NELLCOR®

OPERATOR'S MANUAL

NELLCOR® N-200
Pulse Oximeter

To contact Nellcor's representative: In the United States, call 1-800-NELLCOR or 510 463-4000; outside of the United States, call Nellcor's local representative.

Caution: Federal law (U.S.) restricts this device to sale by or on the order of a physician.

066515-0203

Tyco Healthcare Group LP
Nellcor Puritan Bennett Division
4280 Hacienda Drive
Pleasanton, CA 94588 USA
Toll Free: 1.800.NELLCOR

Authorized Representative
Tyco Healthcare UK LTD
154 Fareham Road
Gosport, PO13 OAS, U.K.

To obtain information about a warranty, if any, for this product, contact Nellcor Technical Services or your local Nellcor representative.

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SAFETY INFORMATION

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WARNINGS

General

DANGER! Explosion hazard. Do not use in the presence of flammable anesthetics.

The N-200 is to be operated by qualified personnel only. Before use, carefully read this manual, accessory directions for use, all precautionary information, and specifications. The user must check that the equipment functions safely and see that it is in proper working condition before being used.

The N-200 is intended only as an adjunct in patient assessment. It must be used in conjunction with clinical signs and symptoms.

Do not use pulse oximeters during magnetic resonance image (MRI) scanning. Adverse reactions include: potential burns to patients as a result of contact with attachments heated by the MRI RF pulse; potential degradation of the MR image; and, potential reduced accuracy of oximeter measurements. Always remove oximetry devices and attachments from the MR imaging environment before scanning a patient.

For preamplification requirements, only an N-200 patient module should be used with the N-200 pulse oximeter. Do not use any other patient module (for example, the N-100 patient module).

Alarms

Do not silence the audible alarm or decrease its volume if patient safety could be compromised.

Check the audible alarm silence duration before temporarily silencing the audible alarm.

Each time the monitor is used, check alarm limits to ensure they are appropriate for the patient being monitored.

Electrical

Electric shock hazard. Cover to be removed only by qualified service personnel. There are no user-serviceable parts inside.

Note: Do not connect to an electrical outlet controlled by a wall switch because power to the monitor could be inadvertently turned off.

Sensors

Before use, carefully read the sensor Directions for Use.

Use only oxygen transducers (sensors). Use of other oxygen transducers may cause improper oximeter performance.

Tissue damage can be caused by incorrect application or use of a sensor (for example, wrapping the sensor too tightly or applying supplemental tape). Inspect the sensor site routinely to ensure skin integrity and correct positioning and adhesion of the sensor. If skin integrity changes, move the sensor to another site.

Inspect the sensor and cable for fraying, cracking, breakage, or other damage. If defects are noted, do not use the sensor. Do not immerse sensor completely in water, solvents, or cleaning solutions (because the connector is not waterproof). Do not sterilize by irradiation, steam, or ethylene oxide.

Measurements

Loss of pulse signal can occur for the following reasons:

- **The sensor is too tight.**
- **There is excessive illumination, such as from sunlight or a surgical or bilirubin lamp.**
- **The sensor is placed on an extremity with a blood pressure cuff, arterial catheter, or intravascular line.**
- **The patient is in shock, has hypotension, severe vasoconstriction or anemia, hypothermia, arterial occlusion proximal to the sensor, or cardiac arrest.**

Inaccurate measurements may be caused by:

- **Incorrect application or use of a sensor.**
- **Significant levels of dysfunctional hemoglobins, such as carboxyhemoglobin or methemoglobin.**
- **Significant levels of indocyanine green, methylene blue, or other intravascular dyes.**
- **Exposure to excessive illumination, such as surgical lamps (especially ones with a xenon light source), bilirubin lamps, fluorescent lights, infrared heating lamps, or direct sunlight. Exposure to excessive illumination can be corrected by covering the sensor with a dark or opaque material.**
- **Excessive patient movement.**
- **Venous pulsations.**
- **High-frequency electrosurgical interference and defibrillators.**
- **Placement of the sensor on an extremity that has a blood pressure cuff, arterial catheter, or intravascular line.**

SYMBOLS

Attention: Refer to Manual

Fuse Replacement Symbol

Caution: Shock Hazard

QUICK GUIDE TO OPERATION

Basic Operation
Alarm Functions
Pulse Tone Volume

BASIC OPERATION

1. Select the appropriate sensor and apply it to the patient, following sensor directions for use. Connect the sensor to the patient module.

2. Plug the N-200 into a properly grounded AC outlet using a hospital-grade power cord. Alternatively, operate the N-200 on its internal battery. Turn on the system: switch the ON/STDBY switch to the ON position.

3. For ® ECG synchronization, connect an appropriate ECG signal source to the N-200.

4. Check alarm limits. If necessary, adjust them to suit the patient's needs.

ALARM FUNCTIONS

Check Alarm Limits

Press the appropriate alarm button (HIGH SAT, LOW SAT, HIGH RATE, or LOW RATE). When the button is pressed, the selected limit will show in the display.

Adjust Alarm Limits

Press the appropriate alarm button (HIGH SAT, LOW SAT, HIGH RATE, or LOW RATE), and turn the control knob until the desired setting appears.

Adjust Alarm Volume

Simultaneously, press the LOW SAT and HIGH SAT buttons. Turn the control knob until the desired setting appears in OXYGEN SATURATION display. Pushing the LOW SAT and HIGH SAT buttons activates the audible alarm to indicate volume.

Silence Alarm Temporarily

Press the AUDIO ALARM OFF button. The ALARM OFF indicator lights steadily during the alarm-off period. **Do not silence the alarm if patient safety could be compromised.**

Adjust Alarm Silence Period

Press and hold AUDIO ALARM OFF button and turn the control knob until the desired setting (30–120 seconds) appears in the OXYGEN SATURATION display.

PULSE TONE VOLUME

Turn the control knob to adjust the pulse tone volume.

OVERVIEW

The N-200 pulse oximeter measures functional oxygen saturation of arterial hemoglobin (SpO_2), and pulse rate. The system consists of three components: the N-200 pulse oximeter, an interface/powerbase, and a patient module. The N-200 monitors SpO_2 and pulse rate continuously and noninvasively, with measurements updated at each pulse beat.

The interface/powerbase is a detachable AC power supply and external interface for the N-200. It provides isolated power for operating the monitor and charging its internal batteries. In addition, the interface/powerbase provides analog and digital outputs for external data recording devices and an input for ECG synchronization. A fiber optic output can be used to connect the N-200 to a N-7500 pulse oximetry network. The patient module (models C-13-200, C-20-200, or C-13-200M) provides a connector for the oximetry sensor and provides initial oximetry signal processing; models C-13-200 and C-20-200 also provide an ECG input connector.

Automatic Self-Test and Startup

The N-200 provides immediate use after startup, without need for operator calibration or configuration. It offers:

- Automatic self-test and error messages
- Automatic oximetry calibration
- Visible oximetry display
- An early warning system that provides an audible indicator for both SpO_2 and pulse rate: a tone sounds on each pulse, and its pitch varies with changes in SpO_2
- Operator-configured visible and audible oximetry alarms, with default alarm limits preset for adults or neonates

Oximeter Configurable Settings

The N-200 provides the operator with the capability to tailor the system for specific clinical applications. Capabilities include:

- Audible alarms that can be silenced; the alarm has adjustable volume.
- ECG synchronization that enhances oximetry signal processing during patient movement or for patients with low perfusion.
- Three oximetry operating modes that change measurement averaging time to suit varied clinical applications.
- Oximetry trend memory, with up to 12-hour SpO_2 and pulse rate trend data storage.
- Oximetry and pulse rate event memory, with 1-hour event data storage. Data storage of event memory markers includes: alarm-limit-defined events and user-defined events.
- Analog and digital output of saturation, pulse rate, and pulse waveform data. When an ECG signal is provided to the patient module three-lead ECG connector, the N-200 provides an analog output of the ECG waveform.

WARNING: Do not use the ECG analog output as a trigger for synchronous defibrillation.

PRINCIPLES OF OPERATION

Operating Principles

OPERATING PRINCIPLES

Pulse oximetry is based on two principles: that oxyhemoglobin and deoxyhemoglobin differ in their absorption of red and infrared light (that is, spectrophotometry), and that the volume of arterial blood in tissue (and hence, light absorption by that blood) changes during the pulse (that is, plethysmography). A pulse oximeter determines SpO_2 by passing red and infrared light into an arteriolar bed and measuring changes in light absorption during the pulsatile cycle. Red and infrared low-power light-emitting diodes (LEDs) in the oximetry sensor serve as light sources; a photodiode serves as the photodetector.

Because oxyhemoglobin and deoxyhemoglobin differ in light absorption, the amount of red and infrared light absorbed by blood is related to hemoglobin oxygen saturation. To identify the oxygen saturation of *arterial* hemoglobin, the monitor uses the pulsatile nature of arterial flow. During systole, a new pulse of arterial blood enters the vascular bed, and blood volume and light absorption increase. During diastole, blood volume and light absorption reach their lowest point. The monitor bases its SpO_2 measurements on the difference between maximum and minimum absorption (that is, measurements at systole and diastole). By doing so, it focuses on light absorption by pulsatile arterial blood, eliminating the effects of nonpulsatile absorbers such as tissue, bone, and venous blood.

C-LOCK ECG Synchronization

C-LOCK ECG synchronization: read through motion to provide valid readings for many types of motion. During *C-LOCK* signal processing, the monitor requires two signals that reflect cardiac activity: the electrical pulse from the ECG and the optical pulse from the oximetry sensor.

The delay between the electrical ECG pulse and the optical pulse at the sensor site is relatively stable for a given patient and sensor site. processing takes advantage of this temporal relationship, using the QRS complex as a reference point for identifying the oximetry pulse and for timing SpO_2 measurements. This enhances "good" pulses and minimizes the effect of random artifacts associated with motion and low perfusion.

Automatic Calibration

Because light absorption by hemoglobin is wavelength dependent and because the mean wavelength of LEDs varies, an oximeter must know the mean wavelength of the sensor's red LED to accurately measure SpO_2. During manufacturing, the mean wavelength of the red LED is encoded in a resistor in the sensor. During monitoring, the instrument's software reads this resistor and selects coefficients that are appropriate for the wavelength of that sensor's red LED; these coefficients are then used to determine SpO_2. This resistor is read when the monitor is turned on, periodically thereafter, and each time a new sensor is connected.

Additionally, to compensate for differences in tissue thickness, the intensity of the sensor's LEDs are adjusted automatically.

Functional versus Fractional Saturation

This monitor measures functional saturation—oxygenated hemoglobin expressed as a percentage of the hemoglobin that can transport oxygen. It does not detect significant amounts of dysfunctional hemoglobin, such as carboxyhemoglobin or methemoglobin. In contrast, laboratory hemoximeters report fractional saturation—oxygenated hemoglobin expressed as a percentage of all measured hemoglobin, including measured dysfunctional hemoglobins. To compare functional saturation measurements to those from an instrument that measures fractional saturation, fractional measurements must be converted as follows:

$$\text{functional saturation} = \frac{\text{fractional saturation}}{100 - (\%\,\text{carboxyhemoglobin} + \%\,\text{methemoglobin})} \times 100$$

Measured versus Calculated Saturation

When saturation is calculated from a blood gas partial pressure of oxygen (PO_2), the calculated value may differ from the SpO_2 measurement of a pulse oximeter. This usually occurs because the calculated saturation was not appropriately corrected for the effects of variables that shift the relationship between PO_2 and saturation (Figure 1): pH, temperature, the partial pressure of carbon dioxide (PCO_2), 2,3-DPG, and fetal hemoglobin.

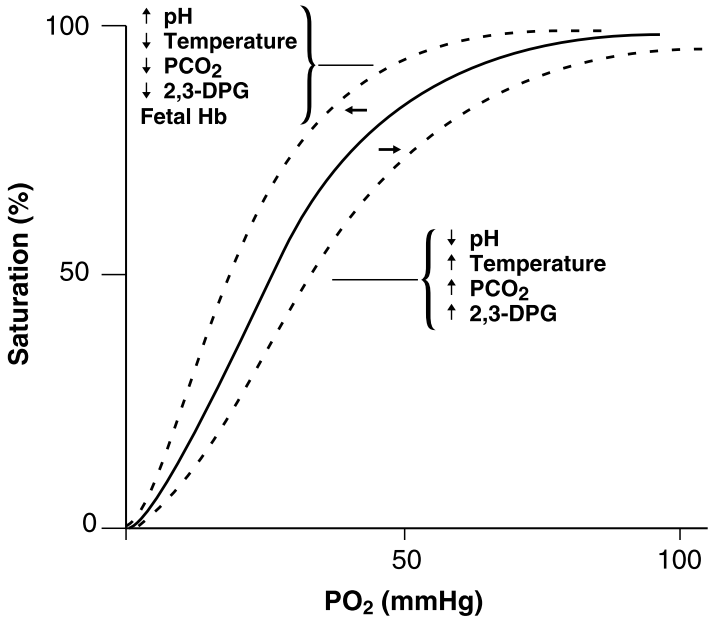

Figure 1: Oxyhemoglobin Dissociation Curve

SETUP

Unpacking and Inspection
Testing
Components

UNPACKING AND INSPECTION

Notify the carrier immediately if the N-200 shipping carton is damaged. Carefully unpack the instrument and its accessories. Confirm that the following items are included:

1 N-200 pulse oximeter

1 interface/powerbase

1 hospital-grade power cord

1 patient module

1 operator's manual

1 guide to operations

Inspect each component. If any component is missing or damaged, contact Nellcor's Customer Service Department or your local Nellcor representative.

TESTING

Verify all functions as described in the
section. If a difficulty occurs, refer to the
section. If that does not resolve the difficulty, contact qualified service personnel or your local Nellcor representative.

COMPONENTS

Display

Two three-digit red alphanumeric displays for oxygen saturation and pulse rate. Sixteen-segment bar graph for pulse amplitude indicator. Indicators for LOW BATT, PULSE SEARCH, HIGH SAT, LOW SAT, HIGH RATE, and LOW RATE alarms, ECG LOST, and AUDIO ALARM OFF. Annunciators for BATT IN USE and ECG IN USE.

Controls

Control knob to adjust volume and set alarm limits, and five buttons to select alarm limits and disable audio alarm.

Rear-panel switches for adult/neonatal alarm settings, analog voltage output range (0–1 V or 0–10 V), analog saturation output scale (0–100% or 50–100%), RS-232 format, baud rate; rear-panel buttons for printing trend and event data, analog full scale output, and analog zero output.

Front Panel

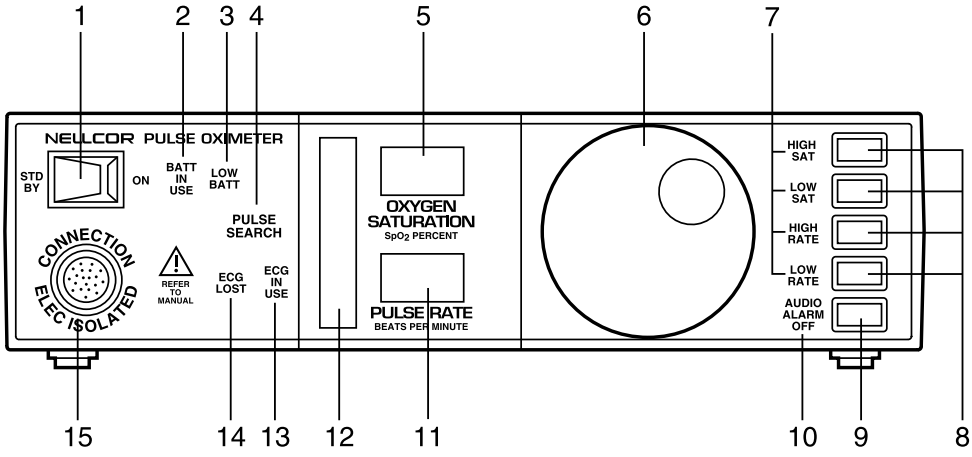

Figure 2: N-200 Front Panel

1. **ON/STDBY switch.**

2. **BATT IN USE indicator.**

3. **LOW BATT indicator:** Flashes when five or fewer minutes of battery power remain.

4. **PULSE SEARCH indicator:** Flashes when the N-200 is attempting to locate the patient's pulse.

5. **OXYGEN SATURATION display.**

6. **Control knob:** Changes instrument settings or limits.

7. **HIGH SAT, LOW SAT, HIGH RATE, LOW RATE indicators:** Flash during an alarm state.

8. **HIGH SAT, LOW SAT, HIGH RATE, LOW RATE buttons:** Display alarm limits.

9. **AUDIO ALARM OFF button:** Temporarily silences audible alarms.

10. **AUDIO ALARM OFF indicator:** Lights steadily when the audio alarm has been temporarily silenced; flashes when the audio alarm has been disabled.

11. **PULSE RATE display.**

12. **Pulse amplitude indicator:** Vertical column of light bars that qualitatively indicates pulse amplitude.

13. **ECG IN USE indicator:** Flashes when the N-200 locates an ECG signal; lights steadily when the N-200 locks onto the signal.

14. **ECG LOST indicator.**

15. **Patient module connection socket.**

Interface/Powerbase Rear Panel

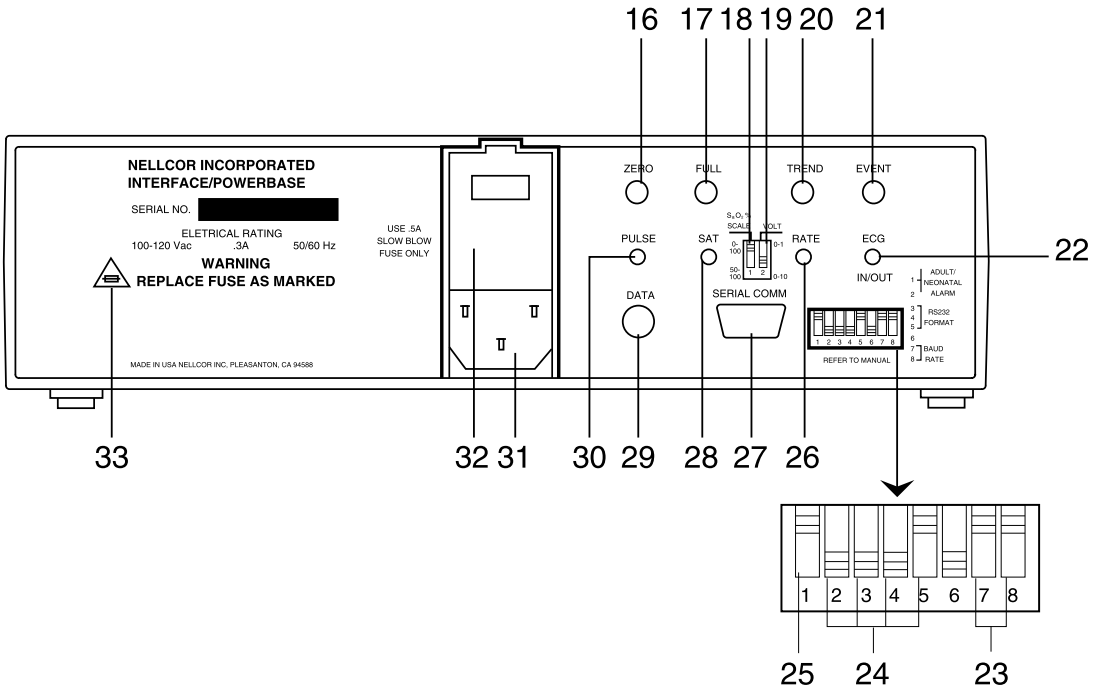

Figure 3: Interface/Powerbase Rear Panel

16. **ZERO button:** Provides a zero-volt signal on PULSE, SAT, and RATE analog outputs.

17. **FULL button:** Provides a full-scale signal on PULSE, SAT, and RATE analog outputs. (The voltage depends on VOLT switch setting).

18. **SpO2% SCALE switch**: Sets the analog output scale for oxygen saturation at 0–100% or 50%–100%.

19. **VOLT switch:** Sets the voltage output range for the analog outputs.

20. **TREND button:** Initiates a trend memory output sequence.

21. **EVENT button:** Initiates an event memory output sequence.

22. **ECG IN/OUT connector**: Provides an analog ECG output signal or can be used for an input from an external ECG monitor.

23. **Baud Rate switches:** Set the baud rate for serial communications.

24. **RS-232 Format switches:** Set the RS-232 format.

25. **Adult/Neonatal Alarm switch:** Sets the default alarm limits for adults or neonates.

26. **RATE connector:** Provides analog voltage output of pulse rate in beats per minute, with a range of 0–250 bpm.

27. **SERIAL COMM connector:** Provides RS-232 digital interface via a 9-pin “D” connector.

28. **SAT connector:** Provides analog output of oxygen saturation data.

29. **DATA connector:** Provides a digital signal via fiber-optic output.

30. **PULSE connector:** Provides analog output of pulse waveform.

31. **AC power inlet.**

32. **Fuse compartment.**

33. **Fuse label.**

Rear-Panel Switches

The rear panel includes eight switches for digital output and adult/neonatal alarm limits.

Table 1: Rear-Panel Dip Switch

Switch Section	Function
1	Adult/neonatal alarm settings
2, 3, 4, 5	RS-232 format
6	Not used
7, 8	Baud rate select

C-13-200 and C-20-200 Patient Modules

Caution: Use only an N-200 patient module. Using an N-100 patient module may adversely affect oximeter performance.

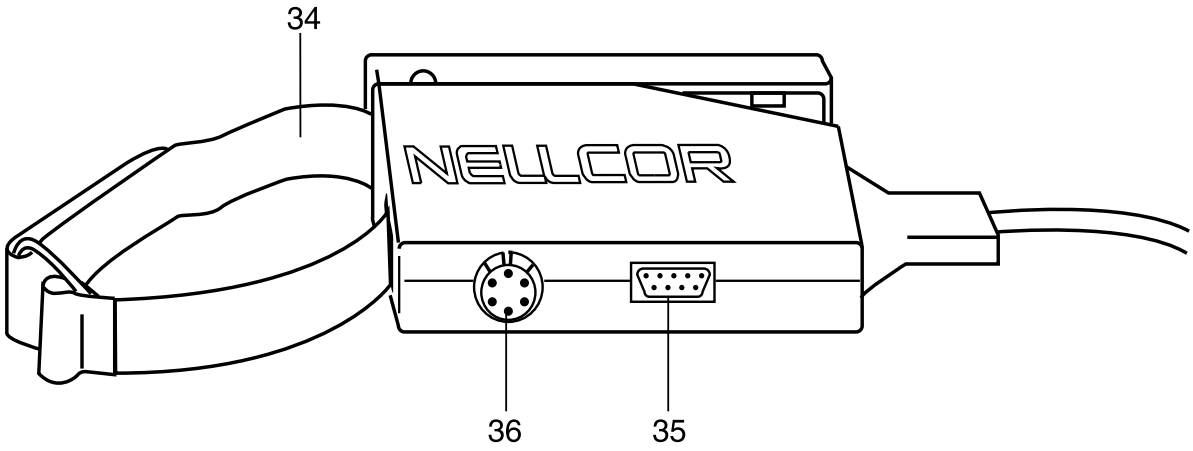

Figure 4: C-13-200 and C-20-200 Patient Modules

34. **Self-adhering strap**

35. **Sensor connector:** For sensors.

36. **ECG connector:** For a Nellcor-approved ECG cable.

C-13-200M Patient Module

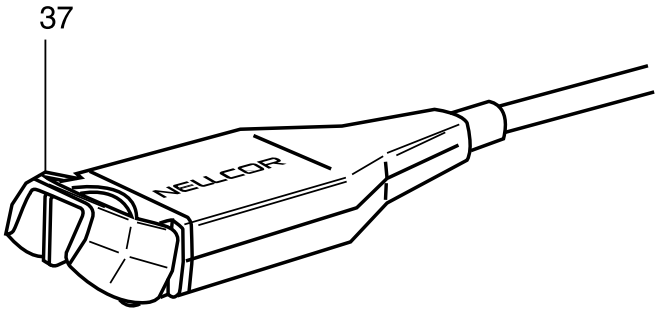

Figure 5: C-13-200M Patient Module

37. **Sensor lock and connector:** For sensors; includes lock to hold sensor in place.

NELLCOR SENSORS

WARNING: Use only oxygen transducers (sensors). Other oxygen transducers may cause improper oximeter performance.

WARNING: Before use, carefully read the sensor directions for use.

SELECTING A *NELLCOR* SENSOR

When selecting a sensor, consider the patient's weight and activity, the adequacy of perfusion, the available sensor sites, the need for sterility, and the anticipated duration of monitoring. For more information, refer to Table 2 or your local Nellcor representative.

Table 2: Selected *NELLCOR* Sensors

Oxygen Transducer	Model	Patient Weight
or	N-25	<3 kg, >40 kg
(sterile, single use)	I-20	3 to 20 kg
	D-20	10 to 50 kg
	D-25(L)	>30 kg
	R-15	>50 kg
(sterile, single use)	A	>30 kg
	P	10 to 50 kg
(nonsterile, reusable)	D-YS	>1 kg
(nonsterile, reusable)	OXI-A/N	<3 kg, >40 kg
	OXI-P/I	3 to 40 kg
(nonsterile, reusable)	DS-100A	>40 kg
reflectance sensor (nonsterile, limited reuse)	RS-10	>40 kg

CLEANING AND REUSE

Caution: Do not sterilize any sensor or adhesive by irradiation, steam, or ethylene oxide, and do not immerse in water or cleaning solutions.

Clean the surface of reusable sensors by wiping with an agent such as 70% isopropyl alcohol. When using adhesive sensors, use a new adhesive sensor, wrap, or bandage for each patient.

PERFORMANCE CONSIDERATIONS

Always select an appropriate sensor, apply it as directed, and observe all warnings and cautions.

If ambient light affects performance, ensure that the sensor is properly applied, and cover the sensor site with opaque material. Failure to do so may result in inaccurate measurements. Light sources that can affect performance include surgical lights (especially those with a xenon light source), bilirubin lamps, fluorescent lights, infrared heating lamps, and direct sunlight.

If patient movement presents a problem, verify that the sensor is properly and securely applied; move the sensor to a less active site; use an adhesive sensor that tolerates some patient motion; or use a new sensor with fresh adhesive backing.

If the patient is unavoidably active, consider using ECG synchronization. If this is not possible, consider using Mode 3 (refer to “Oximetry Operating Modes” in the section).

If poor perfusion affects performance, consider using an R-15 adult nasal sensor or a RS-10 reflectance sensor. The R-15 obtains measurements from an artery supplied by the internal carotid, the nasal septal anterior ethmoid artery; therefore, the R-15 may obtain measurements during low peripheral perfusion. The RS-10 obtains measurements from the forehead or temple, areas that may be spared when peripheral perfusion is poor.

GUIDE TO OPERATION

Basic Operation
Pulse Oximetry Subsystem Features

BASIC OPERATION

1. Place the interface/powerbase on a flat, stable surface. Align the N-200 with the interface/powerbase. Push the N-200 straight in until its latches engage.

   Note: The manual applies to all N-200 monitors and powerbases having software versions 2.7.3 or higher (see “Determining Software Version” in the section).

2. Plug in the power cord to the N-200 power inlet and to an outlet supplying the appropriate mains voltage. Use only an outlet that has a grounding connection and the original hospital-grade plug and cord or an equivalent hospital-grade plug and cord. If in doubt about the integrity of the grounding of the mains supply connection, the unit must be operated from its internal battery.

   The N-200 can operate on battery power. Typically, a new fully charged battery will provide 90 minutes of operation. Age and usage will affect battery performance. The interface/powerbase operates only on AC power.

3. Align the red dot on the patient module connector with the red dot on the patient module connection socket. Push the connector straight in until it locks; Use only C-13-200, C-20-200, or C-13-200M patient modules.

4. If using ECG synchronization, provide an appropriate ECG signal. See “ ECG Synchronization” later in this section for instructions.

5. Apply an appropriate sensor in accordance with its Directions for Use. Plug the sensor into the patient module. With a C-13-200M patient module, close the sensor lock over the plug.

6. Turn on the N-200 using the ON/STDBY switch. After a few seconds, following successful completion of the self-test, measurements are displayed.

   A beep signals each pulse beat, and its pitch increases and decreases to reflect changes in SpO_2. If the oximetry pulse signal is lost and pulse is measured only from the ECG, the pulse tone changes from a beep to a warble.

7. Check the alarm limits each time the N-200 is used by sequentially pressing the HIGH SAT, LOW SAT, HIGH RATE, and LOW RATE buttons.

8. Adjust the alarm limits if necessary. Press and hold the appropriate alarm button, and turn the control knob until the desired value is displayed. SpO_2 alarm limits may be set from 20% to 100%. Pulse rate alarm limits may be set from 20 to 250 beats per minute. The upper limit must be higher than the lower limit.

   Note: When the N-200 is turned off and back on, all operator-adjustable features return to their default state.

PULSE OXIMETRY SUBSYSTEM FEATURES

The pulse oximetry subsystem of the N-200 measures and displays SpO_2 and pulse rate, and provides data for alarms and for the trend memory.

Pulse Tone

When a sensor is connected to the N-200 and a patient, the pulse beat is signaled by a beep that varies in pitch to reflect changes in oxygen saturation, rising as saturation increases and falling as it decreases.

When the N-200 is receiving only an ECG-derived signal (no sensor-derived optical signal), each detected R-wave is signaled by a high-pitched tone that has a slight warble. This tone is distinct from any beep heard when a sensor-derived signal is present. The pitch of the warbling tone that accompanies an ECG-derived signal is related to oxygen saturation.

The pitch of the warbling tone is also significantly higher than any beep that reflects oxygen saturation.

Changing Pulse Tone Volume
Turn the control knob to adjust pulse tone volume. When the N-200 is turned off and back on again, the pulse tone returns to its default volume.

Alarm Functions

WARNING: When the AUDIO ALARM OFF button has been pressed and the AUDIO ALARM OFF indicator is illuminated, no audio alarm sounds in the event of an adverse patient condition. The AUDIO ALARM OFF button must not be used in situations in which patient safety could be compromised.

Audio and visual alarms can be set for high and low oxygen saturation, high and low pulse rate, loss of pulse, and visual alarm for loss of ECG. Audio alarms are interrupted briefly for detected pulses and the volume is adjustable. Audio alarms can be disabled for a 60-second period by pressing the AUDIO ALARM OFF button; the disable period is adjustable between 30–120 seconds, or disabled indefinitely by setting the alarm silence period to OFF. The alarm silence indicator blinks continuously when the audible alarm has been disabled.

Alarm States
If the oxygen saturation level or pulse rate moves beyond the alarm limits, the corresponding alarm indicator flashes, the appropriate display flashes, and an audio alarm sounds (unless or until it has been silenced).

If the alarms activate because the pulse signal is lost, the OXYGEN SATURATION and PULSE RATE displays flash 0, the PULSE SEARCH indicator flashes, and an audio alarm sounds (unless or until it has been silenced). If ECG synchronization is in use and an ECG signal can still be detected, PULSE RATE continues to be displayed.

If alarms activate because the sensor or patient module is disconnected, the displays become blank, the PULSE SEARCH indicator flashes, and an audio alarm sounds (unless or until it has been silenced). If is in use, only the OXYGEN SATURATION display becomes blank.

If the alarm activates because the ECG signal is lost, the ECG LOST indicator flashes. This is accompanied by a single low pitch beep to alert the user.

The audio alarm function can be altered in several ways: it can be silenced temporarily, it can be disabled, and its volume can be adjusted. The visible alarm cannot be turned off.

Checking Alarm Limits
Check the alarm limits each time the N-200 is used, by sequentially pressing the HIGH SAT, LOW SAT, HIGH RATE, and LOW RATE buttons. The unit displays each limit in turn.

Adjusting Alarm Limits
To adjust the alarm limits to meet a specific patient's needs, press and hold the appropriate button (HIGH SAT, LOW SAT, HIGH RATE, or LOW RATE), and turn the control knob until the display shows the desired value. Oxygen saturation alarm limits may be set for any value from 20% to 100%, and the pulse rate alarm limits may be set for any value from 20 to 250beats per minute. The upper limit must be higher than the lower limit.

Note: When the operator turns the N-200 off and back on again, alarm limits return to default values.

Default Alarm Limits
Default alarm limits are in effect when the N-200 is turned on. There are two sets of default alarm limits, one for adults and one for neonates as shown in Table 3.

Table 3: Default Alarm Settings

Alarm Limit	Adult Setting	Neonatal Setting	Adjustable Range
High oxygen saturation	100%	95%	20–100
Low oxygen saturation	85%	80%	20–100
High pulse rate	140 bpm	200 bpm	20–250
Low pulse rate	55 bpm	100 bpm	20–250

Note: When the operator turns the N-200 off and back on again, alarm limits return to default values.

To determine whether the default alarm limits are set for an adult or a neonate, press the HIGH SAT button immediately after turning on the N-200. If the instrument is set for an adult, `100` appears in the OXYGEN SATURATION display; if it is set for a neonate, `95` appears.

Changing From Adult to Neonatal Alarm Limits
To change the adult/neonatal setting, move the adult/neonatal alarm switch UP to change the setting to adult default limits, DOWN for neonatal default limits. Turn the N-200 off and back on to reset default settings (refer to Table 1).

Note: When changing settings, the N-200 must be operating on AC power for the change to be implemented.

Adjusting Audio Alarm Volume

WARNING: Do not set the alarm volume too low to be heard.

WARNING: When the AUDIO ALARM OFF button has been pressed and the AUDIO ALARM OFF indicator is illuminated, no audio alarm sounds in the event of an adverse patient condition. The AUDIO ALARM OFF button must not be used in situations in which patient safety could be compromised.

To adjust audio alarm volume, press and hold both the HIGH SAT and LOW SAT buttons, and turn the control knob clockwise to increase the volume or counterclockwise to decrease it.

Silencing the Audio Alarm Temporarily

WARNING: If the operator silences the audio alarm during a pulse search alarm, then the audio alarm will not resume at the end of the alarm silence period, even if the pulse search event is continuing. If the alarm has been silenced, the operator should continue to visually check whether a pulse is being displayed.

To silence the audio alarm for 60 seconds, press the AUDIO ALARM OFF button once. The AUDIO ALARM OFF indicator lights steadily to show that the audio alarm has been silenced temporarily. After 60 seconds, the alarm sounds again if the alarm state continues.

Adjusting the Temporary Silence Period

To change the period during which the audio alarm is silenced temporarily, press and hold the AUDIO ALARM OFF button, and turn the control knob until the desired period appears in the OXYGEN SATURATION display. Release the button. This period can be set for any value between 30 and 120 seconds.

Disabling the Audio Alarm

WARNING: In normal operation, the AUDIO ALARM OFF button temporarily silences the alarm. Although the audible alarm can be disabled as described, do NOT disable it if patient safety could be compromised.

To disable the audio alarm, press and hold the AUDIO ALARM OFF button, and turn the control knob clockwise until OFF appears on the OXYGEN SATURATION display. The AUDIO ALARM OFF indicator light flashes continuously while the audio alarm is disabled. The audio alarm can be reactivated by pressing the AUDIO ALARM OFF button again.

Note: When the operator turns the N-200 off and back on again, the audio alarm is automatically reenabled and the alarm silence period returns to the default of 60seconds.

Oximetry Operating Modes

The three operating modes of the N-200 enable it to make accurate measurements despite differing levels of patient activity. In all three modes, the N-200 updates its measurements with every pulse beat. Data from the most recent beat replaces data from the oldest beat, and new averages are determined and displayed.

Mode 1, the default operating mode, uses a 5- to 7-second averaging time and is useful in situations in which the patient is relatively inactive. If the patient is unavoidably active, use ECG synchronization. If this is not possible, use Mode3.

Mode 2 uses a 2- to 3-second averaging time and therefore is more affected by patient motion. It is useful for special applications that require a fast response time, such as sleep studies.

Mode 3 uses a 10- to 15-second averaging time and consequently is least affected by patient motion. In this mode, pulse rate is not displayed and there is no pulse tone.

Changing Operating Mode

Press and hold the HIGH RATE and LOW RATE buttons. Turn the control knob until the desired value appears in the PULSE RATE display.

C-LOCK ECG Synchronization

WARNING: An ECG monitor output that is delayed by more than 40 milliseconds from the actual QRS complex may prevent the N-200 from calculating and displaying saturation or may display inaccurate measurements. If this condition is observed, disconnect the patch cord and use the N-200 without ECG synchronization, or substitute a different ECG monitor, or connect the patient ECG leads directly to the connector on the C-13-200 or C-20-200 patient module.

To provide reliable saturation measurements in a high-motion environment or when a patient has poor perfusion, the N-200 can use an ECG (R-wave) signal to identify the pulse and synchronize the saturation measurements.

Connecting the ECG Signal

The N-200 monitor can receive an ECG signal either directly from the patient by a conventional three-lead ECG cable connected to a patient module connection, or from a bedside ECG monitor by the proper patch cord. For proper operation, only a Nellcor-approved three-lead ECG cable from the monitored patient should be connected to a C-13-200 or C-20-200 patient module ECG connector. Do not connect any other signal, such as the output from an ECG monitor, to this connector.

Signal Requirements

For signals from a bedside ECG monitor, the peak of the ECG signal must be between 0.5 and 15volts. The QRS complex must be at least 10 milliseconds wide at 50% of peak amplitude. To ensure optimal performance, the output signal should be delayed by no more than 40milliseconds from the actual QRS complex. For direct, patient-connected ECG signals, the R-wave amplitude must be between 0.5 and 5.0millivolts.

Lost ECG Signal
If the ECG signal is lost or deteriorates to the extent that the N-200 can no longer track it, the ECG LOST indicator flashes. When the ECG signal is lost, oximetry measurements will continue to be derived from the optical sensor signal. During this time the N-200 continues to search for an ECG signal, and, when it finds an adequate signal, ECG synchronization again becomes active. To cancel the ECG LOST indication, press the AUDIO ALARM OFF button.

When using ECG synchronization, either an electrosurgical unit or significant upper-body muscular activity may disrupt the ECG signal and cause the N-200 to begin using the optical signal alone for obtaining measurements. When an adequate ECG signal is again available, ECG synchronization resumes functioning automatically.

Direct, Low-Level ECG Input
To use direct ECG input, position three conventional electrodes in the standard limb lead configuration as illustrated in Figure6.

When applying the electrodes, follow all appropriate instructions and observe institutional standards. Direct ECG capabilities conform to AAMI standards. For optimal performance, position the RA (right arm) and LA (left arm) electrodes below the lateral aspect of each clavicle. Position the LL (left leg) electrode at the left costophrenic margin in the mid-axillary line. Attach the lead wires to the electrodes, and connect the lead wire pins to the ECG cable, observing correct limb connections.

Finally, plug the ECG cable into the patient module's direct ECG connection socket. This is a standard three-lead ECG connector; a Nellcor-approved three-lead ECG cable should be used.

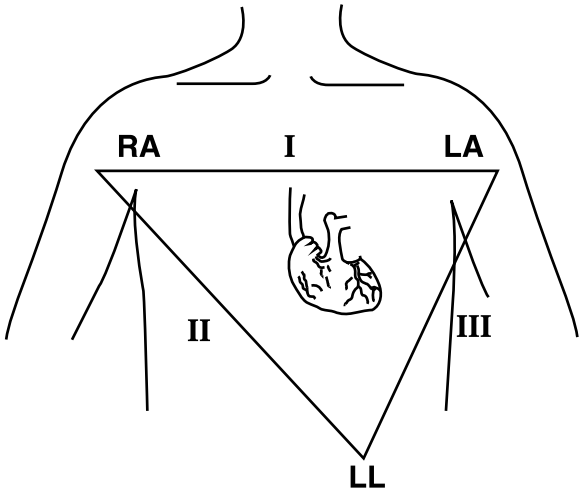

Figure 6: Standard Limb Lead Selection

High-Level ECG Input

To use the signal from a bedside ECG monitor, connect either the defibrillator sync pulse output or the analog ECG waveform output (high-level output) from the external ECG monitor to the interface/powerbase ECG IN/OUT connector. Use only a Nellcor-supplied or Nellcor-approved ECG patch cord and connect the patch cord as described in its Directions for Use. It is important to select the appropriate patch cord for each ECG monitor. If questions arise, contact qualified service personnel or your local Nellcor representative.

Refer to the operator's manual for the ECG monitor before attempting any connection. When using the signal from an ECG monitor, the signal must be connected to the interface/powerbase and it must be operating on AC power.

Testing ECG Patch Cord

WARNING: Before use, confirm that the ECG patch cord connector is compatible with the ECG monitor, and test the patch cord as described in the patch cord Directions for Use. If the patch cord is fabricated at the user's institution, also perform a continuity test before clinical use.

For each ECG monitor to be used with the N-200, test instrument and patch cord function on someone as follows.

1. Position conventional disposable ECG electrodes in the configuration that will be used clinically. (The ECG output signal must have the characteristics previously described.) Use the ECG patch cord to connect the appropriate output of the ECG monitor (ECG out or defibrillator sync) to the interface/powerbase ECG IN/OUT connector. Turn on both instruments.

   Verify that a normal tracing is displayed on the ECG monitor; that the pulse rate displayed by the N-200 is accurate; and that the ECG IN USE indicator lights steadily. Apply a sensor to that same person, following the Directions for Use. Connect the sensor to the patient module, and verify that a saturation value is displayed by the N-200 and that the ECG IN USE indicator lights steadily.

2. Test all instrument functions under both normal and alarm conditions (for example, ECG leads off) to ensure appropriate operation before clinical use (see the operator's and service manuals of the N-200 and the external ECG monitor).

Should problems arise during any test procedure, first check all connections. If that does not resolve the problem, contact qualified service personnel or your local Nellcor representative.

Operation with an ECG Signal

The ECG IN USE indicator flashes when the N-200 locates an ECG signal. When the N-200 locks on to an adequate signal, the ECG IN USE indicator lights steadily. The ECG R-wave is then being used to identify the pulse and synchronize saturation measurements.

Trend and Event Memories

Determining Whether Memories Are Enabled

To determine if trend or event memories are enabled, press HIGH SAT, HIGH RATE, and AUDIO ALARM OFF buttons simultaneously. If trend and event memories are disabled, `t E dis` appears in OXYGEN SATURATION and PULSE RATE displays. If trend and event memories are enabled, `t E on` appears in the displays.

Setting the Clock

Before storing data in the memories initially, set the internal clock as described below.

1. Press and hold the LOW SAT and HIGH RATE buttons simultaneously. The flashing numbers in the OXYGEN SATURATION display are the last two digits of the existing year. While pressing and holding the buttons, turn the control knob until the display shows the correct year. Release the buttons and repeat this step for month, day, hour, and minute.

   Note: Day and minute settings appear in the PULSE RATE display.

   The N-200 sets the year, month, day, hour, and minute sequentially. If more than 5 seconds elapse between any of the steps listed above, the changes made so far are stored and the N-200 starts the sequence again (beginning with year).

2. Allow at least 5 seconds to elapse; check settings by pressing the LOW SAT and HIGH RATE buttons simultaneously, five times in succession.

Trends

Oxygen saturation and pulse rate measurements are sampled every second and the average of the sampled values is computed every 5seconds. That average is then stored in the trend memory. Up to 12hours of this data can be stored. Both trend and event data can be printed in graphic form with either high or low resolution, or output to an external device capable of printing ASCII characters or processing and formatting data.

See the section for further information on available formats.

Printing Trend Data: Data in the trend memory may be printed graphically on a Hewlett-Packard ThinkJet printer with an RS-232 serial interface (model 2225D), or on an analog strip-chart recorder, or by using a N-50 powerbase/ display module. Trend data may also be output in ASCII form to a printer or computer. To print the contents of trend memory, the N-200 must be connected to AC power. The instrument continues to function as a monitor while the trend data is being printed. The data is retained in memory after printing, unless they are erased as described at the end of this section.

Using a ThinkJet Printer: Set up the printer and connect it to the N-200 rear-panel SERIAL COMM connector according to the instructions in the
section. To print trend data in graphic form, set the N-200 RS-232 format switches to graphics mode I or II as described in the same section. In graphics mode I (high resolution) or graphics mode II (low resolution), select either by setting the RS-232 format switches appropriately. Low resolution produces a graph that contains one data point for every 50 seconds of saturation and pulse rate data; high resolution produces a graph that contains one data point for every 5seconds of saturation and pulse rate data. Press the TREND button on the back of the N-200 to begin printing.

When trend data is printed on a ThinkJet printer, up to 12hours of data is printed on one page, with the earliest data in the top left portion of the page. When low resolution is used, each point on the printout represents 50 seconds. When high resolution is selected, the graph will necessarily be more than one page as each dot represents 5 seconds.

The oxygen saturation scale is automatically selected, based on the range of the data: the maximum value is always 100%; the minimum value is 50%, 25%, or 0%. The pulse rate scale is 0 to 250 beats per minute (a narrower range is automatically selected if the data is suited to it.) Time (date, hour, minute) is presented along the horizontal axis.

The following automatic markers appear on ThinkJet trend graphs:

Occurrence	**Marker**
Alarm-limit event	L
User-defined event	E
Power turned off	P
Pulse signal is lost	S
Clock is reset	C
Signal is acquired	A

Whenever an A marker appears, the trend graph ends and a new one begins. If less than 5 minutes elapse, no A marker is printed; instead, the period during which the power was off or the signal was lost is represented on the trend graph by missing data points.

Data is plotted using a fixed time scale on the horizontal axis. The time and date of data acquisition are printed below that axis.

Each event is marked by a tick on the horizontal axis. Identifiers for the events appear in up to four additional lines of text that are printed below the time and date lines. Each identifier consists of a letter that indicates the type of event and its onset time (for example, L3:47 indicates an alarm-limit event that began at 3:47 a.m.). As many identifiers as possible are into these four lines of text, with each identifier approximately aligned with its tick mark on the axis.

If events are very frequent and too closely spaced so that all four lines of text are filled, some identifiers do not print; however, all events are still identified by tick marks. If more than 60 events occurred during the period of time covered by the trend memory, only the last 60 will be identified by type of event and time of occurrence. The remaining events are identified only by tick marks on the horizontal axis. Additionally, there is a limit of 60 minutes of data that can be stored in event memory, regardless of the number of events.

Figure 7 illustrates the trend output from a ThinkJet printer.

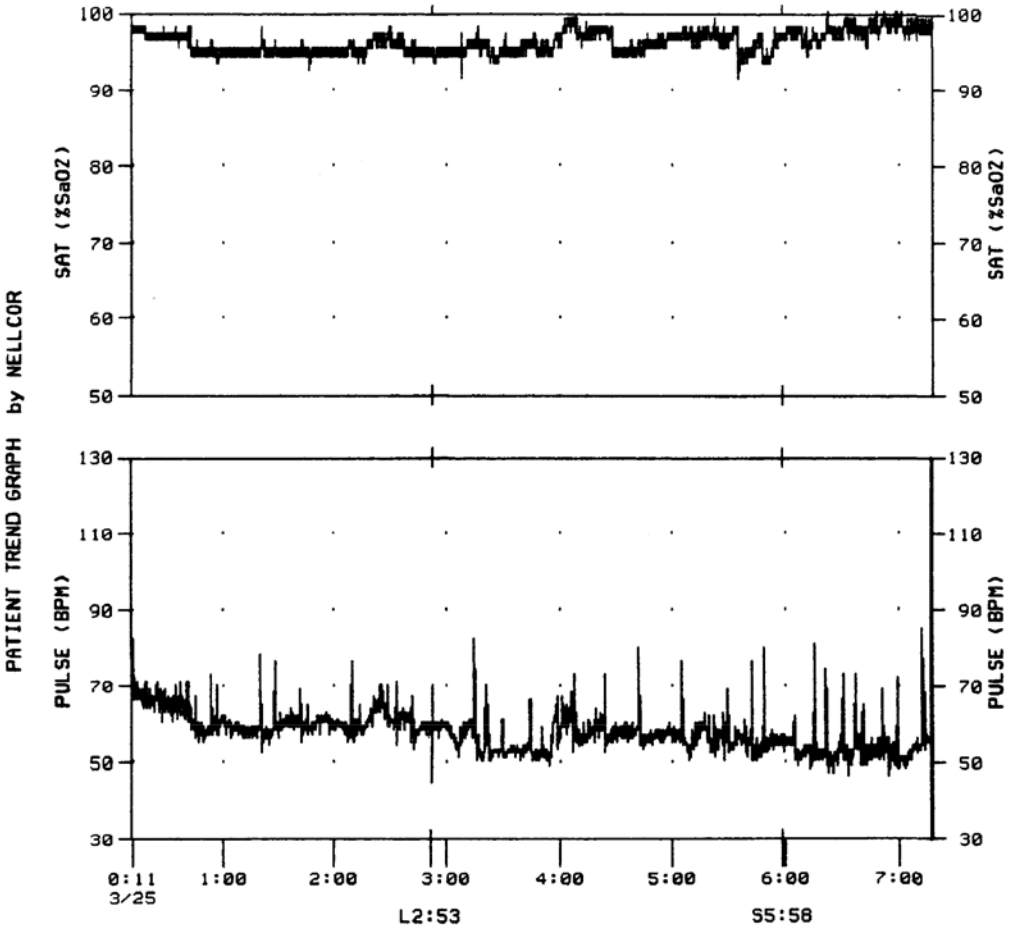

Figure 7: Sample ThinkJet Trend Graph

Note: The graph shows an alarm-limit event at 2:53 a.m. on 3/25 (L2:53) and the signal lost at 5:58 a.m. on 3/25 (S5:58)

Using an Analog Strip-Chart Recorder: Connect the strip-chart recorder to the N-200, as described in the section. Calibrate the recorder, adjust the settings as necessary, and confirm proper operation. If the N-200 is also connected to a graphics printer, that printer must be turned off. Otherwise, the trend memory will be printed by the graphics printer rather than the strip-chart recorder. Do not attempt to print trend data on a N-9000 recorder/interface.

- To print the trend memory, press the TREND button. Data is printed at the rate of approximately 1 hour of data per minute. If prior to printing the trend memory, the strip-chart recorder was printing real-time data, the beginning and end of the trend data are identified by zero-voltage outputs.

- The trend output can be stopped at any time by again pressing the TREND button. To restart it, push the TREND button again—if less than 30 seconds have elapsed, the output continues from the point at which it was stopped; if more than 30 seconds have elapsed, the output starts again at the beginning.

The following automatic markers appear on the trend graphs printed by an analog strip-chart recorder:

Occurrence	Marker
Beginning of trend output	A 1-second, zero-voltage output followed by two full-scale deflections
End of trend output	A 2-second, zero-voltage output
Time when signal is acquired	A full-scale to current-value deflection
Time when pulse signal is lost	A full-scale to current-value deflection
Time when N-200 is turned off	A full-scale to current-value deflection
Event-limit or user-defined event	A full-scale to zero-voltage deflection

Note: The monitor can only store 60 events; if more than 60 occur, only the last 60 will be retained.

Events

The event memory stores a snapshot of concurrent oxygen saturation, pulse rate, and pulse amplitude measurements. During the snapshot, measurements are obtained once every second, resulting in a data display that has higher resolution than the trend memory. Up to 1 hour of event data may be stored. Both trend and event data can be printed in graphic form with either high or low resolution, or output to an external device capable of printing ASCII characters or processing and formatting data. See the section for further information on available formats.

There are two kinds of events: limit events that occur each time the saturation or pulse rate moves beyond the established limits, and user-defined events that the operator initiates.

For a limit event, the snapshot starts 30 seconds before the beginning of the alarm state and ends 30 seconds after the end of the alarm state. If a limit event lasts longer than 60minutes, only the first 60 minutes of data are recorded. For a user-defined event, the snapshot starts 30 seconds before the event is initiated and lasts from 1 to 60 minutes (the operator selects the duration).

User-Defined Events

Initiating a Fixed Duration User-Defined Event

A user-defined event allows the operator to select times during which event data is acquired. Starting 30 seconds before the event is initiated, 1 to 60 minutes of data is stored.

To initiate a user-defined event, press and hold the HIGH RATE and AUDIO ALARM OFF buttons (`UdE 0` appears). Turn the control knob until the `0` is replaced by the desired event duration (1 to 60 minutes). Then release the buttons. The data that is stored in the event memory begins 30 seconds before the buttons are released.

To change the duration of an ongoing user-defined event, press and hold the HIGH RATE and AUDIO ALARM OFF buttons. `UdE n` appears, with `n` representing the number of minutes that remain in the ongoing event.

Turn the control knob until the desired number of minutes appears. Then release the buttons.

To end a user-defined event prematurely, press and hold the HIGH RATE and AUDIO ALARM OFF buttons, and turn the control knob to the left until `UdE OFF` appears. Then release the buttons.

Limit Events

Setting the Limits that Trigger an Event-Limit

Normally, the established alarm limits determine when a limit event occurs (that is, data is stored in the event memory whenever the saturation or pulse rate falls outside the alarm limits).

To set event limits that differ from the alarm limits, the N-200 must be operating on AC power. Press and hold the applicable alarm button (HIGH SAT, LOW SAT, HIGH RATE, or LOW RATE) and the rear-panel EVENT button; while continuing to press and hold the buttons, turn the control knob until the desired setting appears in the display. The saturation event limits may be set for any value from 20% to 100%, and the pulse rate event limits may be set for any value from 20 to 250beats per minute.

To make an event limit equal to the alarm limit again, while the N-200 is operating on AC power, press and hold the applicable alarm button and the EVENT button, and at the same time, turn the control knob to the right until `= AL` appears in the display.

When the N-200 is turned off and back on again, the event limits are reset to the alarm-limit values.

Printing Event Data: Data in the event memory may be printed graphically on a ThinkJet printer with an RS-232 serial interface (model 2225D) or a strip-chart recorder, as described in this section. To print the contents of the event memory, the N-200 must be operating on AC power. The N-200 continues to function as a monitor while the event data is being printed. The data is retained in memory after printing, unless they are erased as described at the end of this section.

Using a ThinkJet Printer: Connect the ThinkJet printer to the N-200, as described in the
section. To print event data in graphic form, set the RS-232 format switches to graphics mode I or II as described in the same section. To print events in graphic form, press the EVENT button on the back of the N-200. The events are printed when the button is released.

When event data is output on a ThinkJet printer, the earliest data is in the top left of the page. The graph begins 30 seconds before the beginning of each event, and an automatic marker identifies the type of event (alarm limit [L] or user-defined [E]). Each marker consists of a tick mark on the horizontal axis, along with a letter that indicates the type of event and the time of onset (for example, E15:10 identifies a user-defined event that began at 3:10 p.m.). New scales are printed for each event. The oxygen saturation scale is automatically selected, based on the range of the data: the maximum value is 100% (the minimum value is 50%, 25%, or 0%). The pulse rate scale is based on the range of the measurements.

Figure 8 illustrates event output on a ThinkJet printer.

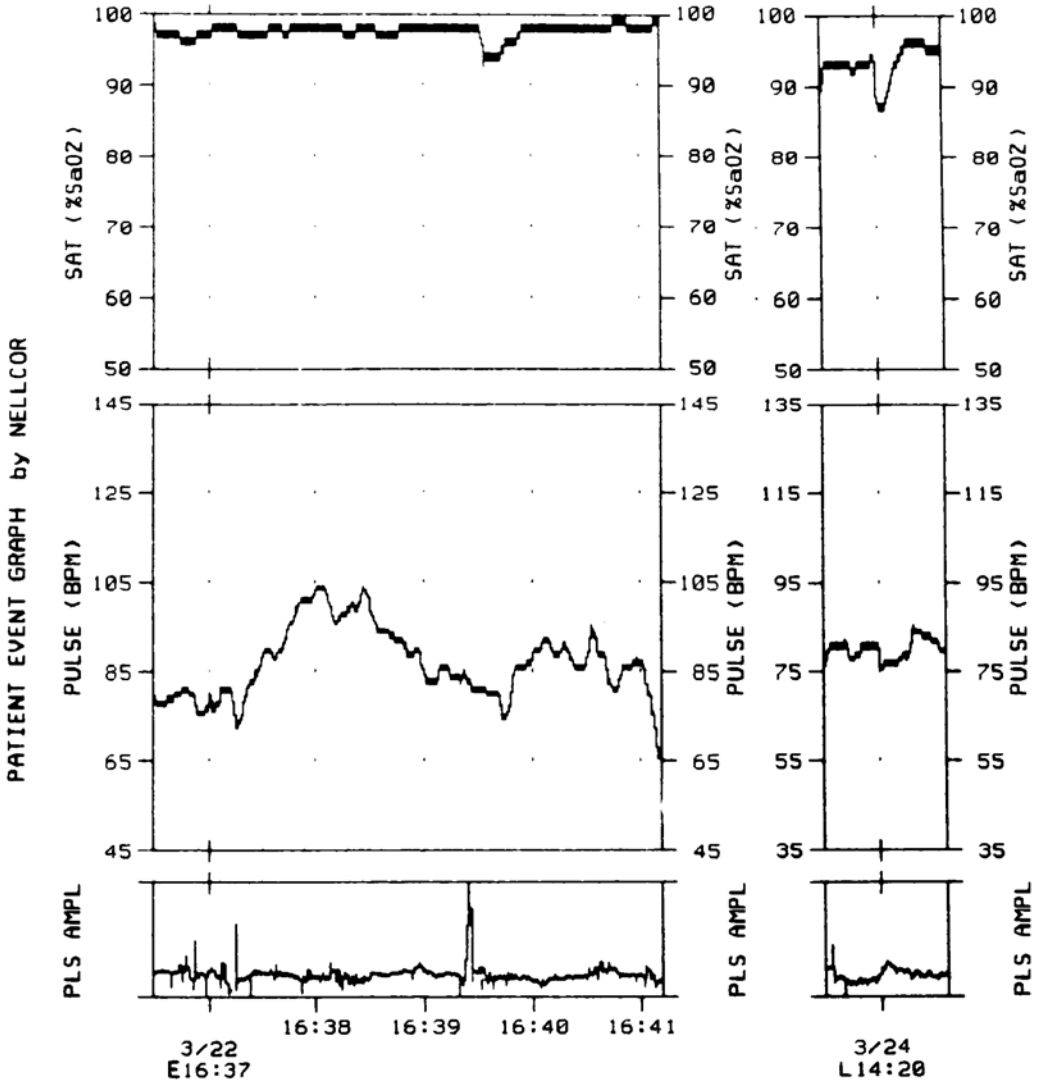

Figure 8: Sample ThinkJet Event Graph

Note: A user-defined event started at 4:37 p.m. on 3/22 (E16:37) and an alarm-limit event started at 2:20p.m. on 3/24 (L14:20).

To Determine the Number of Events in Memory: press and hold the LOW SAT and LOW RATE buttons. If no events are stored in event memory, `no E` is displayed; if 60 or fewer events are stored in event memory, `nn E` is displayed. If more than 60 events occur, only the last 60 are available.

To Print a Specific Event: press the LOW SAT and LOW RATE buttons, and turn the control knob until the identifier for the desired event appears in the display. Then release the buttons and within 10 seconds press the EVENT button. The event is then printed. (Also, pressing the EVENT button for at least 3 seconds and then turning the control knob until the identifier for the desired event appears causes that event to be printed.)

The identifiers for events are the same as those printed on the ThinkJet output: a letter that indicates the type of event, and the hour and minute at which the event started.

Using an Analog Strip-Chart Recorder: Connect the strip-chart recorder to the N-200, as described in the section. Calibrate the recorder, adjust the settings as necessary, and confirm proper operation. If the N-200 is also connected to a graphics printer, that printer must be turned off. Otherwise, the event data will be printed by the graphics printer rather than the strip-chart recorder.

To Print the Event Memory: press the EVENT button on the back of the N-200. Approximately 10 minutes of data is printed each minute. Events are separated by a zero-voltage output on each channel. The earliest event and earliest data are presented first. The following automatic markers appear on the event graphs printed by an analog strip-chart recorder:

Occurrence	Marker
Beginning of the event output (which is 30 seconds before the beginning of the event)	A 1-second, zero-voltage output followed by one full-scale deflection and another 1-second, zero-voltage output
Beginning of the event	Two full-scale to zero-voltage deflections
Time when the signal is acquired	A 2-second, zero-voltage output
Time when the pulse signal islost	A full-scale to current-value deflection
Time when the N-200 is turned off	A full-scale to current-value deflection

The event output can be stopped at any time by again pressing the EVENT button. To restart the output, push the EVENT button again—if fewer than 30 seconds have elapsed, the output continues from the point at which it was stopped; if more than 30 seconds have elapsed, the output starts again at the beginning. While the event output is stopped, there is a zero-voltage output signal.

Do not attempt to print event data on a N-9000 recorder/interface.

Sending Trend and Event Data to ASCII Devices: Trend and event data collected by the N-200 is available to ASCII devices through the SERIAL COMM connector. See section for more information on trend and event data and RS-232 formats.

To Stop an Ongoing Output of Trend or Event Memories: press and hold both TREND and EVENT buttons (`End Prt` appears); while continuing to press and hold the buttons, turn the control knob clockwise until `Prt End` flashes. Release the buttons; `Prt End` lights steadily and the output is canceled.

To avoid canceling the output after starting to do so, before releasing the buttons, turn the control knob to the left until `Prt` appears.

To Erase the Stored Trend and Event Data: press and hold the HIGH SAT and HIGH RATE buttons (`CLr t E` appears in the display); at the same time, turn the control knob to the right until `ALL clr` appears in the display. Then release the buttons. The contents of both memories will be erased.

To preserve the data after starting to erase the memories, while still pressing and holding the buttons, turn the control knob to the left until `not clr` appears. Then release the buttons.

To Disable Trend and Event Memories: simultaneously press the HIGH SAT, HIGH RATE, and AUDIO ALARM OFF buttons and turn the control knob until a flashing `t E diS` appears. If the memories are disabled, reactivate them by pressing and holding the buttons and turning the control knob until a flashing `t E On` appears.

When the memories are disabled, the operator can still trigger a user-defined event, as previously described.

When the N-200 is turned off and back on again, the memories are made active again.

Communications Formats

Of the nine RS-232 formats used with the N-200, six produce ASCII trend and event data output (Full, Conditional Full, Computer, Alternate Computer, Conversation, and Beat-to-Beat). Conversation format is recommended for accessing trend and event data.

WARNING: In Full, Computer, or Beat-to-Beat Formats, real-time data output is inhibited while the trend and event data are being transferred to the ASCII device. The current monitored data for this period is not available.

Full and Conditional Full Formats

These formats are designed for ASCII printer or CRT display output. There are two format variations chosen by switch section 2 (see Table 1).

- If switch section 2 is in the DOWN position (Full format), the once-a-minute RATE/SAT/PULSE line is displayed regardless of alarm conditions.

- If switch section 2 is in the UP position (Conditional Full format), MONITOR STATUS, ALARM ACTIVE, and LIMITS are displayed immediately upon any change in monitor status, limit settings, or alarms.

  Note: Once monitor status has been displayed because of a change in limits or because of an alarm, the RATE/SAT/PULSE line returns to once-a-minute output.

In Full format the following lines appear once a minute:

HH:MM:SS: MONITOR: RATE = nnn %O2 SAT= nnn PULSE AMPL. %FS = nnn

or

HH:MM:SS: MONITOR: NO PULSE DATA

HH:MM:SS is the time set on the N-200's internal clock and %FS is the pulse amplitude expressed as a percentage of full scale.

In Conditional Full format, if alarm status, monitor status, or limits change, one of the preceding lines appears again with the following message, preceded by an asterisk to identify which variable has changed:

MONITOR STATUS:	NORMAL or	SEARCH SENSOR OFF AUDIO ALARM OFF
	and ECG IN USE or ECG NOT IN USE	

Note: If the message ECG UNKNOWN appears instead of ECG IN USE or ECG NOT IN USE, this indicates mismatched software versions in the powerbase and monitor. To determine the powerbase and N-200 software version, refer to the section.

ALARMS ACTIVE:	NONE or LOW SATURATION, HIGH SATURATION, LOW RATE, HIGH RATE
LIMITS:	LOW RATE = nnn HIGH RATE = nnn LOW SAT = nnn HIGH SAT = nnn

If the N-200 is turned off or the interface/powerbase is detached from the monitor, the following sequence is transmitted immediately and again once each minute:

HH:MM:SS: COMMUNICATIONS WITH MONITOR LOST

Computer and Alternate Computer Format
Two computer-compatible digital-output formats are available. Format is selected on the rear-panel DIP switch (see Table 1).

1. Select Computer Format by setting switch section 3 down, 4 up, 5 down.

2. Set switch section 2 up when the N-200 is transmitting data to a Spacelabs 90600-series ECG monitor (Alternate Computer Format). Otherwise, set switch section 2 down (Computer Format).

3. Switch section 2 up (Alternate Computer Format and to some Spacelabs monitors). Once every 10 seconds, and when the status or limits change, the following data is transmitted:

<STX>RnnnSnnnPnnnLnnnHnnnOnnnAnnnMnnnTnnnnnn
Qnnn<CR><LF><ETX><CHKSM><ETX>

Note: STX (start of transmission) and ETX (end of transmission) are shown in hexadecimal equivalents above their positions in the string. CHKSM stands for checksum.

4. Switch section 2 down (normal computer format).

<STX>RnnnSnnnPnnnLnnnHnnnOnnnAnnnMnnnTnnnnnn
Qnnn<CR><LF><CHKSM><ETX>

R = Pulse Rate
S = Saturation %
P = Pulse Amplitude (current sample)
L = Low Rate Alarm Limit
H = High Rate Alarm Limit
O = Low Saturation Alarm Limit
A = Alarm Status in ASCII-coded decimal: logic 1 = alarm condition
Bit 0 = High Rate
Bit 1 = Low Rate
Bit 2 = Low Sat
Bit 3 = High Sat

For example, ASCII 005 = binary 0101 = low sat and high rate alarms.

M = Monitor Status in ASCII-coded decimal.

Bit 0 = Pulse Search Status	1 = Locked	0 = Search
Bit 1 = Sensor Status	1 = Attached	0 = Off
Bit 2 = Audio Alarm Status	1 = Enabled	0 = Disabled
Bit 3 = ECG Status	1 = Not in Use	0 = In Use
Bit 7 = Monitor Communication	1 = Lost	0 = Intact

For example, if the monitor status byte is ASCII 015, (binary 00001111), this means that the monitor is locked on pulse, sensor attached, audio alarms enabled, and ECG not in use.

T = Time hhmmss
Q = High Saturation Alarm Limit
n = ASCII character, normally a number

<CRLF> = Carriage Return and Line Feed
<CHKSM> = 1 Byte Binary Checksum (uncoded)

Conversation Format
In this mode, the output is a single parameter, sent by request only. For example, the computer requests the current pulse rate by sending an R. The interface responds with STX/Rnnn/CR/LF where (nnn is the pulse rate). Other request codes are listed in the preceding section.

Conversation Format is available for all monitor parameters.

N-9000 Recorder Format
This mode is used to communicate with a N-9000 recorder/interface.

Beat-to-Beat Format
This mode transmits saturation and pulse rate data once per beat in the following format:

STXRnnnSnnnCRLF

Trend and Event Command Format: The following information describes the data that will be sent to and received from the N-200. The monitor responds to these commands in any of the six ASCII modes. Common parameters in these expressions are:

Text Marker	Hexadecimal	Meaning of Marker
< STX >	02H	Start of transmission (text)
< ETX >	03H	End of transmission (text)
< CRLF >	0DH, 0AH	Carriage return and line feed

N-200 data packets are described later in this section.

The host device can send one of three commands:

Command: SEND TREND

Device Sends: W< CRLF >

N-200 Responds: < STX > W < CRLF > < ETX > — Sent once when command received.

Z, W, [Y] *

A Z packet, followed by a number of W and Y packets. The number of W packets is given by the first parameter Zn . . . n in the Z packet plus one. The very last (Zn . . . n +1) W packet sent is a guard packet (used for spacing graphics output). The data in this last W-packet is invalid—discard them. Hence, Zn . . . n gives the number of valid W packets or data points. If events have occurred during the trend period, then Y packets will appear spaced among the W packets at the time that the events occurred. The Y packets are not included in the Zn . . . n count.

< STX > E < CRLF > < ETX > — End of data, normal completion

Command: SEND EVENTS

Device Sends: X < CRLF >

N-200 Responds: < STX > X < CRLF > < ETX > — Sent once when command received.

Z, X, [Y] *

*Note: Square brackets indicate optional items.

One or more Z packets, each followed by a number of X and Y packets. Each Z packet marks the beginning of an event period. The number of X packets that follows each Z packet is given by the first parameter Zn . . . n in the Z packet plus one. The very last (Zn . . . n +1) packet sent is a guard packet (used for spacing graphics output). The data in this last packet is invalid and should be discarded.

Hence, Zn . . . n gives the number of valid X packets of data points for each event period.

Thirty seconds (that is, 30 X packets) precede the first Y packet marking the first event. There may be more events following, each represented by a Y packet spaced among the X packets at the time that the events occurred.

< STX > E < CRLF > < ETX > — End of data, normal completion

Command: STOP SENDING

Device Sends: V < CRLF >

N-200 Responds: < STX > V128< CRLF > < ETX > — Sent once when command received.

Note: The Y data packets may occur at any time during the trend or event dump. The positions of the Y packets indicate when the associated event occurred.

The host device must wait for a minimum of 30 seconds after sending the V (stop sending) command before sending another command.

Data Packet Descriptions: The following data packets may be received in trend or event data transmission. For V, W, X, and Z packets, the first field (n . . n) has variable length.

E Packet < STX > E < CRLF > < ETX >

This is the last record sent to indicate end of data in normal completion.

V Packet < STX > Vnnn < CRLF > < ETX >

This is sent only if the N-200 stops before the requested data transmission is complete. It indicates why the N-200 stopped.

nnn	Reason for Stop
4	Timeout error
8	Data error
16	Timed out error
32	Communications lost
64	Data recall error
128	By operator request

W Packet < STX > Wn . . . nSnnnRnnn < CRLF > < ETX >

These are the actual trend data points. Data is sampled every second, so each packet represents 5 seconds of saturation and pulse rate data.

Wn . . . n	Trend data point (n . . . n = current index up to 4 digits)
Snnn	Saturation
Rnnn	Pulse rate

X Packet < STX > Xn . . . nSnnnRnnnPnnn < CRLF > <ETX >

These are the actual event data sampled every second. There is no averaging, so each packet represents 1 second of saturation, pulse rate, and pulse amplitude data.

Xn . . . n	Event data point (n . . . n = current index up to four digits)
Snnn	Saturation
Rnnn	Pulse rate
Pnnn	Pulse amplitude

Y Packet < STX > YnDnnnnnnnn < CRLF > < ETX >

This is the time marker description indicating the type of marker and the time it occurred.

Yn	**Event Type**
0	User-defined event
1	Alarm limit exceeded
2	Patient signal lost
3	Unused
4	Time mark (on hour for trend, on min for event)
5	Power turned off
6	Patient signal acquired
7	Clock reset

Dnnnnnnnn = Time/Date (format mmhhDDMM)

Z Packet < STX > Zn . . . nSnnnsnnnRnnnrnnn < CRLF > < ETX >

This defines the number of data packets, and the maximum and minimum values in the following trend or event information. This can be used for scaling purposes.

Zn . . . n	Starting scale—n . . . n = (number of data points, or number of data packets minus 1—the last W or X packet is a)
Snnn	MAX saturation
snnn	MIN saturation
Rnnn	MAX pulse rate
rnnn	MIN pulse rate

No Real-Time Output Graphics Format
In this mode, there is no output of real-time saturation and pulse rate data. Trend and event data can be transmitted to an output device in low-resolution graphic format, if one is connected. The sign-on message from the powerbase is printed when AC power is first connected.

Graphics Modes I and II
In these modes, the sign-on message is suppressed and there is no output of real-time saturation and pulse rate data. Trend and event data is transmitted to an output device, if one is connected. Data can be output in either high or low resolution.

Transmission of trend and event information can be initiated either by an external command, or with the rear-panel TREND and EVENT buttons. Similarly, transmission can be stopped either by external command, or with the rear-panel buttons.

Upon receiving a command to output either trend or event information, the N-200 checks the serial communications port to see if an ASCII device is connected. If the DSR signal input (pin 6 on the SERIAL COMM connector) is not true, no output occurs. Hence any ASCII device connected to the N-200 must drive the DSR pin 6 to a logic true to output trend and event data to the serial communications port.

Interface/Powerbase

The interface/powerbase is the detachable AC power supply and external interface for the N-200. It provides isolated power for operating the monitor and for recharging the batteries. Also, the powerbase contains the circuits required to communicate with the monitor.

The powerbase provides analog outputs of pulse waveform, oxygen saturation, and pulse rate data, ECG waveform, and a digital output connector (RS-232 serial interface). In addition, it also provides a fiber-optic output connector for use with the N-7000 interface, the ® N-7500 pulse oximetry network, or the N-9000 recorder/interface.

Because the N-200 is patient isolated, the monitor and powerbase communicate through a bidirectional optical link that is established whenever the monitor and powerbase are connected and AC power is supplied. Saturation, pulse rate, pulse waveform, and monitor and alarm status data are transmitted from the monitor to the powerbase where they are translated into analog or digital outputs. ECG input as well as status requests are transmitted from the powerbase to the monitor.

Disconnecting the Powerbase from the Monitor

The monitor can be disconnected from the powerbase for portable use. To do so, place the instrument on a flat, stable surface and firmly push the latches on each side of the monitor, which allows the units to be separated. The analog, digital, and fiber-optic outputs, and ECG/defib sync inputs (from the external monitor) are not available when the powerbase is detached from the monitor or when AC power is not supplied.

To reconnect the units, place them on a flat, stable surface, and position them so that the groove on the powerbase is aligned with the rib on the monitor. Push the powerbase straight in until the latches on the monitor engage.

Battery Operation

If AC power is lost or the interface/powerbase is disconnected, the N-200 operates on its internal battery (typically 90 minutes for a new, fully charged battery). When the battery level is too low to power the instrument reliably, an internal switch turns off the N-200 automatically.

The battery recharges whenever the instrument is plugged into AC power. A minimum of 14 hours is required to fully recharge the battery.

If ECG synchronization is used when the N-200 is operating on battery power, the ECG signal must be supplied directly from the patient through an ECG cable attached to the C-13-200 or C-20-200 patient module. When using battery power, a signal from a bedside ECG monitor cannot be used.

CONNECTING TO OTHER INSTRUMENTS

OVERVIEW

WARNING: When connecting this monitor to any instrument, verify proper operation before clinical use. Refer to the other device's manual for full instructions. Accessory equipment connected to the monitor's analog or digital outputs must be certified according to the respective standards, that is, IEC 950 for data-processing equipment or IEC 601.1 for electromedical equipment and must comply with the requirements for medical systems, IEC 601.1.1. If in doubt, contact Nellcor's Technical Services Department or your local Nellcor representative.

This section contains information to allow the user to provide serial communications between the N-200 and external digital devices.

RS-232 COMMUNICATION PROTOCOL

Serial Data Connector Pin Assignments

Table 4 lists pin assignments on the rear-panel SERIAL COMM connector and the corresponding pin assignments for a 25-pin RS-232 connector.

Table 4: SERIAL COMM Connector Pin Assignments

Connector Pin	Signal	Direction	Output Device Pin	Output Device Signal
1	not used	none	none	none
2	Rx data	←	2	Tx data
3	Tx data	→	3	Rx data
4	DTR	→	6	DSR
5	Signal Ground	↔	7	Signal Ground
6	DSR	←	4	RTS
7	RTS	→	5	CTS
8	CTS	←	20	DTR
9	Alarm Out	→	25	see warning

WARNING: Pin 9 only gives notice of alarm limit violations. It will not alert a remote system of signal loss or sensor disconnection. Do not use this Pin to activate a remote alarm system.

Note: The logic level output of Pin 9 is not intended to activate a remote alarm system. Its use is intended to allow remote sensing of alarm limit events only.

Pin 9 output is less than +0.3 V when no alarm limit is violated and greater than +4.0 V when an alarm limit violation exists. This pin should be connected to a high-impedance circuit (greater than 1 megohm) and protected against transient voltages.

Pin 6 (DSR) must be held high by the connected device if trend and event data are to be output in ASCII format to that device.

Pin 8 (CTS) may be used to control transmission data. When held high (positive voltage), data transmission takes place. When low (negative voltage), data transmission is suspended temporarily.

Communications Formats

The RS-232 format switches are used to set the communication port format, as shown in Table 5. The serial communication format of the N-200 is eight data bits, no parity bit, and one stop bit.

Table 5: Output Format Switch Settings

Format Name	Description	Switch Sections 2	3	4	5
Conversation	Request for parameter	*	Down	Up	Up
Full	Full readable strings for CRT or printer	Down	Down	Down	Up
Conditional Full	Full readable strings for CRT or printer only in alarm condition or when status changes	Up	Down	Down	Up
Computer	Single identifier character plus values (normal format)	Down	Down	Up	Down
Alternate ** Computer	Variation of computer format (above) for Spacelabs 90600 series ECG monitors	Up	Down	Up	Down
Beat-to-Beat	Outputs rate and saturation once per beat	*	Up	Down	Up

* Up or down

** This feature is only available for monitor and powerbase software versions 2.5.0 and higher.

Table 5: Output Format Switch Settings (continued)

Format Name	Description	Switch Sections 2	3	4	5
N-9000 Recorder and N-7000 Interface	Used with N-9000 and N-7000 recorder/ interface units	*	Down	Down	Down
Graphics Mode I	Suppresses sign-on message and real-time data output; trend is output in low resolution graphic form if a printer is connected. Event data is automatically printed in high resolution form.	*	Up	Up	Down
Graphics *** ModeII	Same as Graphics Mode I, but trend data is output only in high resolution graphic form if a printer is connected.	*	Up	Up	Up
No Real-Time Output Graphics Mode	Suppresses real-time data output; low resolution trend and event data is output in graphic form if a printer is connected.	*	Up	Down	Down

* Up or down

*** This feature is only available for monitor and powerbase software versions 2.7.3 and higher.

Setting Baud Rate

Identify the baud rate required by the device that is to be connected, and set the N-200 baud rate using the rear-panel baud rate switches (switch sections 7 and 8). Refer to Table 6.

Table 6: Baud Rate Switch Settings

Baud Rate	Switch Sections	
	7	**8**
1200	Down	Down
2400	Down (off)	Up
9600	Up (on)	Down
19200	Up (on)	Up

CONNECTING THE N-7000 INTERFACE

Note: The N-7000 is not available outside the United States.

The N-7000 provides RS-232 or RS-485 interface capabilities to the N-200. Data from the N-200 is transmitted through a fiber-optic cable to the N-7000. The N-7000 outputs data via a standard 25-pin Dconnector.

Connect the N-7000 to the N-200 as follows:

1. Set the N-200 BAUD RATE switches to 2400 (switch 7 down; 8 up).

2. Set the N-200 RS-232 FORMAT switches to the N-7000/ N-9000 format (switches 3–5 down).

3. Connect the gray end of the fiber-optic cable provided with the N-7000 to the DATA connector on the N-200 powerbase. Connect the blue end to the unlabeled data input connector on the side of the N-7000. Push each connector in until it snaps into place. Route the fiber-optic cable without bending it; poor transmission may occur if the cable is kinked.

CONNECTING TO THE N-7500 NETWORK

Refer to the N-7500 operator's manual for full instructions.

Nellcor's N-7500 pulse oximetry network is a radio-frequency telemetry system that displays data from as many as eight pulse oximeters, such as the N-200, on its central monitoring station. The installed N-7500 includes radio interfaces, connected pulse oximeters, and the central monitoring station.

To connect the N-7500 to the N-200, set the rear-panel DIP switches as follows: switches 3, 4, 5, and 7 down; switch 8 up.

CONNECTING THE N-9000 RECORDER/INTERFACE

Connect the N-9000 to the N-200 as follows:

1. Set the N-200 baud rate switches to 2400 (switch 7 down; 8 up).

2. Set the N-200 RS-232 FORMAT switches to the N-7000/ N-9000 recorder format (switch sections 3–5 down).

3. Connect the gray end of the fiber-optic cable provided with the N-9000 to the DATA connector on the N-200 powerbase. Connect the blue end to the N-9000 connector labeled DATA INPUT. Push each connector in until it snaps into place. Route the fiber-optic cable without bending it; poor transmission may occur if the cable is kinked.

Refer to the N-9000 operator's manual for complete operating instructions.

CONNECTING OTHER STRIP-CHART RECORDERS

A general-purpose strip-chart recorder may be connected to the N-200 to provide a permanent record of oxygen saturation, pulse rate, pulse waveform, ECG data, and/or data in the trend and event memories.

The N-200 analog output connectors are standard 3/32-in. subminiature phone plugs. The output voltage range required by the recorder (0–1 V or 0–10 V) is set with the N-200 VOLTAGE switch. The oxygen saturation output can be set for a 0–100% display or an expanded 50–100% display using the N-200 SpO_2% SCALE switch. The pulse rate output is 0–1 V or 0–10 V, with a range of 0–255 bpm and a resolution of 3.9 or 39mV per beat.

To print oxygen saturation and pulse rate, use the SAT and RATE connectors. Use the ZERO and FULL buttons to generate zero and full-scale voltage signals in order to adjust the recorder controls.

To print the pulse (plethysmographic) waveform, use the PULSE connector; to print the ECG waveform, use the ECG IN/OUT connector. Use the ZERO and FULL buttons to generate zero and full-scale voltage signals at the PULSE connector in order to adjust the recorder controls.

To print trend data on a strip-chart recorder, use the SAT and RATE connectors; to print event data, use the SAT, RATE, and PULSE connectors.

Note: Connect only a high impedance device (1 megohm or higher) to the analog output connectors. Improper loading distorts the correspondence between the measured voltage and the intended output voltage.

CONNECTING THE THINKJET PRINTER

The ThinkJet printer with an RS-232 serial interface (model 2225D) may be used to print the contents of the trend and event memories, as well as to record ongoing saturation, pulse rate, pulse amplitude, and monitor status.

Connect the ThinkJet printer to the N-200 as follows:

1. Set the N-200's baud rate to 19.2 K using the baud rate switches: 7 and 8 up.

2. Set the N-200 format using the RS-232 format switches: 3–4 up, 5 down (Graphics Mode I); or to another desired format.

3. Set the printer's MODE SELECTION switches: 1–5 down, 6 up, 7–8 down.

4. Set the printer's RS-232 switches: 1 up, 2–4 down, 5up.

5. Connect the printer to the N-200 using the interface cable provided by Nellcor with the ThinkJet printer.

WARNING: Provide the ThinkJet with isolated power. If isolated power is not incorporated in the ThinkJet, use a standalone isolation transformer.

6. Provide isolated power (if appropriate), turn on the printer, verify proper operation, and position the paper to start printing near the top of the page.

   Note: If the printer's switch settings are changed while it is turned on, it must be turned off and back on again to implement those changes.

CONNECTING THE P-200 PRINTER

The P-200 printer may be used to print the contents of the trend and event memories, as well as to record ongoing saturation, pulse rate, pulse amplitude, and monitor status.

To use the P-200 with the N-200:

1. Set the N-200 oximeter DIP switches as follows:
   Switches 2, 4, 5, and 8 up
   Switches 3 and 7 down
   Switches 1 and 6 either up or down

2. On the bottom of the P-200, set the DIP switches as follows:
   On the row of eight switches, set 1,2, and 6 down; all others are up
   On the row of six switches, set 4, 5, and 6 down; all others are up

3. Connect the printer to the N-200 using the interface cable provided with the P-200 printer.

4. Turn on the printer and verify proper operation (see the P-200 operator's manual).

MAINTENANCE

SERVICE

WARNING: For continued protection against fire, replace fuses only with those of the same type and rating.

The N-200 requires no routine service other than periodic battery replacement and any performance testing mandated by the operator's institution. The section discusses potential difficulties, their possible causes, and suggestions for resolving them. Complete service instructions, including performance tests checks, are contained in the N-200 service manual.

CLEANING

Caution: Do not immerse the N-200 in liquid or use caustic or abrasive cleaners.

To clean the N-200's surfaces, dampen a cloth with a commercial, nonabrasive cleaner and wipe the top, bottom, and front surfaces lightly. Do not spray or pour any liquid directly on the N-200, interface/powerbase, or their accessories. Do not allow any liquid to come in contact with the power connector, fuse holder, or switches. Do not allow any liquid to penetrate the connectors or openings in the chassis.

BATTERY TESTING

The N-200 is equipped with sealed lead-acid batteries. Battery capacity decreases over time due to several factors, such as temperature, depth of discharge, and number of charge/discharge cycles.

Replacing the battery periodically ensures battery operation when needed. A periodic battery check is also recommended. The interval for this check is at the user's discretion. Depending on how the monitor is used, the user may wish to perform a battery check as often as every 6 months. This check should also include inspecting the battery's physical condition. Any batteries showing leakage or corrosion should be replaced. Qualified service personnel should check the battery following instructions given in the N-200 service manual. Regardless of periodic test results, Nellcor recommends battery replacement every 2 years. Replacement batteries can be purchased through Nellcor's Technical Services Department or your local Nellcor representative.

DETERMINING SOFTWARE VERSION

To determine the N-200 software version, press the HIGH SAT and AUDIO ALARM OFF buttons. A two-digit version number appears in the PULSE RATE display. For example, version 2.7 appears as `27`. It may be necessary to turn the control knob until `0` appears in OXYGEN SATURATION display. To determine the powerbase software version, press the HIGH SAT and AUDIO ALARM OFF buttons again, and turn the control knob to the left until `Pb` appears in the OXYGEN SATURATION display; the version number appears in the PULSE RATE display.

TECHNICAL ASSISTANCE

For technical information or to order parts or a service manual, contact Nellcor's Technical Services Department or your local Nellcor representative. The service manual includes circuit diagrams and a spare parts list, which may be required by qualified personnel when servicing the N-200.

RETURNING THE N-200

If it is necessary to return the monitor to Nellcor, call Nellcor's Technical Services Department for shipping instructions.

To repack the N-200, disconnect the patient module, and wrap each separately. If necessary, the powerbase may be disconnected from the monitor. Each should be wrapped separately. Pack them in the original shipping carton. In case the original carton is not available, use a suitable box with an appropriate amount of packing material. It is not necessary to return sensors or power cords.

STATUS MESSAGES

This section lists status messages, along with the actions that the operator should take. If the recommended actions do not cause the message to disappear, contact qualified service personnel or your local Nellcor representative. The service manual describes additional suggested actions for use by qualified service personnel.

ALL clr
Trend and event memory has been erased.

The N-200 erases and reinitializes the memories if data has been corrupted or were erased. The memories can also be manually cleared and reinitialized. In both cases, the `ALL clr` appears. No further action is necessary.

Note: When `ALL clr` appears because the memory data was corrupted or erased, a simultaneous 5-second alarm sounds.

Note: If the N-200 erases the trend and event memory, a message header appears on the trend graph indicating that the oldest portion of the memory was erased.

CLr t E
Stored trend and event data has been erased by the operator.

Err Pb
The powerbase is not communicating with the N-200. Disconnect the powerbase from AC power, turn the N-200 off and back on again, and reconnect the powerbase to AC power. If this does not solve the problem, contact qualified service personnel.

Note: The instrument will clear the `Err Pb` message if any front-panel button is pushed while the N-200 displays `Err Pb`, but rear-panel buttons and connectors may not operate properly.

Err 1
Defective data memory. Contact qualified service personnel.

Err 2
Defective program memory. Contact qualified service personnel.

Err 3

WARNING: Continue to use the N-200 only in an urgent situation and only if the defective segment or segments have been identified. If a defective segment cannot be identified, do not continue to use the N-200.

Defective display or indicator, or possibly a circuit malfunction. Contact qualified service personnel.

Note: The N-200 may operate if any front-panel button is pressed while `Err 3` is showing. However, if any numeric display segment or indicator is missing, the display or warning indicators may be incorrect.

Err 4
The N-200 lost power without going through the normal shutdown procedure. Turn the ON/STDBY switch to STDBY and back to ON. Contact qualified service personnel if error persists.

Err 5
Hardware error. Contact qualified service personnel.

Note: The N-200 may operate if any button is pressed while `Err 5` is displayed.

Err 6
Battery-backed memory contents have been lost, and the trend memory was erased and reinitialized. The trend memory operates normally as long as the N-200 is turned on, but when the ON/STDBY switch is set to STDBY, the trend memory will be erased. Contact qualified service personnel.

Note: This message may also appear briefly when the N-200 is first turned on after software has been replaced with a different version. No action is required.

t E On
Trend memory is active.

t E diS
Trend memory is disabled.

TROUBLESHOOTING GUIDE

This section discusses potential difficulties and suggestions for resolving them. If the difficulty persists, contact qualified service personnel or your local Nellcor representative. The service manual provides additional troubleshooting information, which is for use by qualified service personnel.

This section is divided into three troubleshooting categories: Items 1 through 3 describe general system problems. Items 4 through 13 describe general oximetry subsystem problems. Item 14 describes trend memory problems.

General System Problems

1. **N-200 does not turn on.**

   - Check the AC and N-200 interface/powerbase connections for proper AC power supply.

   - Check battery operation. If the battery is discharged, connect the N-200 to the interface/powerbase. Plug the power cord into an outlet supplying the appropriate mains voltage. The interface/powerbase requires a minimum of 14hours to recharge the N-200 battery completely.

   - Check AC fuse.

2. **N-200 operates on AC power but not on battery.**

   - The battery may be discharged. To recharge the battery, connect the N-200 to the interface/powerbase. Plug the power cord into an appropriate AC power outlet and confirm that the BATT IN USE indicator is off. A minimum of 14 hours is required to recharge the battery completely.

   - The battery pack or battery charger circuit may be defective, or the battery fuse may be open.

3. **Interface/powerbase is connected to AC power but the N-200Õs BATT IN USE indicator stays on.**

   - Check the N-200/interface/powerbase connection. The BATT IN USE indicator turns off to confirm correct connection.

   - Replace the power cord, check the connections, or try another AC outlet.

   - Check fuse.

General Oximetry Subsystem Problems

4. PULSE SEARCH indicator is on; SpO_2 and pulse rate not displayed.

- . The patient may be experiencing shock, hypotension, severe vasoconstriction, severe anemia, hypothermia, arterial occlusion proximal to the sensor, or cardiac arrest.
- The sensor may be improperly applied (for example, too tight) or it may not be plugged in.
- There may be excessive ambient light; cover the sensor site with opaque material.
- The sensor may be placed on an extremity with a blood pressure cuff, arterial catheter, or intravascular line. Move the sensor to an alternate site that is not affected.
- The patient's perfusion may be too low for the N-200 to detect an acceptable pulse.
- Use ECG synchronization; test the N-200 on someone else; try another sensor site; or try another sensor (see the section for suggestions).
- The sensor may be damaged; replace it.
- The patient module may be damaged; try another patient module.

5. The pulse amplitude indicator tracks a pulse, but there is no oxygen saturation or pulse rate.

-

- Excessive patient motion may be making it impossible for the N-200 to find a pulse pattern. If possible, keep the patient still; check whether the sensor is applied securely and properly and replace if necessary; use ECG synchronization; move the sensor to a new site; use a sensor that tolerates more motion; or set the N-200 for Mode 3.

- The sensor may be damaged; replace it.

- The patient's perfusion may be too low to allow the N-200 to measure saturation and pulse rate.

6. Patient module cannot be connected.

- Use only a C -13-200, C-20-200, or C-13-200M patient module.

- Connector pins may be bent; replace the patient module.

7. SpO_2 or pulse rate change rapidly; pulse amplitude indicator is erratic. ECG waveform is noisy.

- .

- Excessive patient motion may be making it impossible for the N-200 to find a pulse pattern. If possible, keep the patient still; check whether the sensor is applied securely and properly, and replace it if necessary; use ECG synchronization; move the sensor to a new site; use a sensor that tolerates more motion; or set the N-200 for Mode 3.

- An electrosurgical unit (ESU) may be interfering with performance:

  – Move the N-200, the patient module, and the cables as far from the electrosurgical unit as possible.

  – Plug the N-200 and the electrosurgical unit into different AC power supply.

  - Move the electrosurgical unit ground pad as close to the surgical site as possible.

- The sensor may be damp or may have been reused too often. Replace it.

- If using a sensor extension cable, remove it and connect the sensor directly to the patient module.

8. ECG LOST is displayed.

-

- If the ECG signal is provided through the patient module:

  - There may be a loose, unplugged, or defective ECG electrode or electrode cable.

  - Check the connections. If the problem persists, replace the electrodes and/or ECG cables.

  - If ECG is provided through the patient module, the module may be defective. Try another patient module.

- R-wave amplitude may be insufficient.

  - Check the ECG electrode position to verify proper lead configuration.

  - Select (LEAD SELECT) limb lead with greatest R-wave amplitude.

- ECG signal provided via the rear-panel connector is inadequate:

  - There may be a loose, unplugged, or defective ECG cable.

  - Check the connections. If the problem persists, replace the electrodes and/or ECG cables.

– The input signal from the ECG monitor may be incorrect. Use high level (0.5 to 15 V) ECG analog output or defibrillator sync pulse wave.

– AC power to the N-200 may have been interrupted.

– An ESU may be interfering. Refer to discussion in Item 7.

9. When ECG is connected, pulse rate displays but not saturation.

• .

• The sensor may be improperly applied or connected; check it. The patient's perfusion may be inadequate; test the monitor on someone else; try another sensor (see the section for suggestions).

10. Displayed pulse rate does not agree with that of ECG monitor.

• Excessive patient motion may be making it impossible for the N-200 to find a pulse pattern. If possible, keep the patient still; check whether the sensor is applied securely and properly and replace if necessary; use ECG synchronization; move the sensor to a new site; use a sensor that tolerates more motion; or set the N-200 for Mode 3.

• The patient may have a pronounced dicrotic notch, which causes the pulse rate measurement to double. Try another sensor site.

• If ECG synchronization is in use, an artifact or low-quality signal may be present on the ECG monitor. Adjust ECG leads to improve quality of ECG signal. Refer to the manual for that monitor.

• An ESU may be interfering. Refer to discussion under Item 7.

11. Oxygen saturation measurement does not correlate with the value calculated from a blood gas determination.

- The SpO_2 calculation may not have correctly adjusted for the effects of pH, temperature, $PaCO_2$, or 2,3-DPG. Check whether calculations have been corrected appropriately for relevant variables. (See the section for more information.) In general, calculated saturation values are not as reliable as direct laboratory hemoximeter measurements.

- Accuracy can be affected by incorrect sensor application or use, significant levels of dysfunctional hemoglobins, intravascular dyes, bright light, excessive patient movement, venous pulsations, electrosurgical interference, and placement of a sensor on an extremity that has a blood pressure cuff, arterial catheter, or intravascular line. Observe all instructions, warnings, and cautions in this manual and in the sensor Directions for Use.

12. Oxygen saturation does not correlate with laboratory hemoximeter.

- Fractional measurements may not have been converted to functional measurements before the comparison was made. The N-200, as well as other two-wavelength oximeters, measure functional saturation. Multi-wavelength oximeters, such as the Instrumentation Laboratory282 CO -Oximeter and Corning CO-oximeters, measure fractional saturation. Fractional measurements must be converted to functional measurements for comparison. Refer to the equation for this conversion in the section.

- Close correlation requires simultaneous blood sampling and pulse oximeter measurements from the same arterial supply.

13. OXYGEN SATURATION display is erratic; ECG LOST indicator is flashing.

- The ECG electrodes may be displaced, dislodged, or disconnected from the ECG cable.
- The ECG cable may be disconnected from the patient module or powerbase/interface connector.
- If the ECG signal is coming from an ECG monitor, the input cable may have become dislodged from the ECG IN/OUT connector on the rear panel of the N-200.

Trend Memory Problems

14. Trend data is not available.

- The N-200 may not be plugged into a functional outlet supplying mains power.
- Data in the trend memory may have been erased.
- The memory battery may be defective. Contact qualified service personnel.
- Try a different powerbase if one is available.

SPECIFICATIONS

PERFORMANCE

Range

Saturation
0–100%

Pulse Rate
20–250 bpm (beats per minute)

Accuracy and Motion Tolerance [1, 2]

Saturation

Without Motion—Adults:	70 to 100% ±2 digits
Without Motion—Neonate[3]:	70 to 100% ±3 digits
With Motion—Adults and Neonates[3]:	70 to 100% ±3 digits
Low Perfusion[4,5]:	70 to 100% ±2 digits

Pulse Rate

Without Motion[5]	20 to 250 bpm ±3 digits
With Motion	normal physiologic range (55 – 125 bpm) ±5 digits
Low Perfusion[4,5]	20 to 250 bpm ±3 digits

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[1] Applicability: D-25, D-25L, and N-25 sensors.

[2] Definition of Nellcor Standard Motion:
Tapping: 1-2 cm amplitude at an aperiodic* frequency between 1-4 Hz
Rubbing: 1-2 cm amplitude at an aperiodic* frequency between 1-4 Hz
(*Note: "aperiodic" is a randomly changing frequency)

[3] Adult specification is shown for *D-25* and N-25 sensors with the N-200. Neonate specification shown for *N-25* sensors with the N-200. Validation testing of D-25 and N-25 sensors was conducted on adult volunteers. Saturation accuracy will vary by sensor type. Refer to the Sensor Accuracy Grid.

[4] Definition of Low Perfusion:
Low perfusion in the context of oximetry is generally used to mean that the detected signal modulation (pulsatility) is low at the monitoring site. Low percent modulation is defined as a value of 1.5% modulation or less for the infrared (IR) signal.

[5] Specification applies to monitor performance and was validated with Biotek and Nellcor simulators.

ECG

Direct ECG input

Via C-13-200 or C-20-200 patient module

Input
Defibrillator protected, differential; Lead II only

Bandwidth
0.5–40 Hz (monitoring bandwidth)

CMRR
Greater than 100 dB at 50 or 60 Hz with 5 kilohms source imbalance

Input Range
±0.5-5.0 mV for QRS detection

Input Impedance
greater than 10 megohms

Via Rear-Panel ECG IN/OUT Connector

Input
Defibrillator sync or ECG output waveform from bedside ECG monitor. Defibrillator protected, differential, standard Lead II configuration. For optimum performance, waveform with positive deflection recommended.

Input Range
±0.5 V minimum input signal; should not exceed ±15 V. Minimum of 10 ms wide at 50% of peak amplitude, delayed by no more than 40 ms from actual QRS complex.

Digital Data Output

RS-232
Connector: 9-pin D-type, subminiature, female

Baud Rate: Switch-selectable, 1200, 2400, 9600, and 19,200

Formats: Full, Conditional Full, Computer, Alternate Computer, Conversation, and Beat-to-Beat

Fiber-optic transmitter
Baud rate: 2400

Formats: Compatible with N-9000 recorder/interface, N-7500 pulse oximetry network, and N-7000 interface.

Analog Data Output

4 each; 3/32-inch phone jacks

Outputs
SpO_2, Pulse Rate, Pulse Wave

Output/Input
ECG wave out or ECG wave/defib sync input

Voltage
0–1 V or 0–10 V (switch-selectable)

Range Set
SpO_2 0–100% or SpO_2 50–100% (switch-selectable)

Accuracy
±20 mV at zero, ±0.5% of full scale, referred to front-panel display

ENVIRONMENTAL CONDITIONS

Temperature

N-200
41–107.6°F (5–42°C) operating
32–122°F (0–50°C) storage

Sensor
Within physiologic range 82.4–107.6°F (28–42°C) for accurate measurement.

Humidity

Any humidity/temperature combination without condensation.

Altitude

0–10,000 ft (0–3,048 m)

ELECTRICAL CHARACTERISTICS

Protective Class

Class I: mains-supplied unit using a protective ground

Degree of Protection

Type BF: patient electrically isolated

Voltage

100 VAC -10% to 120 VAC +10%, 50/60 Hz

Power Consumption

Maximum rating: 25 VA

Mains Fuse Rating

1 x T 0.5 A, slow-blow, 250 V

Leakage Current

50 µA maximum, power line to ground
10 µA maximum, patient connector to ground
10 µA maximum, patient connector to power line

Battery

Type
Lead-acid battery pack, 2.4 AH

Battery Life
90 minutes typical on new, fully charged battery; age and usage affect battery performance.

Recharge Period
14 hours minimum; 80% charge after 8 hours

Charger Type
Float voltage, 450 mA current limit

PHYSICAL CHARACTERISTICS

Dimensions

N-200 only
2.5 high x 10 wide x 7 in. deep (64 x 254 x 178 mm)

With powerbase
6.5 high x 10 wide x 10 in. deep (165 x 254 x 254 mm)

Weight

N-200 only
5 lb (2.3 kg)

With powerbase
8 lb (3.7 kg)

Patient Module

Cable length
13 ft (4 m) cable (C-13-200, C-13-200M)
20 ft (6 m) cable (C-20-200)

Connector
Lemo B-series, mates with 12-pin connector on N-200 front panel