SERVICE MANUAL

NELLCOR PULSE OXIMETER

MODEL N-100B
(4 BUTTON MODEL)

Nellcor Incorporated
25495 Whitesell Street
Hayward, California 94545
800/433-1244 (outside Calif.)
800/351-9754 (within Calif.)
415/887-5858

A1480, REV F

S/N: 883038

WARNING -- The Nellcor Model N-100 pulse oximeter contains no user-serviceable parts. For protection against electrical hazard refer all servicing to qualified personnel.

WARNING -- For continued protection against fire hazard, replace fuses only with the same type and rating.

WARNING -- The Nellcor Model N-100 pulse oximeter is a patient connected medical device. An isolated patient connector is provided to protect the patient from potentially dangerous electrical potentials or ground paths. To protect the integrity of this connection, the procedures and parts specifications contained in this Manual must be adhered to.

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SECTION 1

INTRODUCTION

1.1 This Manual is provided to qualified service personnel for the purpose of maintaining and repairing the *NELLCOR®* Model N-100 Pulse Oximeter. Dangerous voltages are exposed when the cover is removed, certain components are critical to maintain patient isolation, and improper repair procedures can adversely effect the Instrument's calibration. For the protection of service personnel and patients, the procedures described in this manual are only to be performed by qualified service personnel.

1.2 Repair and testing of the Instrument exposes service personnel to potentially hazardous voltages, and improper repair or adjustment may effect the accuracy or patient protection associated with the Instrument. Where appropriate, warnings or cautions have been included in the text of this Manual. The term WARNING is used to bring attention to a procedure or precaution that is important to the safety of the service personnel or possibly the patient. The word CAUTION brings attention to a procedure that should be carefully followed in order to prevent damage to the Instrument or an error in calibration or performance. It is important that these warnings and cautions be read carefully and followed.

SECTION 2

DESCRIPTION OF THE INSTRUMENT

2.1 The Nellcor Model N-100 Pulse Oximeter is a monitor for continuously monitoring arterial oxygen saturation. The measurement is made non-invasively by applying an adhesive-attached Sensor to a finger or other site on the patient to be monitored. The Instrument itself is a portable unit, weighing about 16 pounds, with a self-contained battery intended for operation for periods of up to one hour during power failures or transport. Front Panel controls allow adjustment of the Beeper volume, Alarm volumes, and adjustment of Alarm Limits for Oxygen Saturation, High Pulse Rate and Low Pulse Rate. A connector is located on the Front Panel for connection of the Patient Cable assembly. The standard Patient Cable is 4 meters in length and is terminated by a module containing a Preamplifier and a Sensor connector. The entire Patient Cable/connector assembly (except for the grounded outer metal shell) is isolated from ground with a maximum leakage current of ten microamps. This provides safety for the patient from currents generated by faulty defibrillators or electrosurgical units.

WARNING -- For continued patient safety, the Patient Cable or Sensors must not be replaced with any other parts than those designated for that purpose manufactured by Nellcor Incorporated.

2.2 The Nellcor Model N-100 Pulse Oximeter incorporates a number of features for convenience and versatility. A handle along the bottom of the unit allows the unit to be easily carried, and can also be used to hang the Instrument from a gurney rail or headboard during transport. Additionally, the Patient Cable can be wrapped around the Instrument through the handle slot and secured by tucking the Preamplifier Module underneath a loop of cord. A pair of rear "feet" provide protection for the power cord and allow the unit to be used standing on its back. The power cord can also be wrapped around these feet for storage. The self-contained battery provides independence from AC power for up to one hour, and automatically switches from AC voltage to battery supply when AC power is lost or disconnected. The battery is recharged whenever the unit is connected to AC power, and will recharge in eight hours.

2.3 Internally, the Nellcor Pulse Oximeter contains five printed circuit boards, a power supply transformer, the battery and a speaker. The largest circuit board (located on the top of the Instrument with the cover removed) contains the analog processing circuitry, the microprocessor and its associated circuitry. The Power Supply Board and the Patient Isolation Assembly are located on the underside of the removable tray that mounts the Processor Board. A Battery Charger Board is located along the left side of the Instrument chassis, and a Display Board is located immediately behind the Front Panel Display, containing the LED displays and Front Panel switches. Voltage selection jumpers for changing the AC input voltage from 100-120 to 220-240VAC are located alongside the power transformer in the bottom of the chassis. (Instructions will be found in SECTION 4 for changing the selected voltage.)

SECTION 3

UNPACKING AND OPERATING INSTRUCTIONS

3.1 The Nellcor Model N-100 Pulse Oximeter is shipped in a single carton containing the Instrument, Patient Cable, one D-25 Digit OxiSensor Transducer, an AC powercord and the Instruction Manual. The box should be carefully unpacked and the contents verified.

3.2 The Instrument is wrapped in a sealed plastic bag to protect it from condensation and moisture due to temperature changes during shipping. If the Instrument is substantially colder than the surrounding ambient temperature, then condensation may occur when the unit is unsealed. For this reason, especially in areas of high humidity, the Instrument must be allowed to return to room temperature before being unsealed.

3.3 Since the batteries may not be fully charged when the unit is received, it should be first tested on AC power and left plugged in for at least eight hours to insure a full charge on the batteries before being placed into service. Connect the AC line cord to the receptacle on the rear of the Instrument and plug it into a 120 volt AC outlet.

WARNING -- To insure safety from electrical leakage currents, the Instrument should only be plugged into receptacles marked HOSPITAL GRADE if it is to be used with patients. The hospital grade cord and plug must not be exchanged for another type which is not hospital approved.

3.4 Once plugged in, the STANDBY/ON Switch should be placed into the ON position. The Instrument should sound a brief beep, the Display will briefly flash and then light up all of the LED segments for a short period, and then will show a display of "0" for Pulse Rate and Saturation. The PULSE SEARCH indicator should be blinking.

3.5 Pressing the LOW SAT button should blank the Pulse Rate display and cause the limit of "85" to be displayed in the upper SATURATION display. Pressing the HIGH RATE button should cause the upper saturation display to blank, and the high pulse rate limit of "140" to be displayed in the lower PULSE RATE display. Pressing the LOW RATE button should cause the upper saturation display to again blank, and the low pulse rate of "55" to be displayed in the PULSE RATE display.

3.6 Pressing the bottom AUDIO ALARM OFF button should cause the LED lamp to the left to alternately light or be extinguished. If the AUDIO ALARM button is held down, the alarm delay will be displayed (initially 60 seconds) and can be adjusted from 30 to 120 seconds. Advancing the delay beyond 120 seconds causes "OFF" to appear, and the alarm timer will be turned off completely. In this case, pressing the AUDIO ALARM OFF button will cause the corresponding light to blink, indicating that the alarm is permentantly disabled and will not time out. Pressing the button again will enable the alarm (light off). Always check the lamp to be sure the alarm status is correctly set. The alarm always reverts to a 60 second period when the instrument is turned off and back on.

3.7 The large round Control Knob in the center of the Instrument is used to adjust the alarm limits upwards or downwards. By pressing the LOW SAT button and then immediately rotating the Control Knob with a finger tip the saturation limit can be adjusted from any value from 50 to 99 by rotating clockwise and counterclockwise.

Three seconds after the last adjustment has been made, the Display will automatically revert to Saturation and Pulse Rate, in this case 0/0. The HIGH PULSE RATE and LOW PULSE RATE are also adjustable in the same fashion. The HIGH PULSE RATE alarm limit can be set from the current setting of the LOW PULSE RATE (initially 55) up to a maximum of 250. The LOW PULSE RATE alarm limit can be set from from a minimum of 40 up to the current setting of the HIGH PULSE RATE (initially 140).

3.8 Battery operation can be checked by disconnecting the AC powercord, either in the back of the Instrument or from the wall. The BATTERY IN USE light should come on within one or two seconds from the loss of AC power. The light will flash if there is less than ten minutes of operation remaining. The Instrument will automatically turn itself off when the battery reaches its lower voltage limit. This feature prevents any possible erroneous data from appearing on the Display as well as preventing possible damage to the battery due to an over-discharged condition.

3.9 The Patient Cable should be connected to the Instrument by carefully lining up the red dot on the cable connector with the red dot on the Front Panel of the Instrument. The connector is then pressed straight in making sure that the keyway is carefully engaged. It is not necessary to disconnect power to the Instrument when connecting the Patient Cable. The connector is removed by pulling straight out on the knurled portion of the connector. Do not twist or attempt to unlock the connector before removing; the connector is locked in place but automatically unlocks when the knurled collar is pulled straight back. Attempting to twist the connector may cause damage to either the connector or the Front Panel of the Instrument.

WARNING -- Since the Patient Cable connector is part of the Patient Isolation, it is not possible to replace either the Cable connector or the Front Panel connector without replacing the entire Cable Assembly with the correct Nellcor assembly.

3.10 Once the Patient Cable is connected to the Front Panel, a Sensor may be placed on a finger in accordance with the instructions on the Sensor package, and plugged into the connector at the end of the Patient Cable Assembly. Be sure that the Sensor connector is correctly oriented and plugged in all the way. The Instrument will automatically adjust the brightness of the light emitting diodes in the Sensor and within five to six seconds the pulse amplitude display on the front panel should begin to follow each heartbeat. After an additional five heartbeats or so, the Instrument will show an oxygen saturation value and a heartrate on the front panel. These values may change over the next five to ten seconds as the Instrument updates its computed values.

3.11 The brightness level of the LED's is shown in the Pulse Amplitude Display as one or two lights representing the brightness of the two LED's. If a finger is too thick for light penetration, one or both lights will be seen to step upwards to the top of the display and start again from the bottom as the Instrument tries to servo the LED's. (This can be demonstrated by taping the Sensor face-down on a table.) If this is observed clinically, try another (smaller) digit. If a finger is too small, as with a child, one or both lights will sit at the bottom and no pulse will display. Changing to a larger finger or toe, or using a D-20 Pediatric Sensor will allow proper operation. The LED levels are also displayed when the MODE is displayed by pressing HIGH RATE and LOW RATE (see below), and can be checked anytime without effecting normal operation.

3.12 The operating mode of the Instrument can be changed by pressing and holding the HIGH RATE and LOW RATE buttons simultaneously. The current mode will be displayed, and can be changed by rotating the Control Knob clockwise or counter-clockwise.

Mode 1 is the normal operating mode, displaying both Saturation and Rate with a filtering time-constant of about 7 seconds.

Mode 2 is a beat-to-beat display, of limited clinical utility but useful for technical diagnosis. The displays should be stable plus or minus one or two counts with a strong pulse and stable patient, and will have a very fast response time to changes in Saturation or Rate.

Mode 3 displays Saturation only (without pulse rate) with a filter time-constant of about 15 seconds. The Pulse beep and Pulse Rate alarms are also disabled. This mode is intended only for exercise testing or similar environments where there is excessive motion and pulse rate information is not desired.

The Operating Mode automatically resets to Mode 1 when the Instrument is turned off.

3.13 The Nellcor Pocket Calibrator can be used to check the accuracy of the Instrument. Connect the Calibrator to the Patient Cable in place of a Sensor. The LED lamp on the Calibrator will light and the Instrument will begin to track the artificial pulse. The Rate should be 54 +/- 1, the Saturation 81 +/- 1, and the Rate and Sat Alarm should be active with the default alarm limits. Adjust each of the alarm limits up and down in turn to verify correct operation of the Alarm lamps, Audio Alarm, and Alarm Disable functions. Change the Instrument to Mode 2 and verify stable Saturation display.

3.14 For accurate measurements, it is important that the hand being measured be held relatively stationary and at about the level of the heart, preferably outstretched so that no occlusion of the veins or arteries will occur. Sensitivity to patient motion is most pronounced in the Pulse Rate Display, and can be minimized by using a fresh Sensor, carefully applied, and shielding the Sensor from bright ambient lights. Most complaints of excessive motion artifact are the result of dirty Sensors with poor adhesive contact.

3.15 If it is necessary to reship the Instrument, the original shipping carton should be used. Remove the Patient Cable and power cord from the Instrument and seal it into a plastic bag. Place the coiled Patient Cable into the recess in the bottom (blue) foam insert, and carefully place the sealed Instrument into the cutout in the bottom foam. Place the top (white) foam over the Instrument and place the coiled power cord in the recess on top of the foam. The carton should be carefully sealed with reinforced packaging tape.

SECTION 4

TESTING AND CALIBRATION

4.1 This Section details procedures for routine test and calibration checks for the Nellcor Model N-100 Pulse Oximeter. Instructions for troubleshooting and repair of Oximeter defects are detailed in Section 5. Refer also to Section 5 for instructions on cover removal and other access procedures. Note that certain component-level repairs require comprehensive tests of the analog section of the Processor Board to verify correct repair. Specification of these tests, as well as additional required test equipment, are detailed in Section 5.5.

CAUTION -- The procedures in this Section require tests and adjustments made with the power applied and the cover removed. These tests should only be made by qualified service personnel and adequate precaution must be taken against electrical shock.

CAUTION -- Adjustment procedures described in this Section could effect the measurement accuracy of the Instrument. To insure continued accuracy the procedures must be performed as described using only test equipment specified in this section. It is particularly important that a Nellcor Oximeter Calibrator be available to verify accuracy before adjustment or service is attempted.

4.2 REQUIRED TEST EQUIPMENT

The following test equipment is required to perform the procedures described in this Section:

1. Oscilloscope, 50 mHz dual channel with 10:1 probes with 20 pf maximum input capacitance.

2. Digital Volt Meter, 3 1/2 digits, .1% accuracy, DC volts, AC volts and ohmmeter functions.

3. Variable voltage DC power supply, 0-15 Volts, 0-2 Amps.

4. Nellcor Model 1460 Pocket Calibrator, or Model 1470 Multi-Function Calibrator (with current calibration certification)

5. Power Resistor, 15 Ohms, 20 Watts.

4.3 BATTERY CHARGER BOARD TESTS

4.3.1 Verify correct operation of the unregulated power supply (consisting of the transformer, bridge rectifier and filter capacitor) by connecting an Oscilloscope to the 4 pin input connector to the Power Supply Board. Connect the Oscilloscope ground clip to the connection on the black wire, and the probe tip to the red wire. Verify that the voltage is 0 with the Standby/On Switch in the STANDBY position, 11-13 volts in the ON position with AC disconnected, and 25-30 volts with the AC connected.

4.3.2 Disconnect the battery by seperating the plug/receptacle pair on the cable connecting the battery to the Charger Board. Connect a Digital Voltmeter to the plug from the Charger Board. With AC power applied, verify an open circuit charging voltage of 14.20 +/-.05 volts. Adjust R1 on the Charger Board (near the center of the board) if necessary to correct the charge voltage. After adjustment, measure the voltage at the ouput terminal of the LM317 regulator (either of the case screws will do) and watch this voltage while connecting a 15 ohm, 20 watt resistor to the battery charger plug. Verify that the LM317 ouput voltage does not change more than +/-.05 volts from no load to load conditions. If it does, the LM317 is defective and should be replaced.

4.3.3 Disconnect AC power, and connect a variable voltage power supply to the Charger Board battery plug (with plus on the red lead). Connect a Digital Voltmeter in parallel with the power supply output. Adjust the power supply to 14.00 volts, and turn the Standby/On Switch to the ON position. Verify correct Instrument operation. Decrease the power supply voltage until the Instrument just shuts off. This turnoff voltage should be 10.60 +/-.10 volt. Adjust R11 (closest to the rear panel of the Instrument) if necessary to adjust the shutoff voltage. Turn the STANDBY/ON switch to STANDBY. Verify that the Instrument turns ON at a voltage of 11.10 +/-.20 volts. Disconnect the power supply and reconnect the battery to the circuit.

4.3.4 Correct battery operation can be verified by connecting AC power for a minimum of eight hours to charge the battery, and then disconnecting AC power and verifying that the Instrument will operate a minimum of one hour on battery power. If the Instrument fails to operate for one hour, then the battery should be replaced (see Section 5).

4.4 POWER SUPPLY TESTS

4.4.1 The power supply generates +5V, used by the Processor Board and the Patient Isolation Board, and +/-15V used by the analog circuitry on the Processor Board. These voltages are generated by two independent power supply sections on the Board, both consisting of pulse width modulation control chips and associated circuitry. All three outputs should be carefully checked for voltage and noise. Since the power supply is of a switching type DC to DC converter, it is quite possible that a component failure may not cause supply failure, but may introduce unacceptable noise levels on the output.

4.4.2 Check the power supply output voltages by first connecting the ground lead of a Digital Voltmeter to pin 1 or 10 of the 10-pin power supply connector (black wires). Set the meter to an appropriate scale. Pin 7 (red wire) should read +5.00 +/-.20 volts. Pin 6 (orange) should read +15 +/-.40 volts and Pin 5 (violet) should read -15.00 +/-.40 volts and read the same as the +15 volt supply within .10 volts. No adjustment is possible; an out-of-spec voltage indicates a defective control chip or other component.

4.4.3 Power supply output noise must be checked with an Oscilloscope. Set the horizontal deflection to 50 us/div, 200 mV/div vertical deflection, AC coupled, and measure the peak-to-peak noise of each voltage output. Peak-to-peak noise measured at the power supply connector should not exceed 100 mV for any of the three output voltages. A very fine "grass" may be observed at the 100 kHz switching speed, depending on measurment technique. The major part of this grass is stray pick up by the Oscilloscope probe (and will be observed at a much lower magnitude on the Processor Board input) and is filtered out by the coupling capacitors on the Processor Board.

Noise of concern will be observed at much lower frequencies of 100 to 1,000 Hz. Some load variation with LED current is also observable and is acceptable as long as it lies within the same 100 mV peak-to-peak limit. If a noise problem is suspected, but not identified by the above tests, they should be repeated at an elevated temperature since occasionaly an unstable component will be temperature sensitive. The Instrument may be warmed in a controlled oven to a maximum temperature of 40 degrees C with the cover in place, or 50 degrees C without the cover.

4.5 PROCESSOR BOARD TESTS

4.5.1 The following tests of the Processor Board should be made as part of a routine test of the Instrument. Additional tests described in Section 5 are required if components are changed on the Processor Board, or if the Instrument measures out of calibration in these tests.

4.5.2 The first check is for offset voltage and amplifier noise, and is made with an Oscilloscope. With the cable from the Patient Isolation Board disconnected and the Patient Isolation Board input signal grounded with a clip lead (connected between the "top" end of R26, towards the rear panel, and the plus end of C99), measure the DC voltage offset at the outputs of each amplifier channel at 5K-1 for channel A and 5K-7 for channel B. This measurement should be made with the Oscilloscope grounded to the plus end of C99, and set to 100 us/div horizontally and 100 mV/div vertically. The offset voltage of each channel should be less than 300 mV at this point and there should be less than 10 mV of visible noise on the referenced settings. If the offset voltage is outside this limit, it may be adjusted with the appropriate trimpot on Rev E or later Processor Boards (R84 for channel A and R79 for channel B). Earlier PC Boards have no offset adjustment, but use Op Amps selected for low offset. In this case, the offending Opamp must be traced and replaced with a selected low offset part.

4.5.3 Disconnect the ground clip, reconnect the cable from the Patient Isolation Board, and connect the Nellcor Pocket Calibrator to the Patient Cable/Preamp. After a delay of a few seconds, the instrument should start following the artificial pulse and display a Rate of 54 +/- 1 and a Saturation of 81 +/-1. If the Alarm Limits are set to the default values then both the Saturation and Rate Alarms will be active. Both displays and the lights next to Low Sat and Low Rate will be blinking, and the Audio Alarm will be active if not disabled.

SECTION 5

TROUBLESHOOTING AND REPAIR

5.1 Instrument failures can be broadly divided into two classes: an outright failure of a component in one of the Instrument modules will cause consistently incorrect operation or no operation at all. The Trouble Shooting guide below should be used as a guide to diagnosing these failures. Subsequent sections dealing with repairs to each specific module can then be used to correct the diagnosed problem. The second, more difficult, problem deals with intermittent, noisy, or out- of-spec performance of the Instrument. While these problems may also be related to a component failure, they can also be caused in some cases by noise in the environment (such as "Bovie" interference), an improperly functioning Sensor or misapplication of the Sensor by the user. If an Instrument is suspected of having substandard performance, the procedures outlined in the Test and Calibration Section (Section 4) should be followed to help diagnose the problem.

5.1.2 TROUBLESHOOTING GUIDE

SYMPTOM	PROBABLE DIAGNOSIS
1. INSTRUMENT COMPLETELY INOPERATIVE (AC or battery)	A. Blown AC fuse. Refer to Section 5.3. B. Failure of the switching circuitry on the Charger Board. Refer to Section 5.2.2. C. Power supply failure. Refer to Section 5.2.3. D. Logic failure on the Processor Board. Refer to Section 5.2.4.
2. INSTRUMENT INOPERATIVE ON BATTERY (functional on AC)	A. A failure of battery charger circuit on Charger Board. Refer to Section 5.2.2. B. Battery failure. Refer to Section 5.2.2. C. Blown battery fuse. Refer to Section 5.2.2.
3. INSTRUMENT FUNCTIONS CORRECTLY ON BATTERY ("Battery in Use" light stays on for AC.) (NOTE: This sympton may turn into Symptom 1 once the battery discharges.)	A. Blown AC fuse. Refer to Section 5.3. B. AC rectifier failure on the Battery Charger Board. Refer to Section 5.2.2 C. Transformer failure. Refer to Section 5.2.1 D. +/-15 volt power supplies out of spec. Refer to Section 5.2.3

4. INSTRUMENT INOPERATIVE, RANDOM STEADY DISPLAY SEGMENTS AND/OR CONTINUOUS BEEP	A. Failure of microprocessor logic on the Processor Board (including the micro-processor, ROM. RAM and associated circuitry). Refer to Section 5.2.4 B. +5 Volt power supply out of spec. Refer to Section 5.2.3
5. INSTRUMENT OPERATES, DISPLAY SHOWS "ERR 1".	A. Failure of RAM memory on the Processor Board diagnosed during power up test. Refer to Section 5.2.4.
6. INSTRUMENT OPERATES, DISPLAY SHOWS "ERR 2".	A. Failure of ROM memory on the Processor Board diagnosed during power up test. Refer to Section 5.2.4.
7. INSTRUMENT OPERATES, DISPLAY SHOWS "ERR 3".	A. Failure of an LED segment or lamp diagnosed during power up test. Refer to Section 5.2.5. B. +/-15 Volt power supplies out of spec. Refer to Section 5.2.3. C. Failure of D/A conversion circuitry on the Processor Board. Refer to Section 5.2.5.

8. INSTRUMENT OPERATES, NO PULSE INDICATION, PULSE RATE OR SATURATION.	A. Sensor disconnected or in-operative. Refer to Section 5.2.7 B. Instrument cable/preamplifier defective. Refer to Section 5.2.7. C. +/-15 Volt power supplies out of spec. Refer to Section 5.2.3. D. Circuit failure of the analog signal processing circuitry on the Processor Board. Refer to Section 5.2.4. E. A/D converter circuitry failure on the Processor Board. Refer to Section 5.2.4. F. Defective LED drive or amplifier on PI Board. Refer to Section 5.2.6.
9. INSTRUMENT OPERATES, PULSE INDICATION, NO SATURATION OR PULSE RATE DISPLAY.	A. Defective red LED on the Sensor. Refer to Section 5.2.7. B. Defective red LED driver circuit on PI Board. Refer to Section 5.2.6. C. Circuit failure in the "B channel" of the analog processing circuitry on the Processor Board. Refer to Section 5.2.5.
10. INSTRUMENT OPERATES, PULSE WAVEFORM AND SATURATION/RATE VALUES "NOISY".	A. Defective Sensor or tester. Refer to Section 5.2.7. B. Noisy +5 or +/-15 Volt power supply. Refer to Section 5.2.3. C. Partial failure of the A/D conversion circuitry on the Processor Board. Refer to Section 5.2.4.

11.	INSTRUMENT OPERATES, BEEPER "RASPY".	A. Noisy +5V power supply. Refer to Section 5.2.3.
12.	INSTRUMENT OPERATES, DOES NOT TURN OFF WITH SWITCH IN "STANDBY".	A. Defective relay on Charger Board, Refer to Section 5.2.2.

5.2 DETAILED DIAGNOSIS

WARNING: Tests described in this Section require voltage measurements with power applied to the Instrument and the cover removed. These tests should only be performed by qualified personnel and appropriate safety precautions must be observed. Dangerous voltages are exposed with the top cover removed.

5.2.1 AC POWER CHECKS

If the Instrument fails to operate normally on AC power, the AC fuse (on the rear panel) should be checked first (see Section 5.3). With the top cover removed (Section 5.4.1) the AC transformer output voltage of approximately 24 Volts can be checked on the 2 pin connector on the Charger Board. If this voltage is not present, it indicates a blown AC fuse, a defective AC line filter, a defective transformer or a problem with the AC wiring.

5.2.2 CHARGER BOARD CHECKS

The Charger Board provides two voltages: a voltage of approximately 14.5 Volts, limited to about 1 Amp, is provided to charge the battery; and DC voltage of 11 to 32 Volts is provided to the power supply under the control of the Standby/On Switch. The battery charge voltage should be measured with the battery plug disconnected (see Section 4.3.2). If this charge voltage is present, yet the Instrument will not operate under battery, the battery itself may be defective. With the battery connected, the output voltage to the Power Supply

Board should be about 12 Volts under battery operation and about 28 Volts under AC operation, depending on AC line voltage (see Section 4.3.1). This voltage should be switched on and off by the Front Panel Switch. If this power supply input voltage is always 0, the relay/control circuitry on the Charger Board may be defective. If the voltage cannot be switched off with the Front Panel Switch, the relay itself is most likely defective. If the DC voltage remains at 12 Volts when AC power is applied, then there is a problem with the AC circuitry or a defective bridge rectifier or other component on the Charger Board. (See Section 5.2.1)

5.2.3 POWER SUPPLY CHECKS

With the correct input voltage to the power supply on the 4 pin connector (approxamatly 12 Volts DC for battery operation, 28 Volts DC for AC operation) the output voltages from the power supply can be measured at the 10 pin connector to the Processor Board. The +5 Volt supply can be measured from the red wire to black wire and should be 4.8-5.2 Volts DC. The +15 Volt supply appears on the orange wire, and the -15 Volt supply appears on the violet wire, and each should be 14.6-15.4 Volts DC and within 0.1V of each other. These voltages should also be checked with an Oscilloscope for excessive noise, which should not exceed 100 mV. (See section 4.4 for more information).

5.2.4 PROCESSOR BOARD CHECKS

If correct voltages are available to the Processor Board, but the microprocessor appears not to be operating, the microprocessor and crystal should be checked. A defective pROM memory will generally cause an Error 2 code on the display, but if the defect is in the error detection program then unpredictable results will occur. A defective RAM memory will be diagnosed as an Error 1 code (unless a total RAM failure prevents any Instrument operation).

5.2.5 DISPLAY BOARD CHECKS

The LED lamps and display segments are checked when the Instrument is turned on. The amount of current drawn by each individual segment is measured using the Instrument's analog to digital converter circuitry, and if a segment is found outside normal limits then "ERR 3" is displayed. This error code can also be caused by a defective digital to analog converter or associated circuitry, or by a defective +/-15 volt power supply, since either of these defects will "fool" the microprocessor into thinking the LED's are defective. Error 3 can be circumvented by pressing the "AUDIO ALARM OFF" button which will cause the Instrument to proceed to operate normally. The Instrument also lights all LED's and segments during its power on sequence, so a defective LED can be spotted during this period.

5.2.6 PATIENT ISOLATION BOARD CHECKS

A failure of a Patient Isolation Board could either be in the photodetector circuitry, in which case no photodetector signal will be present at the input amplifier on the Processor Board, a failure of the LED drive circuitry, in which case the bipolar current drive will not be present at the Preamp, or a failure in the calibration resistor measuring circuitry.

5.2.7 PREAMPLIFIER CHECKS

The best way to check the Preamplifier/Instrument Cable Assembly is by exchanging it with another known good assembly. Either a Sensor or a Calibration unit can be used to establish proper function.

5.3 FUSE REPLACEMENT

5.3.1 The AC power fuse is contained in a fuse holder on the rear panel of Instrument. Using a slotted screwdriver, remove the fuse holder and the fuse and inspect it for failure. It is possible for a fuse to be open without looking "blown", so it may be necessary to use an Ohmmeter or Continuity Tester to check the fuse. A single fuse failure may simply be the result of a defective fuse. If the fuse blows more than once, it indicates a circuit failure that must be corrected. A fuse that is partially or completely blackened indicates a short circuit, while a fuse that appears to have gently melted indicates a marginal overload. The correct fuse is a type 3AG, 1 Amp Slow Blow fuse rated at 250 volts.

WARNING -- FOR CONTINUED PROCTECTION AGAINST RISK OF FIRE, REPLACE ONLY WITH SAME TYPE AND RATING OF FUSE.

5.4 AC VOLTAGE SELECTION

The Nellcor Model N-100 Pulse Oximeter is configured for operation from 100-120 VAC 50-60Hz current. To reconfigure this Instrument for 220-240 VAC operation, disconnect the power cord, remove the cover and lift up the Processor Board as outlined in Sections 5.5.1 and 5.5.2. Locate the terminal block for the transformer wiring in the bottom of the chassis, and remove the two leads from terminals 3 and 8 by pulling straight up. Insert these leads into positions 5 and 6, and press into position with a screwdriver (leaving positions 3 and 8 empty). Replace the fuse with a 0.5 Amp Slow-Blow type and attach a label over the rear panel voltage label specifying that the unit has been rewired for 220-240VAC, and that only a 0.5 Amp fuse must be used.

5.5 INSTRUMENT DISASSEMBLY

The top cover must be removed for access to all internal circuitry.

WARNING -- THE INSTRUMENT CONTAINS NO USER-SERVICED PARTS. THE COVER SHOULD ONLY BE REMOVED BY QUALIFIED SERVICE PERSONNEL AND ALL CAUTIONS AND WARNINGS IN THIS SECTION MUST BE CAREFULLY FOLLOWED.

WARNING -- DANGEROUS VOLTAGES ARE EXPOSED WITH THE TOP COVER REMOVED.

5.5.1 TOP COVER REMOVAL

The top cover is secured by four phillips-head screws with lockwashers located on the bottom surface of the Instrument. Turn the Instrument upside down (on a non-scratching surface), remove the four screws and then turn the Instrument right-side up, sitting on its bottom feet. Remove the cover by carefully sliding it towards the rear of the Instrument. With the top cover removed, the Processor Board is exposed. Other subassemblies are located underneath the "tray" supporting the Processor Board.

5.5.2 POWER SUPPLY ACCESS

To lift the Processor Board for access to the Power Supply and Patient Isolation Boards, lift up the four black nylon latches, located at the four corners of the Processor Board, about 1/4 inch. Lift the sheet metal tray underneath the Processor Board from the right hand side. Lift up gently on the tray, disengaging all four latches, and swing the assembly up and to the left. The Patient Isolation Board will be to the left, covered by a sheet metal shield, and the Power Supply Board is next to it. The Patient Isolation Board is connected to the Processor Board around one end by a 10 pin ribbon cable. A 4 wire jumper provides power from the Power Supply to the Patient Isolation Board, and a 10 wire cable provides power from the Power Supply to the Processor Board around the opposite end. The Battery Charger Board is located in the chassis itself, to the left and the battery and power transformer are located in the center and right portions of the chassis. A 26-wire ribbon cable connects the Processor Board to the Front Panel Display Board.

5.5.3 PROCESSOR BOARD REMOVAL

To remove the Processor Board from the tray, disconnect the 10 wire cable to the P.I. Board at one end, the ribbon cable to the Display, and the power cable at the other end. Remove six phillips-head screws from the four corners and top and bottom of the Board, being careful not to drop screws or lock washers into the chassis. The ROM and microprocessor ICs are separately removable with an IC extractor tool (or by gently and evenly prying up with a pair of tweezers or small screwdriver). The microprocessor, an Intel 8085A or equivalent, occupies the 40 pin socket. The program is contained in three ROM memories located in the three 24 pin sockets. Programs are labled with a part number ending in "0", "1", or "2" designating their position. They must always be used as a set of sequential part numbers (with the first five digits the same) with chip 0 located closest to the microprocessor, followed by 1 and then 2.

5.5.4 PATIENT ISOLATION BOARD REMOVAL

CAUTION -- The Patient Isolation Board protects the patient from dangerous voltages and ground paths that may result from faulty equipment. To insure continued patient protection, the procedures in this manual must be followed exactly.

Removal of the Patient Isolation Board requires first removing the top cover shield. Ten 4-40 phillips-head screws secure the top cover to the bottom cover through the PC Board. One screw is located underneath the Patient Cable Assembly, so it will first be necessary to cut two tiewraps securing this cable to the top cover shield. Remove the ten small phillips-head screws and lock washers being careful that none fall into the chassis. Note that one screw secures the ground wire from the shielded Patient Cable. Remove the top cover and disconnect the Patient Cable plug from the connector on the PC Board. Remove the 10 pin jumper cable to the Processor Board and the 4 pin jumper to the Power Supply Board, and remove the four larger phillips-head screws located near the corners of the Board. Remove the PC Board and the bottom shield assembly.

5.5.5 POWER SUPPLY REMOVAL

The Power Supply Board, also located on the back of the PC Board tray next to the P.I. Board, can be easily removed by disconnecting the 4 wire jumper to the P.I. Board, and the 10 wire jumper to the Processor Board on the opposite side, and the 4 wire power inlet cable from the Charger Board. Removal of the four phillips-head screws and lock washers from the corners of the Board allows it to be removed.

5.5.6 BATTERY CHARGER BOARD REMOVAL

The Battery Charger Board is removed along with the large electrolytic filter capacitor. The battery should be disconnected first, using the connector on the battery leads. Remove the power jumper on the Power Supply Board, and disconnect the connector from the Front Panel Switch. Remove also the 2 wire connector from the AC transformer. Using a nut driver, remove the nut holding the capacitor in place. Remove the two nuts securing the heatsink bracket to the bottom of the chassis, and carefully lift the Charger Board out of the chassis.

5.5.7 FRONT PANEL REMOVAL

The Instrument Front Panel must first be removed for access to the Front Panel PC Board. The plastic Front Panel is secured by three brackets and two hexhead screws (with lock washers) located on two of the brackets. Using a screwdriver or a nutdriver remove these two screws and remove the Front Panel by pulling away from the chassis. Disconnect the 26 wire cable from the

Processor Board, the 2 wire cable to the speaker, and the ground wire. To remove the panel assembly completely from the Instrument it is also necessary to disconnect the Front Panel Switch and the Patient Isolation Cable. The switch is disconnected by removing the three terminals from the back of the switch, and the Patient Isolation Cable is disconnected from the Patient Isolation Board by disassembly of the top cover shield on the PI Board. (Refer to Section 5.5.4.)

To remove the Front Panel PC Board from the Front Panel itself, remove the six slotted hexhead screws securing the board to the panel.

The shielded and isolated Patient Isolation Cable cannot be removed from the Front Panel without removal of the 3M connector at the PI Board end. In the event of a problem with this cable, it is recommended that the Front Panel be changed as an assembly. Repair of the cable requires special tooling to install the 10 pin ribbon connector and must be done very carefully to avoid compromising the patient integrity.

5.5.8 BATTERY REMOVAL

Exchange of the battery pack may be accomplished without removal of any of the PC Boards. Open the Processor Board tray (Section 5.5.2) and locate the battery support bracket. This bracket is secured by two nuts attaching it to the bottom of the chassis and two flat head phillips screws securing it to the lip inside the rear panel of the Instrument. Using diagonal cutters, cut the tiewraps securing the transformer and battery wiring. Remove the two flathead phillips screws on the rear panel lip, and remove the two nuts at the forward edge of the batteries securing the bracket to the chassis bottom. Pull the bracket and battery pack away from the rear panel until the back edge of the bracket can be rotated upwards and towards the front panel. Lift the bracket and the batteries straight up from the chassis.

CAUTION -- The batteries used in the instrument are of a starved-electrolyte construction. While they cannot leak acid or fluid, they should not be used in sealed environments (such as Hypobaric Chambers) and are capable of very high short circuit currents. A 4 amp fuse is provided for protection of the instrument from these currents in the event of failure. This fuse is a 4 amp slow blow fuse, and for continued protection from risk of fire replace only with the same type and rating.

5.5.9 BATTERY INSTALLATION

The battery should be installed using the reverse of the above procedure. Fit the bracket around the battery pack, insuring that the battery leads are not crimped behind the bracket. Tip the battery back toward the Front Panel and install over the two studs on the chassis bottom. Rotate the battery down and back toward the rear panel, and then slide the battery pack under the rear lip. Install the two phillips-head screws in the rear lip and the two nuts on the bottom of the chassis. Tighten carefully.

5.5.10 FRONT PANEL ASSEMBLY

The Front Panel Assembly includes the Patient Isolation Cable from the Front Panel to the PI Board. This Cable Assembly consists of the inner cable itself, with a molded strain relief on the back of the Front Panel connector, and insulator/shield assembly which slips over the cable, and a 10 pin connector at the opposite end for connection to the PI Board. The shield assembly will not easily pass through the Front Panel connector opening so it is necessary to install the 10 pin connector after the cable has been installed in the Front Panel and the shield assembly placed over the cable. For this reason, it is recommended that the Front Panel and Patient Isolation Cable be serviced as a unit and replaced if the cable is damaged. When reassembling the Front Panel Assembly, inspect the Patient Cable carefully for damage to the insulation (the outer shield is at ground potential so the outer insulation is not critical, however, the inside insulation is important in providing patient isolation).

The Display Board is assembled to the inside of the Front Panel with six hexhead screws and lock washers. All six screws should be started in their holes and then the panel carefully positioned so that the Control Knob is centered in its opening before the screws are tightened. Do not overtighten these screws or stripping may result. Check the Control Knob for smooth and free rotation without any rubbing on the Front Panel. The Front Panel is installed onto the chassis by carefully positioning it over the brackets, making sure the panel fits flushly against the aluminum handle on both sides, and installing two hexhead screws through the left and right bracket end of the plastic Front Panel. Use caution not to over tighten the screws to avoid stripping the screws. The Front Panel brackets are secured to the aluminum handle by six socket head screws. If it is necessary to adjust the fit of the Front Panel, these screws may be loosened or removed and the brackets adjusted as necessary. This adjustment will not be required for simple removal/replacement of the Front Panel.

5.5.11 BATTERY CHARGER BOARD INSTALLATION

Check the chassis area to be sure that wiring is out of the way of the capacitor. Be sure the screws that mount the large capacitor to the Charger Board are tight (do not over tighten, the capacitor studs are soft aluminum) and place the plastic clamp around the capacitor. Place the Charger Board into the chassis, aligning the heatsink bracket over the two studs along the left edge of the chassis and placing the plastic clamp over the mounting stud near the center of the chassis. Place two nuts over the bracket studs and a washer and a nut over the plastic clamp. Check the position of the Board and bracket and then tighten all three nuts. Reconnect the 3 pin connector for the Front Panel switch, the 2 pin connector for the transformer, connect the 4 pin pigtail to the Power Supply Board (if installed) and reconnect the battery (only if the instrument is otherwise complete). Using fresh tiewraps, resecure the transformer and battery wiring to the tiewrap mounts provided on the battery bracket and check that the AC and battery wiring is secure and away from sheetmetal edges.

5.5.12 POWER SUPPLY BOARD INSTALLATION

Position the Power Supply Board over the four shorter studs on the bottom of the PC board tray, and mount with four phillips-head screws and lock washers. Connect the 4 wire pigtail from the Charger Board, the 10 wire jumper to the Processor Board and the 4 wire jumper to the Patient Isolation Board (if installed).

5.5.13 PATIENT ISOLATION BOARD INSTALLATION

Inspect the Patient Isolation Board carefully for any stray material that may compromise the integrity of the isolation. Check that the insulator is in place inside the (smaller) bottom cover and position the cover on the back of the PC Board so that the holes align. Place the cover and Board into position over the longer studs on the PC Board tray, and loosely install four phillips-head screws and lock washers into the studs to secure the Board. Recheck alignment of the cover mounting holes and tighten the PC Board mounting screws.

Connect the 10 pin connector on the Patient Isolation Cable to the PC Board, and check the insulation carefully where it will pass underneath the top cover. Insert two new tiewraps through the holes in the top cover, check that the insulator is in place, check that the small piece of foam securing the 10 pin connector is in place, and install the cover on the top of the PI Board. Attach the top cover to the bottom cover through the PC Board with ten small phillips screws. Secure the tiewraps around the shield assembly of the P.I. Cable, tighten and remove excess.

5.5.14 PROCESSOR BOARD INSTALLATION

The Processor Board is installed on the top of the tray with six phillips-head screws and lockwashers. Connect the 10-wire ribbon cable to the PI Board and the 10-wire jumper from the Power Supply Board (checking that the chassis ground wire is at the Processor Board end of that jumper). Connect the 26-wire jumper from the display board. Recheck all of the chassis wiring and the position of the Patient Cable, and then close the PC Board tray. Be sure that all 4 locks are correctly positioned and that no cables are pinched, and then push down on all four locks to latch the tray in place.

5.5.15 COVER REPLACEMENT

Make a final check of connector seating and cable position, and then slide the top cover on from the back of the Instrument. Use care when engaging the top cover to the front panel, invert the Instrument and fasten the cover with 4 #4 phillips-head screws and lockwashers.

5.6 DETAILED INSTRUMENT TESTS

5.6.1 The following tests are required whenever changes have been made to the analog section of the Processor Board or when the Instrument calibration is suspect and the tests defined in Section 4 do not provide a dignosis.

5.6.2 REQUIRED TEST EQUIPMENT

The following equipment is required to carry out these tests:

1. Oscilloscope, 50 mHz dual channel with 10:1 probes with 20pf maximum input capacitance.

2. Waveform generator, capable of 0-10 volt peak-to-peak sine wave output at 0-100 Hz.

3. Nellcor Model 1470 Multi-Function Calibrator (incorporating Calibration Resistor testing).

5.6.3 Synchronous detector balance is checked with a waveform generator and an Oscilloscope. With the Patient Isolation Cable disconnected from J1, and the ground clip removed from R26, connect a Waveform Generator to the top of R26, grounded to the plus end of C99. Connect the Oscilloscope to 1K-7, and adjust the Waveform Generator for approximately 8 volts p-p at 1 Hz. Move the Oscilloscope to Pin 2K-1 and check for waveform symetry at the syncronous detector amplifier output. Check for an identical signal at 2K-7. Move the Oscilloscope probe to Pins 1 and 7 of 3K, 4K and 5K and check for less than 20mV of visible noise, less than 60 mV of residual 1 Hz signal, and less than 300 mV DC offset at each of the six points.

5.6.4 The frequency response of the two amplifier channels is checked by unbalancing the synchronous detectors. Using the same setup as above, ground the left side of R31 and R34 (to the plus terminal of C99. Check for approximately 12 volts p-p output at 4K-1 and 4K-7 (it may be necessary to adjust the DC offset of the Function Generator for symetry). Connect two Oscilloscope channels to 4K-1, 2 volts per division vertically, 100 ms/div horizontally. Verify correct Oscilloscope response by overlaying the two traces with one millimeter of separation between them. Move the second Oscilloscope channel to 4K-7, and verify identical response of the two amplifiers. The two traces should again be separated by one millimeter with no distortion or deviation between the two channels. Adjust the Oscilloscope to 20 ms/div, adjust the Waveform Generator frequency to 5 Hz, and check that the signals still track within two millimeters vertically and are approximately 12 Volts p-p. Increase the generator frequency to 10 Hz, again verify that the signals are identical within 2 millimeters vertically and approximately 6 to 7 Volts p-p. Increase the frequency again to 60 Hz and verify no visible signal on the same vertical scale as before. Disconnect the test equipment and reconnect J1 to the Patient Isolation Board.

5.6.5 The Instrument calibration is determined by the checks and adjustments described above. In order to verify correct overall response of the Instrument it is necessary to use the Nellcor Calibrator identified in Section 4.2. It is not possible to use a Waveform Generator, no matter how sophisticated, to generate the composite waveforms required. Connect an Instrument Cable to the Oximeter Front Panel connector and connect the calibrator to the Preamp connector on the Instrument Cable. Turn on both the Instrument and calibrator and set the calibrator's pulse amplitude control to mid-scale. Adjust the calibrator to each Saturation and Pulse Rate setting and verify correct readings on the Oximeter +/-1 for Saturation and +/-1 beat for Pulse Rate. Allow approximately ten seconds for the readings to stabilize after changing.

5.6.6 Check the beat-to-beat stability by pressing the top and bottom buttons simultaneously (LOW SAT and AUDIO ALARM OFF) and rotate the Control Knob to show "1" in the upper display. The contents of memory location 1, the beat-to-beat Saturation, will be shown in the lower display and should not vary more than +/-2 beats from the nominal value. (Note that this stability test is only valid for the calibrator, and patient measurements will vary by sometimes as much as +/-5 beats depending on the person and configuration). Reset the calibrator to 95%, 60 beats per minutes and adjust the pulse amplitude control to full scale, and down until the pulse side shows 3 to 4 bars of amplitude. The Saturation and Pulse Rate should remain stable over this entire range (although one or two beats may be lost if the Control Knob is rotated quickly).

5.6.7 Check the calibration resistor circuit by disconnecting the Instrument Cable and connecting the Calibration Index Tester. Press and hold the top and bottom buttons on the Instrument and rotate the Control Knob to show address "9" in the upper display. With the buttons held down the lower display will show the calibration index selected on the Tester and must be +/-1 from the Tester value (except zero, which must read zero). Select each index on the Tester and verify correct display +/-1 count.

SECTION 6

THEORY OF OPERATION

6.1 INTRODUCTION

Refer to Section 8 for the Instrument schematic and block diagrams. The major circuit sections consist of the Sensor Preamp (contained in the Instrument Cable), the Patient Isolation Board (contained in the Instrument itself), the analog processing circuitry and the microprocessor circuitry (contained on the Processor Board in the Instrument), the Front Panel Display logic, and the Battery Charger and Power Supply Boards (also contained in the Instrument). Since the measurement of oxygen saturation requires light of two different wavelengths, two LED's (one IR and one red) are used to generate light which is passed through the fingertip into a single photodiode. The LED's are illuminated alternately with a 4-state clock. The photodiode signal, representing light from both LED's in sequence, is amplified and then separated by a two-channel synchronous detector, one channel sensitive to the infrared light waveform and the other sensitive to the red light waveform. These signals are then filtered to remove the LED switching frequency as well as electrical or ambient noise, and then digitized by an analog to digital converter. This digital signal is then processed by the microprocessor in order to identify individual pulses and compute the oxygen saturation from the ratio of the pulse seen by the red wavelength compared to the pulse seen by the IR wavelength.

6.2 PRE-AMP/SENSOR

6.2.1 The drive current for the pair of LED's is supplied from the Instrument, generated on the Patient Isolation Board. This waveform is a bipolar current drive which is passed through the preamplifier to the back-to-back sensor LED's. A positive current pulse drives the IR LED and a negative current pulse drives the red LED. The size of each current pulse is independently set by the microprocessor according to the thickness of the tissue being measured (detailed below). The Sensor photodiode generates a current proportional to the amount of light recieved. This photo current is amplified by a current-to-voltage converter, located in the Patient Cable/Preamp unit, with a conversion ratio of one volt per microamp. Also contained in the Sensor is the calibration resistor, which codes the wavelength of the specific LED's used for the measurement. The wavelength of the LED's will vary from one Sensor to another and would cause an error in the computation for oxygen saturation if not corrected for. This calibration resistor is connected directly through the Preamp Assembly to the Patient Isolation Board. The Preamp Assembly, since it is used close to the patient environment, is potted to prevent any damage from moisture and is not repairable. In the event of failure or damage to the Sensor contacts or to the cable or connector itself, the assembly must be replaced.

6.3 PATIENT ISOLATION

6.3.1 The Patient Isolation Assembly provides low-leakage isolation for the LED drive current, calibration resistor and photodetector signal. The Board consists of four major sections: the power converter, which generates isolated +/-5 and +/-15 volts; the current driver for the LED's; the preamplifier for the photodetector current; and the resistance to voltage converters for the calibration resistor.

6.3.2 The power supply section consists of an oscillator (U16, a CMOS oscillator) driving two transformers through drive transistor networks. Transformer T2 generates +/-15 Volt used by the analog circuitry. Transistor Q9 drives current from the main +5 Volt supply through the transformer primary winding during the "on" state of the oscillator. During the oscillator's "off" state, energy in the primary circuit is coupled into the second winding and flows through CR5. The output of this transformer, approximately 20 Volts on either side of a center tap, is rectified and regulated to +/-15 Volts by a pair of solid state regulators (U12 and U13). The current for the Sensor LED's is derived from a +/-5 Volt supply driven by T3, U14 and U15 in exactly the same manner.

6.3.3 The drive waveform for the LED's is transmitted from the Oximeter across the isolation by three high-speed optical couplers. The waveforms are shown on the timing diagram in Section 8 for the optically coupled signals (Slope, Phase and Zero) as well as for a typical current waveform. Note that the current waveform has a precisely controlled rise and fall time, so that the magnitude of the current can be determined by controlling the width of the Slope signal. The Slope signal is coupled through U4, which controls the ramping of the integrator formed by the opamp U11 and capacitor C6. The voltage source for the integrator is switched between +15 and -15 by the Phase signal, coupled by U6 and processed by the analog switch U8. This Phase signal determines the direction of integration for each step of the waveform generation and will change state between the rising and falling edges of each pulse. The output of U11, a voltage waveform proportional to the desired current drive, is converted into a current by a current driver consisting of the power opamp U10 and a current feedback resistor R25. In order to prevent leakage current from causing a progressive error in the integrator, another analog switch section (U8) is used to rezero the integrator between pulses. This analog switch is driven by the Zero signal coupled through U5.

6.3.4. The preamplifier signal is coupled through a unity gain amplifier, U9. This amplifier is AC coupled in order to prevent any DC current from flowing through the coupling transformer T1, as well as reducing interference from ambient light.

6.3.5 The calibration resistor is connected to a 10K pull-up resistor (R19) to +15V, generating a voltage that will vary with the value of the calibration resistor. This resulting voltage is compared to a sawtooth generated by U9 and associated circuitry and converted to a pulsewidth modulation by comparator U7. The sawtooth ramps linearly from 0 to approximately 8.4 Volts so that the duty cycle of the comparator will vary from 100 percent for a Zero-ohm calibration resistor down to approximately 20 percent for a maximum value of 10K. A reference resistor (R15) is encoded by an identical circuit. The microprocessor measures the value of both the calibration resistor and reference and computes the ratio between them to eliminate any error due to power supply or sawtooth variation. Opto-coupler U1 transmits the calibration resistor waveform while U3 transmits the reference resistor.

6.4 PROCESSOR BOARD

6.4.1 The Processor Board is divided into two sections, analog signal processing circuitry and the digital microprocessor circuitry. The analog section is shown on Sheet 2 of the processor schematic. The analog photodetector waveform, coupled through transformer T1 on the Patient Isolation Board, enters the Processor Board on pin 10 of J1. This signal consists of the time-sequenced photodetector response to the infrared and red LED's, as shown in the timing diagram (Section 8). This signal is amplified by one-half of the dual opamp 1K (output on pin 7).

6.4.2 The output of this input amplifier is connected to four analog switches, forming the switching element of the two-channel synchronous detector. The purpose of this detector is to separate the infrared and red photodetector pulses, as well as to cancel low frequency noise and offset voltages. Referring again to the timing diagram it can be seen that there are four time states. Time state 0 is the "on state" for the IR LED, time state 1 is the corresponding "off state", time state 2 is the "on state" for the red LED and time state 3 is the corresponding "off state". During the first "on" state the top analog switch (2H-10) closes, coupling the preamp signal through an amplifier 2K-1, with a gain of -1 formed by R33 and R34. During the "off" state the first switch opens and the second switch is closes (2H-7), configuring the same amplifier for a gain of +1 (essentially a voltage follower with R34 open and R33 forming the feedback loop). During the on and off states for the red LED a similar switching occurs for the second detector channel. The output of these two detector amplifiers will thus be active with a duty cycle of 50 percent, half of that inverting and half noninverting. Any DC or low-frequency voltage will be canceled by the two adjacent pulses of opposite polarity, while the photodetector signal (present in only one of the two time states) will be amplified with an effective gain of .25.

6.4.3 The output of the two detector amplifiers are fed to a pair of matched low-pass filters with a gain of 4 and a cutoff frequency of 10Hz. These filters remove the switching component (approximately 1 kilohertz) injected by the sychronous detectors, filter any high frequency noise and amplify the photodetector signal. The output signal from the two low pass filters will be approximately 3.0 Volts for the IR channel (4K-1) and 0.7 volts for the red channel (4k-7). The discrepancy is due to the lower ouput from the red LED, compensated for by higher gain in the postamplifier. This post-amplifier is provided for each channel to boost the signal level to the 7.5-10 Volt range.

6.4.4 The brightness of each LED is controlled independently to establish the photodetector voltage within the 7.5-10 Volt range to provide an optimum signal-to-noise ratio. If the output voltage of one channel is less than 7.5 Volts, the LED current is boosted (under software control), and if greater than 10 Volts the LED current is reduced, and similarly for the second channel. These adjustments are made in small steps to prevent "hunting", and the program is completely indifferent to the actual levels, provided they are in the proper range. Since the signal from each channel is always 7.5 Volts or more, is not necessary to do the analog/digital conversion on the first 7.5 Volts of the signal. Each photodetector signal is therefore fed to an offset amplifier which, with a gain of 4 and and offset of 7.5 volts, which expands the 7.5-10 volt range present at the post-amplifier to a 0-10 volt range at the output of the offset amplifier. The signal from this amplifier corresponding to the IR channel is termed Va' and for the red channel Vb'. (The signals at the output of the postamp, before offset, are also available at the multiplexer as Va and Vb for diagnostic purposes.)

6.4.5 The interface between the analog circuitry and the microprocessor consists of an analog multiplexer and digital-to-analog converter (DAC). The analog multiplexer is a pair of 8:1 CMOS analog switches, 5G and 6G. The output of this multiplexer is fed through a single-pole filter to a comparator, 5H, which compares the selected analog channel to the output of the DAC. The channel to be converted is selected by 4 bits of a register (6F, labeled MUX0-MUX3). The DAC itself consists of a 12-bit register formed by 9K and 8H, a 12-bit D/A converter chip (8K), a buffer amplifier and a 10 volt reference chip (7H). Two other amplifiers provide output buffers for the 7.5V reference for the offset amplifier and also for use by the calibration resistor decoding circuitry. The actual digital-to-analog conversion is software controlled, which consists of first selection of the desired input on the analog multiplexer to be converted (by setting the correct code in latch 6F), and then doing a successive approximation to the correct value starting with the most significant bit in the DAC. The output of comparator 5H is sampled by the program after each successive DAC bit is set to determine if the DAC output is higher or lower. If the comparator indicates that the DAC output is high, then the last bit set will be changed to a 0, and the next lower significant bit will be set to a 1. This process is repeated until the least significant bit is reached and the conversion is complete.

6.4.6 The DAC is also used to store output voltages to determine the volume and pitch of the beeper circuit and the drive current to each LED. This is accomplished between analog conversions by selecting one of four analog switches (5F) through the same latch that controls the analog multiplexer (6F). The DAC is set to the desired value, one of the switches is closed, and the corresponding storage capacitors (C29, C30, C33, C34) will charge to the DAC voltage. The analog switch is then opened and the capacitor will retain that value until the next refresh. These voltages are refreshed at a period of approximately 75 milliseconds. A set of voltage follower buffers (4E, 5E) prevent circuit loading from discharging the storage capacitors.

6.4.7 The LED drive currents must be encoded and transmitted across optical couplers to the Patient Isolation Board. This is accomplished by generating a ramp for the beginning of each of the four time states. The timing diagram shows the relationship between the ramp control signals "A" and "B" and the four time states. During the first time state a positive ramp is generated by integrator 3E-7, and is compared to the desired level for LED 1 by comparator 4F. Gate 3F-11 will generate a pulse beginning at the beginning of time state 0 and ending when the ramp crosses the reference voltage for LED 1 (VL1). During the second time state (1), the phase control signal "P" is reversed and the same pulse is generated but will be interpreted as an opposite polarity by the patient isolation logic. A second integrator, comparator and gate generate an identical signal for the red LED, controlled by VL2. Since this voltage will be transmitted to the LED as a negative pulse by the Patient Isolation Board, the sense of the phase signal "P" is reversed for time states 3 and 4.

6.4.8 The Patient Isolation Board converts the calibration and reference resistors into pulsewidth modulated signals and transmits these back to the Processor Board via additional optical couplers. These variable duty cycle pulses are converted back into a corresponding voltage by an analog switch, a pull-up resistor to the buffered 10-volt reference, and an integrating amplifier to generate a voltage proportional to the duty cycle.

6.4.9 Sheet 1 of the Processor Board Schematic shows the digital logic associated with the microprocessor itself. The microprocessor is an 8-bit Intel 8085 processor clocked by a 6.144 mHz crystal. Since the address bus of this processor is multiplexed with the data bus, a latch (6C) is provided to latch the lower 8 address bits during the address state. An 8 bit buffer (8G) is provided for the same pins used as output data. Memory for the microprocessor consists of three 2716 pROMs, and a pair of 1Kx4 bit RAM chips, 6A and 6B. Decoder 9D provides memory decoding, maping the ROMs into addresses from 0 to 17FFH, and decoders 6D and 9F provide address strobes for output and input registers, respectively.

6.4.10 Counter chips 5B, 4B and 3B generate a 2400Hz clock interrupt used for transmitting data over the optical serial data link. Counters 3C, 4C and 4D are used to generate the time states for the sensor LED clocking. The 3.072 mHz clock provided by the microprocessor is divided by 1680 to generate a basic time state of 547us, a frequency with no harmonic relationship to 50 or 60Hz. (This is important to avoid beat-frequency interference with ambient light). Decoder 1D provides the time state signals for the analog switches as well as the LED encoding circuitry.

6.4.11 J2 connects the Processor Board to the Front Panel Display Board. Buffer 9H handles the Front Panel switches and the step and direction pulses from the Control Knob.

6.5 FRONT PANEL DISPLAY BOARD

6.5.1 The Display Board is located immediately behind the Front Panel and contains the numeric LED's, the LED indicator lamps, the control buttons and the Control Knob as well as associated circuitry.

6.5.2 The numeric LED's and indicator LED's are multiplexed with a 1-of-9 select. Latch U8 is loaded with the select code representing the address of a numeric digit, one-half of the bar graph display, or the set of indicator LED's. This code is decoded into one of nine select lines by decoder U7, which drives the selected set of LED's to +5V by the corresponding transistor Q1-Q9. Latch U6 is loaded with the corresponding code for that digit, and drives the LED's to ground through driver U5 and U4. The total current driven to ground by those drivers is monitored by amplifier U9 and returned to the analog multiplexer on the Processor Board for diagnostic purposes. (This is used during the power on testing to sequentially test each LED for correct function.)

6.5.3 The Control Knob consists of a two channel optical chopper, with the two channels mechanically 90 degrees out of phase to each other, and a dual channel optical slot detector. The output from the two channels of this detector are amplified by schmidt trigger U1 and decoded by a set of four flip-flops (U2) and an exclusive-OR network (U3). When the Control Knob is rotated clockwise, the output from U1-10 will lead the output from U1-12 by 90 degrees. These pulses are clocked into U2-2 and U2-7 by the display clock (which is considerably higher in frequency than the Control Knob pulses). Whenever the first and second flip-flops of each pair have different outputs it indicates that the input pulse has changed state during the previous clock time and a step pulse is generated. By comparing the first latch output of one channel with the second latch output of the other channel, a corresponding direction pulse is also generated. The phase of this direction pulse will be different depending upon the direction of rotation, and is only valid during a step pulse.

6.5.4 The beeper circuit, implemented by amplifier U9 and analog switch U10, is driven by two voltages generated on the Processor Board. The pitch voltage "beep" determines the charging rate of capacitor C11, amplified by U9-7, and compared to a reference by U9-8. When the voltage reaches the threshold, switch U10 is triggered, discharging the capacitor and starting the cycle over again. U9-14 provides an output buffer to drive the speaker through Q9. Q11 provides volume control by the "Vvol" signal.

6.6 POWER SUPPLY BOARD

6.6.1 Operating voltages for the Processor and Patient Isolation Board are generated by the power supply circuit (refer to the Schematics). Unregulated voltage from the Battery Charger Board, either generated by the battery itself or from the transformer/bridge rectifier combination from AC power, enters the board through J2. The voltage at this point will be a minimum of about 11 volts for low battery operation up to as much as 32 volts for high AC line conditions.

6.6.2 The power supply consists of two independent DC-DC converters, one generating +5 (at approximately 2 amps) and the other generating +/-15 Volts (at approximately 0.3 amps). Each of these two power supply sections is controlled by a 3524 pulsewidth control chip, which senses the output voltage and controls the pulsewidth of an active switching element. In the case of the +5 Volt supply, U1 controls the duty cycle of drive transistor U3 through R14. When this transistor is "on", current flows from the input through the transitor, through the inductor L1 and to the load, J3 for the Processor Board and J1 for the Patient Isolation Board. When the control chip senses the output voltage exceeding the 5 Volt reference level, U3 is switched off, and current will then flow from ground through the diode in U3, through L1 and through the load. Enough energy is stored in the inductor to carry this essentially constant current through the load until the next "on" state begins. The switching frequency for the power supply is approximately 100 kilohertz.

6.6.3 The +/-15 Volt supply operates similarly. During the "on" state current is driven through transformer T1 by switch Q1, and current is coupled to the output magnetically. When the control chip senses the output voltage rising above 15 volts, the switch is turned off, and current will flow through diode CR2, through the second magnetically coupled primary winding, to ground. An amplifier, U4, is provided to sense the battery voltage to allow the microprocessor to display low battery condition.

6.7 BATTERY CHARGER BOARD

6.7.1 The battery charging circuit consists of a 12 Volt battery, an AC driven transformer, bridge rectifier, a large filter capacitor, and associated battery charging and switching circuitry. Regulator U3 provides battery charge voltage through diode CR3 whenever AC power is present. During AC operation, this voltage is also coupled directly to the Instrument (bypassing the battery) through diode CR8 and relay K1. This relay is closed by the control circuitry when the Front Panel Switch is operated from the STANDBY to the ON position. Power to intially close the relay is provided by the 2200uf capacitor (located off of the Charger Board in the chassis) and then current to maintain relay closure is provided directly by CR6 or CR7 for AC line operation.

6.7.2 Regulator U2 and comparator U4 are used to sense the battery voltage and open the relay if a minimum battery voltage is reached. This prevents the battery voltage from becoming too low for the power supply to function reliably, preventing erratic instrument operation, and also prevents damage to battery due to an excess discharge condition. This battery voltage is sensed through the Standby/On Switch so that moving the Switch to the Standby position automatically opens the relay turning off the Instrument. Note that the battery charging circuit continues to operate whether the relay is open or closed. In the event of loss of AC power, battery voltage will be coupled to the relay through CR4 and the Instrument will continue to operate normally.

760-9691

SECTION 7

SPARE PARTS

This section contains the replacement assemblies and parts that are available for the N-100B (4 Button) oximeter. The listings are organized by board type and mechanical assembly.

The available spare components for the listed PCB assemblies include all diodes, transistors, ICs, and other unique, specially qualified, or limited availability items. Cross referencing of listed components, and identification of components that are not listed, may be accomplished by referring to the PCB schematic and assembly drawings in Section 8. Use the device part number and description to cross reference between Sections 7 and 8.

To order Nellcor spare parts, please call the Customer Service Order Desk with your purchase order number. The minimum order for spare parts is $50.

7.1 Front Panel/Cord Wrap Kit
Part No. 073396

See sections 7.6 (Front Panel) and 7.7 (Display Knob) for additional available parts.

N-100 (4 Button)

ITEM	DESCRIPTION	PART NO.
1	Assembly, Front Panel/Cord Wrap Kit, N-100B (4 Button)	073396

The following items are included in these kits:

ITEM	QUANTITY
Front panel assembly without switch, connector or Display PCB	1
Cord wrap feet	2
Cable ties	6
Rear chassis feet	2
Interconnect cable diagram	1
Set of installation instructions	1

ITEM	DESCRIPTION	PART NO.
2	17 mm Offset flare nut wrench	901152

This item is available separately and is needed to properly remove and reinstall the Display to Processor Cable.

7.2 Complete PCB Assemblies

All PCB assemblies available as either outright purchase, or at reduced cost on swap-out rebate program.

N-100 (4 Button)

BOARDS AVAILABLE ONLY AS COMPLETE ASSEMBLIES
(FACTORY REPAIR OR REPLACEMENT ONLY)

ITEM	DESCRIPTION	PART NO.
1	Assembly, Patient Isolation PCB	**071076**
2	Assembly, Processor PCB	**071080**
3	Assembly, Display Daughter PCB (with knob detector)	**071104**

BOARDS AVAILABLE AS COMPLETE ASSEMBLIES OR REPAIRABLE BY CUSTOMER.
SEE SECTIONS 7.3, 7.4 AND 7.5 FOR AVAILABLE REPLACEMENT COMPONENTS.

ITEM	DESCRIPTION	PART NO.
1	Assembly, Battery Charger PCB	**071084**
2	Assembly, Power Supply	**071086**
3	Assembly, Display / Knob (includes Daughter PCB and Knob)	**071102**

7.3 Battery Charger PCB Assembly
Part No. 071084

N-100 (4 Button)

ITEM	DESCRIPTION	PART NO.
1	Bridge rectifier, MDA970A2	691004
2	Regulator, 7806 (+6 V)	612006
3	Bracket, PCB support	051077
4	Regulator, LM317K	614317
5	IC LM393N (Interchangeable with LM412)	120393
6	Relay, 5 V, Gould MPC2C5VDC	691005
7	Capacitor, 13,000UF, 40 V	390133
8	Transistor, 2N4403	604403
9	Diode, 1N4934 (MR811)	584934
10	Diode, 1N5400	585400
11	Diode, 1N4148	584148
12	Diode, 1N4004	584004
13	2-pin PCB connector	411002
14	3-pin PCB connector	411003
15	Terminals, 24-18GA crimp (5 required)	481003
16	Connector housing, 4-pin	440004
17	Terminals, male (5 required)	481008
18	3-pin connector housing	441003
19	Heatsink, regulator	051201

7.4 Power Supply PCB Assembly
Part No. 071086

N-100 (4 Button)

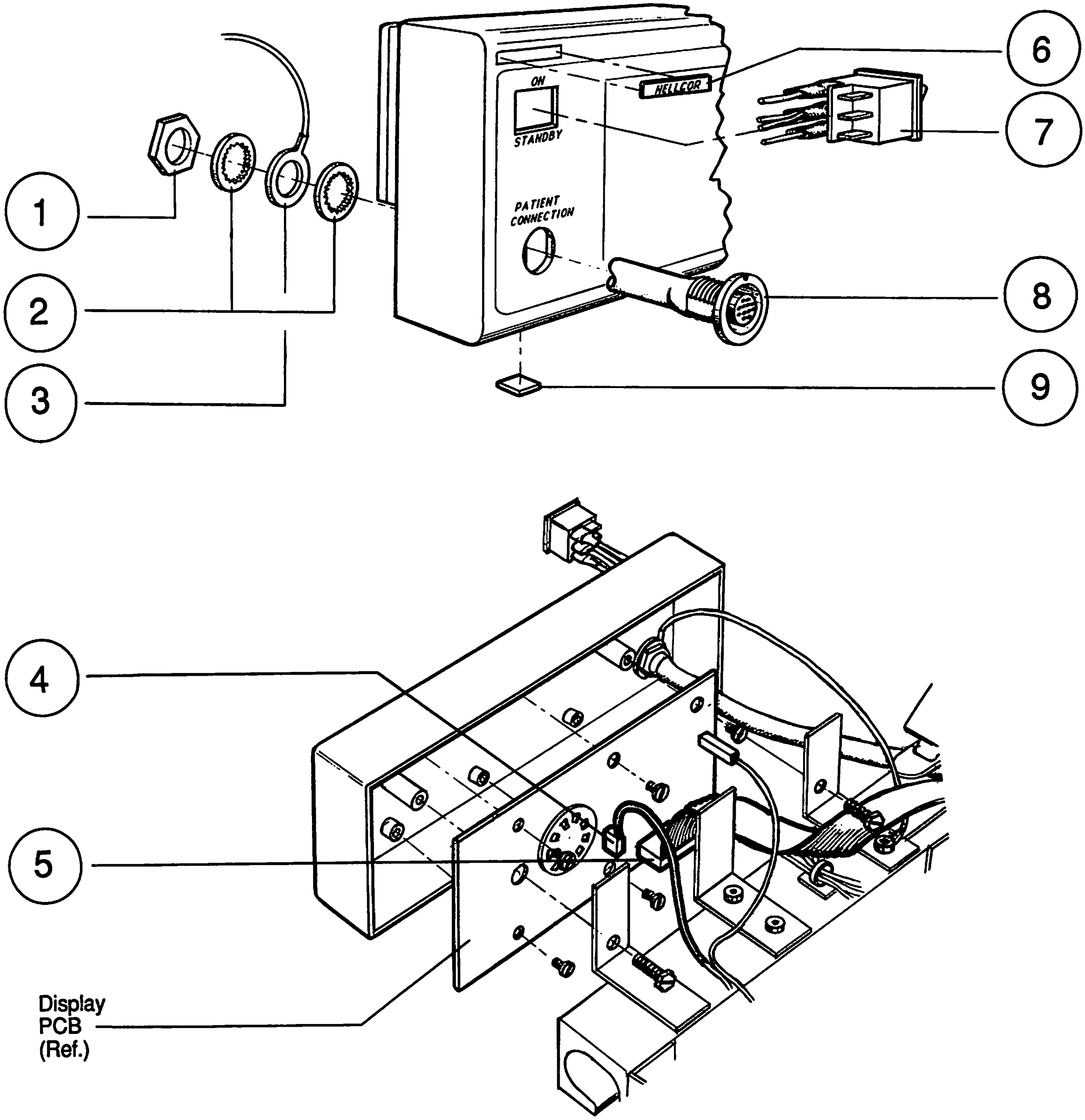
ITEM	DESCRIPTION	PART NO.
1	IC, LM3524N	193524
2	Transistor, power (PIC601 or SM601)	600601
3	IC, LF353 (replaced with LF412)	120412
4	Capacitor, dual, 1700UF, 10 V	353178
5	Capacitor, dual, 700UF, 30 V	353707
6	Diode, 1N4934 (MR811)	584934
7	Transistor, IRF532	600532
8	4-pin right-angle connector	410004
9	10-pin right-angle connector	410010
10	Bead, ferrite	691010
11	Assembly, inductor	071168
12	Assembly, transformer	071167
13	Resistor, 0.1 ohm, 1% wire wound	291001
14	4-pin straight connector	401004

7.5 Display PCB Assembly
Part No. 071082

NOTE: Part nos. 510101 and 520101 (Items 13 and 14) are to be matched brightness codes; all either code "E" or code "F" for a given part part number. Spares are available only as matched sets.

N-100 (4 Button)

ITEM	DESCRIPTION	PART NO.
1	IC, SN74C14	102014
2	IC, SN74LS175	101175
3	IC, SN74LS86	101086
4	IC, ULN2003	192003
5	IC, SN74LS42	101042
6	IC, LM324N	120324
7	IC, CD4066	114066
8	Potentiometer, 25K - side adjust	291010
9	Diode, 1N4148	584148
10	Transistor, 2N4403	604403
11	Transistor, 2N5307	605307
12	LED lamp	500101
13	LED display, 7-segment (3 required)	510101
14	LED bar graph (2 required)	520101
15	Diode, 1N4615	584615
16	Switch, push-button	630101
17	2-pin connector header	401002
18	26-pin connector header	401126
19	6-pin connector header	401006
20	Disconnect tab, 0.250 male	481014
21	Transistor, 2N3646	603646
22	IC, SN74LS373	101373
23	1K ohm 16-pin resistor package	240102



FRONT PANEL

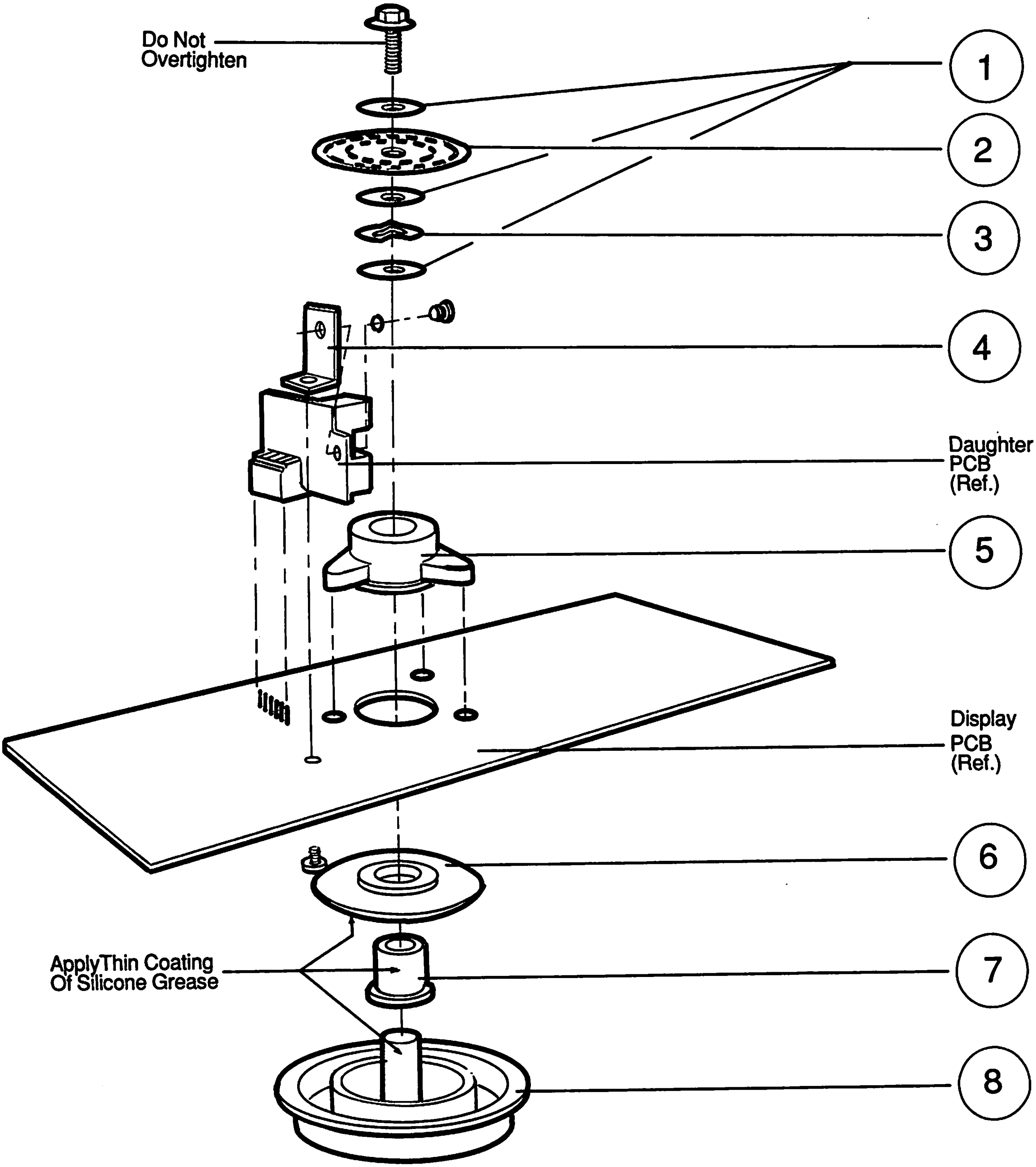
Figure 7.6.1

7.6 Front Panel

See "Front panel/cord wrap kit" for panel repair.
Switch, cables, etc. are shown in this section.
See Fig. 7.6.1.

N-100 (4 Button)

REF.	DESCRIPTION	PART NO.
1	LEMO connector nut	491006
2	LEMO connector washers (2 required)	491005
3	Assembly, ground ring	071169
4	Assembly, Display ground cable	071255
5	Display to Processor cable assembly	051119
6	Nellcor logo nameplate	051040
7	Assembly, ON/STANDBY switch	071243
8	Assembly, front panel to Patient Isolation PCB cable	071346
9	Front panel feet (2 required)	051073



DISPLAY KNOB

Figure 7.7.1

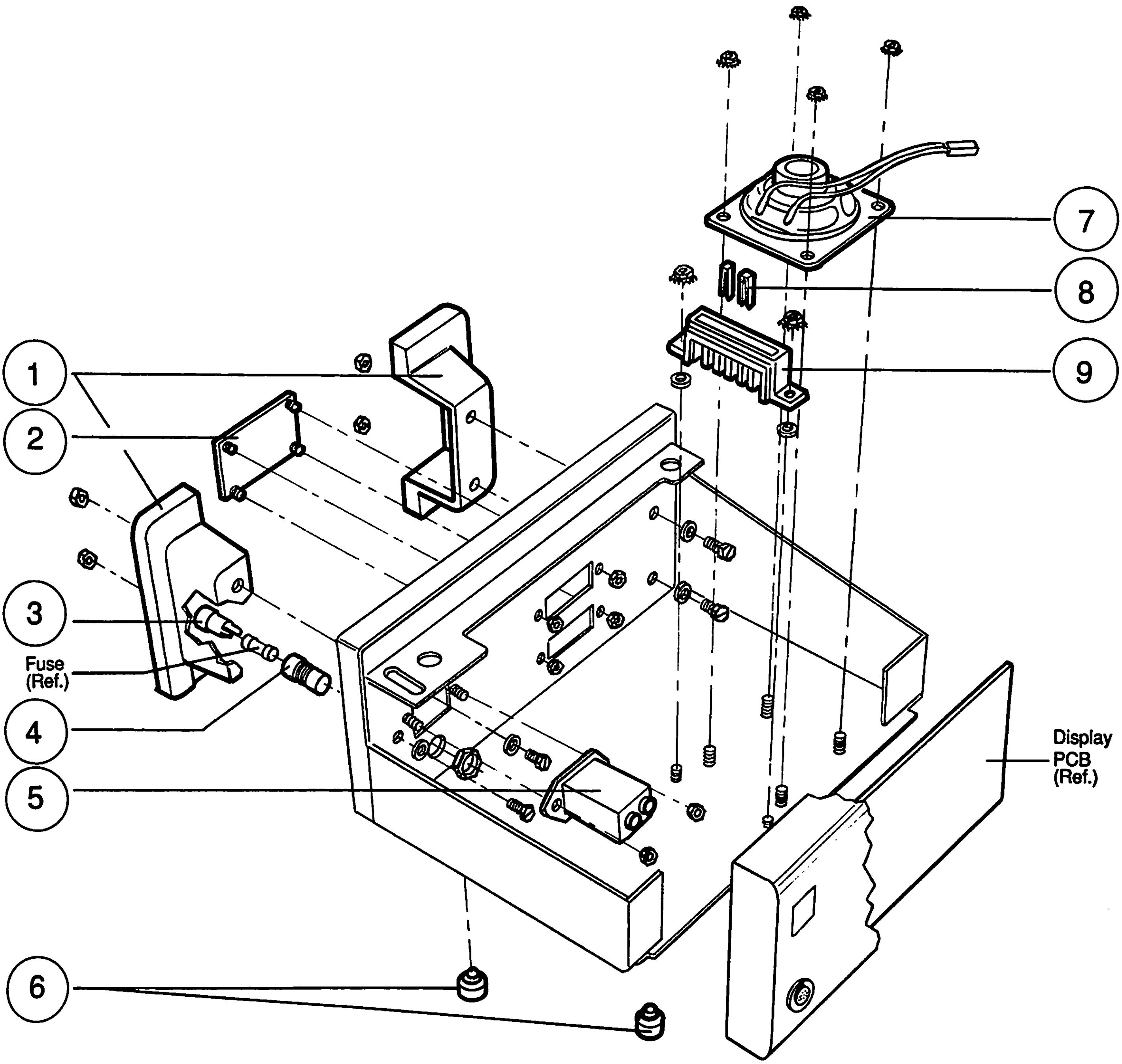
7.7 Display Knob

A complete Display / Knob assembly consists of a Display PCB assembly (071082), a Daughter Board PCB assembly (071104), and the following mechanical parts.

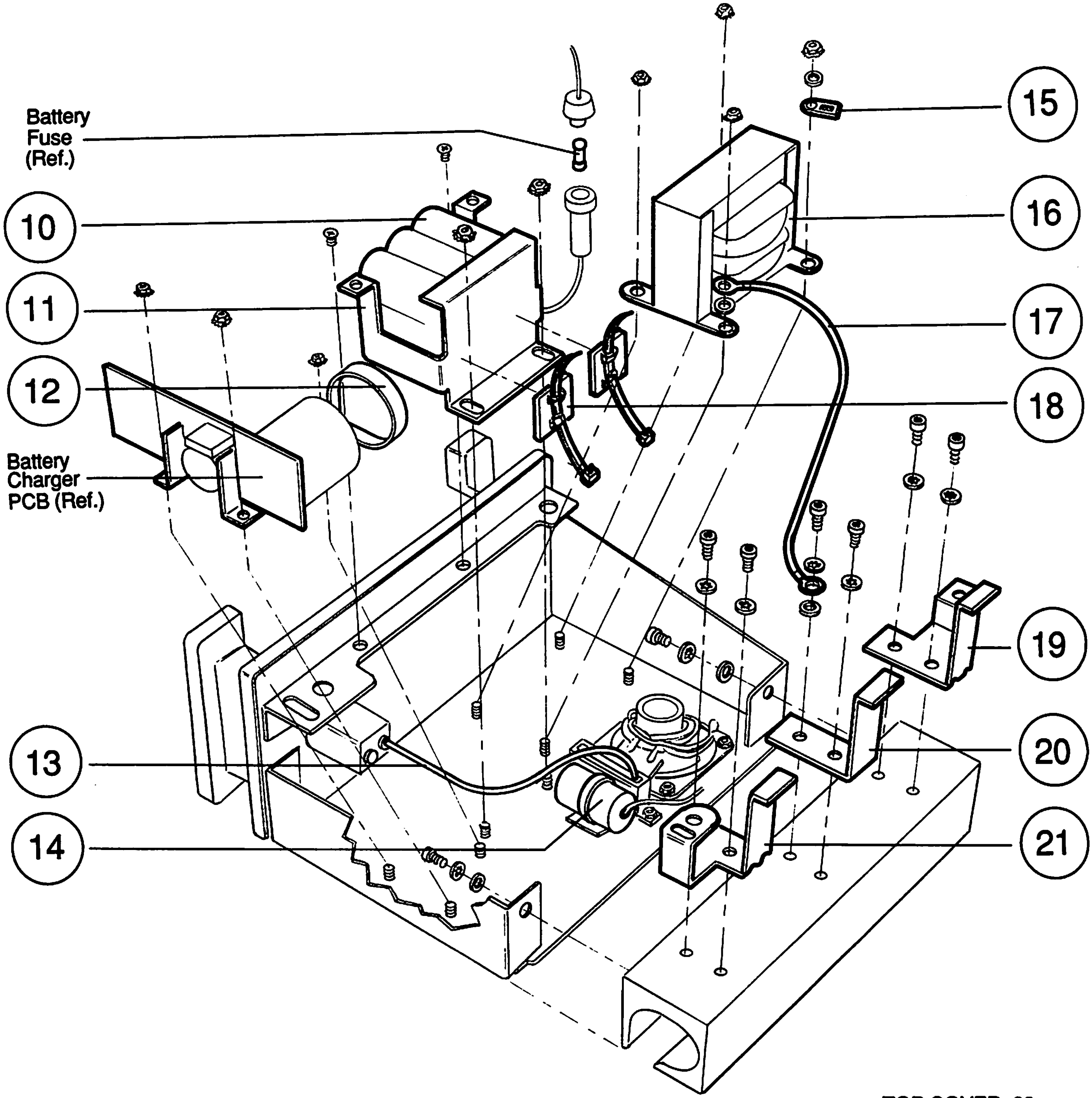
See Fig. 7.7.1.

N-100 (4 Button)

REF.	DESCRIPTION	PART NO.
1	Steel washer (3 required)	891081
2	Encoder disc	051072
3	Spring washer	865201
4	Daughter PCB bracket	051159
5	Knob bushing	051043
6	Thrust washer	891006
7	Flange bushing	891001
8	Knob	051044



CHASSIS
Figure 7.8.1



TOP COVER -22
(NOT SHOWN)

CHASSIS (CONT.)

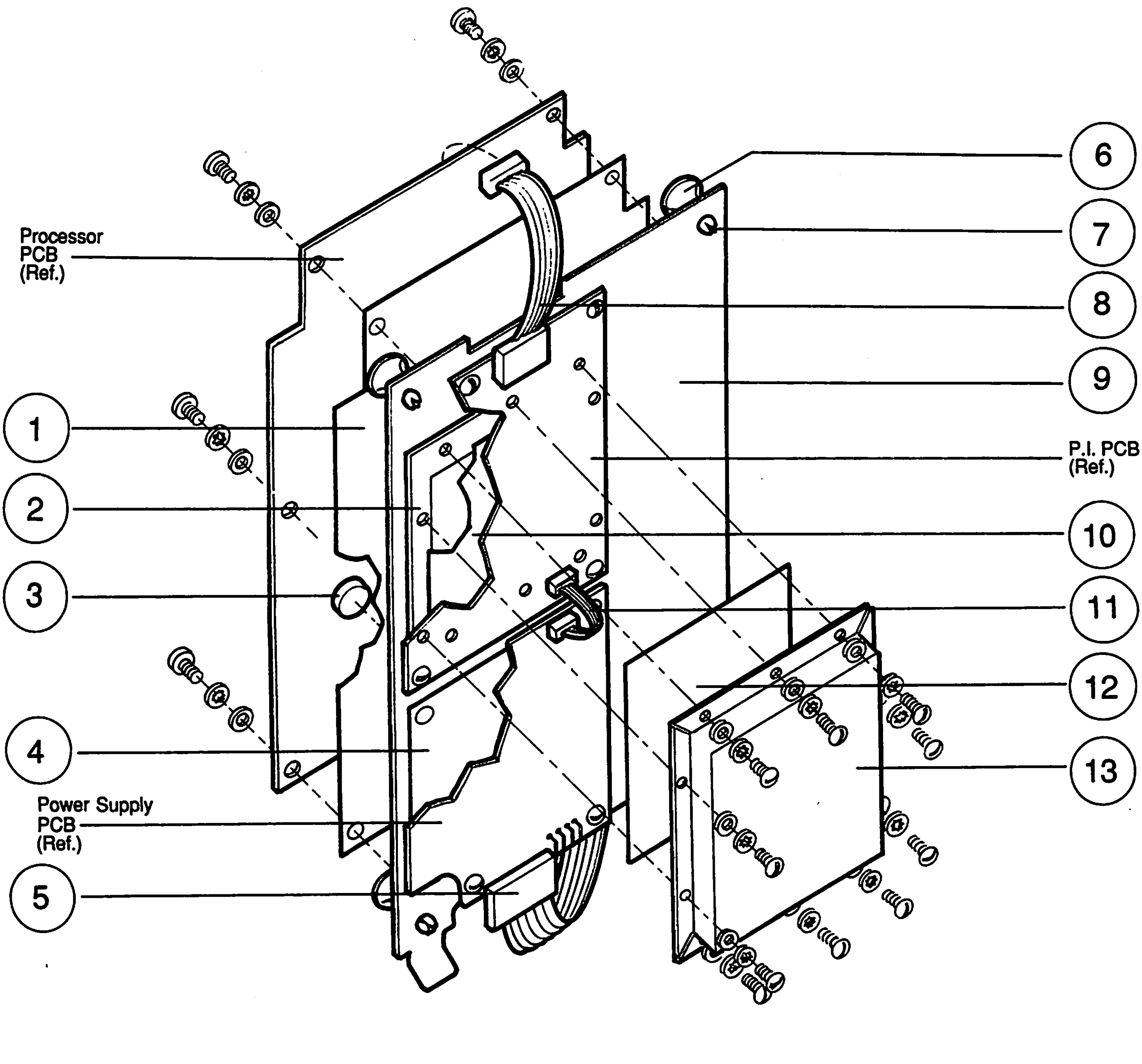
Figure 7.8.2

7.8 Chassis

See Fig. 7.8.1 and 7.8.2.

N-100 (4 Button)

REF.	DESCRIPTION	PART NO.
1	Cord wrap foot (2 required)	051045
2	Rear panel cover plate	051739
3	Slotted fuse carrier	891008
4	Assembly, fuse holder	071121
5	Assembly, AC inlet filter	071120
6	Rear chassis feet, ½" diameter (2 required)	891002
7	Assembly, speaker, N-100 Replaces assembly 071123	052487
8	Voltage selection block key (4 required)	491004
9	Voltage selection block	491003
10	Assembly, battery	071122
11	Assembly, battery bracket	071126
12	Bracket, capacitor	891011
13	Assembly, AC filter to select block cable	071149
14	Assembly, battery capacitor	071244
15	Screw mount cable clamp	759111
16	Assembly, power transformer	071124
17	Assembly, chassis ground cable	071542
18	Cable clamp (4 required)	759104
19	Right front panel mount bracket	051051
20	Center front panel mount bracket	051078
21	Left front panel mount bracket	051052
22	Instrument top cover	051182



SUPPORT PLATE

Figure 7.9.1

7.9 Support Plate

See Fig. 7.9.1.

REF.	DESCRIPTION	PART NO.
1	Insulator for Processor PCB	051160
2	Bottom cover for Patient Isolation PCB	051171
3	Black rubber bumper	759110
4	Insulator for Power Supply PCB	051164
5	Assembly, Processor PCB to Power Supply PCB cable	071128
6	Plunger, Nylatch (4 required)	891005
7	Grommet, Nylatch (4 required)	891004
8	Patient Isolation to Processor PCB cable	051131
9	Electronics support plate	051057
10	Bottom cover insulator for Patient Isolation PCB	051183
11	Assembly, Patient Isolation to Power Supply PCB cable	071132
12	Top cover insulator for Patient Isolation PCB	051329
13	Top cover for Patient Isolation PCB	051298

7.10 Accessories

ITEM	DESCRIPTION	PART NO.
1	Assembly, power cord	071505
2	User manual, N-100B (4 button) oximeter	051185
3	Service manual, N-100B (4 button) oximeter	051480
4	Assembly, Patient Module, 13', N-100B	071136
5	Assembly, Patient Module, 20', N-100B	071275
6	Assembly, Patient Module Extension Cable, 20', N-100B	071991
7	Patient Module clip	051094
8	Patient Module clip spring	051095
9	Fuse, 1 amp, Slo-Blo (for 100/120 V)	691018
10	Fuse, ½ amp, Slo-Blo (for 220/240 V)	691011
11	Fuse, 4 amp, Slo-Blo (battery fuse)	691014
12	Pocket Tester, Model 1460	071791
13	Fiberoptic cable for Interface and Recorder	621003

SPARE PARTS WARRANTY

Nellcor Incorporated warrants to the initial Purchaser that each printed circuit board listed *herein* will be free from defects in workmanship and materials for a period of 60 days after the initial shipment of the printed circuit board to the Purchaser from Nellcor.

Nellcor Incorporated warrants to the initial Purchaser that each of the spare parts listed herein (other than printed circuit boards) will be free from defects in workmanship and materials upon shipment of the spare part to the Purchaser from Nellcor, provided that any claim under this warranty with respect to spare parts other than printed circuit boards must be presented to Nellcor within 15 days after such shipment.

Nellcor's only obligation under this warranty is to repair or replace any product covered by this warranty that Nellcor reasonably determines to be covered by this warranty and to be defective in workmanship or materials under the procedures described below.

To request repair or replacement under this warranty, Purchaser should contact Nellcor at 25495 Whitesell Street, Hayward, California 94545, (800) 433-1244 or (800) 351-9754 in California. If, on the basis of the information provided by Purchaser, Nellcor reasonably believes that the defect is covered by this warranty, Nellcor will authorize Purchaser to return the warranted product to Nellcor. Nellcor shall repair or replace products reasonably determined by Nellcor to be covered by this warranty. Nellcor shall determine whether to repair or replace products, and all products replaced shall become Nellcor's property.

Shipping Procedures

If Nellcor reasonably determines that a repair or replacement is covered by the warranty, Nellcor shall bear the costs of shipping the repaired or replacement product to Purchaser. All other shipping costs shall be paid by Purchaser. Risk of loss or damage during shipments under this warranty shall be borne by the party shipping the product.

Exclusions

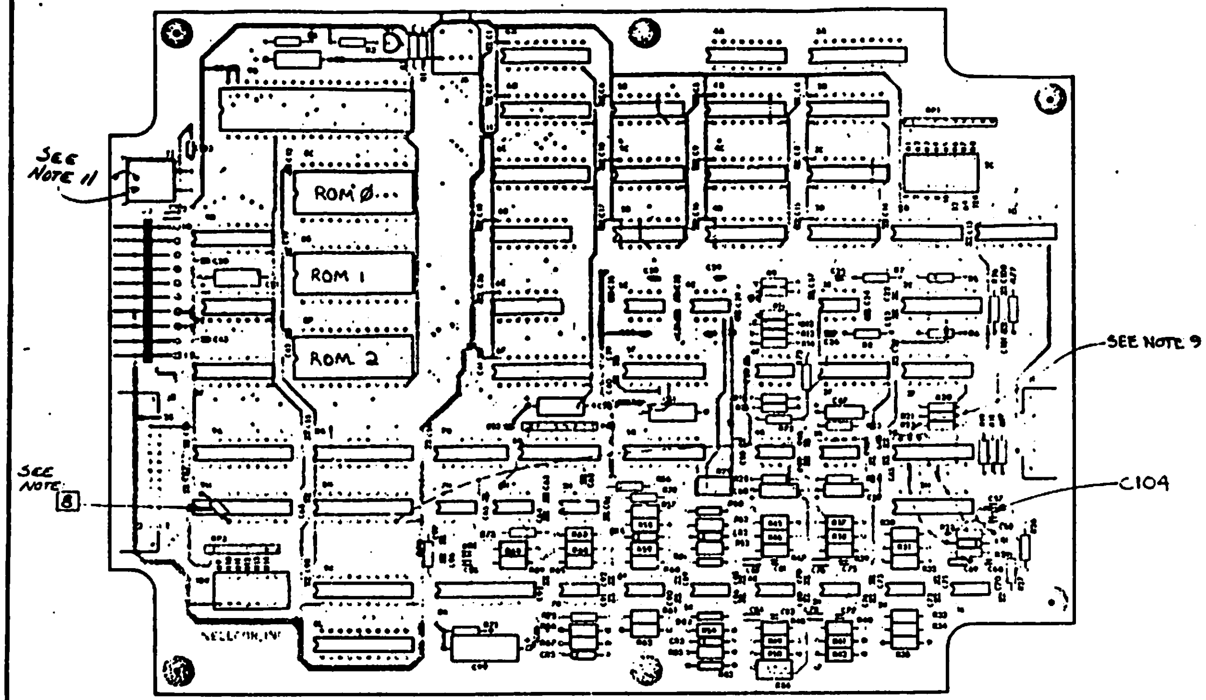
This warranty does not extend to any warranted products that have been subject to misuse, neglect, modification or accident; that have been damaged by causes external to the warranted products, including but not limited to failure of or faulty electrical power; or that have been used in violation of Nellcor's instructions or for the repair of any product other than as described herein.

THIS WARRANTY IS THE SOLE AND EXCLUSIVE WARRANTY AS TO ANY SPARE PARTS SOLD BY NELLCOR. THIS WARRANTY EXTENDS ONLY TO THE PURCHASER AND IS EXPRESSLY IN LIEU OF ANY ORAL OR IMPLIED WARRANTIES, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR AGAINST INFRINGEMENT. NELLCOR SHALL NOT BE LIABLE FOR ANY INCIDENTAL, SPECIAL OR CONSEQUENTIAL LOSS, DAMAGE OR EXPENSE DIRECTLY OR INDIRECTLY ARISING FROM THE SALE, FAILURE TO SELL, USE OR LOSS OF USE OF ANY PRODUCT.

DETAIL A

Program Assy 1240 Placement

ROM 0 - 8C; ROM 1 - 8D; ROM 2 - 8F



10. NOTE: THIS BOARD CONTAINS STATIC SENSITIVE COMPONENTS AND SHOULD BE HANDLED ACCORDINGLY. AFTER ASSEMBLY, PLACE IN ANTI-STATIC PLASTIC BAG.
11. Crystal may be secured by Buss wire, hot melt glue, foam tape, or by pin inserted into board and bent over top of Crystal.

REFERENCE NOTE:

1. REFERENCE MADIC BILL OF MATERIALS 991080 FOR OUTSIDE VENDOR PROCESSING OF PCB ASSEMBLY.

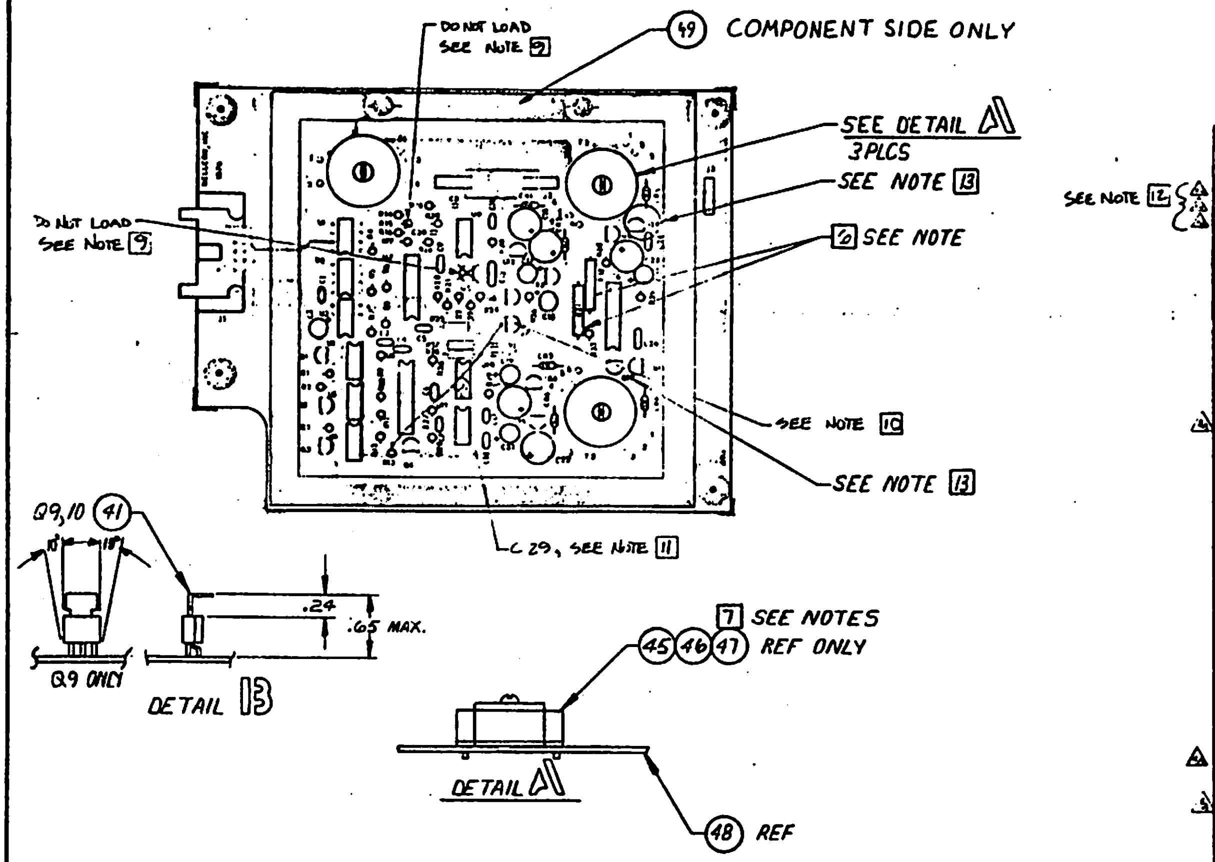
NOTES:

1. Orient I.C.'s with Pin 1 to Square Pad.
2. Polarized Capacitors to be mounted with Positive (+) side to Square Pad.
3. Color code Carbon Comp. Resistors to be LEFT or UP as appropriate.
4. All Capacitors and Precision Resistors to be mounted with value visible.
5. Diodes to be mounted with banded (Cathode) side to Square Pad.
6. Component leads not to exceed 1/16" MAX.
7. REFERENCE INFORMATION: Decoupling Caps include: C1, C3 thru C20; C22, C23, C24, C27, C28, C32, C31, C35 thru C46; C48, C49, C50, C53 thru C58; C61; C63 thru C67, C70 thru C74; C79, C80, C85, C86; C89 thru C93; C98.
8. Add R85 as shown. NOTE: R85 must be added to ALL Processor PCB's used with Display PCB Assy 1082, Rev A or B.
9. Add Jumpers (30 GA KYNAR): Solder Side
   1. From I.C. 2G, Pin 14 to C69 as shown.
   2. From I.C. 2G, Pin 15 to empty CR1 (RND Pad) as shown.
   3. From I.C. 26, Pin 16 to I.C. 8H, Pin 9.

ITEM	P/N	DESCRIPTION	QTY	DESIGNATION
8a.	071240	Assy PROGRAM, N100B	1	SEE DETAIL A
81.	304470	CAP. 47pf, MONOSTABLE	1	C104
80.	051079	PCB, Processor REV F	1	-
79.	752016	Socket, I.C., 16 Pin	1	10K
78.	410010	CONN. PCB R/A 10 Pin	1	J3
77.	400126	CONN. HDR R/A 26 Pin	1	J2
76.	400110	CONN. HDR R/A 10 Pin	1	J1
75.	621001	Fiber Optics, Transmitter	1	J5
74.	603646	TRANSISTOR, 2N3646	1	Q1
73.	584148	DIODE, 1N4148	4	CR2 thru CR5
72.	691001	CRYSTAL, 6.144MHz	1	Y1
71.	310104	CAP. .10uf Monolithic GP	68	Decoupling Caps (See Note 7)
70.	330226	CAP. 22uf Tant. 35V	1	C99
69.	304104	CAP. .10uf Monolithic	3	C95, C96, C97
68.				
67.				
66.	051465	CAP. .22uf Mat'd (4) Assy	1	C76/C78 & C82 / C84
65.	051466	CAP. .047uf Mat'd (4) Assy	1	C75/C77 & C81 / C83
64.	324200	CAP. 20pf Ceramic	3	C69, C102, C103
63.	304102	CAP. .001uf Monolithic	3	C62, C100, C101
62.	330105	CAP. 1uf Tant. 35V	3	C47, C59, C60
61.	304103	CAP. .01uf Monolithic	6	C29, C30, C33, C34, C[illegible], C94
60.	304222	CAP. .0022uf Monolithic	2	C25, C26

ITEM	P/N:	DESCRIPTION:	QTY	DESIGNATION:
59.	[illegible]685	CAP. 6.8uf Tant. 35V	4	C2, C21, C51, C52
58.	230472	RES. PKG. 4.7K, 8 Pin SIP	2	RP2, RP3
57.	220472	RES. PKG. 4.7K, 10 Pin SIP	1	RP1
56.	200334	RES. 330K, 1/4W, 5%	1	R80
55.	291025	POTENTIOMETER, 25K	2	R79, R84
54.	200331	RES. 330 Ohm, 1/4W 5% CC	2	R76, R77
53.	200270	RES. 27 Ohm, 1/4W 5% CC	2	R70, R71
52.	213321	RES. 3.32K, 1% M.F.	1	R65
51.	212491	RES. 2.49K, 1% M.F.	2	R63, R78
50.	214022	RES. 40.2K, 1% M.F.	4	R58, R59, R62, R66
49.	200102	RES. 1K, 1/4W 5% CC	3	R56, R74, R75
48.	214322	RES. 43.2K, 1% M.F.	1	R54
47.	211213	RES. 121K, 1% M.F.	2	R52, R55
46.	218662	RES. 86.6K, 1% M.F.	4	R39, R40, R47, R48
45.	211653	RES. 165K, 1% M.F	5	R38, R41, R46, R49, R28
44.	211693	RES. 169K, 1% M.F.	4	R37, R42, R45, R50
43.	291015	RES. 20.0K, .1% M.F.	2	R32, R33
42.	291009	RES. 10.0K, .1% M.F.	8	R30, R31, R34, R35, R57, R60, R61, R67
41.	214993	RES. 499K, 1% M.F.	1	R29
39.	200106	RES. 10 Meg Ohm 1/4W 5% CC	1	R27
38.	211002	RES. 10.0K, 1% M.F.	5	R26, R53, R64, R68, R69
37.	200105	RES. 1 Meg Ohm 1/4W 5% CC	4	R23, R24, R25, R83
36.	200103	RES. 10K, 1/4W 5% CC	6	R20, R21, R22, R81, R82, R85
35.	200225	RES. 2.2 Meg Ohm 1/4W 5%	2	R14, R16
34.	200222	RES. 2.2K, 1/4W 5% CC	2	R13, R15
33.	211004	RES. 1 Meg Ohm 1% M.F.	2	R10, R11
32.	212001	RES. 2.00K, 1% M.F.	2	R9, R12
31.	200333	RES. 33K, 1/4W 5% CC	2	R5, R6
30.	200472	RES. 4.7K, 1/4W 5% CC	8	R4, R7, R8, R17, R18, R19, R72, R73
29.	200332	RES. 3.3K, 1/4W 5% CC	1	R3
28.	200101	RES. 100 Ohm, 1/4W 5% CC	1	R2
27.	200471	RES. 470 Ohm, 1/4W 5% CC	1	R1
26.	150085	I.C. D8085 (CPU)	REF	9B
25.	752040	I.C. SOCKET, 40 Pin	1	9B
24.	196012	I.C. DAC6012	1	8K
23.	101244	I.C. SN74LS244	3	8G, 9G, 9H
22.	170016	I.C. D2716 (ROM)	REF	8C, 8E, 8F
21.	752024	I.C. SOCKET, 24 Pin	3	8C, 8E, 8F
20.	190001	I.C. REF-01	1	7B
19.	100007	I.C. SN7407	1	7G
18.	101004	I.C. SN74LS04	1	6E
17.	101138	I.C. SN74LS138	3	6D, 9D, 9F
16.	101373	I.C. SN74LS373	4	6C, 6F, 8B, 9K
15.	160014	I.C. D2114AL-3 (RAM)	2	6A, 6B
14.	120311	I.C. LM311	1	5B
13.	114051	I.C. CD4051	2	5G, 6G
12.	101074	I.C. SN74LS74	1	5D
11.	101086	I.C. SN74LS86	1	5C
10.	101090	I.C. SN74LS90	1	5B
9.	120393	I.C. LM393	1	4F
8.	120353	I.C. LF353 (OR LF412)	9	3E, 3G, 4E, 4G, 5E, 5K, 6B, 6K, 7K
7.	101002	I.C. SN74LS02	1	3D
6.	101161	I.C. SN74LS161	5	3B, 3C, 4B, 4C, 4D
5.	102000	I.C. SN74C00	2	2F, 3F
4.	190201	I.C. DG201CJ	4	2E, 2G, 2H, 5F
3.	101000	I.C. SN74LS00	2	2D, 9E
2.	120412	I.C. LF412 (or Selected LF353's)	4	1K, 2K, 3K, 4K
1.	101139	I.C. SN74LS139	1	1D

PROCESSOR PCB ASSEMBLY



ITEM	P/N	DESCRIPTION:	QTY	DESIGNATIONS:
54.	200511	RESISTOR, 510Ω 5% C.C.	6	R1-R5, R7
53.	200562	RESISTOR, 5.6 K, 1/4W 5%	2	R33, R34
52.	304470	CAPACITOR, 47pf M.S.	1	C29
51.	291018	RESISTOR, 7.5K .1% M.F.	1	R16
50.	291003	RESISTOR, 10 K, .1% M.F.	2	R17, R19
49.	051250	INSULATION GASKET, PI PCB	1	–
48.	051075	PCB, Patient Isolation, REV E	1	--
47.	071483	ASSY, PI Transformer III Potted	1	T3
46.	071482	ASSY, PI Transformer II Potted	1	T2
45.	071481	ASSY, PI Transformer I Potted	1	T1
44.	401004	Conn. Hdr. Str. 4 Pin	1	J3
43.	401110	Conn. Hdr. Str. 10 Pin	1	J2
42.	400110	Conn. Hdr. R/A 10 Pin	1	J1
41.	691026	Transistor, DARLINGTON NSDU45	2	Q9, Q10
40.	604403	Transistor, 2N4403	3	Q2, Q3, Q7
39.	603646	Transistor, 2N3646	5	Q1, Q4, Q6, Q8, Q11
38.	584148	Diode, 1N4148	6	CR1 thru CR6
37.	304391	CAP. 390nf Monolithic	1	C28
36.	304473	CAP. .047uf Monolithic	1	C27
35.	304471	CAP, 470nf, Monolithic	1	C26
34.	344207	CAP, 220uf, Dipped Tant.(10V)	1	C23
33.	344107	CAP, 100uf, " " (20V)	2	C20, C22
32.	344686	CAP, 68uf, " " (25V)	2	C15, C16
31.	390473	CAP, .047uf, M.F. 5%	1	C12
30.	304104	CAP, .10uf, Monolithic	2	C8, C10
29.	304223	CAP. .022uf, Monolithic	1	C6
28.	344105	CAP. 1uf, Dipped Tant. (35V)	6	C2, C17 thru C19, C21, C25
27.	310104	CAP. .10uf, Monolithic GP	10	C1, C3 thru C5, C7, C9, C11, C13, C14, C24
26.	213322	RES. 33.2K, 1% M.F.	1	R39
25.	210100	RES. 10 OHM, 1% M.F.	1	R38
24.	200103	RES. 10K, 1/4W 5% CC	1	R37
23.	213651	RES. 3.65K, 1% M.F.	1	R35
22.	200221	RES. 220 Ohm, 1/4W, 5%	1	R36
21.	291014	RES. .3 Ohm, 1% WW	2	R31, R32
20.	217682	RES. 16.8K, 1% M.F.	1	R30
19.	216813	RES. 681K, 1% M.F.	1	R29
18.	210200	RES. 20 Ohm, 1% M.F.	1	R25
17.	212001	RES. 2.00K, 1% M.F.	3	R21, R22, R23
16.	212493	RES. 249K, 1% M.F.	1	R18
15.	211002	RES. 10.0K, 1% M.F.	1	R14
14.	211822	RES. 18.2K, 1% M.F.	4	R11, R13, R24, R27
13.	200472	RES. 4.7K, 1/4W, 5%	4	R9, R10, R12, R28
12.	212004	RES. 2 Meg Ohm, 1%, M.F.	3	R6, R8, R20
11.	211001	RES. 1.00K, 1% M.F.	1	R26
10.	114047	I.C., CD4047	1	U16
9.	611005	REGULATOR, 79L05, -5V	1	U15
8.	610005	REGULATOR, 78L05, +5V	1	U14
7.	611015	REGULATOR, 79L15, -15V	1	U13
6.	610015	REGULATOR, 78L15, +15V	1	U12
5.	120080	I.C., LM1308ON	1	U10
4.	120412	I.C., LF412	2	U9, U11
3.	190201	I.C., DG201CJ	1	U8
2.	120339	I.C., LM339	1	U7
1.	192601	I.C., HCPL 2601	6	U1 thru U6 (SEE NOTE 13)

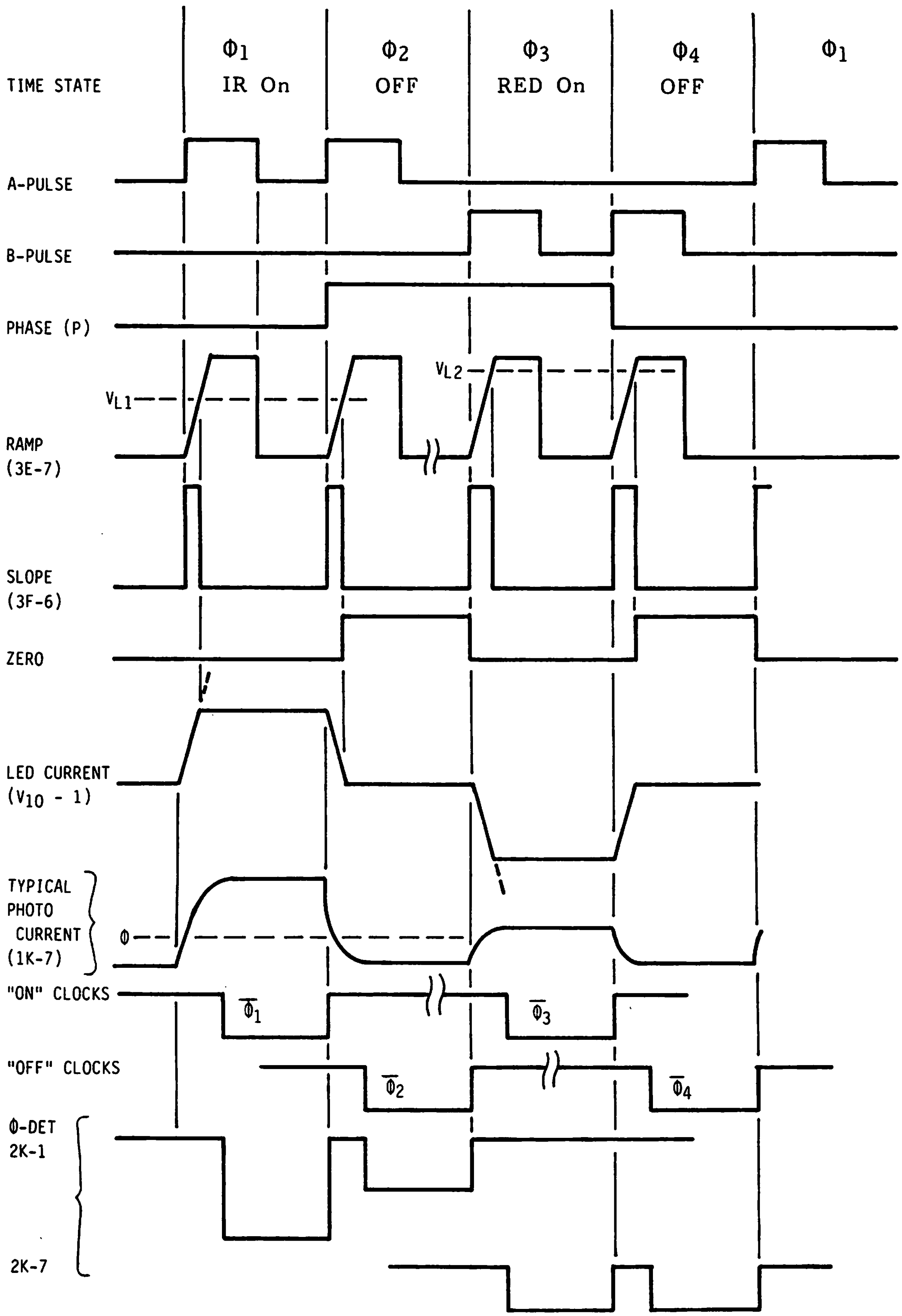
NOTES:

1. Orient I.C.'s with Pin 1 to Square Pad.
2. Polarized Capacitors to be mounted with Positive (+) side to Square Pad.
3. Color Code Resistors to be Left or Up as appropriate.
4. All Capacitors and Precision Resistors to be mounted with value visible.
5. Diodes to be mounted with banded (Cathode) side to Square Pad.
6. R31 and R32 to be spaced above Board 1/8" ±1/16".
7. Solder Terminals of each Transformer Assy, Item's 45, 46 and 47, to PCB matching Pin 1's (shorter Terminal).
8. Do not load Q5, Transistor 2N3646. Place jumper between square and middle pads. Do not load R15, Resistor 10.0K, 1%. REWORK: Remove R15 and Q5, adding jumper as stated.
9. Load Q7, 2N4403, opposite silkscreen layout. REWORK: Remove and reinsert.
10. Add Capacitor, 47pf (52), C29, between exposed lead of R13 and center lead of Q7, adding Teflon tubing to leads and Tak-pak body of Capacitor to I.C., U10.
11. Use P/N 217501 (Resistor 7.5K, 1%) until P/N 291018 available. REWORK: Do not change R17 and R19 to 10.0K, .1% resistor.
12. MOUNT TRANSISTORS Q9 AND Q10 PER DETAIL B. Q9 SHOULD TILT NO MORE THAN 10° EITHER SIDE.
13. FOR REVISIONS A thru E: Rework boards required as follows (Ref EO #902):
    Change U1 thru U5 from 193600 (HCPL3600/2600A) to 192601 (HCPL2601).
    Change R1 thru R5 and R7 from 1K, 1% to 510 Ohm.
    If only one IC is changed, the corresponding Resistor must be changed. MATRIX: U1-R4, U2-R5, U3-R7, U4-R1, U5-R3, U6-R2.

REFERENCE NOTE:

1. Reference "MADIC" Bill of Materials 991076 for outside Vendor processing of PCB Assembly.

PATIENT ISOLATION PCB ASSEMBLY



TIMING DIAGRAM, OXIMETER