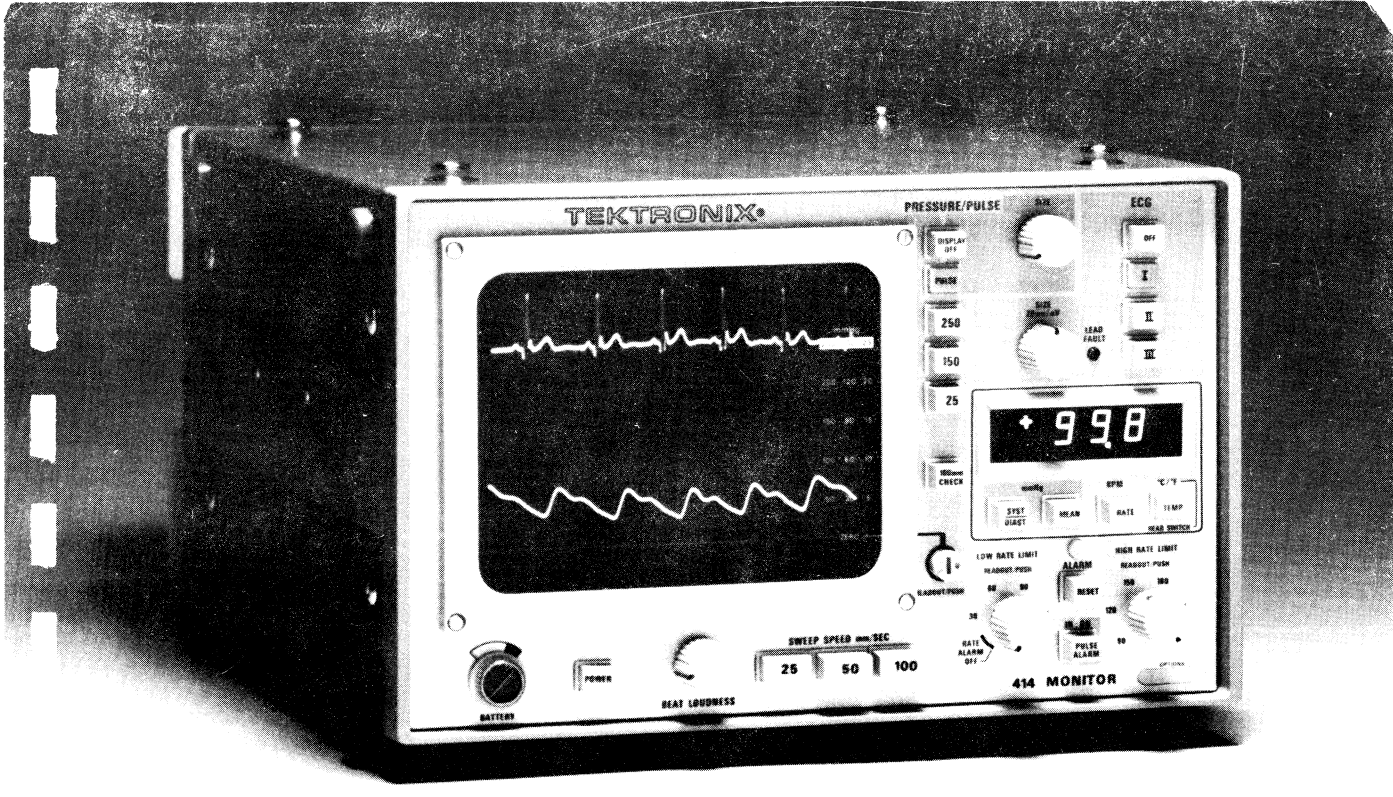

414 PORTABLE PATIENT MONITOR OPERATORS INSTRUCTION MANUAL

WARRANTY

All TEKTRONIX instruments are warranted against defective materials and workmanship for one year. Any questions with respect to the warranty should be taken up with the TEKTRONIX Medical Products Sales Representative in your area.

U.S.A. and foreign Tektronix products covered by U.S. and foreign patents and/or patents pending.

TEKTRONIX is a registered trademark of Tektronix, Inc.

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SAFETY INFORMATION

The 414 monitor has fully isolated ECG circuitry and is suitable for use with electrically susceptible patients when operated from either the specific ac power source or the internal battery pack. ECG leakage current does not exceed 5 μA rms at 120 V, 60 Hz.

Electric appliances applied to a patient create hazards for both the patient and the operator unless the equipment is suitable for the application and the operator is skilled in its use. Several appliances used simultaneously compound the hazard situation. This manual contains informative and warning instructions that must be followed by the user to ensure safe operation and to retain the monitor in safe condition.

WARNING

The monitor is not explosion proof. When used in locations with flammable anesthetics, the monitor must be at least five feet above the floor. See NFPA No. 56A, Standard for the use of Inhalation Anesthetics, articles 24114(c) and 24032.[1]

If the monitor is dropped or severely abused, it should be checked by qualified service personnel to ensure that the safety features are intact.

High voltage inside. Do not remove covers. Operating voltages can cause injurious or fatal electric shock. Refer servicing to qualified personnel.

---

[1]Safety Documents

Additional safety information will be found in the Safety documents listed on page iii.

AC Power Source

The 414 is compatible with isolated power systems such as those used in operating rooms.

The monitor is intended to be operated from a single-phase earth-referenced power source having one current-carrying conductor (the neutral conductor) near earth potential. Operation from power sources where both current-carrying conductors are live with respect to earth (such as phase-to-phase on a three-phase system) is not recommended, since only one conductor has fuse protection within the monitor.

AC Power Cord and Plug

The monitor has a three-wire power cord with a three-terminal polarized plug "Hospital Grade" for connection to the power source and safety earth. The ground (earth) terminal of the plug is directly connected to the monitor frame. For electric shock protection, insert this plug only in a mating outlet with a safety-earth contact and which is marked "Hospital Grade".

Inspect the power cord periodically for fraying, or other damage, and repair as needed. Do not operate the apparatus from ac power with a damaged power cord or plug.

NOTE

The power cord on Tektronix instruments may conform to either of the following two electrical codes:

Conductor	*USA (NEC) & Canada*	*IEC*
Line	*Black*	*Brown*
Neutral	*White*	*Light Blue**
Safety-Earth	*Green w/ yellow stripe*	*Green w/ yellow stripe*

**Tinned copper conductor.*

Grounding

To assure protection against electrical shock whenever auxiliary, line-operated equipment (e.g., strip-chart recorder) is electrically connected to the monitor, the monitor **must** be properly grounded. The monitor power cord provides the required ground when properly connected to a "Hospital Grade" outlet. Battery operation should be avoided when the monitor is connected to 'other' line-operated equipment. If it cannot be avoided, the monitor **must** be grounded using the GND binding post on the rear panel.

Pulse Sensors

Only two of the pulse sensors presently offered (late 1975) by Tektronix, Inc. meet all requirements for patient safety—the Finger and Radial Sensors. The Lobe Sensor has not been redesigned to provide adequate electrical isolation between the patient and the monitor. The metal housing of the Lobe Sensor is connected to ground through the monitor's frame, a practice which should be avoided; therefore, the present Lobe Sensor is not recommended.

Pressure Transducers

The following pressure transducers have adequate isolation to withstand the full ac line voltage with less than 10 μA leakage (not all transducers listed are available from Tektronix, Inc.) Pressure transducers exceeding 10 μA leakage should not be used.

Trantec 800

Gould-Statham P23 Id

Gould-Statham P50A

Bell & Howell 4-327 I-0109

Temperature Transducers

The monitor is compatible with the 700 Series temperature probes manufactured by Yellow Springs Instrument Co. These probes will withstand full ac power source voltage with less than 10 μA leakage. Probes other than the Yellow Springs Instrument Co. 700 Series should not be used.

Outputs

See Grounding paragraph on page ii.

Safety Documents

National Fire Protection Association
60 Batterymarch Street
Boston, Massachusetts, 02110

NFPA No. 76B, Safe Use of Electricity in Hospitals, 1973

NFPA No. 56A, Standard for the Use of Inhalation Anesthetics, 1972

NFPA No. 70, National Electrical Code (Article 517), 1971

Underwriters' Laboratories, Inc.

U.L. 544, Standard for Safety, Medical and Dental Equipment.

CAUTION

DO NOT AUTOCLAVE ACCESSORIES unless the accessory manufacturer's instructions clearly approve this procedure. Many accessories can be severely damaged by autoclaving. Inherent isolation may be defeated.

PRESSURE TRANSDUCERS

All transducers recommended by Tektronix can be gas sterilized. Refer to manufacturer's instructions.

Pre-sterilized, disposable domes are available for some types of transducers; contact the transducer manufacturer or his representative. These domes have an integral isolation diaphragm which prevents fluid contact with the transducer and thereby eliminates the need for transducer sterilization.

PULSE SENSORS

Usually, pulse sensors do not require sterilization. Sensors can be cleaned by wiping with an alcohol-dampened pad.

TEMPERATURE SENSORS

Temperature sensors can be gas sterilized. However, adequate time must be allowed after sterilization for the ethylene oxide, which was absorbed by the plastics in the sensor, to be dissipated.

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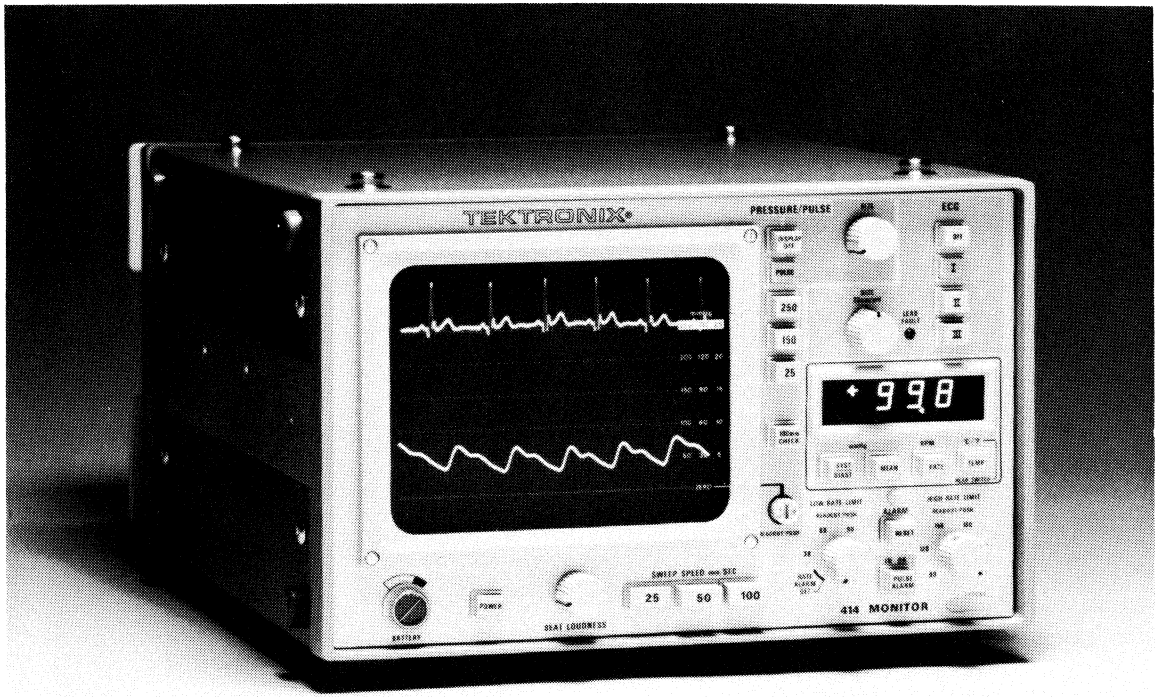

2041-2

414 Portable Patient Monitor.

ECG

If the ECG monitoring is primarily for heart rate measurement, as opposed to diagnosis, electrodes can be placed to reduce muscle artifacts and maximize signal amplitude. Experimentation with electrode placement is recommended. The placement shown is the one most likely to give maximum signal and minimum muscle artifacts. Always properly connect all three electrodes. Verify that the gel-filled sponge is still in the electrode-cup prior to attaching the electrode.

LEAD I Signal is from RA to LA - LL is the reference.

LEAD II Signal is from RA to LL - LA is the reference.

LEAD III Signal is from LA to LL - RA is the reference.

The input characteristics of the monitor and the electrodes supplied reduce the need for skin preparation.

NOTE

Always connect all three electrodes properly. The third electrode serves as reference and without it, no display will be obtained.

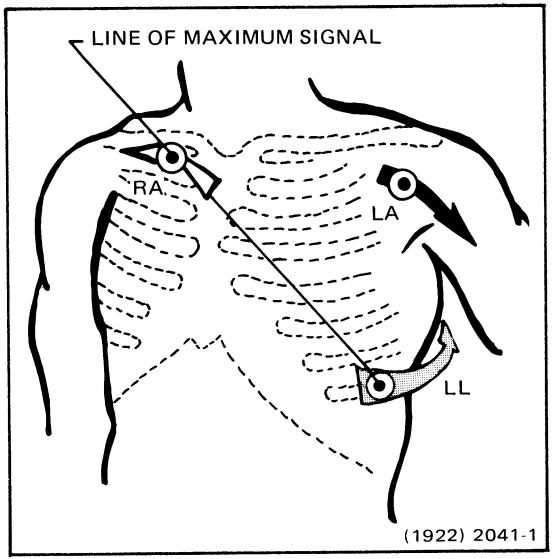

Fig. 1-1. Torso electrode placement range.

TORSO CABLE

Use the torso cable whenever possible. A shorter distance between electrode sites includes fewer skeletal muscles to produce artifacts and permits shorter electrode wires to be used, reducing power line (50-60Hz) interference. The shorter electrode wires are less likely to tangle and may be stored separately.

LIMB CABLE

The limb cable provides access to the "classical" ECG electrode sites on the arms and legs. The limbs provide a consistent ECG signal over a wide variation of electrode locations.

The limb cable is not recommended for monitoring purposes unless access to the torso is not available. Susceptibility to interference is greater when the electrodes are on the limbs. Also the limb cable is cumbersome and more likely to become tangled. The permanently attached electrode wires require complete cable replacement if damaged.

ELECTRODE WIRES

Broken or frayed electrode wires or loose snap fittings may cause interference or loss of signal. Frequent electrical and visual checks should be made on cables and electrode wires. Particular attention should be paid to the point at which the wire enters the terminals, since flexure will eventually cause breakage of strands there. Wires may be electrically checked prior to patient attachment, using the ECG LEAD CHECK terminals on the right-hand side of the monitor.

MONITOR INTERNAL PROTECTION

The patient cable furnished protects the monitor from damage by defibrillators and electro-cauterizers. The recommended cables can be identified by the "SERIES RESISTORS INSIDE" identification on the branch block. See Fig. 1-2. In rare, severe cases these resistors will fail, requiring cable replacement. For example, the resistors can fail during defibrillator discharge if the paddles are partially covering the ECG electrodes, thereby making ineffective paddle contact with the patient. Such a cable failure would automatically be indicated by LEAD FAULT lamp lighting.

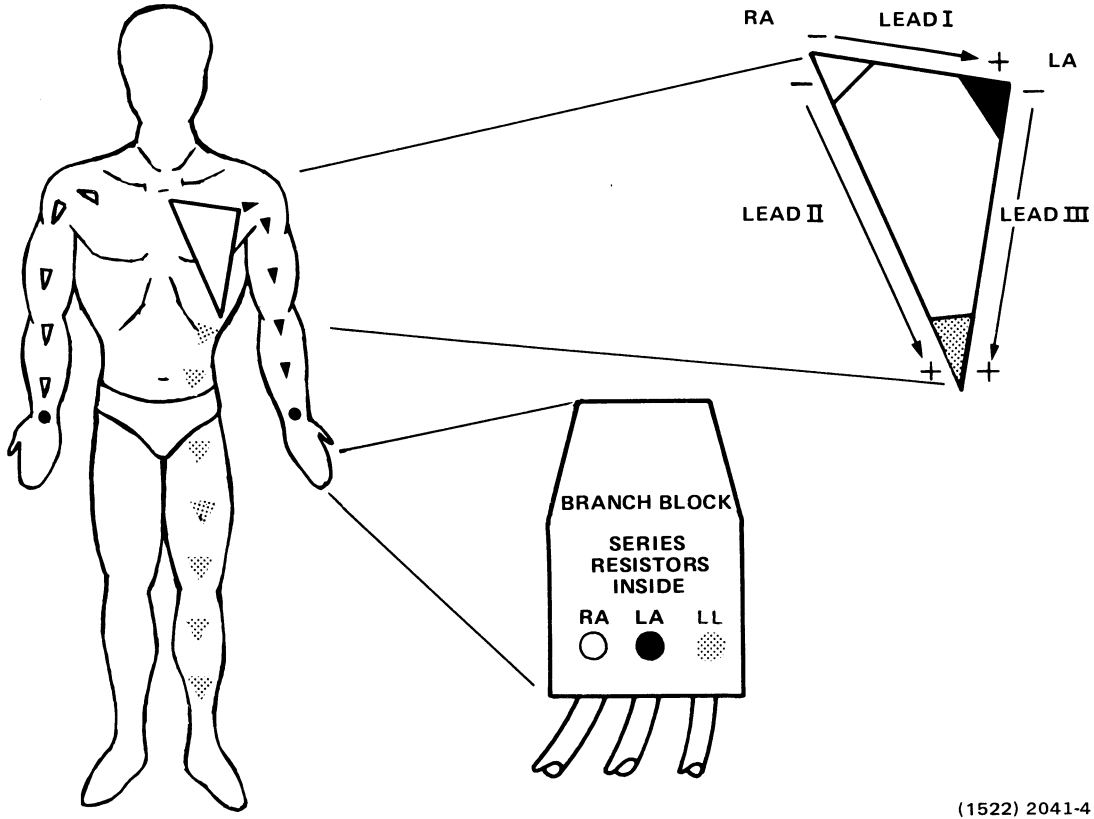

Fig. 1-2. Limb electrode placement range.

ALTERNATIVE CABLES AND WIRES

Use of other cables without the series resistors during defibrillation or electrocautery may result in damage to the monitor.

If the application does not involve electrocauterizers or defibrillators, other manufacturers' cables may be used interchangeably. However, other cables may introduce substantially more cable motion artifacts.

INTERFERENCE

The torso cable, the limb cable, and the electrode wires on the limb cable are shielded to reduce effects of electrostatic interference.

SKIN PREPARATION

Skin preparation can often be omitted. However, some skin conditions, such as excessive oil, will require cleansing or other suitable preparation. A saline solution or a small amount of electrode paste rubbed into the skin, then wiped off, provides an improved signal path between the body fluids and skin surface.

When skin preparation is omitted, baseline drift may occur during the first ten to fifteen minutes, until the electrode paste (gel) from the electrode permeates the skin.

Poor skin preparation may result in signal distortion, noise, or other interference.

ELECTRODES

A good electrode contains Ag/AgCl (silver/silver chloride). It does not touch the skin, since it is separated by a saline column. The gel completes the circuit between the electrode button and the fluid system of the body. For optimum signal, the saline must permeate the skin.

The preferred electrodes are disposable Ag/AgCl electrodes with adhesive foam pads. Each electrode also contains a small gel-filled sponge. They are easily attached to the skin and will function correctly for several days (until the electrode paste dehydrates).

Reusable Ag/AgCl electrodes and various electrode adapters are available from Tektronix, Inc.

PRECAUTIONS

Skin reaction to some types of electrode paste may appear, especially on infants. Check for reddening of the skin.

Removal of the disposable electrodes during the first few hours after application may be difficult as the adhesive sticks tightly. One method is to "roll" the electrode as opposed to peeling. The skin may be cleaned with rubbing alcohol.

LEAD FAULT INDICATOR

See Fig. 1-3 for the indicator location. Lamp indicates:

1. An open circuit (break) in the patient cable or in the attachment wires.

2. Insufficient gel or paste on the electrode(s).

3. One or more electrodes or electrode attachment wires disconnected.

4. No button pushed in on the ECG Selector Switch.

5. Two or more buttons pushed in on the ECG Selector Switch.

6. Excessive dc offset in one or more electrodes.

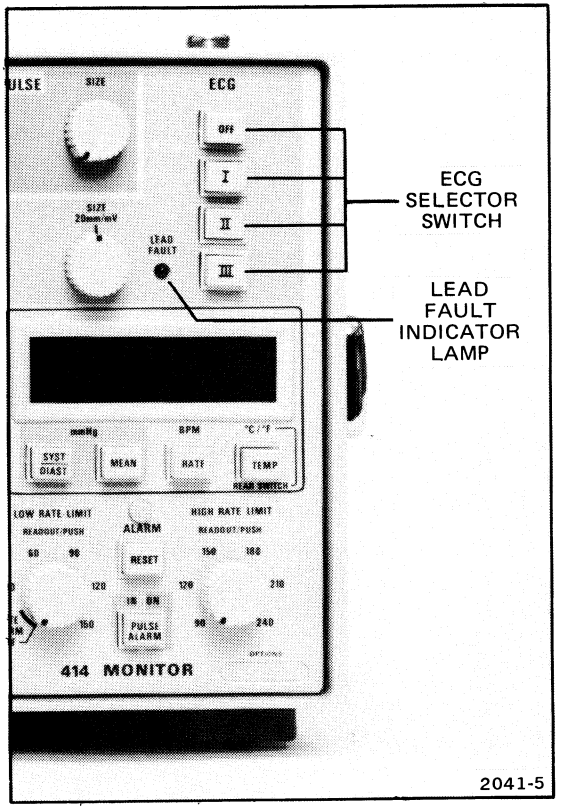

Fig. 1-3. LEAD FAULT indicator and ECG lead selector.

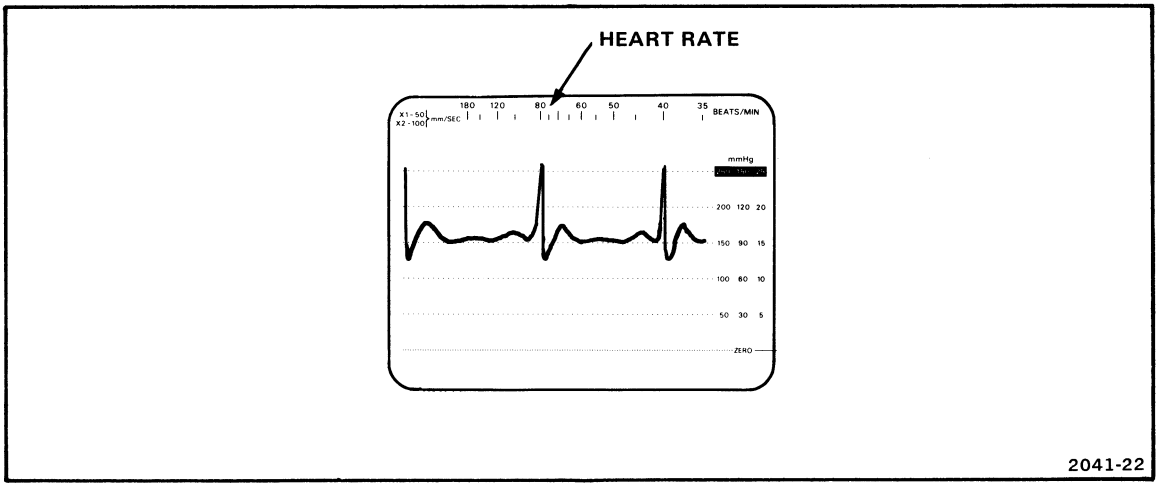

Fig. 1-4. BEATS/MIN scale with ECG waveform.

BEATS/MIN SCALE

The heart rate is read by moving vertically from the QRS portion of the **second** ECG signal to the BEATS/MIN scale. This scale is direct reading when used with the 50 mm/sweep speed and provides a "beat-to-beat" indication, of the heart rate. The example shown in Fig. 1-4 is for a heart rate of approximately 78 beats per minute.

To read beats per minute at the 100 mm/SEC sweep speed multiply the BEATS/MIN reading by 2. This scale is not usable on the 25 mm/SEC sweep speed since the sweep is not triggered at that speed.

QRS DETECTOR

The QRS detector is responsible for much of the rate alarm's immunity to false alarms. The detector generates a trigger each time a QRS wave is detected in the ECG. This circuitry does not rely on amplitude as the key factor because pacer pulses, muscle artifacts, and other extraneous signals may be of greater amplitude. QRS waves vary in amplitude, polarity and waveshape as a function of electrode placement, lead selector setting, time, patient health, body size, body position, and other factors.

The circuit initially requires several seconds to accommodate the ECG signal. Then, several tests are applied to the incoming signals. Pacers have a faster rate of voltage change than any physiological signal and are rejected. The slow rate of voltage change of the P and T waves is less than required, causing them to be rejected. The remaining elements of the signal are segregated according to time duration of voltage excursions between reversals of direction. Muscle artifacts have a rate of voltage change that is equal to or greater than a QRS wave, but they are rejected because the time duration of any one voltage excursion between reversals is very short. The QRS portion of the signal remains. Either the leading or trailing slope may be accepted, but once accepted, no additional events can be accepted until 150 milliseconds have elapsed. Probability is very high that every QRS wave will be detected on most patients. Limiting factors include long periods of heavy skeletal muscle activity and deterioration of the ECG to a point where QRS waves are visually unrecognizable. The same circuit that rejects pacers may detect electrocautery, preventing proper detection of QRS events. Under these conditions, the alarm limits will not be usable.

PULSE

The primary use of all peripheral pulse sensors is to monitor heart rate. The figures show pulse sensor placement. The sensors are light operated and require unrestricted capillary action. The finger and radial sensors transmit light into the tissue. The light reflected to the sensors depends on the amount of blood in the capillaries at any one moment. The lobe sensors transmit light through the tissue rather than relying upon reflection.

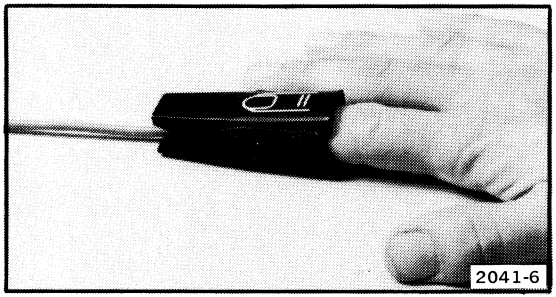

Fig. 2-1. Placement of finger sensor.

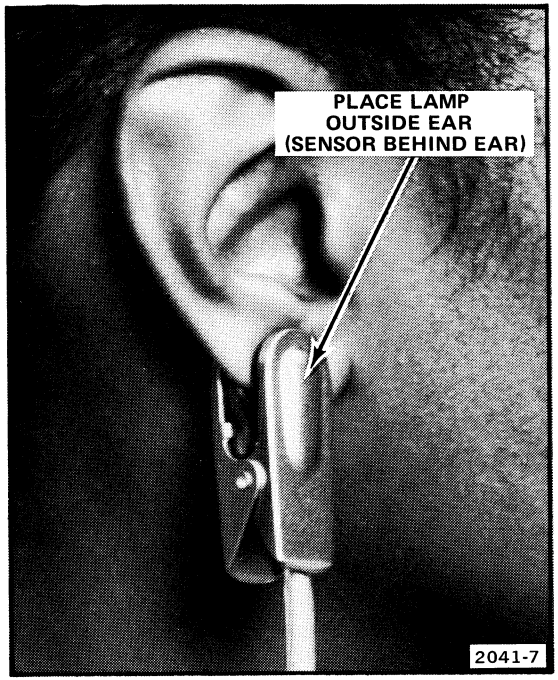

Fig. 2-2. Lower ear placement of lobe sensor.

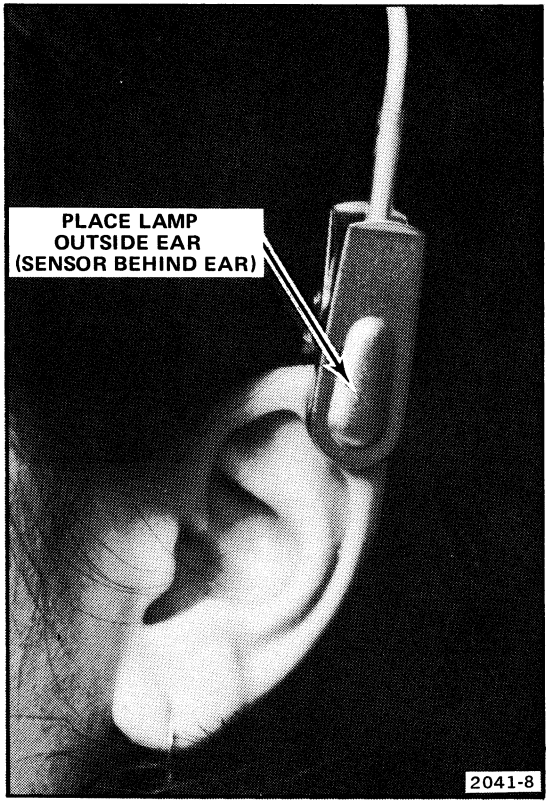

Fig. 2-3. Upper ear placement of lobe sensor.

It may be necessary to shield the sensors from undesirable light, such as fluorescent lamps, with an opaque material such as a heavy towel, etc.

While skin pigmentation appears to have no effect on the usefulness of the sensors, heavy calluses may disrupt the optical path to such an extent that little or no signal is obtained.

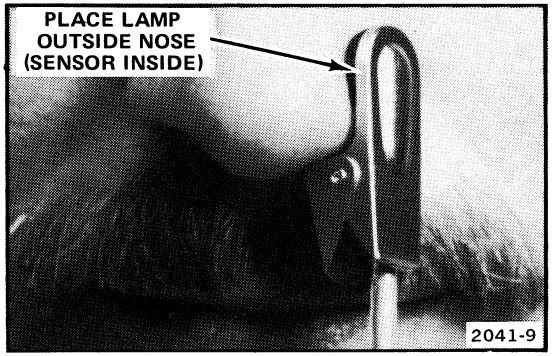

Fig. 2-4. Nostril placement of lobe sensor.

In marginal cases there is some evidence that optical coupling may be improved and the usefulness of the sensor enhanced by the use of a small amount of glycerin on the skin (in the area beneath the light source and the sensor).

The present lobe sensor has exposed metal that is connected to the safety ground of the monitor.

LOBE SENSORS

The lobe sensor may be used on the ear or nose primarily to monitor heart rate.

Finger or radial sensors may lose the pulse signal with vasoconstriction, while the ear lobe and nostril areas are less affected.

Additional support may be desirable for the lobe sensor to provide patient comfort and reduce sensor movement. For example, tape the cable to the skin several inches from the sensor.

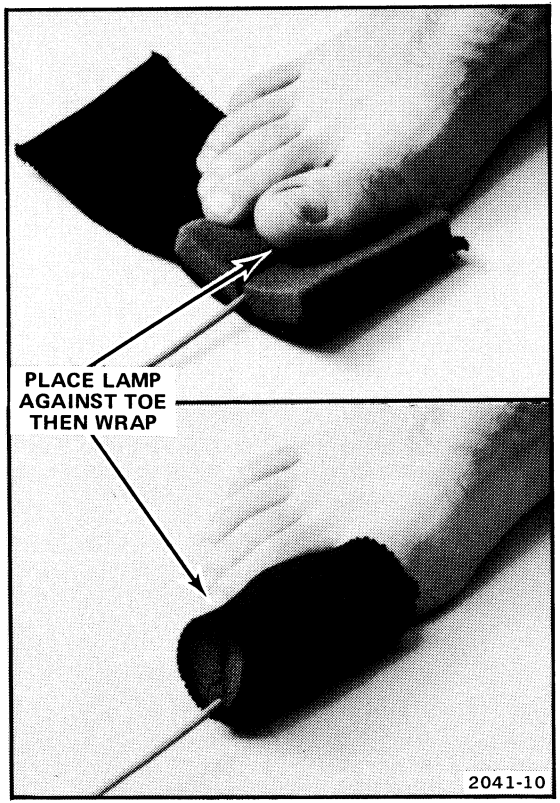

Fig. 2-5. Great toe placement of radial sensor.

FINGER AND RADIAL SENSORS

In addition to monitoring the heart rate, the finger and radial types can be used to monitor peripheral circulation so that vasoconstriction or vasodilation can be noted.

Finger Sensor

The finger sensor is generally the easiest sensor to install and remove.

Radial Sensor

The radial sensor may be applied to the great toe or foot to monitor leg circulation. It may also be used as a finger sensor.

BEATS/MIN SCALE

The slow rising pulse waveform requires care in making an accurate heart rate reading. See Fig. 2-6. Adjust the PULSE SIZE control for a three- to five- division display.

(1) The sweep starting point of the first waveform is referred to the same point on the next waveform.

(2) The heart rate scale is indicated on the BEATS/MIN scale directly above the reference point on the pulse waveform.

The sample shown is for approximately 75 beats per minute on the 50 mm/SEC scale.

To read beats per minute at the 100 mm/SEC sweep speed multiply the BEATS/MIN reading by 2. This scale is not usable on the 25 mm/SEC sweep speed since the sweep is not triggered at that speed.

PRECAUTIONS

Tissue Damage

Pulse sensors currently available have either incandescent lamp or light-emitting diode (LED) light sources. Incandescent lamps can be identified by a yellow-white light; whereas LED's produce a red light.

Sensors with incandescent light sources produce heat which could cause tissue damage in patients with poor peripheral circulation.

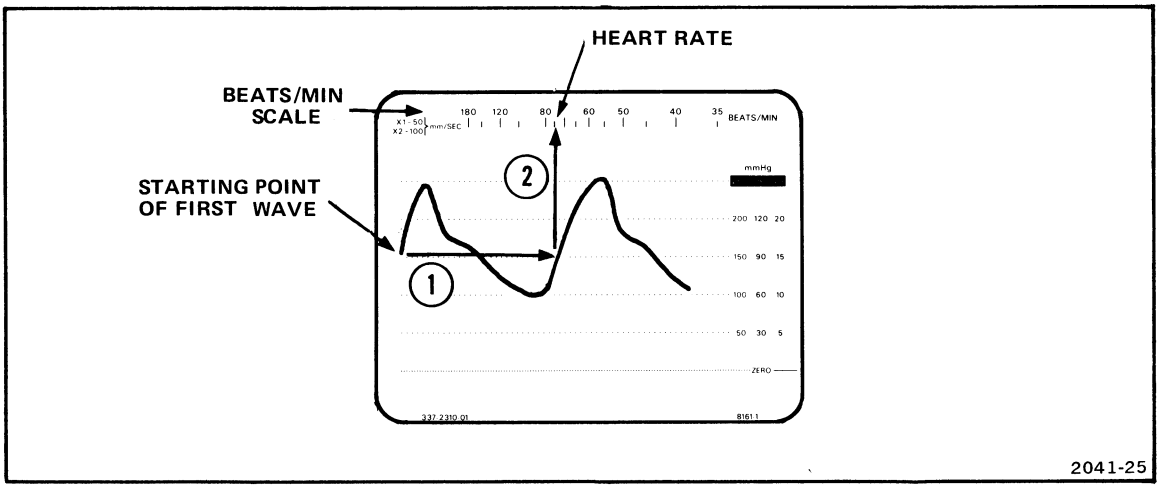

Fig. 2-6. BEATS/MIN scale with pulse-waveform.

Pinching

If the sensor is allowed to pinch or apply too much pressure to the flesh, the signal may be reduced or distorted due to capillary constriction.

Double Beat

Very large dicrotic notches may produce double audible beats. This will also prevent proper use of the rate alarm limits if ECG is off.

Ambient Light

Some sensors are sensitive to ambient light, especially fluorescent lights. The lobe sensor light source should be placed outside the ear or nose and the sensing element inside. Additional light shielding may be needed.

Motion

Sensors are motion sensitive. Movement of the sensor with respect to tissue will also move the blood and this will be sensed.

PRESSURE

CAUTION

Transducers are delicate devices. Mechanical shock can cause a severe shift in the zero balance and calibration.

The diaphragm should be protected from excessive pressure, denting and scratching.

DRY TRANSDUCER ZERO ADJUST

1. Connect pressure transducer to PRESSURE TRANSDUCER INPUT connector on rear panel.

2. Select desired pressure range.

3. Adjust Zero Adjustment knob so that trace is under ZERO reference line.

4. Press in and adjust Zero Adjustment knob so that digital meter indicates 0.

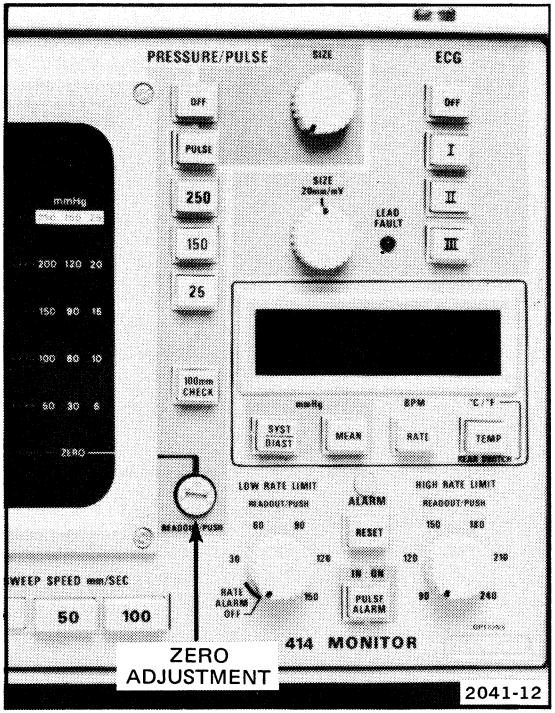

Fig. 3-1. Zero adjustment.

PRESSURE

CAUTION

Transducers are delicate devices. Mechanical shock can cause a severe shift in the zero balance and calibration.

The diaphragm should be protected from excessive pressure, denting and scratching.

DRY TRANSDUCER ZERO ADJUST

1. Connect pressure transducer to PRESSURE TRANSDUCER INPUT connector on rear panel.

2. Select desired pressure range.

3. Adjust Zero Adjustment knob so that trace is under ZERO reference line.

4. Press in and adjust Zero Adjustment knob so that digital meter indicates 0.

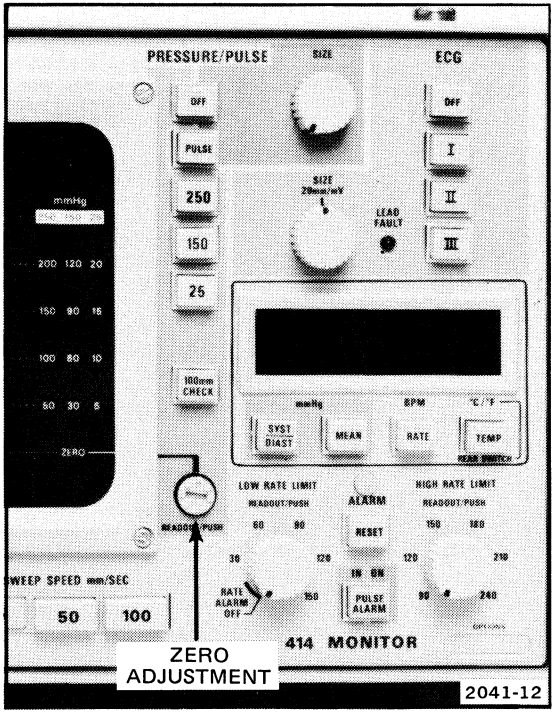

Fig. 3-1. Zero adjustment.

NOTE

Avoid pressing the Zero Adjustment knob after the pressure is applied to the transducer. Doing so will not cause the digital display to indicate the zero level of the transducer. Also the zero balance previously set could be disturbed, causing an incorrect pressure reading.

TRANSDUCER POSITIONING

If the catheter tip is to be at the same elevation as the dome of the pressure transducer the zero adjustment can be done "dry", as shown.

If the tip of the catheter and the transducer dome are at different levels there will be a hydrostatic pressure difference that can be canceled by proper zero adjustment.

When a continuous flow, catheter-flush system is being used, the pressure transducer head must be mounted at the desired level and the fluid line filled until the dome of the pressure transducer is filled, before the zero adjustment is made. Refer to the transducer instruction manual for information on catheter insertion, flushing and care.

In all cases, remember that many transducers are position-sensitive and should be mounted in the position of use before adjusting zero.

TRANSDUCER STANDARDIZATION

Pressure transducers to be used on the 414 monitor must be standardized to 50 μV/V/cmHg, within 1%.

Transducers originally used with other equipment can often be reworked by their manufacturer to comply with Tektronix, Inc. specifications and requirements, including the proper mating connector.

TRANSDUCER REPLACEMENT

Pressure transducer replacement or repair should normally be handled directly through the manufacturer. However, for transducers purchased through Tektronix, warranty repair or replacement should be handled through your local representative for Tektronix medical products.

SAFETY AND ISOLATION

The following pressure transducers have adequate isolation to withstand the full line voltage with less than 10 μA leakage: Trantec 800, Gould-Statham P23 Id, Gould-Statham P50A, and Bell and Howell 4-327 I-0109. Do not use pressure transducers that do not meet this minimum requirement.

Tektronix believes a more stringent requirement should be observed for greater assurance of patient safety and to prevent damage to either the transducer or the monitor during defibrillation and electrocautery. The abbreviated technical statement of this requirement is "The transducer shall withstand 2500 V rms at 60 Hz and 5000 V dc, applied separately across the barrier between the electrical and fluid systems for one minute each."

The transducers listed above meet this requirement.

CAUTION

Unless the pressure transducer breakdown rating is equal to or greater than 5 kV dc, we recommend that the transducer be disconnected from the monitor during defibrillation or electrocautery. This prevents damage to the pressure transducer or to the monitor. It is not necessary to disconnect the transducer from the patient.

100 mm CHECK Button

Usable only with a pressure transducer, standardized to Tektronix specifications, which contains a calibration resistor. Simultaneously pressing the 100 mm CHECK Button and the Zero Adjustment knob provides a digital indication on the 250 and 150 pressure ranges of between 95 mmHg and 105 mmHg. Since 100 mmHg is overrange on the 25 mmHg scale, the display will flash on that scale. The 100 mm CHECK button verifies that the electrical system is operating. It does not verify the accuracy of the pressure transducer conversion between the fluid and electrical media.

TRANSDUCER CALIBRATION

CAUTION

Transducers are delicate devices. Mechanical shock can cause a severe shift in the zero balance and calibration.

The diaphragm should be protected from excessive pressure, denting and scratching.

Calibration of pressure transducers can be verified by using a mercury column manometer or an accurate aneroid manometer.

VACUUM

Vacuum may also be measured, using the pressure transducer. The display will be in the one centimeter area between the bottom of the screen and the ZERO reference line.

The digital readout will indicate vacuum by displaying a minus sign before the pressure reading.

The display is limited by the bottom of the screen. The PRESSURE/PULSE OUTPUT signal, however, does not have this limitation and will indicate the same range as for pressure.

TEMPERATURE

The 414 monitor will accept only dual thermistor temperature probes of the Yellow Springs Instrument Co. 700 series.

To read the temperature on the digital display:

1. Insert the temperature probe connector into the TEMPERATURE SENSOR INPUT on the rear panel of the monitor.

2. Select either °C or °F range using the rear panel switch.

3. Push the TEMP pushbutton in.

4. Read the temperature from the digital display.

DIGITAL DISPLAY

The digital display on the front panel indicates temperature, heart rate, systolic/diastolic, or mean blood pressure. Pushbuttons select SYST/DIAST, MEAN, RATE, or TEMP.

CAUTION

The reliability and operating life of the digital display devices may be significantly and permanently reduced if they are operated below 0° C (+32° F for more than a few minutes. When the instrument is operating, infrequent ambient temperature excursions slightly below 0° C can be tolerated. This is due to inherent self-heating from the instrument and the device itself.

SYST/DIAST—Press in to display the diastolic pressure alternately with the systolic pressure. A blank period precedes each cycle. Select either the 250, 150, or 25 pressure range. The DISPLAY OFF button can be in either position to obtain a digital reading. Selecting the PULSE mode will cause the digital display to blank. If the pressure waveform leaves the upper or lower edge of the cathode-ray tube (crt), the digital display flashes to indicate overrange.

MEAN—Press in to read the arithmetic mean of the pressure. Select the 250, 150, or 25 pressure range of the PRESSURE/PULSE channel. The readout meter will display the pressure with the DISPLAY OFF depressed. Selecting PULSE mode will cause the digital display to blank. Any time the pressure signal leaves the crt upper or lower edge, the display flashes to indicate overrange.

RATE—Press in to read heart rate. Rate information is obtained from the ECG source whenever it is present. If the ECG channel is turned OFF, the rate information is derived from the PRESSURE/PULSE channel. The PULSE signal display should be about 1.5 cm high to provide reliable rate information. The RATE display flashes to indicate overrange starting between 250 and 300 beats per minute.

TEMP—Press in to display temperature. The temperature probe input is on the rear of the instrument. The °C/°F switch is also on the rear panel. Below −10°C and above +50°C (+14°F and +122°F) display flashes to indicate overrange. Display is blanked if no temperature probe is connected to the input.

Rate Limits—For approximate settings of high-rate and low-rate alarm limits, adjust HIGH RATE LIMIT and LOW RATE LIMIT controls to values printed on front panel. For more accurate settings, press in knobs and adjust for desired limit on digital display. As long as one of the RATE LIMIT knobs is pushed in, any other selected digital display is interrupted.

Zero Adjustment Knob—Use a screwdriver or finger tip to adjust the zero pressure reference. Pressure transducer must be connected and a range (250, 150, or 25) selected. Press in knob while adjusting to get more accurate, digital reading and to speed the zero level response. As long as knob is pushed in, any other selected digital display is interrupted.

100 mm CHECK—Press in both the 100 mm CHECK button and the Zero Adjustment knob to read the 100 mm CHECK on the digital meter. The reading should be between 95 mmHg and 105 mHg. The digital display will flash if the 25 pressure range is used, since 100 mmHg is overrange.

CAUTION

Avoid pressing the Zero Adjustment knob after the pressure is applied to the transducer. Doing so will not cause the digital display to indicate the zero level of the transducer. Also the zero balance previously set could be disturbed, causing an incorrect pressure reading.

ALARM

RATE ALARM LIMITS

Establish the desired signals on the monitor. Listen to the beat tone; verify that it is coincident with the signal being displayed. The beat tone occurrence is a true indication of the information given to the alarm.

A faulty or erratic beat will be sensed by the alarm, regardless of the cause: patient heart-rate, excessive muscle artifacts, poor electrical signal path between the patient and the monitor, etc.

For approximate settings of high-rate and low-rate alarm limits, adjust HIGH RATE LIMIT and LOW RATE LIMIT controls to values printed on front panel. For more accurate settings, press in knobs and adjust for desired limit on digital display.

The alarm can be checked and the loudness set by removing an electrode wire and waiting for the arrest alarm to sound. The ALARM LOUDNESS control is located on the rear panel.

Set the ALARM LOUDNESS control to the desired level. Temporarily set the LOW RATE LIMIT to RATE ALARM OFF. Connect the electrode wire. Wait several seconds for the monitor circuitry to "lock-on" to the R-wave signal. Then again set the LOW RATE LIMIT to the desired value.

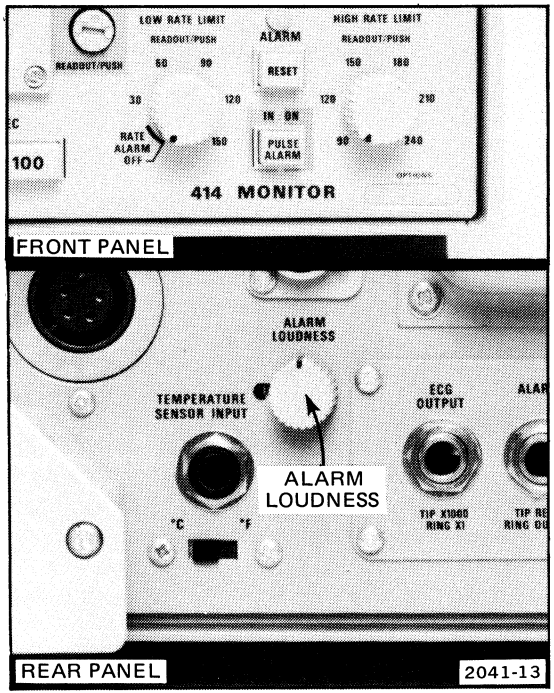

Fig. 6-1. ALARM LOUDNESS and ALARM LIMITS controls.

The 414 alarm depends on the ECG rate any time the ECG channel is on—ECG & PULSE, ECG & PRESSURE, or ECG only.

PULSE or PRESSURE provides a heart-rate signal for the alarm when the ECG channel is off. The beat tone for this signal is coincident with the positive-going portion of the signal. The HIGH RATE LIMIT and LOW RATE LIMIT controls are set in the same manner as ECG for pressure or pulse operation.

The alarm must be turned off if the ECG & PRESSURE/PULSE channels are unused or it will sound.

Alarm Condition Requirement

High rate or low rate violation must be continuous for between 4 and 15 seconds for the alarm condition to be indicated. The seconds of delay depends to some degree upon the amount the rate exceeds the alarm limit and the proximity of the rate to the limit at the time of the alarm. Arrest is indicated by passing of the rate through the lower limit setting and requires between 4 and 15 seconds for indication.

Pulse Alarm

PRESSURE MODE. A pressure signal display should be visible on the screen. Ensure that the display has a pronounced difference between the systolic and diastolic peaks. Activate the alarm by pressing the PULSE ALARM pushbutton. The alarm will sound if the systolic-diastolic separation becomes small for a period of a few seconds. The DISPLAY OFF pushbutton can be in or out for pulse-alarm operation.

PULSE MODE. At least a 1 cm high pulse signal should be present on the screen. Activate the alarm by pressing the PULSE ALARM pushbutton. The alarm will sound if the pulse signal remains less than about 0.5 cm for a few seconds.

POWER

AC POWER LINE OPERATION

This monitor is designed for safe ac line operation. Battery operation has been provided specifically for mobile monitoring (e.g., during movement of the patient from O.R. to recovery).

The monitor is shipped from the factory with; (1) the LINE VOLTAGE RANGE switch set at 115, (2) the correct fuse installed for 115 volt operation and (3) the correct line cord cap (plug) for operation in the U.S.A. on 115 volts.

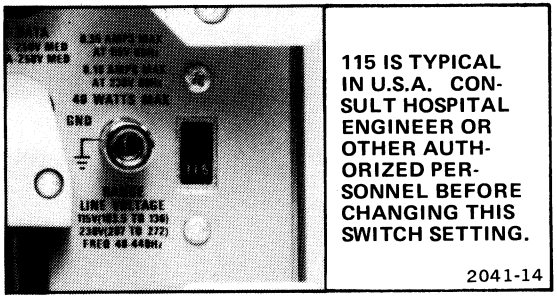

Fig. 7-1. LINE VOLTAGE RANGE switch (rear panel).

CAUTION

This monitor may be damaged if connected to a 230 volt source with the LINE VOLTAGE RANGE switch set at 115.

AC Power Source

The 414 is compatible with isolated power systems such as used in operating rooms.

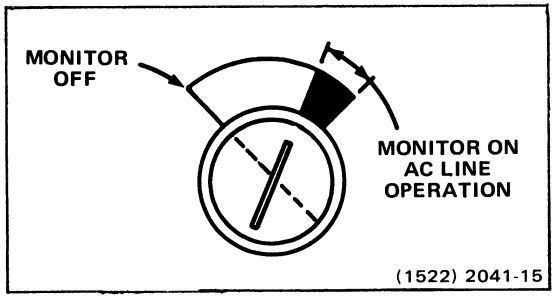

Fig. 7-2. Battery meter.

The monitor is intended to be operated from a single-phase earth-referenced power source having one current-carrying conductor (the neutral conductor) near earth potential. Operation from power sources where both current-carrying conductors are live with respect to earth (such as phase-to-phase on a three-phase system) is not recommended, since only one conductor has fuse protection within the monitor.

AC Power Cord and Plug

The monitor has a three-wire power cord with a three-terminal polarized "Hospital Grade" plug for connection to the power source and safety earth. The ground (earth) terminal of the plug is directly connected to the monitor frame. For electrical shock protection, insert this plug only in a mating outlet with a safety-earth contact which is marked "Hospital Grade".

Inspect the power cord periodically for fraying, or other damage, and repair as needed. Do not operate the apparatus from ac power with a damaged power cord or plug.

BATTERY OPERATION AND CONDITION

Operation

Battery characteristics dictate that charging should be done in a temperature range between 0°C and +25°C for the battery to accept the maximum charge.

The greater the temperature above +25°C, the less charge the battery will accept. Playback time is reduced 50% or more if charging takes place in a +50°C environment. Longer charging time will not compensate for a high temperature.

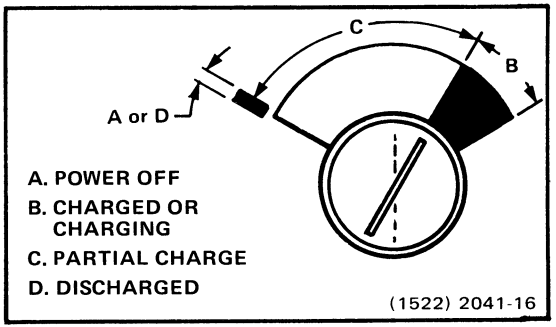

Fig. 7-3. Battery condition.

A correctly charged new battery provides a minimum of 1.5 hours of operating time. Operating time varies with the functions used.

Battery Condition (Fig. 7-3)

(A.) Power Off. Battery is charging if the monitor is plugged into an ac outlet.

(B.) Charge or Charging. Power is on. If the monitor is plugged into an ac outlet, this is a correct indication, but does not show battery condition. A battery peculiarity may cause the meter to read high during the first fifteen minutes of operation following disconnection from an ac outlet—this may be a false indication of a charged battery.

(C.) Partial charge. Power is on. Few minutes of use time remaining.

(D.) Discharged. POWER button is pushed in. The monitor shuts itself off at this point. The monitor will operate on ac power line. Plug it into an ac outlet to use it and recharge the battery pack. To fully charge the battery pack, leave the monitor connected to the ac outlet for at least sixteen hours.

OUTPUTS

CAUTION

To assure protection against electrical shock whenever auxillary, line-operated equipment (e.g., strip-chart recorder) is electrically connected to the monitor, the monitor ***must*** *be properly grounded. The monitor power cord provides the required ground when properly connected to a "Hospital Grade" outlet. When the monitor is connected to 'other' line-operated equipment, battery operation should be avoided. If it cannot be avoided, the monitor* ***must*** *be grounded using the GND binding post on the rear panel.*

ECG OUTPUT

The TIP output is ±2.5 volts of linear range and X1000 gain, within 5%; 10 volts maximum during overdrive conditions.

The RING output is ±2.5 millivolts of linear range and X1 gain, within 5%; 10 millivolts maximum during overdrive.

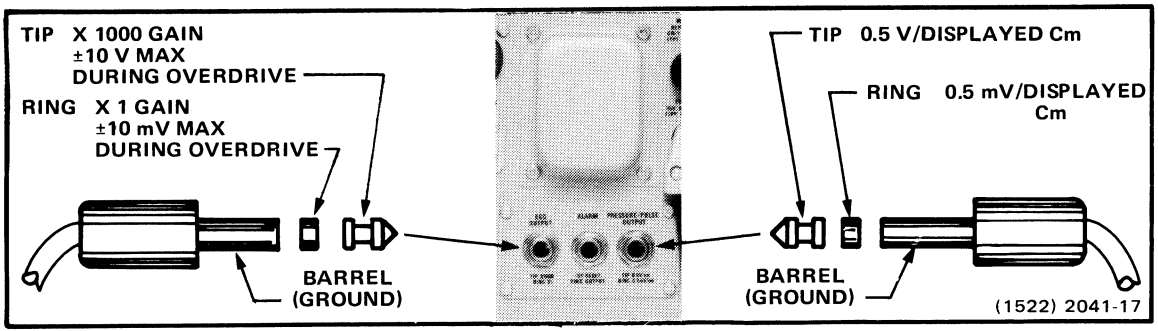

Fig. 8-1. Output connectors.

PRESSURE/PULSE OUTPUT

The TIP output is 0 to +2.5 volts within 5% of full scale (5 cm display) for pressure; 0 to −2.5 volts for vacuum.

The RING output is 0 to +2.5 millivolts within 5% of full scale for pressure; 0 to −2.5 millivolts for vacuum.

Vacuum signals displayed on the monitor will be limited by the bottom edge of the screen.

For Pulse, the TIP output is −2.5 to +2.5 volts (approximately 0.5 volt per displayed cm).

For Pulse, the RING output is −2.5 to +2.5 millivolts (approximately 0.5 millivolt per displayed cm).

ALARM

Shorting the ALARM tip to barrel (ground) causes the alarm to be reset. This allows the ALARM to be reset either with the front panel RESET switch or with a remotely located switch.

The ALARM ring OUTPUT provides a signal for a remote alarm indicator, a light or other indicator. The Output is 12 mA for alarm, and the voltage is limited to about +5.5 V. The barrel contact is the current return path for this output. This current output is suitable for driving solid-state relays having Light-Emitting Diode (LED) inputs.

OUTPUT CONNECTORS

The output connections are typical stereo phone jacks and plugs. See Fig. 8-1. Shorting the output signal to monitor ground will not damage the monitor. Should the ring be shorted to ground (e.g., by a non-stereo plug), the tip output and the display will not be affected. Should the ECG tip output be shorted, the display will be affected but not the beat or alarm. Should the PRESSURE/PULSE tip output be shorted, the display, beat, and alarm will be affected. If the ALARM tip is shorted to ground, the alarm can not sound or light.

OPERATION

FUNCTIONS OF CONTROLS, CONNECTORS AND INDICATORS

(1) **BATTERY.** The meter indicates the approximate state of charge of the battery pack when the monitor is in battery operation. To interpret the meter reading, see Fig. 7-2 and Fig. 7-3.

(2) **POWER.** This pushbutton switch turns the monitor on or off. The battery charger operates continuously as long as the monitor is connected to an ac power source.

(3) **BEAT LOUDNESS.** This control adjusts the loudness of the beat tone and should be set fully clockwise if maximum loudness is desired. The beat is heard once for each QRS pulse during ECG use, or once for each rising portion of the pulse waveform during pulse operation (or pressure waveform in pressure operation).

(4) **SWEEP SPEED mm/SEC.** Three pushbuttons select the speed of the trace across the screen. The sweep speeds are 25,50, or 100 mm/SEC. The total time it takes the trace to cross the screen is 4,2, or 1 seconds, respectively.

(5) **Zero Adjustment Knob.** Adjustable with finger tip or screwdriver. It permits establishment of a zero-pressure reference. See Fig. 3-1. Pressing knob while rotating provides fast accurate indication on digital display.

(6) **Pressure and BEATS/MIN Scales.** The BEATS/MIN scale is used with the 50 mm/SEC and 100 mm/SEC sweep speeds. The scale shows the correct display multiplier for the sweep speed used. This scale is not usable on the 25 mm/SEC sweep speed since the sweep is not triggered at that speed. At certain heart rates, a spot appears at the left edge of the display. This is the starting point of the sweep, which has been reset and is awaiting the next triggering event. Any vertical movement of this spot is an accurate indication of the events prior to triggering.

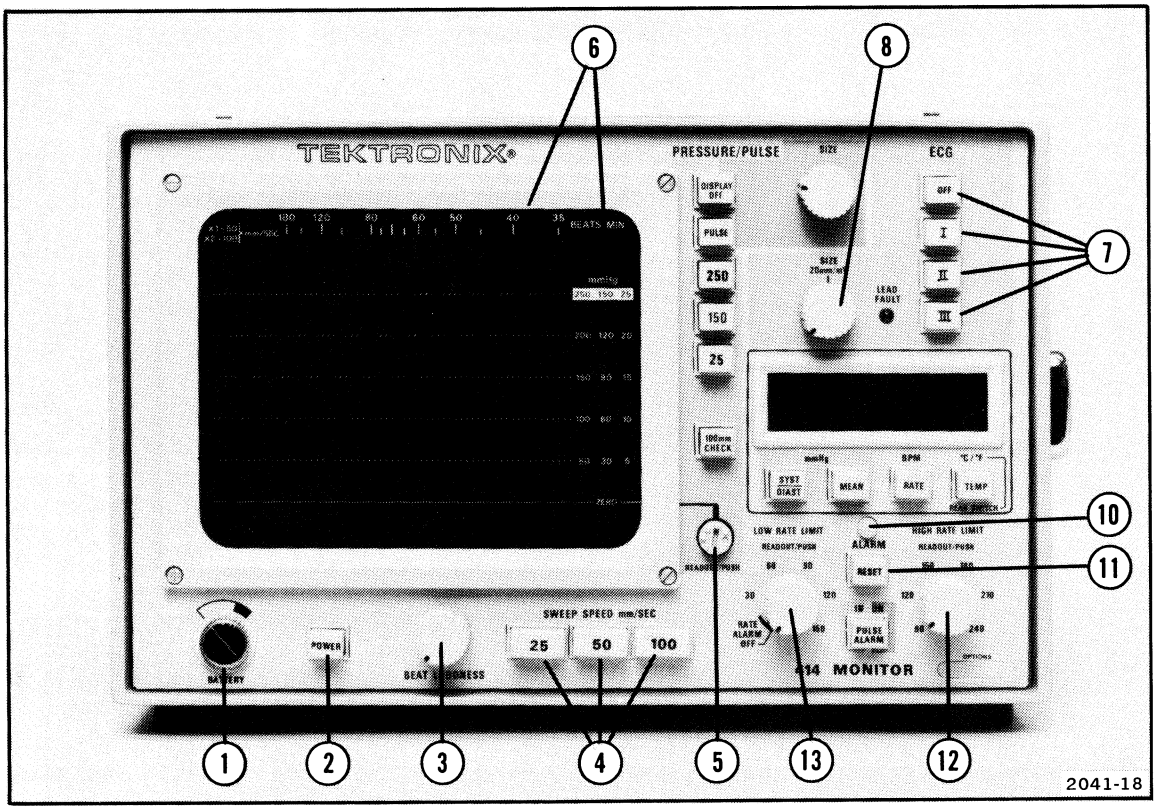

Fig. 9-1. Front panel controls.

The three pressure scales correspond to the PRESSURE range selected — 250, 150, or 25. The vertical portion of the pressure signal is compared to the appropriate scale to determine pressure amplitude in mmHg.

(7) **ECG.** Pushbuttons control the lead selection for ECG. They are I, II, and III.

The four pushbuttons control the display on the upper half of the screen (if the PRESSURE/PULSE channel display is off, the ECG signal will move to the display center). The OFF pushbutton turns off the upper display and centers the remaining display on the screen, except a pressure display will remain referenced to the ZERO line.

(8) **ECG SIZE.** This control varies the height of the ECG display. The ECG OUTPUT signal is not affected by the SIZE control.

(9) **LEAD FAULT INDICATOR.** This lamp, when lighted, indicates the following possible problems:

a. An open circuit (break) in the patient cable or in the electrode wires or electrodes.

b. There is insufficient gel or paste on the electrode(s).

c. One or more electrodes or electrode attachment wires disconnected.

d. No button pushed in on the ECG switches.

e. Two or more buttons pushed in on the ECG switches.

f. Excessive dc offset in one or more electrodes.

(10) **ALARM LIGHT.** Lights whenever an alarm condition occurs.

(11) **RESET.** This pushbutton resets the alarm. If the condition which caused the alarm still exists, the alarm occurs again soon after the button is released. If the alarm was the result of an acceptable change in patient condition, then new limits must be selected and the RESET button must be pushed again.

(12) **HIGH RATE LIMIT.** This control sets the upper rate alarm limit between 90 to 240 beats per minute. For more accurate setting, press control in while adjusting and set desired value on digital display.

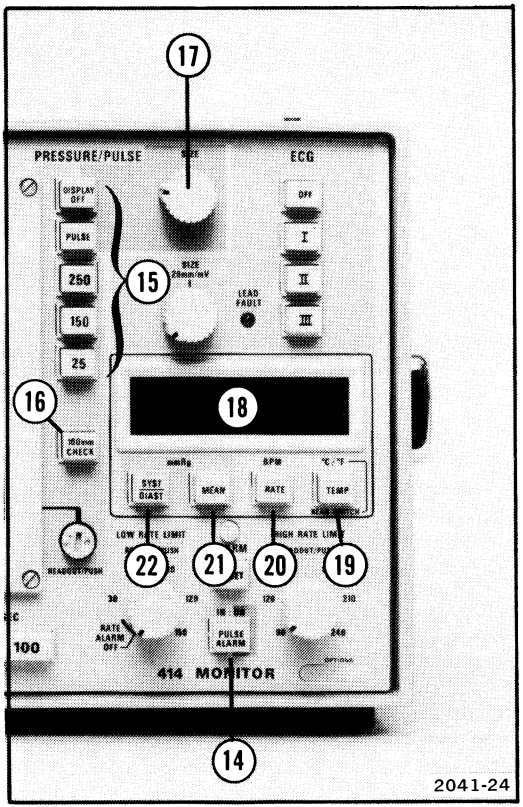

Fig. 9-2. Front panel controls.

(13) **LOW RATE LIMIT.** This control sets the lower rate alarm limit between 30 and 150 beats per minute. For more accurate setting, press control in while adjusting and set desired value on digital display.

(14) **PULSE ALARM.** Activates alarm if peak-to-peak value of pressure or pulse signal falls below a certain limit. For pressure, this can indicate a broken, plugged, or dislodged catheter. For pulse, it can indicate a loss of peripheral circulation (e.g., in Great Toe during catheterization of femural artery). Alarm is inhibited when switch is in out position.

(15) **PRESSURE/PULSE.** Five pushbuttons control the display on the lower half of the screen (if the ECG channel is off, the pulse signal moves to screen center). They are DISPLAY OFF, Pulse, 250, 150, and 25. DISPLAY OFF turns off the lower display and centers the remaining display on the screen. The PRESSURE/PULSE channel is always on and values can be selected on the digital display. PULSE permits the display from a pulse sensor to appear on the screen. 250, 150, and 25 select the mmHg (millimeters of mercury) range for the pressure transducer.

Small signals (one-half division or less) may not cause a beat tone and the pulse alarm would be set off. Display amplitudes that go off the screen may cause extra beats to be heard (when the ECG channel is off and the pressure channel is providing the beat information). Select the appropriate pressure range.

(16) **100mm CHECK.** Usable only with standardized pressure transducers containing a calibration resistor. With such a transducer connected to the monitor, this pushbutton displays a 100 mm test signal each time it is pressed, on the pressure range. There is no display change when a transducer without a calibration resistor is used. A reading between 95 and 105 mmHg is expected on the digital meter when depressing this button and the Zero Adjustment knob simultaneously. Be careful not to disturb the ZERO setting while pressing the Zero Adjustment knob.

(17) **PULSE SIZE.** This control varies the height of the pulse display when the pulse mode of operation is being used. The PRESSURE/ PULSE OUTPUT signal varies as the display signal varies during the pulse mode of operation. Small signals (one-half division or less) may not cause a beat tone (when the ECG channel is off and the pulse channel is providing the beat information). Display amplitudes that go off the screen may cause extra beats to be heard. Adjust the SIZE control for a two to three centimeter display where possible.

(18) **DIGITAL DISPLAY.** Provides digital display of Pressure (mmHg), rate (beats/minute), temperature (°C/°F), rate limits setting, or ZERO Adjustment knob setting. Polarity is indicated automatically to aid in setting of transducer zero and for reading vacuum. Readout display flashes to indicate overrange and is blanked if combination of functions selected is invalid.

(19) **TEMP.** Displays temperature in °C or °F as selected by the rear panel switch. Resolution is 0.1°. Use only dual thermistor Yellow Springs Instrument Co. 700 series probes.

(20) **RATE.** Displays heart rate in beats per minute. Source is ECG when ECG is on. When ECG is off, either pressure or pulse provides the rate information.

(21) **MEAN.** Displays arithmetic mean of pressure signal in mmHg. DISPLAY OFF pushbutton can be in or out.

(22) **SYST/DIAST.** Display alternates between systolic and diastolic readings expressed in millimeters of mercury (mmHg). Complete readout cycle takes about 3 seconds. DISPLAY OFF pushbutton can be in or out.

(23) **ECG LEAD CHECK TERMINALS.** The three terminals provide pulses which permit checking cable defects, electrode wire defects, amplifier operation and QRS detector function. When the patient wires are connected to the ECG LEAD CHECK terminals, an ECG lead selector button is pushed in and the ECG SIZE control is at 20 mm/mV, the display should be:

Lead	Display
I	2 centimeters of positive-going signal
II	3 centimeters of positive-going signal
III	1 centimeter of positive-going signal

414 Rear Panel

(24) **ECG INPUT.**

(25) **TEMPERATURE SENSOR INPUT.**

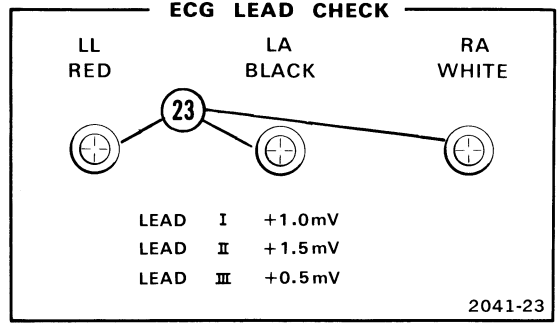

Fig. 9-3. ECG LEAD CHECK terminals.

(26) **°C/°F.** Switch selects temperature scale for the digital display.

(27) **PRESSURE TRANSDUCER INPUT.**

(28) **PULSE SENSOR INPUT.**

(29) **ALARM LOUDNESS.** Adjusts the loudness of the alarm signal. Set fully clockwise if maximum loudness is desired.

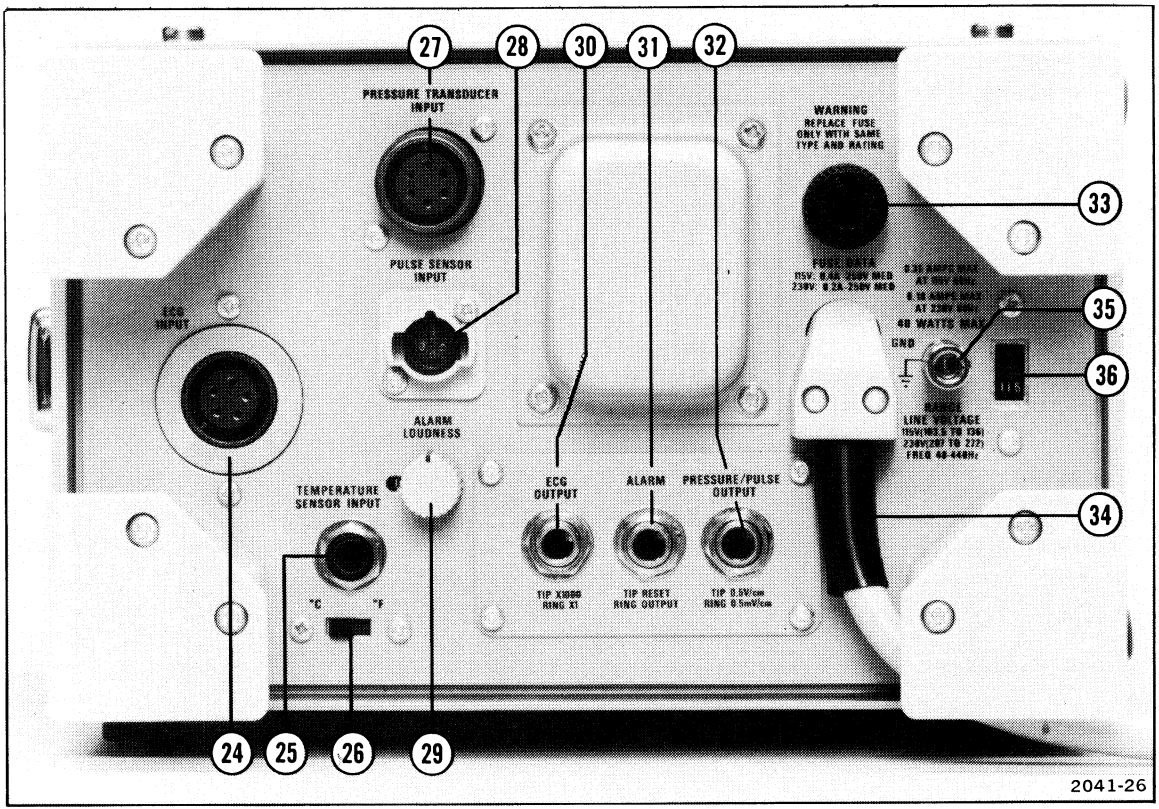

Fig. 9-4. Rear panel controls and connectors.

(30) **ECG OUTPUT.** Provides two output levels through stereo phone plug. The tip is times 1000 gain. The ring is times one gain for direct recording on a standard ECG machine or slaving one monitor to another.

(31) **ALARM.** Provides for remote indication and resetting of alarms through a stereo phone plug. Shorting the phone plug tip to the barrel (ground) resets the alarms. The ring provides a 12 mA signal to indicate an alarm condition.

(32) **PRESSURE/PULSE OUTPUT.** This output connector provides two output levels. The tip is 0.5 volt output for each centimeter of displayed signal. The ring is 0.5 millivolt for each centimeter of display.

(33) **Fuse Holder.** Contains the ac power line fuse.

(34) **Ac Power Line Cord and Plug.** Permits connection to the line for ac operation and battery charging.

(35) **GND.** Provides an additional grounding point (there is one in the power cord) for the instrument case. When the power cord is not connected to a power source, the case may be grounded as added protection against any voltage source (that might contact the case) reaching the patient. Grounding through the power cord requires an appropriate three-wire outlet. Do not use a three-terminal to two-terminal adapter.

(36) **LINE-VOLTAGE RANGE.** This switch is a screwdriver-operated slide switch. It should indicate the proper ac power line voltage. The range selections are 115 and 230 V ac.

OPERATING TEMPERATURES

CAUTION

The reliability and operating life of the digital display devices may be significantly and permanently reduced if they are operated below 0° C (+32° F) for more than a few minutes. When the instrument is operating, infrequent ambient temperature excursions slightly below 0° C can be tolerated. This is due to inherent self-heating from the instrument and the device itself.

The monitor will operate and meet all specifications over a range of 0° C to +50° C.

The monitor will function, but not necessarily meet its specifications over the extended range of −15° C to +55° C. See CAUTION above.

The monitor may be stored over a temperature range of −40° C to +60° C.

A cool monitor, taken into a warm, humid environment may cause condensation within the case. This condensation may create discharge paths on the circuit boards. The monitor should be allowed to dry thoroughly before using. The appearance of condensation on the monitor case is a good indication that moisture may have been drawn into the case.

Battery characteristics dictate that charging should be done in a temperature range between 0° C and +25° C for the battery to accept the maximum charge.

The greater the temperature above +25° C the less charge the battery will accept. Playback time is reduced 50% or more if charging takes place in a +50° C environment. Longer charging time will not compensate for a high temperature.

MOUNTING

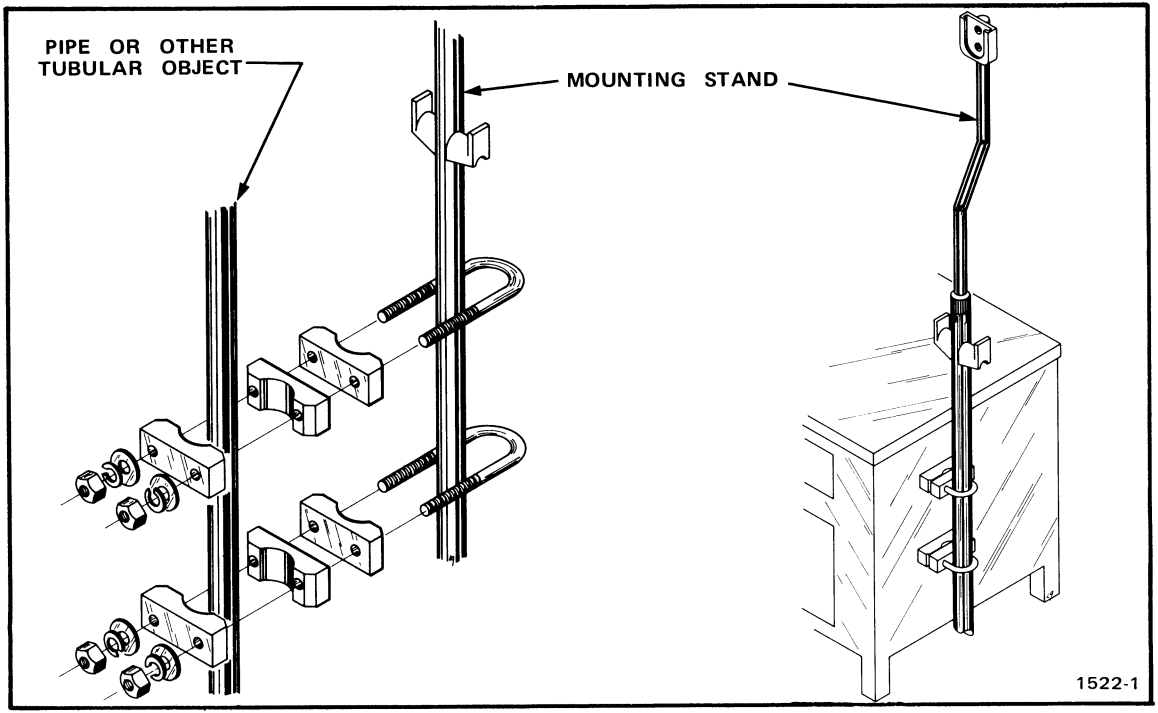

Fig. 10-1. Method of mounting to tubular object (pipe) or cabinet side.

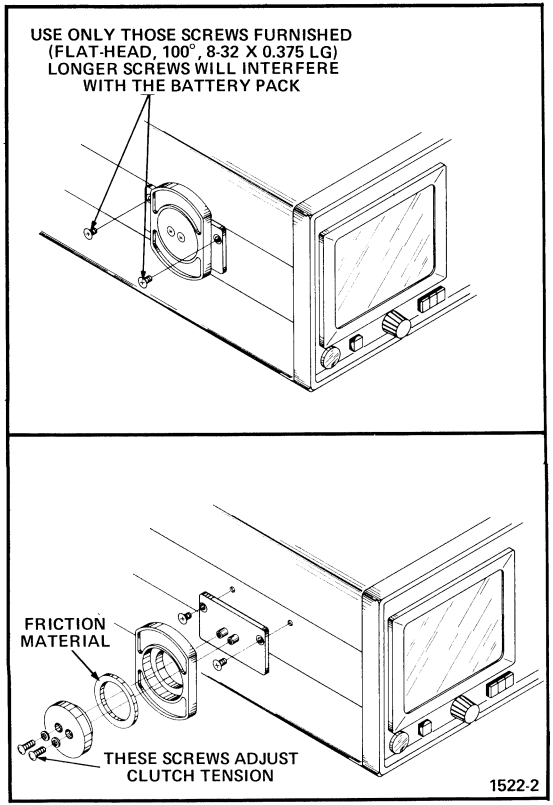

Fig. 10-2. Adapter attachment.

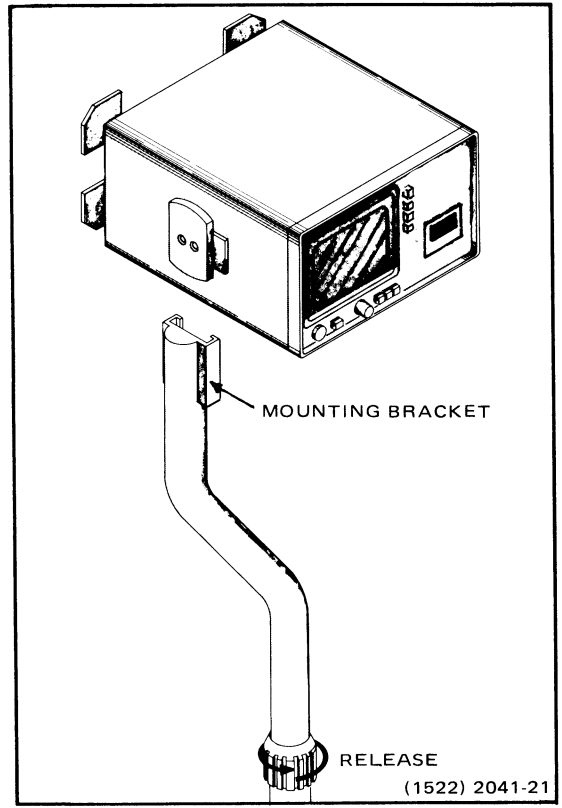

Fig. 10-3. Monitor mounting on a stand.

MAINTENANCE

Maintenance to be performed by the operator consists of cleaning and visual inspection.

CLEANING

The recommended method of cleaning the exterior surfaces of the instrument is with a cloth or swab dampened with a warm water and mild soap solution. Do not permit fluids to run behind the knobs and pushbuttons or into the connectors.

INSPECTION

Inspect all removable cables, wire, etc. Pay careful attention to the points that bend most as the repeated flexing at these points eventually causes breakage there. Replace frayed or otherwise damaged cables.

Inspect the power cord and plug for damage. Repair or replacement should be performed only by qualified personnel.

ABUSE

Monitors that have been dropped, or otherwise abused, should be referred to qualified service personnel to verify all safety features are intact.

CALIBRATION & SAFETY

Qualified service personnel should check the calibration of this instrument at least every two years. It is also recommended that the electrical safety features be inspected and leakage current measured every six months. Complete instructions are given in the service manual.

WARNING

Electric shock hazard exists when the instrument covers are removed. Refer servicing to qualified personnel.

MAINTENANCE SCHEDULE

The following is a suggested maintenance schedule for instruments in continuous use. Obvious defects should be immediately remedied.

	1 Month	6 Month	2 Year
Inspect Removable Wire & Cables	X		
Inspect Power Cord & Plug	X		
Safety Inspection		X	
Calibration (by qualified Service Personnel only)			X
Clean Exterior	As Required		

INSTRUMENT FAILURE

In the event of monitor failure or malfunction, an accurate description of the operator's observations can be of considerable value. Describe the problem and attach this information to the monitor with your name, phone number, and department to permit the service technician to contact you. For example:

1. Is the malfunction intermittent?
2. Does the malfunction affect only one function (such as audio) or is the monitor totally inoperative?
3. If totally inoperative, does this apply to both ac and battery?
4. If the monitor is not totally inoperative, which function(s) are operative and which are not?

	YES	NO
a. ECG		
1. Trace	_____	_____
2. Lead Selector	_____	_____
3. LEAD FAULT	_____	_____
4. Audible Beat	_____	_____
b. Pulse		
1. Trace	_____	_____
2. SIZE	_____	_____
3. Audible Beat (with ECG off)	_____	_____
c. Pressure		
1. Trace	_____	_____
2. Zero	_____	_____
3. Range	_____	_____
4. Audible Beat (with ECG off)	_____	_____
d. Sweep		
1. All Speeds	_____	_____
e. Alarms		
1. ECG rate	_____	_____
2. Pulse rate (with ECG off)	_____	_____
3. Pressure rate (with ECG off)	_____	_____
4. High Rate Limit	_____	_____
5. Low Rate Limit	_____	_____
6. Pulse Alarm, Pulse transducer	_____	_____
7. Pulse Alarm, Pressure transducer	_____	_____
8. Reset	_____	_____
f. Digital Display		
1. mmHg, SYST/ DIAST-MEAN	_____	_____
2. BPM - RATE	_____	_____
3. °C/°F - TEMP	_____	_____
4. ZERO Adjust (when pressed)	_____	_____
5. Low Rate Limit (when pressed)	_____	_____
6. High Rate Limit (when pressed)	_____	_____