 acts as a simple filter and ensures the negative polarity of the rail.

The - 5Vdc rail is derived from the -10Vdc rail by means of D15, R58 and C50.

The microcontroller IC1 (80C31) controls most of the operation of the Thermocot via its control ports. Port and pin assignments are summarised in the following table:

Port No	*Pin No*	*Name*	*Use*
0	32-39	AD0-AD7	Data/low address to peripheral IC's
1	1	P1.0	Fan control phase 01
	2	P1.1	Fan control phase 02
	3	P1.2	Heater Control
	4	P1.3	Buzzer output
	5	P1.4	Capacitor availability
	6	P1.5	Test output
	7	P1.6	24V detection
	8	P1.7	Heater cutoff (software overtemp protection)
2	22-28	A8 - A15	High address to peripheral IC's
3	10	SI	Low 12-24Vdc rail detect
	11	SO	HWOT latch inhibit
	12	IRQO	Interrupt request from keyboard (8279)
	13	IRQ1	Fan pulse input (to be counted)
	14	T0	9V internal battery detect
	15	T1	Watchdog reset pulse
	16	WE	Write enable
	17	RE	Read enable

Power to the microcontroller is normally supplied from the +5Vdc rail. Circuitry comprising Q20, Q21 and D18 ensures that if the rail is greater than 3.1V, supply to IC1 is directly connected to +5V.

In the case where the supply drops below 3.1V, Q20 switches off and C62 (0.1F) discharges via D21 providing IC1 with a rail until discharged.

XTAL 1, C4 and C5 provide the 8mHz clock signal for the microcontroller.

WATCHDOG TIMER:
The microcontroller IC1 provides a timing signal to the watchdog circuitry via pin 15 (T1). This signal is a high 10mSec pulse sent every 100mSec and is used to reset the timer/counter IC3. IC3 has its own clock, set up via R54, R55 and C10. If the microcontroller fails to send a pulse every 100mSec, the selected output of IC3 (pin 1) will go high thereby switching on Q15 via D13 and R32. The collector of Q15 will then be pulled low and activate the external buzzer via J4.

The microcontroller may be reset by the watchdog timer. This is done when the output of the watchdog is always high i.e. the microcontroller sends no timing signals via pin 15. The high signal at IC3 pin 1 also switches on Q7 and, provided the +5Vdc rail is available, will further switch on Q6 thus setting the reset line of the microcontroller (pin 9) high.

TEST OUTPUT:
The test output provided at IC1 (pin 6) can readily be used to determine correct operation of both IC1 and IC20 (Eprom).

The test output is controlled by the software and should appear as a constant pulse with flickering pulses which vary in length depending upon the mode the system is in.

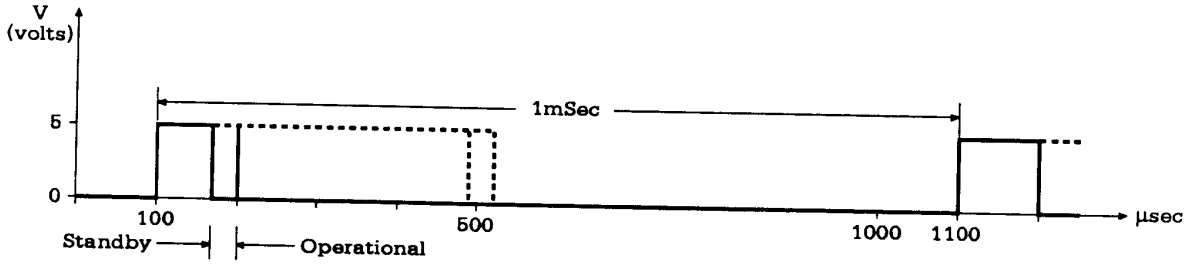
See Graph B. When the system is in Standby, the width should be at least 50µsec, and the pulse frequency a steady 1kHz. The pulse width will vary beyond 50µSec (up to 390µSec), but should not be less.

In Operational mode, the pulse width should be at least 80µSec and the frequency again is 1kHz. The pulse could occasionally be as long as 435µSec.

SENSOR CIRCUITRY:
The temperature sensing circuitry basically involves the Analog to Digital conversion of voltage levels across temperature sensitive devices (thermistors), and the transfer of the resultant digital data to the microcontroller, to be analysed internally. Since the sensors are similarly configured, a description of the operation of a typical sensor will be used to describe all.

For example, Sensor 1 connected between pins 1 and 3 of J1.

Resistor R1 connected to +5v provides the bias current required for the operation of the sensor. R65 and NTC thermistor R66 across the sensor provide compensation for internal heating effects. The sensor input line has a potential maximum range of 0.9 to 3.5V (sensor open circuit) and is typically at about 1.1 volts at normal operating temperatures.



GRAPH B

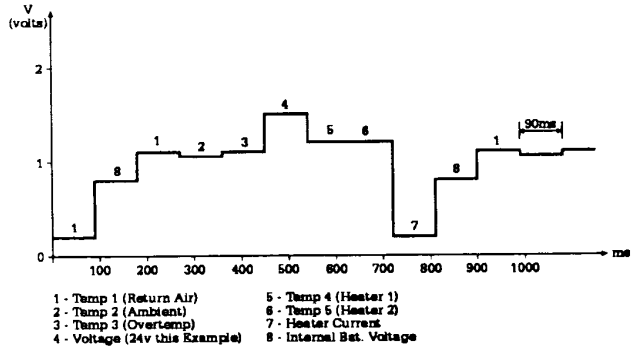
IC13 is a quad SPST analog switch arranged such that only one input may be selected to be output at any one time, depending upon the address sent by the microcontroller.

In the case of sensor 1 it is required that input C1 (pin 1) of IC13 is high to enable the input at pin 2 to appear at pin 3 of IC13. This output is then fed to pin 35 of the A/D converter, IC4, which converts the voltage level to a digital signal which is in turn input to the microcontroller's data bus.

Due to the continual polling of the address sequence at IC13 and IC14, the input to pin 35 IC4 will resemble a stepped waveform. The polling sequence is, in order:

IC14-S1
IC13-S2
IC13-S3
IC13-S4
IC13-S1
IC14-S2
IC14-S3
IC14-S4

The stepped waveform at pin 35 IC4 will resemble that below in Graph C with the range of values varying from as low as 0.15 volts (IC14 S3) up to 5V (IC14 S1) with each pulse width being about 90 mSec.



Components R28 and C24 determine the clock frequency of operation of IC4, being 200 kHz measurable at pin 25 of IC4. The digital result of the conversion is fed back to the microcontroller in an 8 bit format.

The A/D conversion not only involves the temperature sensors, but also includes other required readings such as:

1. Heater Current- input at pin 11 of IC14 via J3 pin 4 connected to the Power Supply PCB. Typical Voltage:
   @12Vdc, 0.22 volt
   @24Vdc, 0.1 volt

2. 12-24Vdc rail- input at pin 14 of IC13 via R16 and D5 and via J3 pin 5 connected to the Power Supply PCB. Typical Voltages:
   @ 12Vdc - 0.9 V
   @ 24Vdc - 1.5 V

3. Battery Voltage- input at pin 14 of IC14 via R17 directly connected to the battery. Typical voltage at IC14 pin 14 = 0.8V

Calibration of the A/D converter is by RV6 which is accessible from the back panel. This pot is used to tune the display so that it corresponds to the incubator temperture. Typically, the voltages at the reference inputs to the A/D converter are 3.5 volt at pin 36 and 2.5 volt at pin 39.

POWER DOWN MODE:

The Thermocot will go into power down mode if it detects less than approximately 8.2V on the 12-24Vdc rail. This is done through Q13 and 7.5V Zener diode D20 which ensures Q13 is switched on normally when the supply is greater than 8.2V. If the supply is less than 8.2V, Q13 will switch off and pin 10 of IC1 will go high. The circuit comprising Q23 and Q24 acts as a comparator which gives a low to pin 5 of the microcontroller until C62 is adequately charged (via Q22 and R71).

POWER FAIL:
In the event of a loss of mains power the microcontroller's on-board memory will remain active for at least 60 minutes due to the charge in C62. The unit detects the difference between mains failure and being switched off by means of the ON/OFF switch through the input to pin 14 of IC1 from Q10 which will remain high for a short time after a mains failure. If both mains and battery are switched off together (normal operation) Q10 will instantly go low.

HARDWARE OVERTEMPERATURE:
RV2, the hardware overtemperature set potentiometer, sets up a voltage level at pin 2 of IC21. The sensor input at pin 2 of J1 is directly connected to R78 which feeds pin 3 of IC21 (other input of the comparator). When the input at pin 3 exceeds the input at pin 2 the output at pin 1 of IC21, will go high, thus switching on both Q1 and Q2. D17 and R79, which are in a positive feedback loop, cause the comparator to latch until power is turned off. Q1 is turned on, activating the buzzer continuously. Q2 is also turned on and pulls low pin 17 of IC1 which controls the cutout relay.

AUDIBLE ALARM:
The audible alarm can be activated as follows:

a. From pin 4 of the microcontroller to indicate a "normal" alarm condition. The signal will be pulsating and can be muted.
b. By the watchdog timer - Q15. The signal will be steady and will indicate a catastrophic failure of the microprocessor or its associated circuitry.
c. By the Hardware Overtemperature alarm. The signal will be steady and cannot be muted. The heaters will automatically be disconnected by the cut-out relay.
d. By the loss of the 12-24v rail. Pin 6 of IC16 senses the rail, and a steady alarm results when pin 12 of IC16 goes low. In this case, normally caused by external power failure, the alarm is powered by the internal 9 volt battery. The alarm cannot be muted, but can be cancelled by turning OFF the incubator.

FAN SPEED:
The fan speed sensor provides a low level (approximately 5mV) square wave whose frequency is proportional to the fan speed. The ac signal is amplified in the first OP AMP stage of IC17, with the output appearing at pin 1. The output at pin 1 is approximately 0.7V pp about a dc level of +5.6V. The second OP AMP stage is a comparator stage which effectively results in the waveform output at pin 7 going from +10V to OV and is typically 8-10V p-p.

The zener diode at the output ensures a pulse train of 0-5V is fed to the interrupt input (IRQ1) of the microcontroller at pin 13. The microcontroller then determines the frequency by counting the pulses in a specified time frame.

PERIPHERAL DEVICES:
Peripheral support IC's include EPROM IC20, which holds the software required to direct the operation of the microcontroller, IC19, a transparent D-type latch to hold data when a peripheral is not ready and IC2, an 8279 display/ keyboard interface.

DISPLAY/KEYPAD:
The Display PCB is driven directly from the 8279 via J8. The code on the data bus is organised to determine how the output display array is switched. This array switching determines which segments on each display to light, and sets up numbers and also the individual LED's on both the Display PCB and the alarm PCB. Transistors Q1 to Q4 and transistor array IC10 are required to drive all LED segments and single LEDs. The 8279 is clocked using the ALE (pin 30 of IC1) and the RE and WE lines (pins 16 and 17 of IC1) and external logic to ensure continuation of the clock sequence.

The 8279 has an internal array which holds the return lines (RLx) high until a key is pressed. When a key is pressed, the corresponding return line is pulsed low. This activates the IRQ line (pin 4 IC2) to be pulled high thus informing the microcontroller that a key was pressed. The 8279 then provides the identity of the key via an encoded sequence on the data bus.

Software Description

STANDBY:
This mode is automatically selected when the incubator is turned ON at the ON/OFF switch. The audible alarm will be pulsed and can be permanently muted, and the STANDBY light will flash until another mode is selected.

At turn-on, all displays and the audible alarm are briefly tested in sequence. Pushing the TEST button will also initiate this sequence - the operator should make sure that all the LED's are working, including the digital display.

In STANDBY, the temperature of the two heaters is controlled using the heater sensors. The fan does not operate, and air circulation within the incubator is by convection only (and a baby should not be nursed under these conditions.) There is no adjustment of the heater temperature setting, and the digital display does not come on in this mode. All the alarm conditions assessment tests are still active.

STANDBY mode can only be entered by turning the incubator to ON with the ON/OFF switch.

OPERATIONAL:
To change to OPERATIONAL mode, push the ON button on the front panel. The TEST sequence will automatically test all displays again.

The fan will start, being driven by a quasi-square wave at 33Hz from the microcontroller, and the digital display will show the incubator temperature. Pushing either of the SET buttons will cause it to show the set temperature - if the SET button is continuously held for 2 seconds or more, the SET temperature display will change in 0.1°C increments.

The incubator temperature is calculated from the input from 5 temperature sensors - 2 are in the return air stream, 1 on each heater, and an ambient temperature sensor near the front of the left hand handle. By performing this calculation (to a pre-determined algorithm) it is possible to know the incubator temperature without having a sensor 100mm above the centre of the mattress.

The readings from the two return air sensors are checked against each other and an alarm is initiated if the difference is more than 3°C (which would be an indication of modified air flows or sensor failure). Similarly, the two heater sensors are checked for a difference greater than 10°C. On all sensors an "expected range" check is performed.

There is a digital sensor which checks the fan speed, and analogue inputs to the A/D converter for heater current, internal battery voltage and power supply rail voltage.

The alarms for sensor fail, fan speed, heater current being other than expected (on instead of off, off instead of on, or the wrong value), and internal battery, are all lumped together as equipment or SYSTEM alarms because they could not normally be rectified by nursing staff. To determine which fault has caused a SYSTEM alarm, push the TEST button (while the alarm is still on). See the alarm chart.

The LOW VOLTAGE alarm (power supply rail) indicates that the power supplied to the incubator is low in voltage and that the heaters will not be providing the normal power. The incubator does not shut-down at this point, but the operator should be aware that the heater capacity has been severely reduced (25% reduction in power compared to nominal supply voltage).

A software overtemperature alarm is sounded when the display exceeds 37.5°C for 3 consecutive seconds. This can be muted. It will reset automatically when the display goes below 36.0°C.

(Independent of the software, a hardware overtemperature alarm will be initiated when the incubator temperature reaches 38.0°C. The alarm will be steady, the heaters will be cut off, it cannot be muted, and can only be reset by turning OFF the incubator.)

There is a diagnostic facility whereby certain signals within the program can be output to the digital display. These are listed in the Diagnostic Chart.

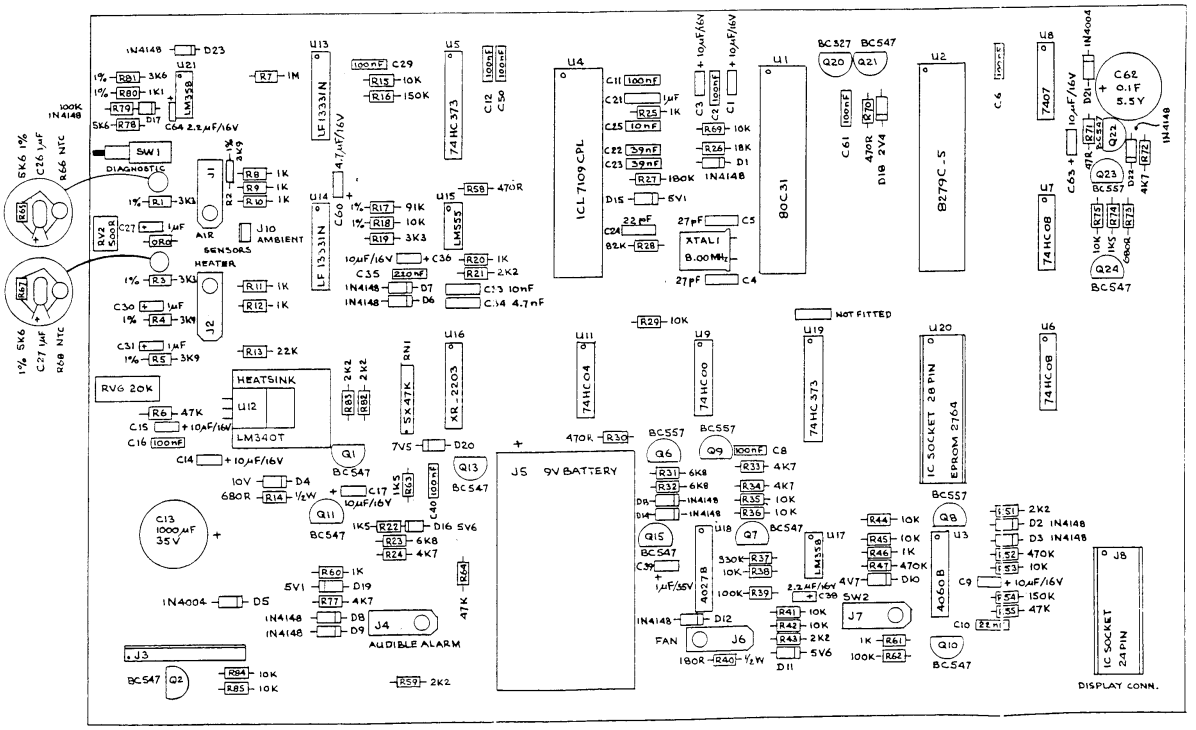
Control Board Parts List

Item	Description	Part No.
Control Board Assembly		**NWT 9018-000-00**
PCB	Double sided, plated through holes	**NWT 7021-0813-01**
R1,3	3k3, .25w, 1%	
R2,4,5	3k9, .25w, 1%	
R6,55,64	47k, .25w, 5%	
R7	1M, .25w, 5%	
R8,9,10,11, 12,20,20,25, 46,60,61	1k, .25w, 5%	
R13	22k, .25w, 5%	
R14	680R, .5w, 5%	
R15,18	10k, .25w, 1%	
R16	150k, .25w, 1%	
R17	91k, .25w, 5%	
R19	3k3, .25w, 5%	
R21,43,51, 59,82,83	2k2, .25w, 5%	
R22,63,74	1k5, .25w, 5%	
R23,31,32	6k8, .25w, 5%	
R24,33,34, 72,77	4k7, .25w, 5%	
R26	18K, .25W, 5%	
R27	180k, .25w, 5%	
R28	82k, .25w, 5%	
R29,35,36,38, 41,42,44,45, 53, 69,75,84,85	10k, .25w, 5%	
R30,70	470R, .25w, 5%	
R37	330k, .25w, 5%	
R39,62,79	100k, .25w, 5%	
R40	180R, .25w, 5%	
R47,52	470k, .25w, 5%	
R54	150k, .25w, 5%	
R65,67	5k6, .25w, 5%	
R66,68	NTC 1500ohm (at 25°C)/ 23226421.152 PHILIPS	

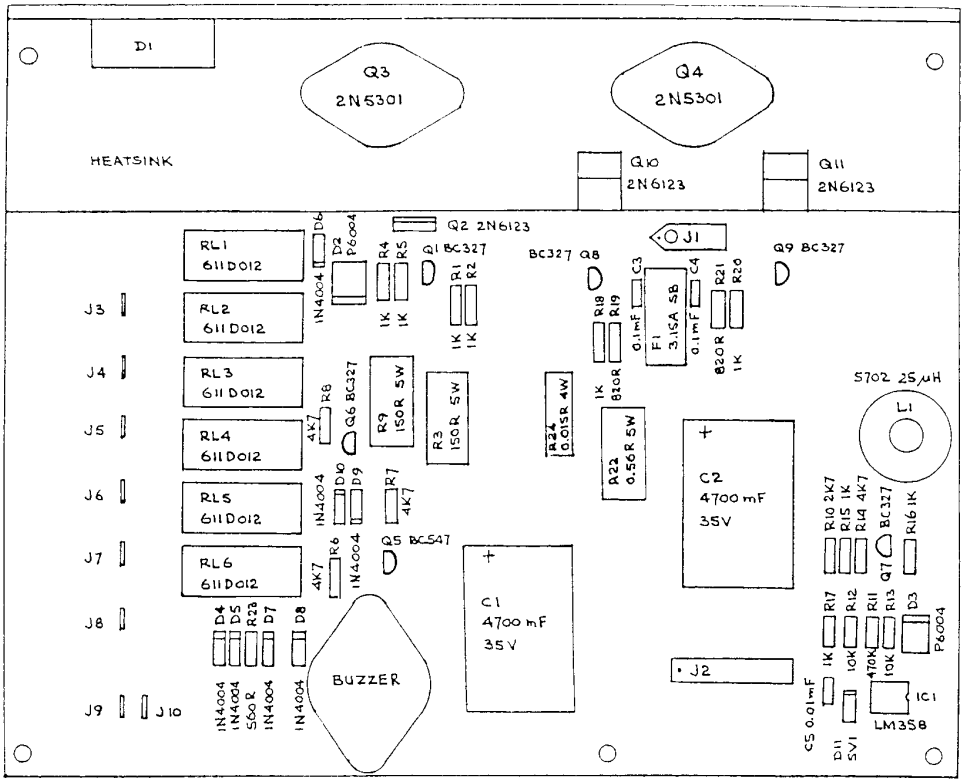
Item	Description	Part No.
R71	47R, .25w, 5%	
R73	680R, .25w, 5%	
R78	5k6, .25w, 5%	
R80	1k1, .25w, 1%	
R81	3k6, .25w, 1%	
RN1	Network (5*47k, 5%, X type)	
RV2	500R, 20 turn/ 85P Allen Bradley	
RV6	20k/ Spectrol	
C1,3,9,14,15 17,36,63	10uF, 16v, TAG	
C2,6,8,11,12,16, 29,40,50,61	100nF, 50v, polyester	
C4,5	27pF, 50v, ceramic	
C10	22nF, 100v, polyester	
C13	1000uF, 35v, Electrolytic	
C2	11uF, 50v, ceramic	
C22,23	39nF, 100v, polyester	
C26,27,28,30, 31,39	1uF,TAG	
C34	4.7nF, 100v, polyester	
C35	220nF, 50v, ceramic	
C38,64	2.2uF, 16v, TAG	
C60	4.7uF, 16v, TAG	
C62	0.1F, 5.5v/ AC206G104Z5R5 Murata	
D1,2,3,6,7 8,9,12,13 14,17,22,23	1N4148, 75v, 200mA	
D4	10v, 400mW, Zener	
D5,21	1N4004, 400v, 1A	
D10	4.7v, 400mW, Zener	
D11,16	5.6v, 400mW, Zener	
D15,19	5.1v, 400mW, Zener	
D18	2.4v, 400mW, Zener	
D20	7.7v, 400mW, Zener	

Item	Description	Part No.
Q1,2,7,10,11,13, 15,21,22,24	BC547, NPN	
Q6,8,9,23	BC557, PNP	
Q20	BC327, PNP	
U1	80C31BH, Microcontroller	
U2	8279C-5, Control board/Display interface	
U3	4060B, Binary counter, 14 stage, CMOS	
U4	ICL7109CPL, A-D Converter	
U5,19	74HC373, octal D type Latch, Tri-state	
U6,7	74HC08, Quad 2 Input AND Gate	
U8	7407N, Hex Buffer	
U9	74HC00, Quad 2 Input NAND	
U11	74HC04, Hex Inverter	
U12	LM340T, Voltage Regulator, 5v, 1A	
U13,14	LF13331N, Quad SPST Analogue Switch	
U15	LM555CN, Timer	
U16	XR-2203/ULN2003, Darlington Array	
U17,21	LM358P, Dual OP-AMP	
U18	4027B, Dual J-K Flip-Flop	
U20	EPROM, 8k, To be Programmed	**NWT 9018 002 00**
XTAL1	8MHz,case HC18/U	**NWT 4089 004 01**
SW1	Push-button, TP11-H9AV-B	
J1,4,7	Connector, 3 way male, M1840-3-2 Utilux	
J2,6	Connector, 3 way male, M1840-3-6 Utilux	
J3	Connector, 12 way male, M6410-12A Utilux	
J5	Battery Holder, 489-611 RS Components	
J8	IC Socket, 24 pin	
J9	IC Socket, 28 pin	
J10	Connector, 3 way male, M6410-3A Utilux	
Heatsink	U-shaped Aluminium	**NWT 7111 031 01**
Battery	Eveready No 216 Heavy Duty	

Control Board Assembly

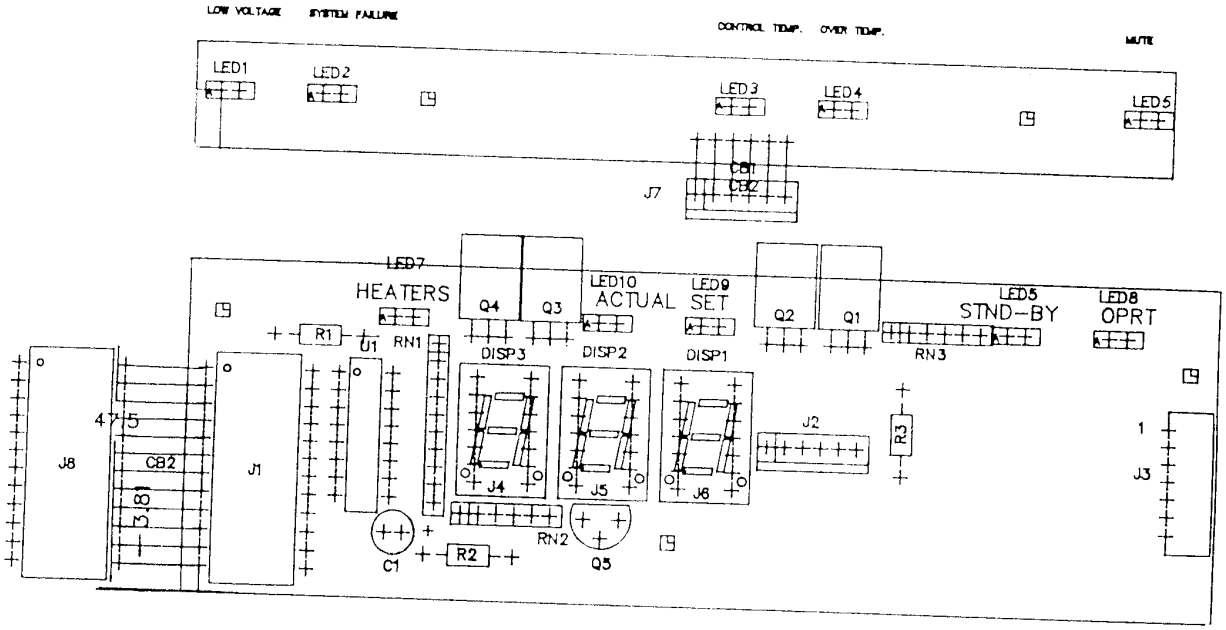


Power Board Assembly



Item	Description	Part No.
Power Board Assembly		**NWT 9019-000-00**
PCB	PCB, Single sided	**NWT 7021 0814 01A**
R1,2,4,5,15 16,17,18,20	1k,.25w, 5%	
R3,9	150, 5 watt,5%	
R6,7,8,14	4K7, .25w, 5%	
R10	2K7, .25w, 5%	
R11	470K, .25w, 5%	
R12,13	10K,.25w, 5%	
R19,21	820,.25w, 5%	
R22	0.56R, 5w, 5%	
R23	560R, .5w, 5%	
R24	.015R, 4 Watt, KN350-8-4W/VTM Farnell	
C1,2	4700uf/25V electrolytic	
C3,4	0.1uf/50V polyester	
C5	.01uf/100V polyester	
L1	Toroid, 25uH, 5.5A, 5702/ MILLER	**NWT9019 003 00**
D1	Bridge 400v/25A, KBPC2504/G.I.	
D2,3	400V/6A, P6004	
D4-D10	400v/1A, IN4004	
D11	5.1V/400mW Zener	
Q1, Q6-Q9	PNP, BC327	
Q2, Q10,11	NPN, 2N6123	
Q3,4	NPN, 2N5301	
Q5	NPN, BC547	
IC1	Dual Op-Amp, LM358P	
RL1-RL6	12V/10A SPDT relay, 611D012-FA6/UR	
BUZ1	Buzzer 12Vdc	**NWT 4052 007-01**
FUSE HOLDER	Fuse Holder (PCB Mount), PTF15	
F1	Fuse 3.15 amp slow acting, DA205	
J1	Connector 3 way male, M1840-3-2/Utilux	
J2	Connector 12 way male, M6410-12A/Utilux	
J3-J10	6.3mm Q.C. TABS, H25706/Utilux	
HEATSINK	L shaped aluminium extrusion	**NWT 9019-002-00**

Alarm Board Assembly



Display Board Assembly

Item	Description	Part No.
Display Board Assembly		**NWT 9008-000-00**
PCB	PCB Single Sided	**NWT 7012-0817-01A3**
R1	4K7, .25w, 5%	
R2	3K3, .25w, 5%	
R3	22R, .25w, 5%	
RN1	Network (5*22 OHM 5% Y type)	
RN2	Network (3*22 OHM 5% Y type)	
RN3	Network (3*4K7 OHM 5% Y type)	
C1	10uF/16V Tag Tantalum	
Q1-Q4	PNP Darlington, MJE700	
Q5	NPN, BC547	
DISP1-DISP3	Common anode, red LED, 5082-7750	
LED 5,7,9,10	LED, yellow, rectangular, HLMP0401	
LED 8	LED, green, rectangular, HLMP0504	
UI	Darlington Array, XR-2203/ ULN2003	
J2	Connector, 6 way male, L shaped, M7478-6A	
J3	Connector, 7 pin, M4850-7, Utilux	
SKT1-SKT3	Socket, 14 pin I.C.	
LOOM1	Loom with: 2 off, 24 pin connector Ribbon cable, 24 way, 120mm	**NWT 9008 001 00**
Alarm Board Assembly		**NWT 9007-000-00**
PCB	PCB Single Sided	**NWT 7021-0811-01A3**
LED1-LED5	Red, rectangular, HLMP0301	
P1	Loom with: Ribbon cable, 6 way, 120mm M6471-6-1 plug with M2759 terminals	**NWT 9007 001 00**

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