

Infant Incubator

Infant Incubator

Infant incubator is a Bio Medical Device which provides Warmth, Humidity and Oxygen all in a controlled environment as required by the New born

History

- ★ In 1891 - First modern Incubator invented by Dr.Alexander Lyon
- ★ 1898 - First American Incubator Hospital was set up at the Trans Mississippi Exposition in Omaha , Nebraska.
- ★ 1907 - Pierre Constant Budin released the study of Influence of Body temperature on Infant Mortality

History

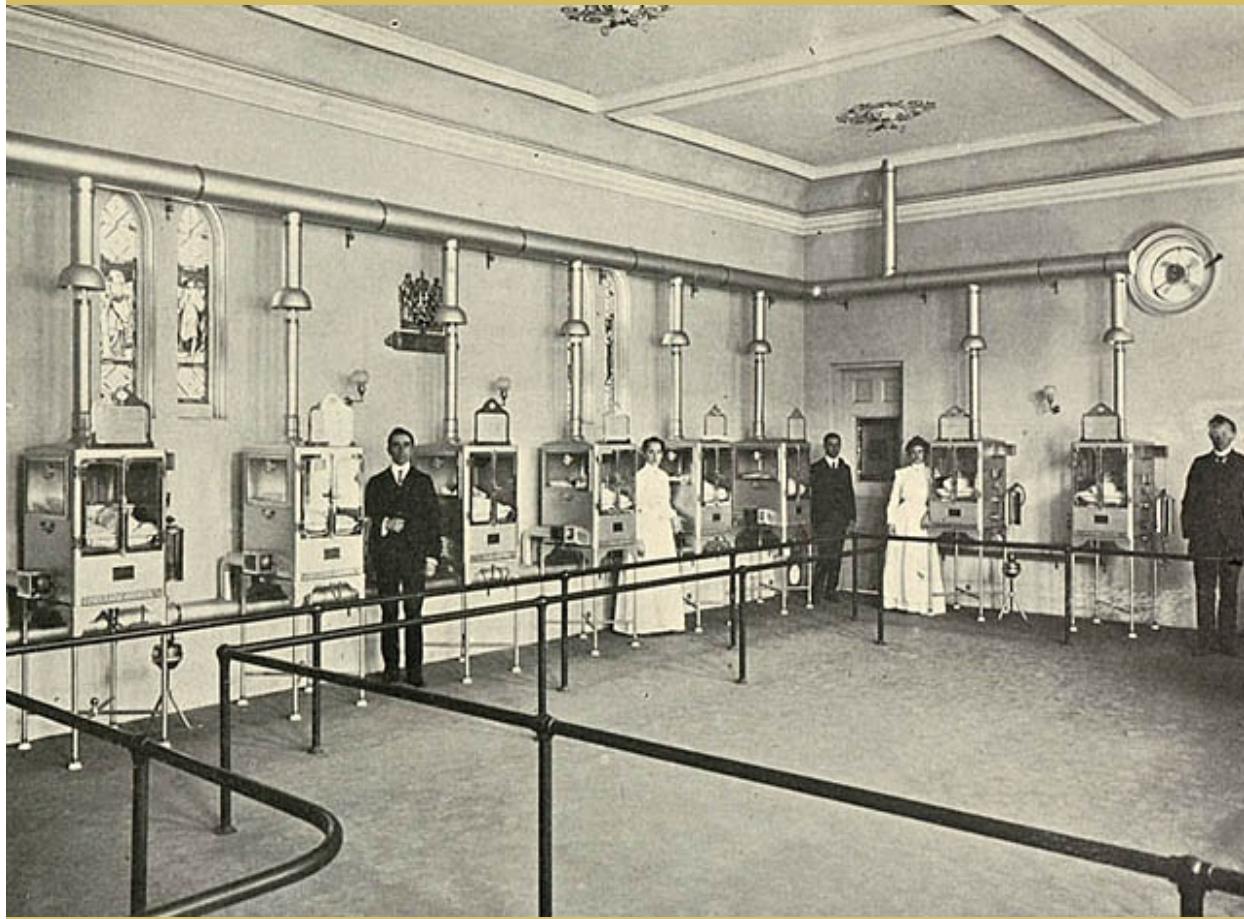
- ★ **In 1932** - Julius Hess in his patents for incubators proposed a mechanism for the addition of supplemental oxygen in the Incubator.

- ★ **1933** - Blackfan and Yaglaw released report on the Improved survival for New Born infants nurtured in Humidity enriched environment.

History



History



Principle

- The infant incubator is normally in the form of a trolley with a small mattress on the top covered by a rigid clear plastic cover.

- Incubator chamber provides a clean environment, and helps to protect the baby from noise, dust, infection, and excess handling.

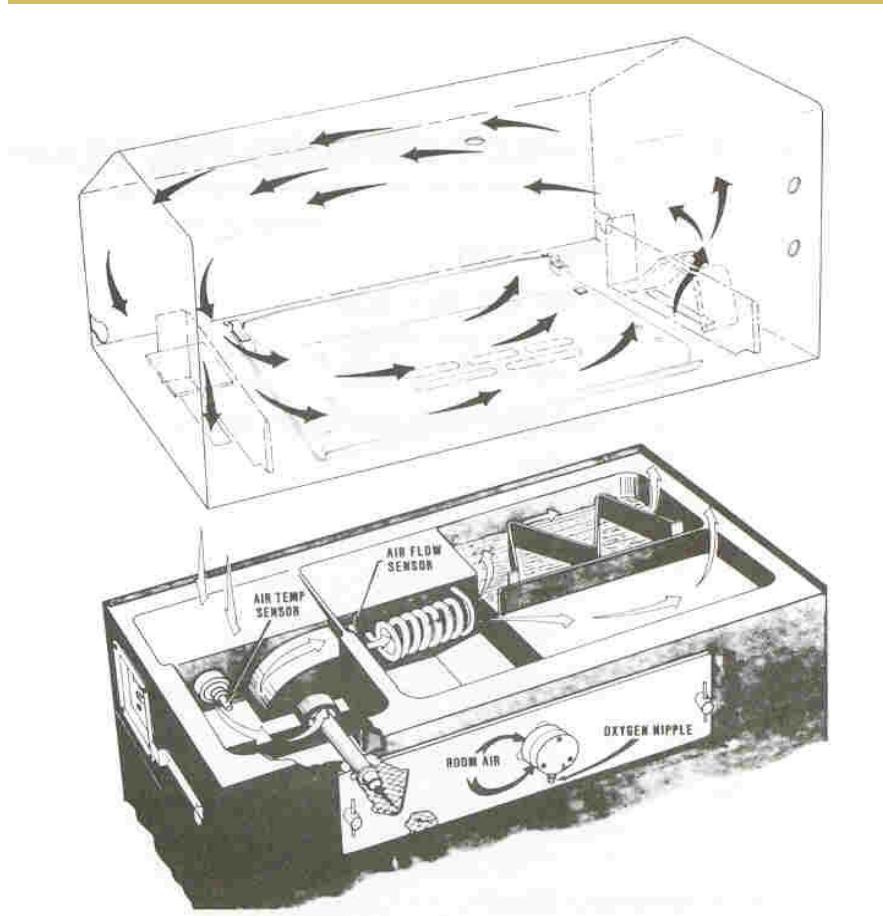
Principle

- A temperature sensor is taped to the baby's skin, and the incubator heater adjusts to maintain the baby at a constant temperature or, the temperature is controlled by a thermostat in the heated air stream.

Principle

- Underneath the baby is an air-blown electric heating system and humidification system which circulates heated humid air at a desired temperature and humidity through the incubator chamber.
- Additional oxygen may also be introduced into the chamber.

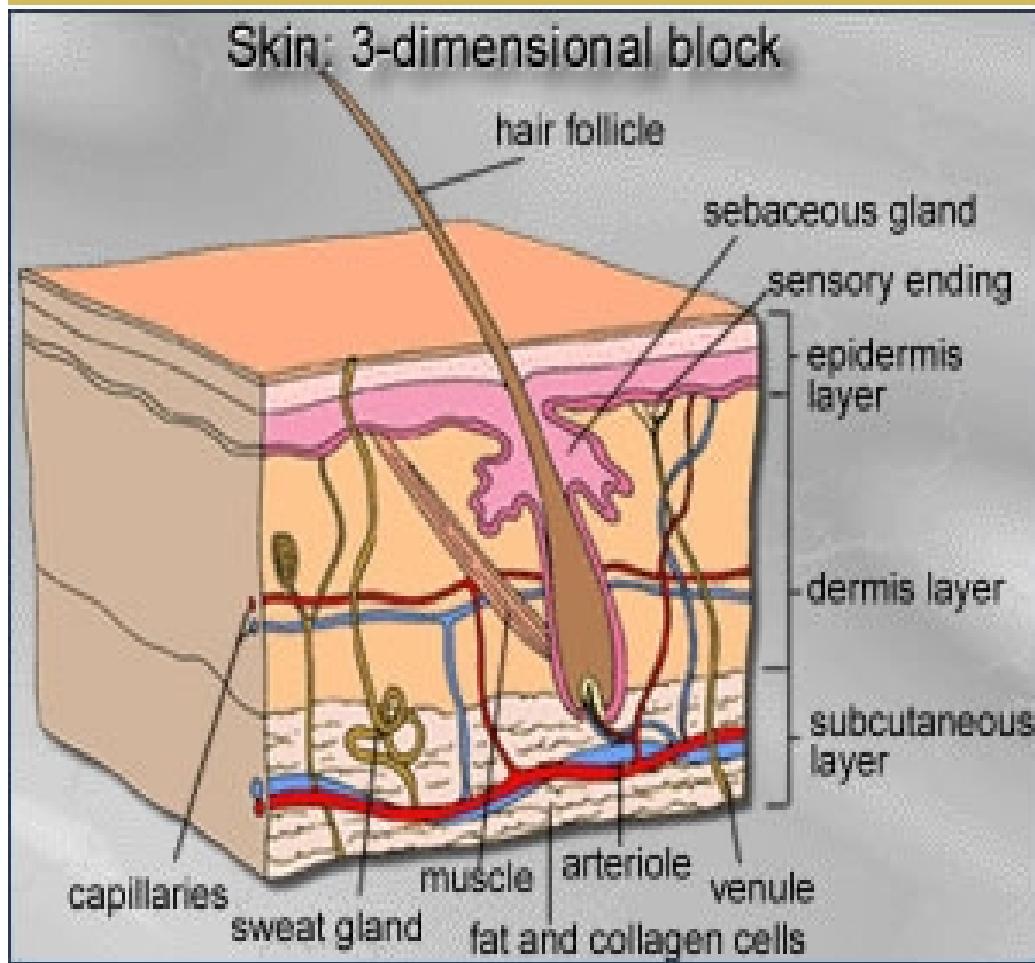
Principle



Anatomy of Skin

- Skin is often considered the largest organ system of the human body.
- The average adult male has 18 square feet of skin weighing over 6 pounds.
- Skin is comprised of three layers, the Epidermis, Dermis and Subcutaneous tissue.

Anatomy



Skin

Epidermis

- Outer Layer of the Skin
- Contains upto 5 layers
- Thinnest in eyelids and thickest in soles
- Continuously regenerates itself

Skin

Dermis

- Middle Layer of the Skin
- They contain blood vessels, hair follicles , oil and gland and nerve endings
- They transmit sensation of pain, itch and temperature

Skin

Subcutaneous Tissue

- Made up of fat and connective tissue
- Houses larger blood vessels and nerves
- Regulates body temperature

Skin - Function

- Provides a physical barrier to the outside environment.
- Assists in the development of the immune system
- Conserves body fluid by preventing evaporative loss.
- Maintains body temperature.

Skin - Function

- Excretes water and oils.
- Produces vitamin D in the presence of sunlight.
- Provides sensations of temperature and touch.
- Stores water, fat, and vitamin D.

Important Parameters

- Temperature
- Humidity

Body Temperature

- **Normal core body temperature can range between 98.9 F and 99.9 F.**
- **Cells, tissues and organs operate efficiently only within this narrow temperature limits.**
- **If the temperature rises 2°F above the normal of 98.6°F, we become ill. If it rises 7°F, we become critically ill.**
- **If our temperature decreases 2°F, we feel cold. A 7°F decrease puts our life in jeopardy**

Body Temperatures

➤ **Hypothermia**

Low body temperature is called Hypothermia

➤ **Hyperthermia**

High body temperature is called Hyperthermia

Hypothermia

- It occurs when core body temperature drops To 95°F or lower
- Happens when heat loss exceeds heat gain
- New born with temperature below 36.0-36.4°C (96.8-97.5°F) is in moderate Hypothermia

Hypothermia

Remedy

- Skin-to-skin contact with the mother
- Use a heated water-filled mattress
- Use radiant heater
- Use Incubator

Hyperthermia

- Hyperthermia can be defined as a core temperature greater than 98.6° F (37.0° C)

- In adults it may lead to Fever, Heat syndromes like collapse, cramps, stroke etc.

Hyperthermia

In neonates hyperthermia rarely does occur but for an external source like

- Overzealous re-warming
- Poorly serviced equipment
- Misuse of warming lamps
- Incubator too close to a sunny window
- Temperature probe not in good contact with the skin

Hyperthermia

Hyperthermia in Neonates can lead to

- Increased oxygen requirements
- Apnea
- Dehydration
- Metabolic acidosis
- Heat stroke, brain damage, shock and even death.

Thermoregulation

Thermo regulation is the ability of the body to balance the heat produced in the body with the heat lost by the body thereby maintaining the body temperature in the normal range.

Thermoregulation

- The temperature of the body is regulated by hypothalamus
- Sweating begins almost precisely at a skin temperature of 37°C
- If the skin temperature drops below 37°C , a variety of responses are initiated to conserve the heat in the body and to increase heat production

Thermoregulation

Heat Production

- Due to metabolic activities

Heat Loss

- Evaporation
- Conduction
- Convection
- Radiation

Heat Loss

Evaporation

- Heat loss due to water evaporation from skin and respiratory tracts

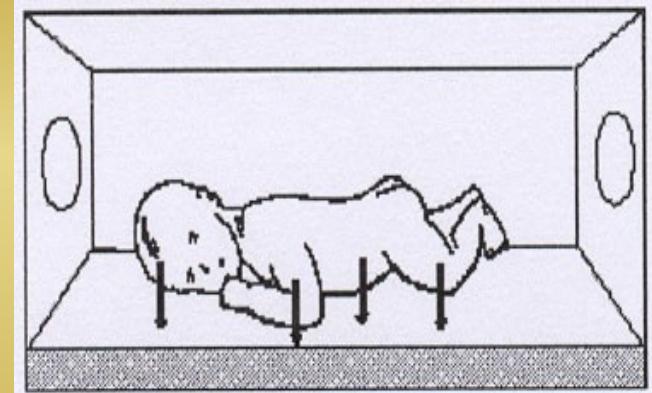


Evaporation

Heat Loss

Conduction

Heat loss to cool the surrounding air.



Conduction

Heat Loss

Convection

Heat loss to cool solid objects which are in direct physical contact.

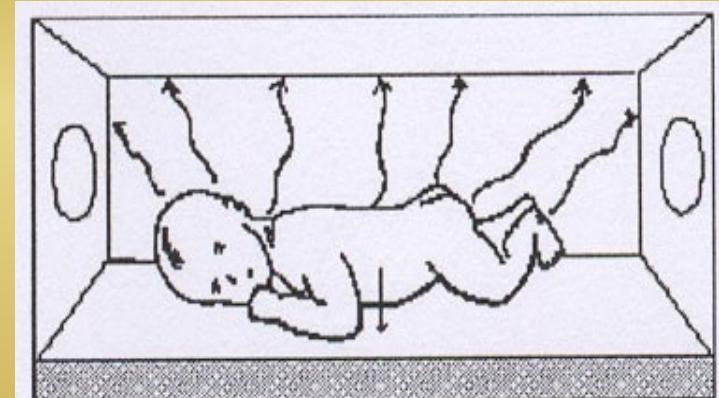


Convection

Heat Loss

Radiation

Heat loss to cool solid objects which are not in direct physical contact.



Radiation

Thermoregulation

In Uterus

- Baby is essentially a cold blooded creature unable to thermoregulate like adults
- It therefore adapts to the mothers core temperature.
- The baby's core temperature is generally 0.5° C above the mother's core temperature

Thermoregulation

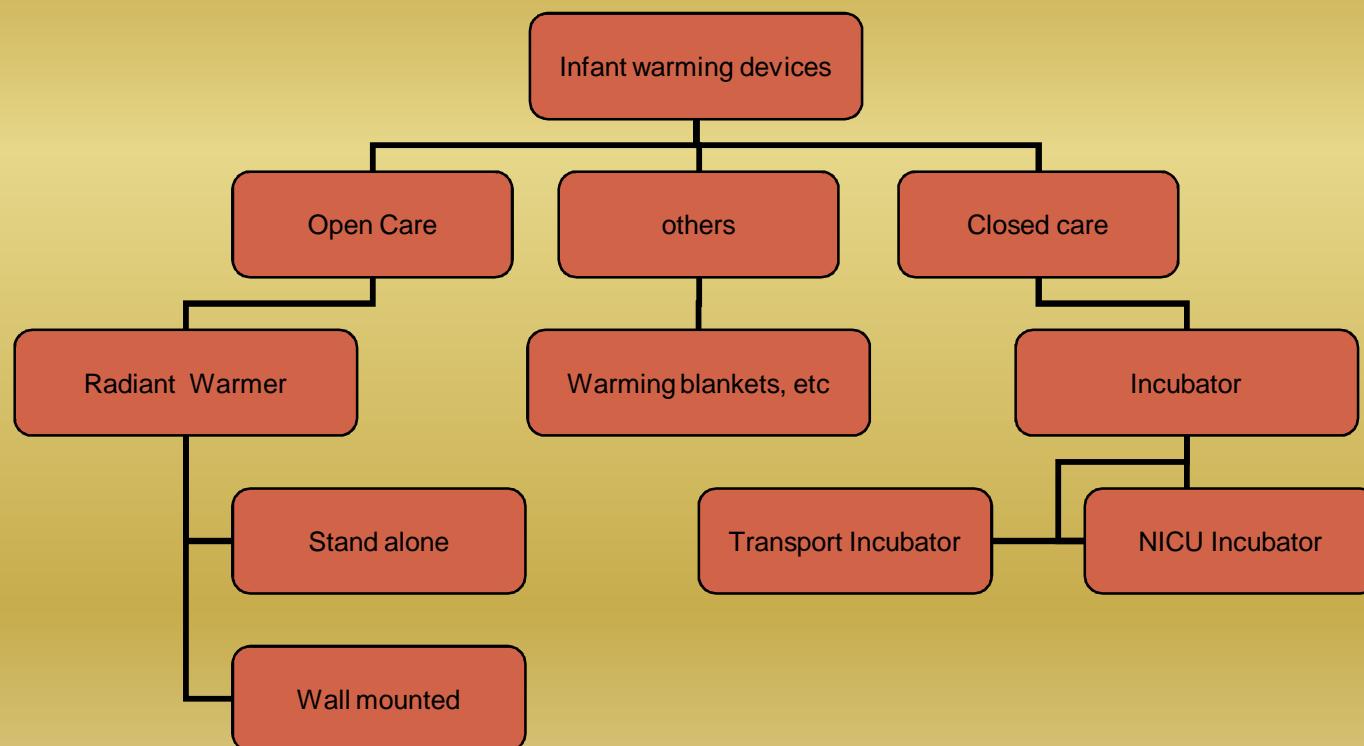
Neonatal Risk

- Have limited thermoregulatory ability
- Transition from the Poikilothermic to Homeothermic state is delayed.
- Rely on external heat to maintain their core temperature.
- Thermal instability can last for several days or even weeks!

Application

- NICU
- SCN
- Post natal care wards
- Transport Incubators can be found in Labour ward to transport the new born to Post natal wards or NICU.
- Hospitals that don't have a dedicated NICU will have a transport incubator so that critical new born can be shifted via ambulance or helicopters to the nearest hospital having an NICU facility.

Infant Warming Devices

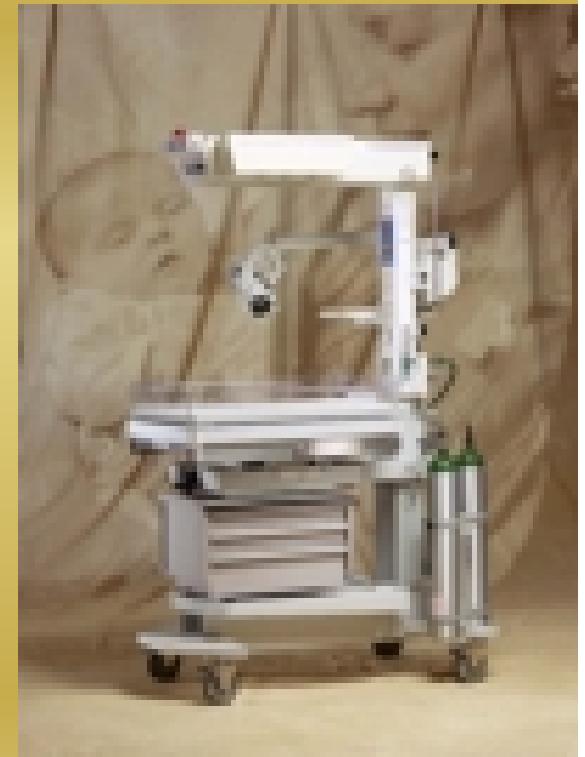


Types - Radiant Warmer

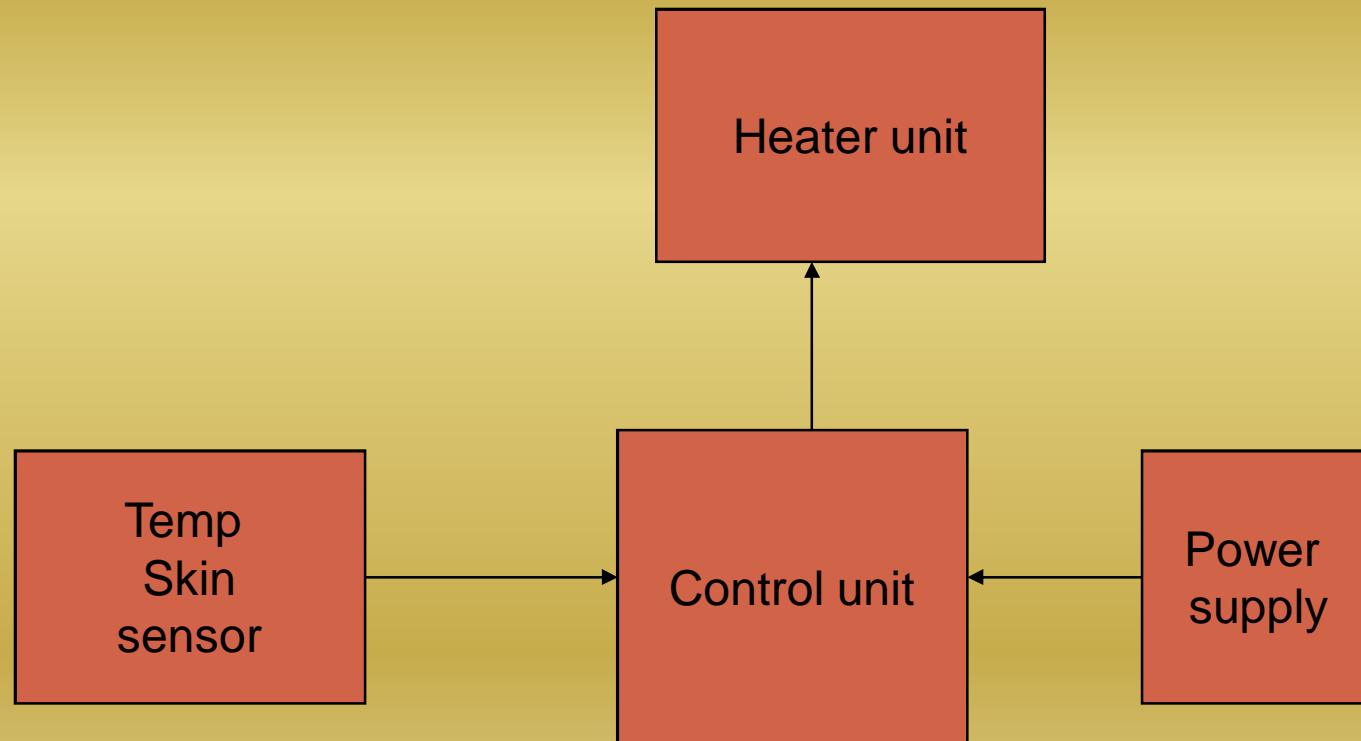
The radiant warmer is a bed with an overhead heating element.

A temperature sensor is taped to the infant's skin, and the warmer regulates its heat output to maintain the baby at a constant temperature

Radiant Warmer



Principle of Operation – Radiant Warmer



Radiant Warmer

Advantages

Allows physician and nurse to have easy access to the baby from all sides during the most critical period.

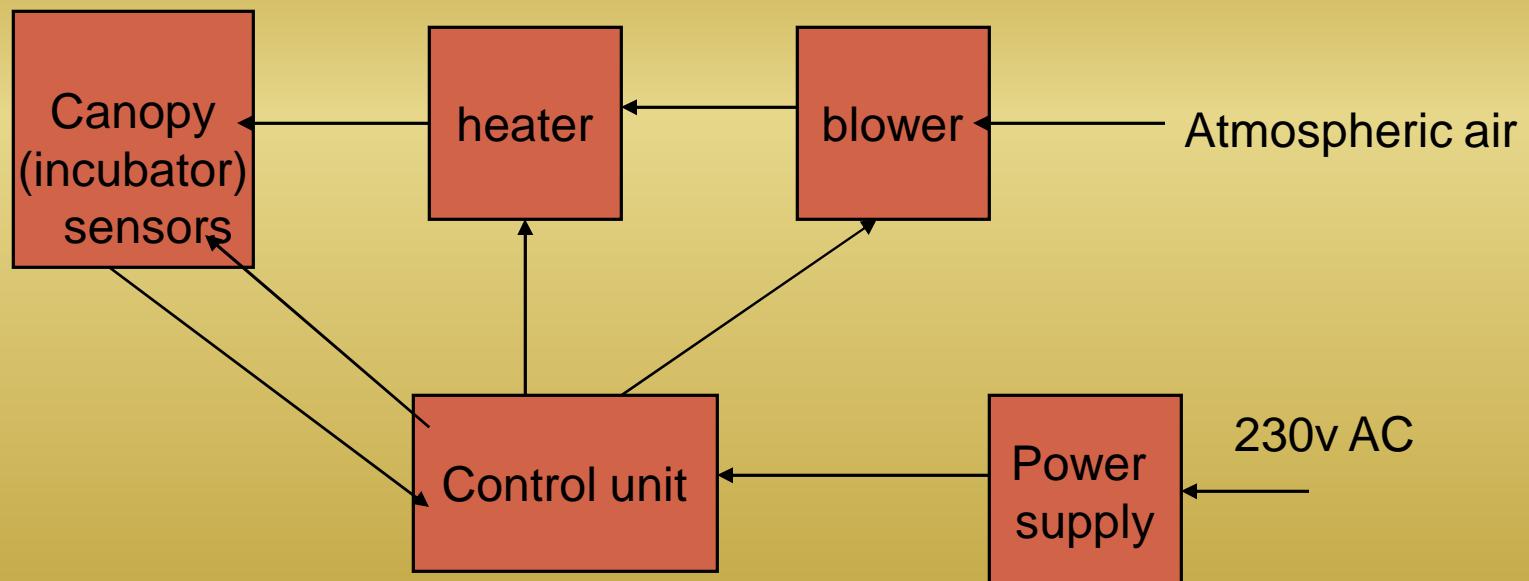
Disadvantages

Baby is open to all the disturbance and infection in the NICU and it is difficult to control Humidity.

Infant Incubator

The incubator keeps the baby warm with heated moist air in a clean environment.

Principle of Operation Infant Incubator



Infant Incubator

Advantages

- It provides the closest environment to that of the mother's uterus
- Temperature at a uniform airflow and the Humidity can be controlled to the desired level
- It protects the baby from all the disturbances and infection in the NICU

Infant Incubator

Disadvantages

- The disadvantage is that since the baby lies in a closed hood it is difficult to access the baby for medical procedure or care.



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Infant Incubator



Transport Incubator

- A transport incubator is used when a sick or premature baby is moved from one hospital to another
- It is similar to the Infant Incubator but is battery powered

Transport Incubator



Versalet TM

- A totally integrated microenvironment that functions as either a radiant warmer or incubator, and converts between them at the touch of a button.



Differences

Incubator

- Closed care
- Convection principle
- Humidity Adjustment
- Less disturbances
- Oxygen control available

Radiant warmer

- Open care
- Radiation Principle
- No Hy.Adjust
- External Disturbances more
- No O₂ control

Differences

Transport Incubator

- Battery powered
- Air (Manual) Mode only
- Resuscitation apparatus attached
- Compactable in size

NICU Incubator

- Mains operated
- Both Air & Patient mode of operation
- Not attached
- Bigger

Modes of Operation

Incubator

1. Air Mode – Air Temp will be taken as reference for the control.
 2. Skin Mode- Skin Temp taken as reference for control
- Note:** safety temp sensor present for auto cutoff at higher temp.

Radiant Warmer

1. Manual mode- constant heater output as per setting

2. Servo (skin) Mode

Skin Temp taken as reference for control of heater output

Incubator

Control- air temp(in air mode), patient Temp (in patient mode), O₂ %, Humidity.

Alarms- low temp, high temp

Radiant warmer

control - % of heater o/p in Manual Mode, patient temp in skin mode.

Alarms-low temp, high temp

Auxiliary & Remedies

- Low Temp – check Alarm limits, sensor& calibrate if required
- High Temp- check Alarm limits, sensor& calibrate if required
- Probe Fail – check probe for any damage & calibrate if required

Hardware Alarms

- Power fail- check mains present, power cord, fuse, power supply PCB
- Fan fail- check Fan, Fan voltage, Fan control circuit.
- Heater Fail- check Heater resistance, heater voltage, heater control circuit.
- Air probe, Patient probe, safety probe- check respective sensors, calibrate if necessary.

Hardware Details

- **Incubator**
- Trolley Part-Motorized or Manual
- Main Body- Heater, Fan, Humidity chamber, control module ,filter& O₂ inlet
- Canopy (glass hood)
- Base frame or stand
- Control Module
- Heater box

Control Module

- Power supply – Fan control, Heater control, Voltage outputs. Types-Linear & SMPS .
- Control PCB- CPU, Ram, EPROM, ADC, CLK, interfacing ICS, Display drivers & amplifiers.
- Temperature sensors – Linear op-amps, Thermisters, Thermocouples.
- Display PCB – 7 segment LED display, LCD, Alphanumeric displays
- Observation Lamp section.

PPM & Consumables

- **Cleaning of Fan Filters/Replacement**
- **Sensors check & calibration**
- **Safety test & all other functional check**
- **Bearings of Motor (Fan)**
- **Heater coil resistance & its contacts**
- **Casters & Wheels**
- **Consumables- Iris Port covers, sensors, Air Filters**

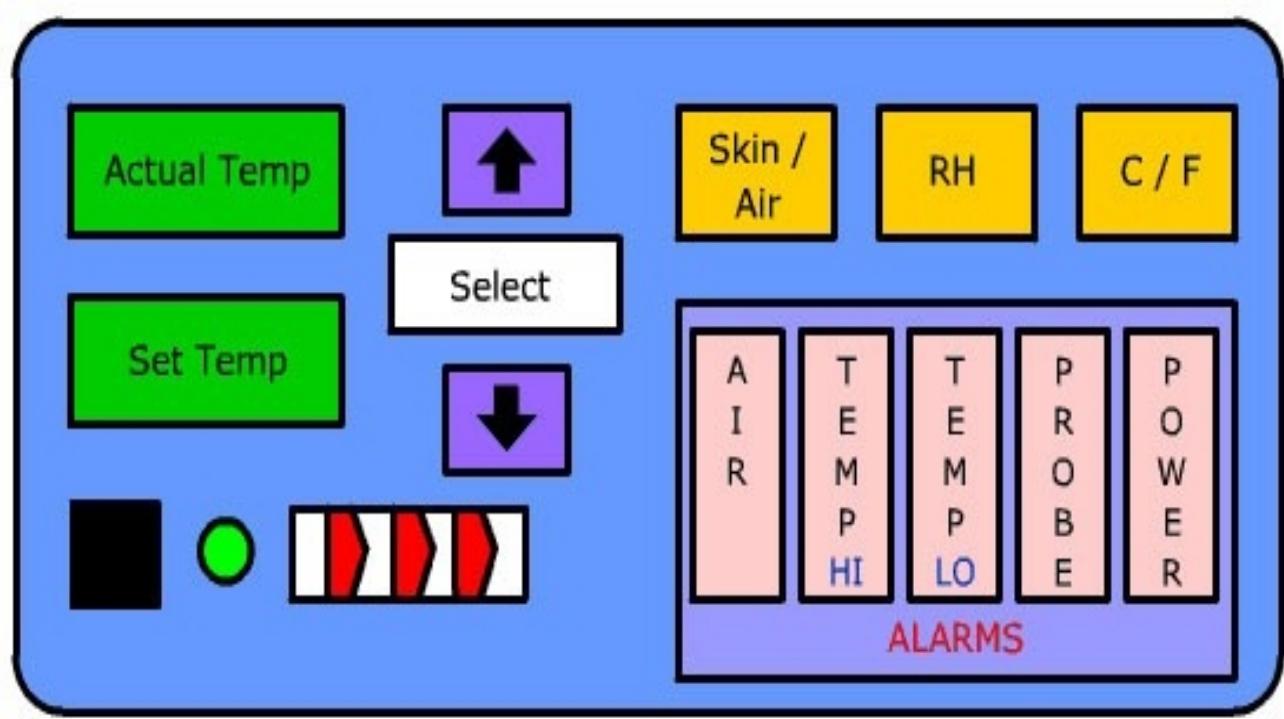
Advancements

- Warmers with Resuscitators (cpap, suction, o2 flow o/p) & phototherapy
- Incubators With servo oxygen, Humidity control & Double Walled mechanism
- High Accuracy Thermister probes
- Lightchorom Display
- With build-in weighing scale (electronic) & Trends view for all parameters

Others

- Fan types- Blower , Impeller
- Heater types- ceramic, Quartz tube

FRONT PANEL



Noise

Premature babies are fragile. One of their special needs is quiet environment. However, in the neonatal intensive care unit (NICU), high noise levels and frequent handling leave the babies sleep deprived and may disrupt their normal growth and development.

Noise

Noise effects on the infant are,

- Hearing Impairment
- Sleep disturbance
- Somatic Effects
- Auditory Perception and Emotional Development

Avoiding Noise

- No tapping or writing on top of the Incubator or hood.
- Careful and soft closure of the Incubator pot hole doors.
- Neonatal Noise mufflers can be used.
- Medical staff should be advised to wear soft shoe.
- To identify noisy areas and to isolate them.
- Check existing machines for noise level
- Check all incoming new machines for their noise level before being put to use

Noise Levels

Quality	Peak Intensity dBA	Example	Equivalent Inside Incubator	Effect
Just Audible	10	Heartbeat		
Very Quiet	20 - 30	Whisper		<35 dBA desired for sleep
Quiet	40	Average Home		
	50	Light Traffic	Background	<50 dBA desired for work
Moderately Loud	60	Normal Conversation	Motor on and off	
	70	Vacuum Cleaner	Bubbling in Ventillator tubing	
Loud	80	Heavy traffic or telephone ringing	Tapping incubator with fingers	
	90	Pneumatic drill	Closing the metal cabinet doors under the incubator	Hearing loss with persistent exposure
Very Loud	100	Power mower	Closing solid plastic porthole	
Uncomfortably Loud	120	Boom box in car	Dropping the head of the mattress	Pain and distress
	140	Jet plane 30 meter overhead		

Patient Preparation

- Defer bathing until medically stable.
- For Infants still in their Incubators use only sponge baths followed by immediate drying within their Incubator.
- Warm all surfaces – scales, stethoscopes, bedding, etc., before making contact with the infant to prevent conductive loss.

Patient Preparation

- **Run the** Incubator till it reaches the desired temperature before you place the Infant inside it.
- For Infants in an incubator, always use a skin temperature probe as it is too easy to overheat infants when using the manual mode as compared to the skin mode.
- Phototherapy lights will also produce radiant heat within the incubator and therefore these infants require more diligent monitoring

Patient Preparation

- Skin temperature probes should never be placed over a bony area
- Make sure the skin temperature probe is in good contact with the infant. A probe, which is not in good contact with the skin will read a low temperature thereby heating up the infant more than what is required.
- When treating an infant with phototherapy lights, be careful that the spotlights are not aimed directly at the probe.

Patient Preparation

- When using a skin probe on a radiant warmer, always use one that is reflective. This protects the probe from the infrared heat source. The probe must be protected from sensing a temperature higher than skin temperature, which will decrease the heater output and may cool the infant.
- The head has the greatest potential for heat loss due to its surface area, therefore cover it to minimize heat losses in smaller babies.

Operation

- Make sure that IV lines, Pulse oximeter cables, Ventilator tubing and all other cables and tubing connected to the patient pass through the tubing access port and they don't impede with the proper closing of the Hood.
- Place the patient inside the Incubator and fix the Skin temperature correctly on the patient.
- Switch to Skin Temperature Mode and check for a few minutes that no alarm sounds.

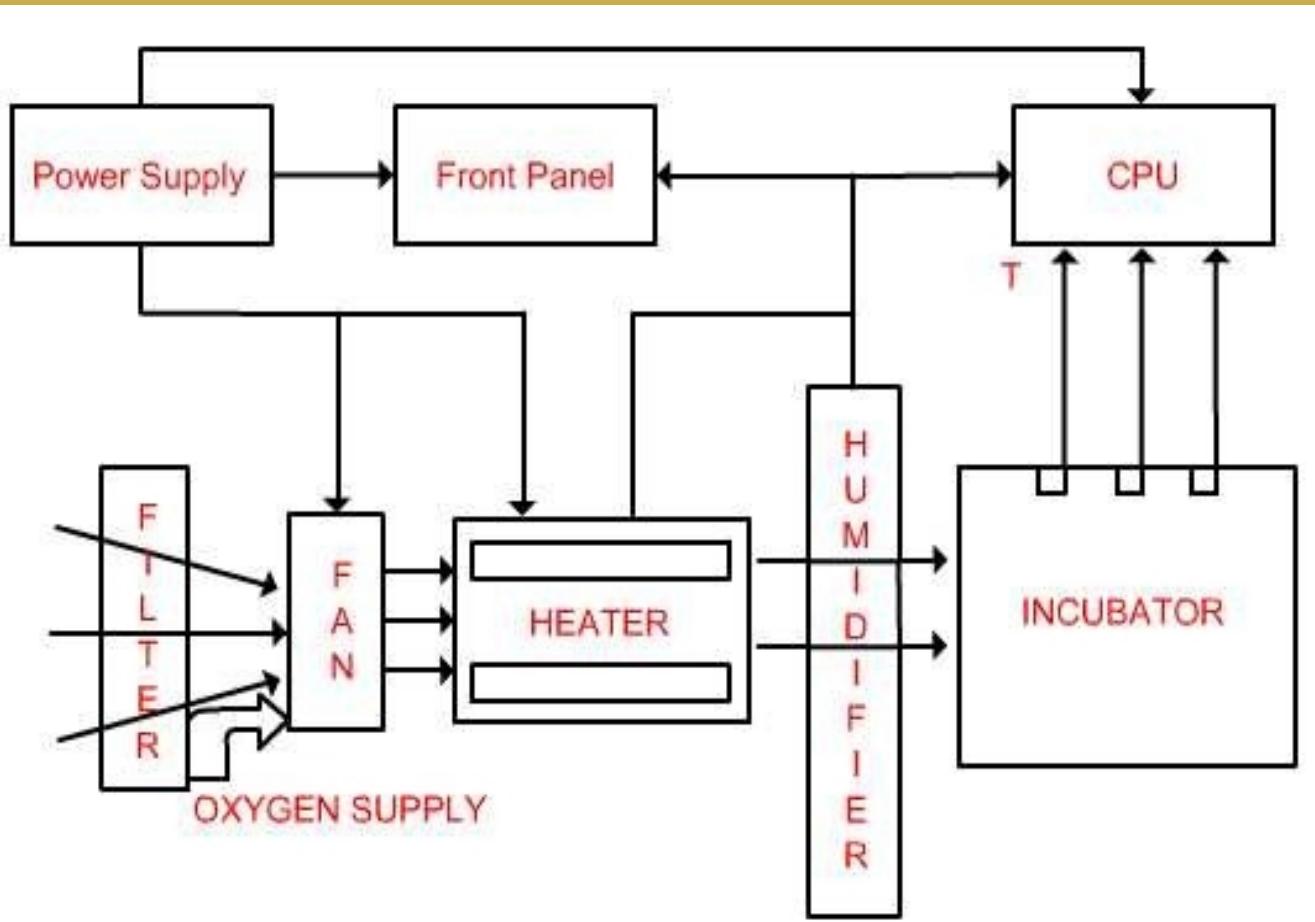
Temperature Range

Age	1000 To 1200 gms	1201 To 1500 gms	1501 To 2500 gms	>2500 gms & >36 weeks
0 - 12 hrs	35.0	34.0	33.3	32.8
12 - 24 hrs	34.5	33.8	32.8	32.4
24 - 96 hrs	34.5	33.5	32.3	32.0

Temperature Range

Age	< 1500 gms	< 1501 To 2000 gms	< 2500 gms to 36 weeks
5 - 14 days	33.5	32.1	32.0
2 - 3 weeks	33.1	31.7	30.0
3 - 4 weeks	32.6	31.4	
4 - 5 weeks	32.0	30.9	
5 - 6 weeks	31.4	30.4	

Block Diagram - Infant Incubator



Incubator Blocks

Power Supply:

This provides the necessary voltage for the operation of the Incubator

Filter:

Incubator filters protect the infant from airborne bacteria and other impurities

Fan:

This is used to circulate air in the Incubator

Incubator Blocks

Heater:

The room air that is passed over the heater is heated to the desired temperature

Humidifier:

The heated air pass through the humidifier to be humidified to desired level

Front Panel:

This is used to interface with the machine to get the desired operation

Maintenance

User Maintenance

- Cleaning
- Disinfection
- Functional Checks

Cleaning

- Cleaning should be done at least once a week or when every time the patient is changed.
- The heater rod can be hot enough to cause severe burns. So switch off the machine, unplug the power cord and allow the unit to cool down before disassembly or cleaning.

Maintenance

Cleaning

Procedure

- Clean all porthole seals and Hood seals parts with a solution of general purpose neutral detergent and warm water.
- Clean frame, mattress and accessories with a solution of general purpose neutral detergent and warm water, applied with a disposable wipe.
- Clean the oxygen inlet with mild cleaning solution.

- Reusable Patient probes can be cleaned by soaking the probe tip and wire in a cleaning solution. The connector tip should not be soaked.
- Pat the probe tip and wire with a clean cloth to dry it.
- Clean the castor wheels and remove the lint and dirt accumulated in it

Disinfection

- If used by infected babies , after cleaning, wipe over with a chlorine-releasing agent rinse and dry thoroughly.
- If visibly contaminated with blood or faeces, clean as above then wipe it with a chlorine releasing agent, rinse and dry.
- Phenolics or alcohols should not be used as they will damage the waterproof coating of the mattress cover.

Functional Checks- Mechanical

- Check the Incubator exterior especially the plexi glass for any signs of damage.
- Check the braking system in the wheels work properly.
- Check the Hood seals are placed properly.
- Check that the access ports can be opened and closed properly.
- Check the Hood tilt latch. Verify its locking and release mechanism is OK.

Functional Checks- Operation

- Switch on the machine and make sure that the self check passes successfully.
- Check whether the Manual and Servo mode can be selected.
- Check the switch for Selection of Temperature unit (Centigrade or Farenheit)
- Check whether the set Temperature can be raised and lowered.
- Check whether the set Humidity can be raised and lowered.

Functional Checks- Operation

- In Servo mode remove the Skin Temperature probe and check whether the Probe Fail alarm sounds.
- With the machine switched on disconnect the main power supply and check whether the Power Failure Alarm sounds.
- Trigger any alarm and verify the operation of Silence switch.

- Do not leave any patient inside the Incubator unattended for a long time.
- Humidifier compartment should be fixed even if it is not used.
- Do not place the Infant Incubator in direct sunlight or other source of light as it might overheat the infant.
- If ambient temperature is higher than the set value then Incubator will be ineffective.
- When oxygen is administered always check the level using an independent oxygen monitor

Safety

- Never oil or grease the oxygen inlets
- If Incubator is cleaned with flammable agents like ether , alcohol etc, it should be air dried before being put to use.
- The airfilter should not be cleaned and should be replaced at least every three months or when it is dirty.
- Avoid moisture or contact with water, excessive humidity and temperature. The Incubator should be kept in a clean and dry place whenever not in use.

Safety

- Use only the temperature probe recommended by manufacturer
- The Incubator's air circulation and Ventilation ports should not be obstructed otherwise heat loss and CO₂ build up will happen.
- For post operative patients care should be taken as the residual anesthetic gases exhaled by the patient can be decomposed by the heater to produce formaldehyde.

Electro Magnetic Hazard

Studies of a possible relation between exposure to extremely low-frequency magnetic fields and some types of childhood leukemia indicate that most of the power frequency magnetic field measured in the incubator originates from the fan blower motor rather than the electric heating coils. If this is correct, it can be easily reduced by using different fan motors, by magnetic shielding, or by relocating the incubator motor further from the infant.

PPM

- Qualitative Task
- PPM Task
- Quantitative Task
- Electrical Safety Test

Incubator Analyzer

- The Incubator Analyzer, is a portable device designed to verify the proper operation of infant incubators.
- This unit is placed on the mattress of the unit under test.
- The Temperature and Humidity are all adjusted just as it is done on a patient .
- This unit records parameters important to the care of infants such as airflow, sound level, temperature and relative humidity.

Trouble Shooting

- Electrical safety analyzer
- Digital Thermometer
- Sound Level Meter
- Multimeter

Trouble Shooting

Error Message	Probable Cause	Corrective Actions
No power	Circuit Breaker Tripped.	Reset Circuit Breaker.
High Temperature /High Set Temperature Alarm	Main Deck or Hood seat Gasket not properly installed.	Install the Gasket properly.
Low Temperature/Low set Temperature Alarm	Access Door or Iris port not closed properly.	Close the Door and Iris port properly
	Skin temperature probe not connected properly.	Check skin probe connection.
Air Flow Alarm	Air outlets blocked by mattress or diapers etc.	Clear the blockage.
	Fan Failure.	Fan Motor needs to be replaced.
Low oxygen concentration	Access Door or Iris port not closed properly, hood or main deck not seated properly, Air inlet filter not installed.	Fix Door, Iris port, Hood, Deck, Filter properly.
High Oxygen concentration	Dirty Air Filter.	Replace Air filter.
	Air intake tube not installed.	Install air intake tube properly.
	Dirty fan impeller	Clean fan impeller.

ACCESSORIES OF AN INCUBATOR



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Head hood



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Head hood

- Single piece, Round Shape, made of autoclavable Polycarbonate material.
- Trauma free Silicone neck adjustment flap.
- Bilateral oxygen nozzle (prevents direct flow of cold oxygen on patient's head.
- Height : 7.5”.
- Width : 8.5”.

Baby with Head Hood inside Incubator



Nasal cannula



Nasal cannula



NICE 5060 Bubble CPAP



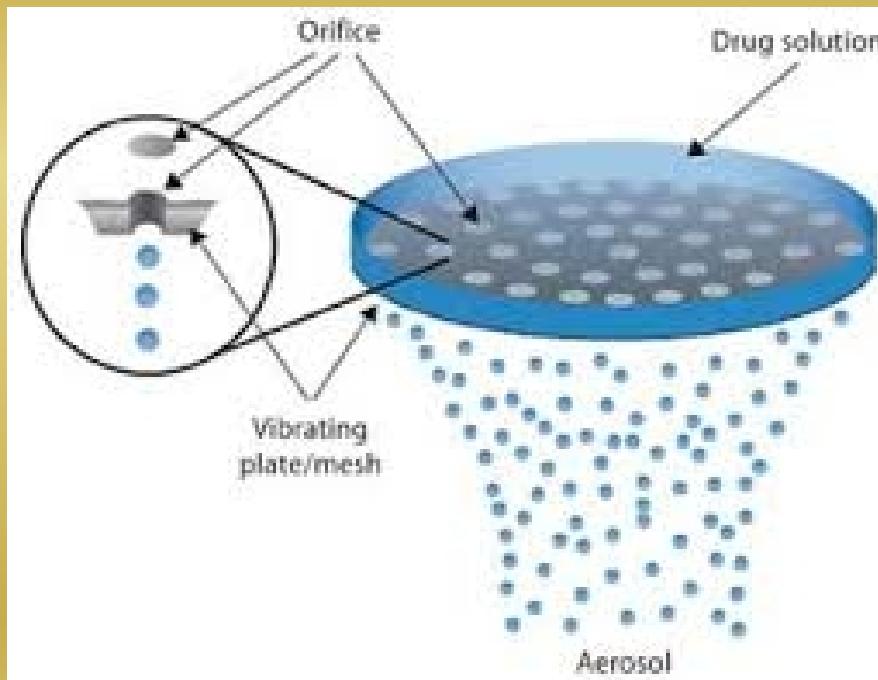
NICE 5060 Bubble CPAP

- The Unique bubble CPAP generator provides consistent and accurate delivery of CPAP
- The Reusable Pressure Manifold with pressure relief valve for infant safety
- The Manometer is provided to ensure the delivery of accurate PEEP
- Rotating PEEP adjustment knob to prevent the use error of setting the PEEP
- Servo control humidifier with temperature indication with heater wire for humidity of delivered gas
- Easy to adjust the PEEP setting on the bubble CPAP generator
- Easy to set the modes of humidifier
- Easy to fix the nasal prong with the neonates
- The Bubble CPAP System Provides respiratory supports with body temperature, pressure saturated gas to the infant

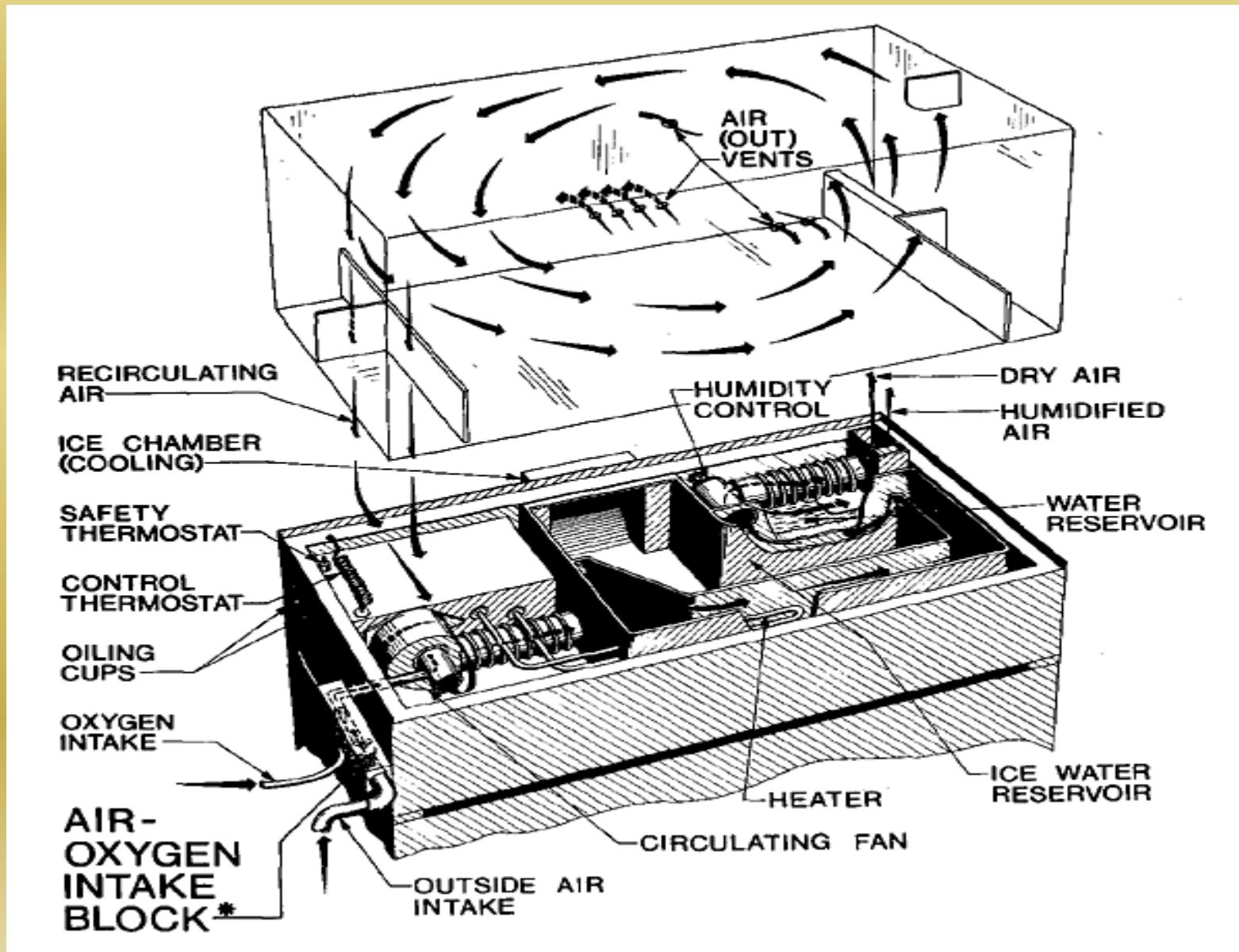
NICE 5060 Bubble CPAP

- Optimal humidity promotes mucociliary clearance and reduces the work of breathing
- Contoured nasal prongs made from non reactive silicone along with a unique cannula body provides stability during therapy.
- The integrated pressure monitoring line allows the monitoring of nasal prong pressure without having lines near the infant's face
- Offered in seven different sizes, it can be used on a wide range of patients for premature to new born baby
- Bubble Generator provides a convenient means to apply positive airway pressure, freeing the clinician to focus on patient care, not the device.
- This design delivers accuracy and stability throughout the course of therapy
- The ergonomic design allows airway pressure to be easily set without the cumbersome time consuming tasks normally associated with bubble devices.
- Water feeding port allows water to be added or removed with disconnecting the expiratory circuit
- Minimum and maximum lines clearly visible in highly transparent jar

Surfactant Administration



Incubator



GENERAL FEATURES -INCUBATOR

- Oxygenation, through oxygen supplementation by head hood or nasal cannula, or evencontinuous positive airway pressure (cpap) or mechanical ventilation.
- Infant respiratory distress syndrome is the leading cause of death in preterm infants, and the main treatments are cpap, in addition to administering surfactant and stabilizing the blood sugar, blood salts, andblood pressure.
- Observation: modern neonatal intensive care involves sophisticated measurement of temperature, respiration, cardiac function, oxygenation, and brain activity.

GENERAL FEATURES -INCUBATOR

- Protection from cold temperature, infection, noise, drafts and excess handling: incubators may be described as bassinets enclosed in plastic, with climate control equipment designed to keep them warm and limit their exposure to germs.
- Provision of nutrition, through intravenous catheter or ng tube.
- Administration of medications.
- Maintaining fluid balance by providing fluid and keeping a high air humidity to prevent too great a loss from skin and respiratory evaporation.

TYPICAL VALUES

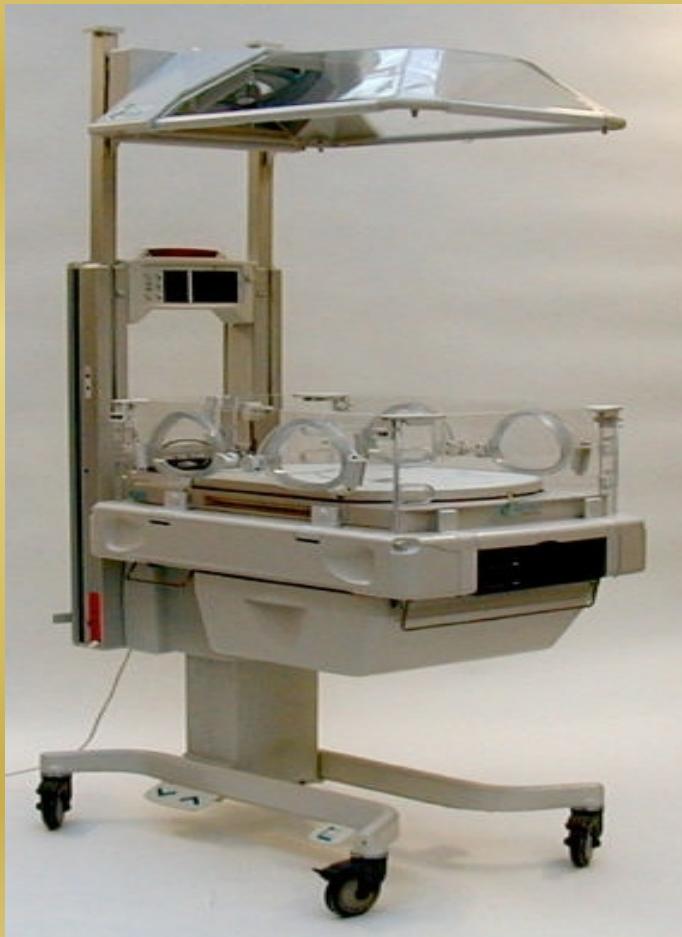
AIR TEMPERATURE: 32 TO 38 C°

BABY SKIN TEMPERATURE: 34 TO 36 C°

TOTAL GAS INTAKE: 35 L/MIN

RELATIVE HUMIDITY: 50-100%

Neonatal Incubator / Infant Radiant Warmer *Ohmeda Giraffe OmniBed*



Neonatal Incubator / Infant Radiant Warmer

Ohmeda Giraffe OmniBed

Advantages:

- Incubator and infant radiant warmer in one device.
- Relative humidity option, swivel mattress, all around access, uniform central thermal environment.

Disadvantages:

- Care needed on raising canopy to avoid collisions with other equipment close by.
- Expensive.
- Water reservoir- difficult to open.

MAIN FEATURES

Incubator Mode

- Air temperature control
- Baby temperature control
- Integral humidification
- Access doors two
- Access ports up to five

Radiant Warmer Mode

- Maximum power 450W
- Manual control
- Baby temperature control

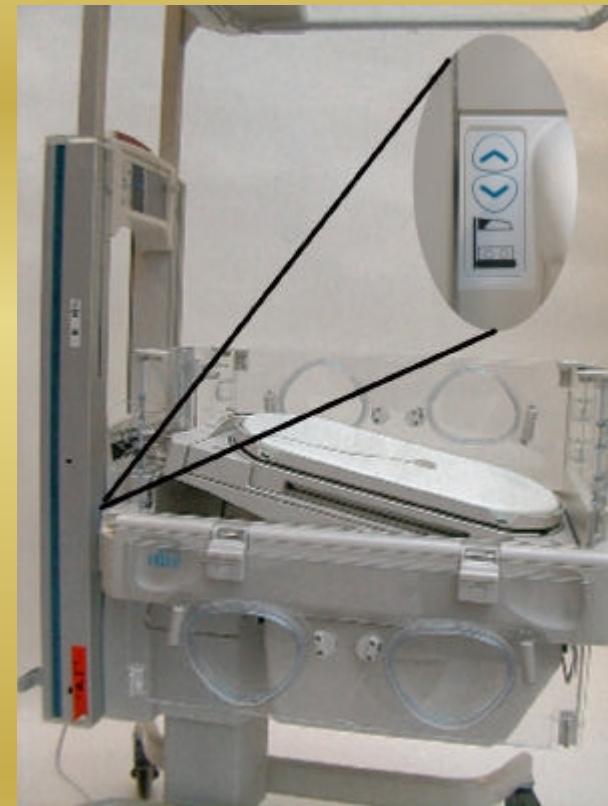
General Features

- Vertical height adjustment - foot-switch
- Canopy control Foot-switch (raise only)
- Finger-switch (raise and lower)
- Mattress rotates - 360°
- Electroluminescent control screen
- Four wheel locks
- X-ray tray
- Sliding storage draw
- Integral scales

Vertical Height Adjustment (VHA): By Footswitches located on the wheel base frame



Special foot pedal for raising canopy



Access door open and mattress tilted.



Control and information panel

Control and information panel

Two areas

- The left hand side -consisting of buttons and indicators for temperature adjustment and display
- The right hand side containing an electroluminescent (EL) control/information screen which displays and controls all the accessory options on the Giraffe OmniBed.

X-ray tray withdrawn

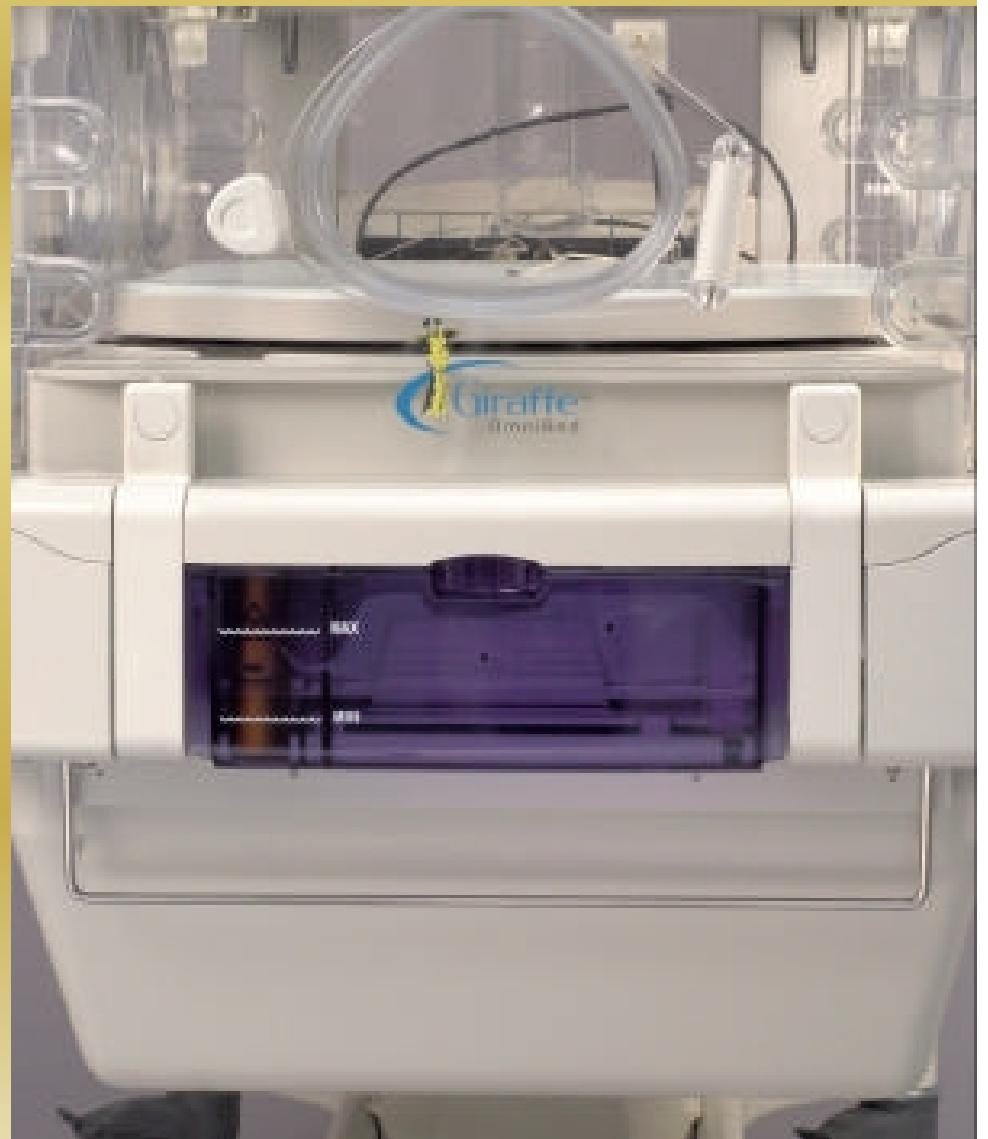


- **X-ray tray:**

An X-ray tray may be fitted beneath the bassinet to enable X-rays to be taken without disturbing the infant. This may be done with the canopy up or down.

- X-rays taken using the tray may result in a higher dose to the patient because of the bedding, the mattress and other plastics.
- In a previous user assessment of incubators incorporating X-ray trays or slots,

The water reservoir



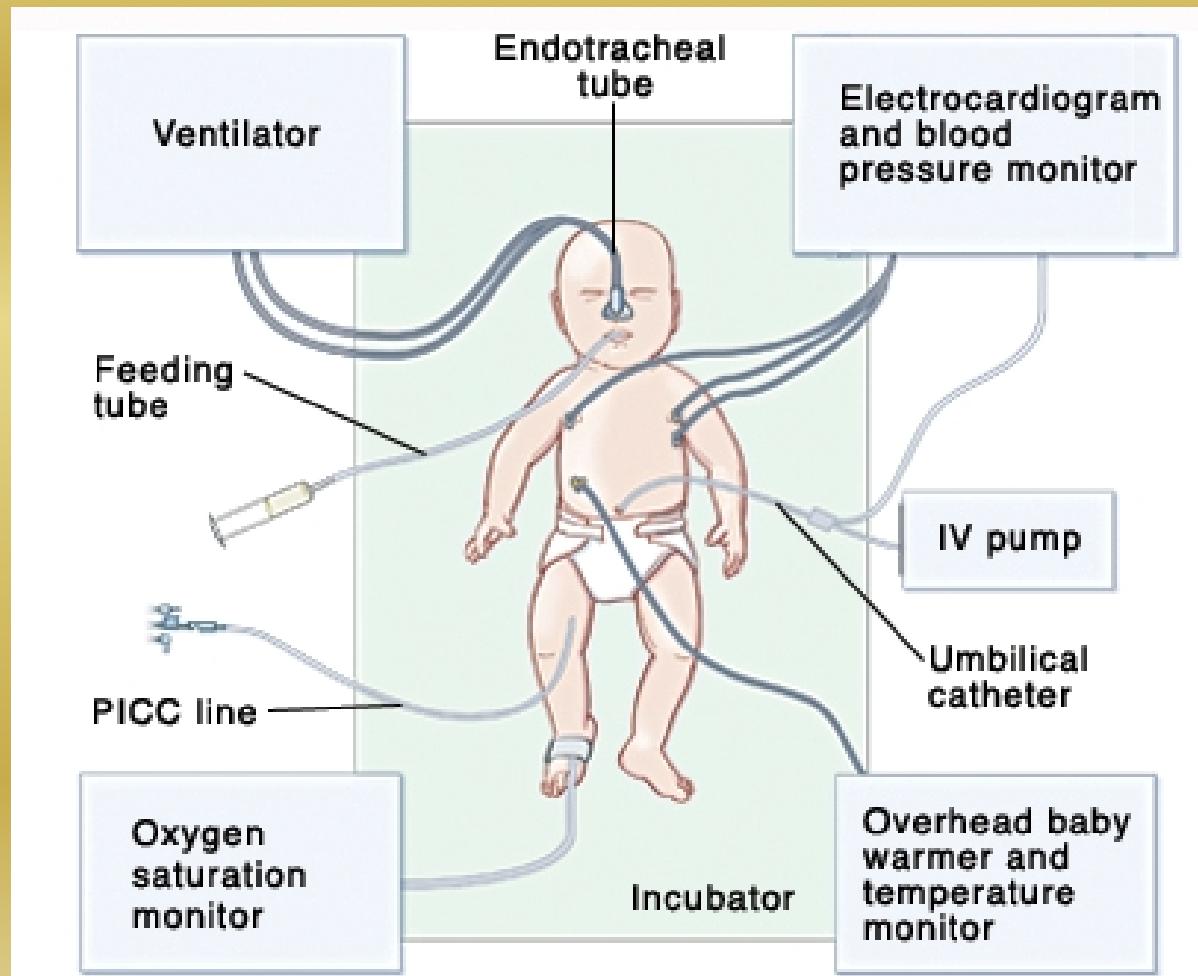
Humidification

- Has an integral humidification system option.
- The water reservoir is built into the end of the bassinet, furthest from the controls and contains a heater column

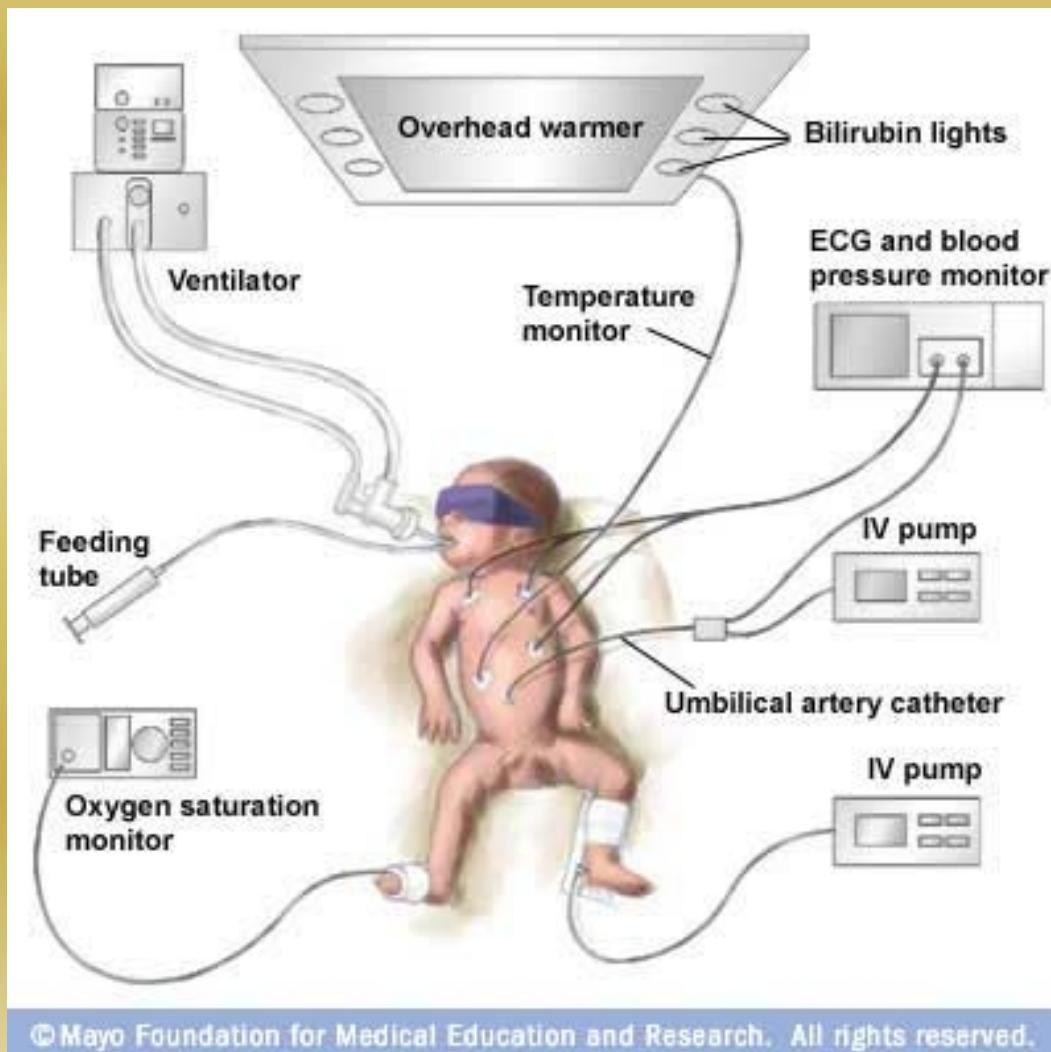
Activating the relative humidity option



Schematic of Baby inside the Incubator with all connections



Schematic of Baby inside the Incubator with all connections



Radian Warmer mode – with monitor



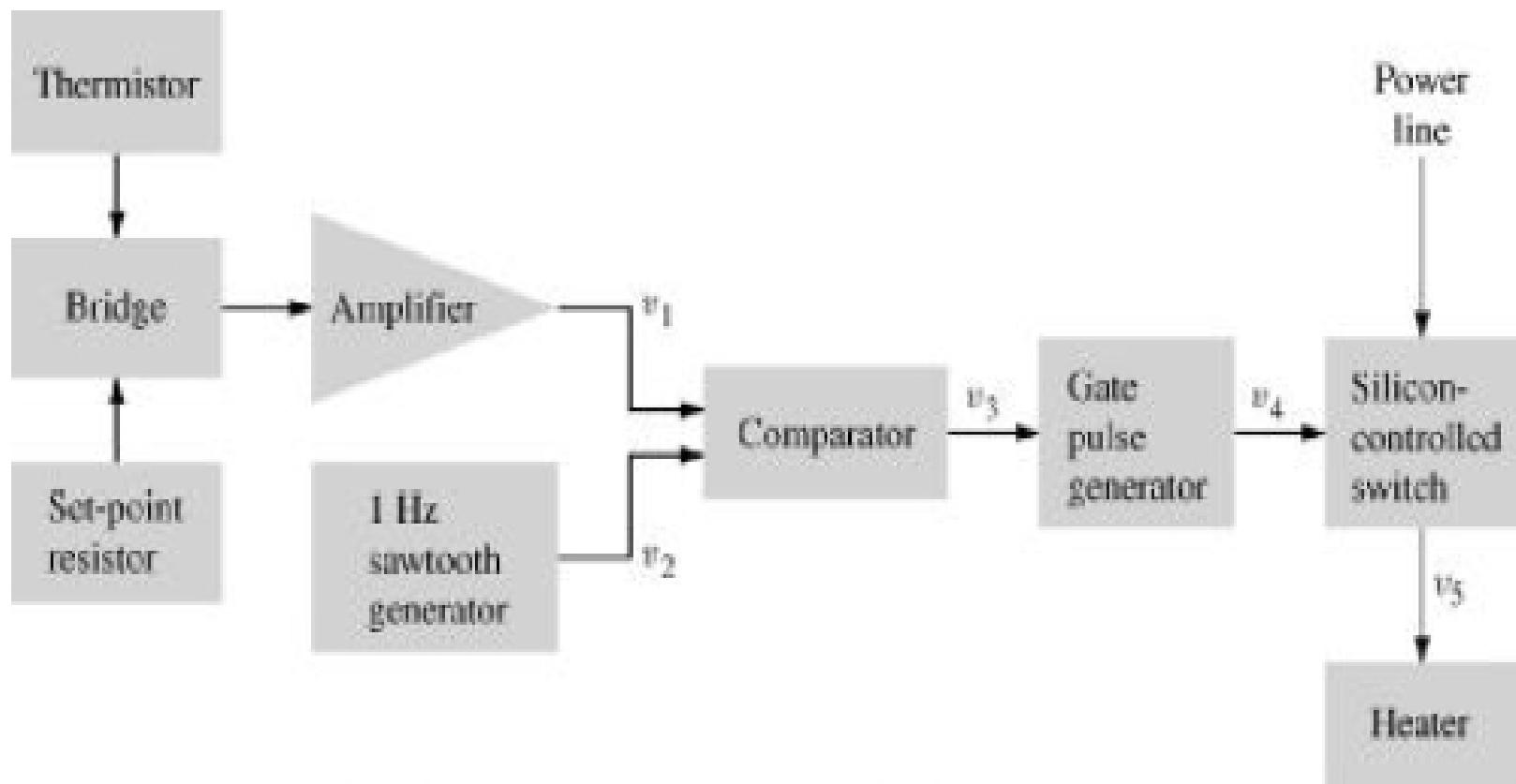


Figure 13.17 Block diagram of a proportional temperature controller used to maintain the temperature of air inside an infant incubator.

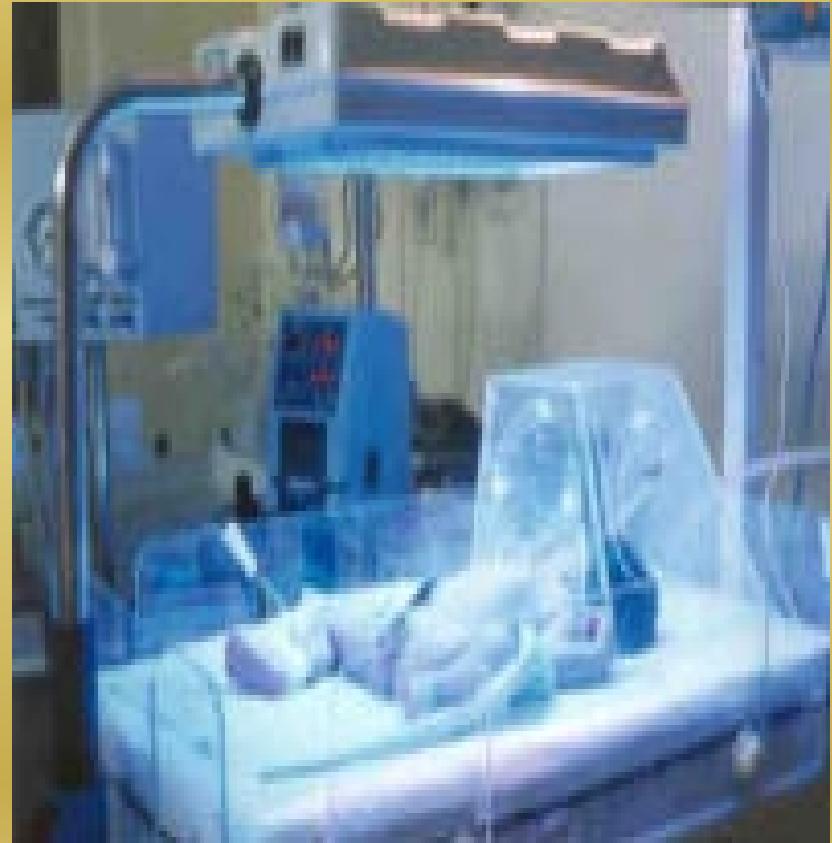


PHOTOTHERAPY UNIT

PHOTOTHERAPY UNIT

- Photo therapy is a therapy which uses Electromagnetic Spectrum or specific wavelengths of light to treat physical & emotional problems.
- May direct solid or flashes of light into patient's eyes or onto parts of body.
- Treatment usually takes place under physician's direction in a medical setting.

PHOTOTHERAPY UNIT



Units of Measurement

- Lumen: Measure of light output (luminous flux) is lumen .
- Irradiance: measure of radiometric flux per unit area or the amount of energy received from the source surface. Expressed in W/cm².

Units of Measurement

- **Illuminance** is the measure of photometric flux per unit area. Expressed in Lux or foot candles (lumen per sq. foot)
- Foot candles X 10.76 = Lux

History of Phototherapy

- From ancient to modern times, **Sunlight** has played a central role in cure of diseases.
- In 1905, **Dr. Niel Finsen** was awarded the Nobel Prize for proving Blue –violet & UV Light could cure TB, measles & scarlet Fever. Red light for treating small pox .
- Sunbathing was initially prescribed to treat TB, cholera, pneumonia, asthma, and jaundice .

History of Phototherapy

- With the development of electric lightening, artificial light was used to treat cardiovascular & degenerative disorders.
- **Dr. Spitler & Dr. Rosenthal** pioneered the application of Light/ Photo therapy.

Effects of Light on the Body

- The production of vitamin D.
- Inhibition of **melatonin** (a hormone that affects mood).
- The secretion of **serotonine & norepinephrine** (influences mental alertness & well being).

VISUAL STIMULI

- Light through the eyes reaches not only the visual centres in our brain but also the hypothalamus.
- This controls most of the functions of endocranial hormonal system & the autonomic nervous system.
- Light from the Hypothalamus is sent to the pineal gland, the body's light meter.
- It transforms retinally perceived light waves into neuronal impulses for melatonin production.
- Melatonin is both created & released by the pineal gland in response to light .

APPLICATIONS OF PHOTOTHERAPY

- Use the entire spectrum or specific wavelengths of light to treat physical & emotional problems .
- Treatment of Hyperbilirubinaemia (Jaundice) in Newborns.
- Treatment of skin diseases like psoriasis, vitiligo etc. in Dermatology using UV Light.

Neuro-sensory Development

- Light is administered using a combination of 12 colored glass filters from red to violet in flashes.
- The colors & flash rates on the photons are adjusted to counteract & balance the person's neurological problems.
- This has lead to an increase in the patient's visual field, treatment of fatigue, thyroid problems, sleep disorders, depression etc.

Bright Light therapy

- In treatment of SAD.
- Seasonal Affective Disorder (SAD) is a form of mood depression disorder due to decrease in exposure to sunlight.
- It is caused due to the secretion of melatonin (the sleep induced hormone) produced at high levels when it is dark.
- Symptoms are drowsiness, fatigue, diminished concentration etc.

Bright Light therapy

- Bright light therapy helps the patient to be exposed to light & thus reduce the symptoms .

Photo dynamics Therapy

- Where light is used to activate the cancer medication (given intravenously) & this helps to locate the cancer affected area & treat the diseased tissue .
- **Photoluminescence Therapy :**
- Where UV light is used to sterilize infected blood.

Lights used in Phototherapy

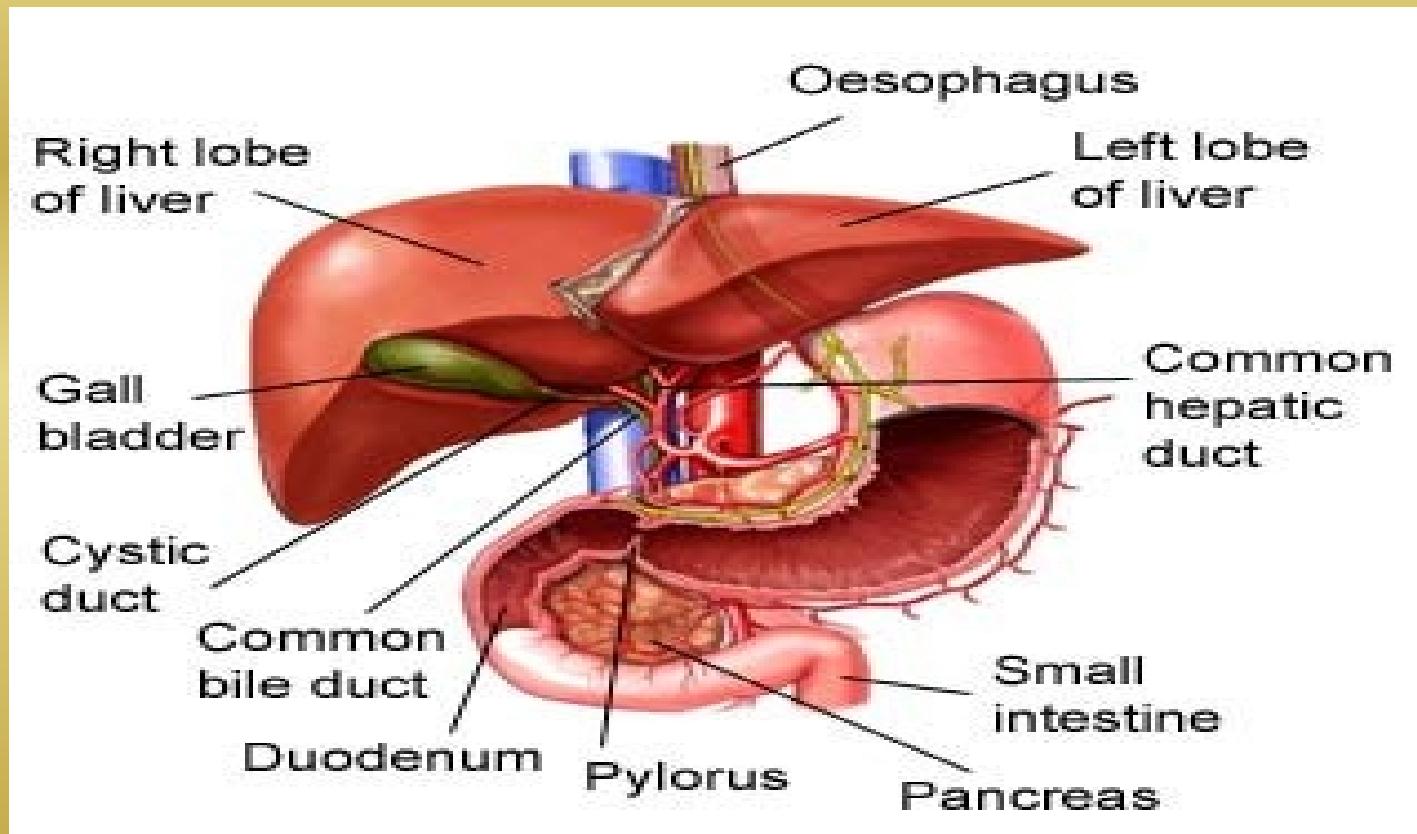
- Red = Energise
- Orange = Spirit raising
- Yellow = Stimulates elimination of toxins.
- Green = Cooling, Relaxing. Reduces Inflammation.
- Blue = Peaceful effect
- Violet = Promotes awareness, consciousness.
Improves mental ability.
- UV Spectrum = Penetrating effect. High energy to kill diseased areas.

Lights used in Phototherapy

- Infrared Spectrum = Heating ability.



LIVER



Anatomy of the Liver

- It is the largest glandular organ of the body, weighing about 1.36 kg.
- It is reddish brown in colours and is divided into 4 lobes of unequal size & shape.
- The liver lies on the right side of the abdominal cavity beneath the diaphragm .

FUNCTIONS

- Production of bile.
- Metabolism of bilirubin.
- Clearing of unwanted drugs & poisonous substance from the blood.

Metabolic Processes in the Liver

- PRODUCTION OF BILIRUBIN
- RBC contains haemoglobin.
- When the dead RBCs are sent to the liver to be cleared, the haemoglobin gets broken down into Haem & Globin.
- This gets oxidized due to the chemicals present in the liver to BILIVERDIN.
- This gets rapidly reduced to unconjugated Bilirubin, which is not water-soluble.
- When this unconjugated part gets reacted with the Glucuronic acid, we get conjugated Bilirubin, which is easily excreted from the body through bile, stools or urine

JAUNDICE

- If the liver is not functioning properly there will be excessive amounts of bile circulating in the blood stream & this gets deposited into the layer of fat beneath the **skin**.
- This leads to yellow discoloring of the skin & eyes, nausea, weight loss, dark urine, and fever & if not treated death may result.
- This condition is known as **Hyperbilirubinaemia or Jaundice**.

JAUNDICE

- Normal Bilirubin levels in adult is 1 mg/dl (micrograms/decilitre of blood).
- There are 2 types of Jaundice
- Physiological Hyperbilirubinaemia
- Pathological Hyperbilirubinaemia.

Physiological Hyperbilirubinaemia

- In infants, since the liver is not fully developed, it is not able to process the bilirubin quickly enough.
- This builds up leading to mild infantile jaundice, which is common.
- The average full term newborn will have peak level of 6 mg/dl which usually gradually comes down to the adult level by the end of second week.
- But if the concentration rises too high it can lead to serious neurological damage such as brain damage, hearing loss & even death.
- Hence it needs to be treated immediately.

Pathological Hyperbilirubinaemia,

- **Principle:**
- The phototherapy light shines onto the baby's skin.
- The Bilirubin peak response to convert into the conjugated type, which can be easily excreted, takes place between the 420 – 480 nm of blue-green spectrum.
- The bilirubin gets photoisomerized (change of shape due to light) into the products, which are less toxic.
- This travels to the liver & is easily excreted without undergoing the conjugation process.

Effectiveness

- Effectiveness of the Phototherapy depends upon:
- Wavelength of the spectrum.
- Intensity of the Light.
- Duration of the therapy.
- Area of skin exposed to the light.
- More the area, more the effectiveness.

Indications

- Indications for the Phototherapy:
- Level of the serum bilirubin.
- Rate of rise of serum bilirubin.
- Gestational/ postnatal age.
- Cause of the Jaundice.

TYPES OF PHOTOTHERAPY UNITS

- *Halogen Spotlights.*
- *Fluorescent Lights .*
- *Fiber-optic Phototherapy .*

Halogen Spotlights

- Initial type of phototherapy units.
- Seen less often nowadays.
- Here a white halogen bulb is used.
- Delivers 20- 25 $\mu\text{W}/\text{cm}^2/\text{nm}$.
- As white light contains blue range spectrum, this is used to treat the neonate though the treatment time will be more .

Fluorescent Lights

- Most common type of unit seen nowadays in the NICU.
- Blue or white tube-lights are available.
- Effective types are the blue tube-lights with the spectrum o/p at 450-470nm.
- Used alone or in combination with white light.
- Disadvantage is that they degenerate with time.
- So any tube-light delivering less than $8 \mu\text{W}/\text{cm}^2/\text{nm}$ should be replaced.

Fiber-optic Phototherapy

- Most recent & advanced type.
- A fiber-optic cable containing about 2000-2400 individual acrylic fibers deliver the light from a tungsten halogen lamp to a fiber-optic pad or blanket on which the infant lies.

Fiber-optic Phototherapy

- Easy to use and as effective as the conventional phototherapy.
- Though expensive, the treatment time is less; treatment is precise & controlled on the affected area .
- Other units available are band of optical fibers wrapped around the patient, double phototherapy units etc .

PATIENT PREPARATION

- Keep the infant clean & at a distance of 30- 45cms from the light.
- Try to keep the infant naked, as it will increase the treatment area.
- Clean infant only with water. Do not apply oils and creams in order to prevent skin rashes.
- Eye shielding & genitalia covering should be done to reduce the dangers due to prolonged illumination.
- To prevent burns, place the infant on top of saline water bags.

Patient Care by the Staff Nurses

- Eye pads should be removed regularly & eye care to be done.
- The infant's temperature, pulse & respiration rate should be checked regularly.
- Phototherapy may be interrupted during feeding and brief parental visits

Patient Care by the Staff Nurses

- Phototherapy may lead to excessive fluid loss so ensure that adequate fluid intake is provided to prevent dehydration.
- Periodic monitoring of the bilirubin levels is required to check the effectiveness of the therapy.
- Phototherapy may sometimes interfere with intravenous fluids or drugs administered for the infant. Hence it is advisable to cover the tubing's

Safety Precautions to be followed:

- Do not place the phototherapy in direct sunlight or any other source of light as it may lead to over-heating .
- The air circulation & ventilation ports should not be obstructed to prevent over- heating.
- If phototherapy is used in conjunction with Infant Incubator, there will be risk of elevated temperature. Therefore check the temperature periodically

Safety Precautions to be followed:

- If phototherapy is used in conjunction with Infant Radiant Warmer, make sure that the heat from the warmer is not blocked to the baby by placing the phototherapy unit at an angle.
- If light affected drugs & other infusion liquids are being used the tubing's needs to be covered.

Safety Precautions to be followed

- No fluid spillage should take place on the tube-lights to avoid shorting.
- Kindly ensure that the above tube-light section is covered with acrylic sheets in order to prevent the tube-lights from falling on the infant.

Risks in NICU Phototherapy

- Ophthalmic Risks :
- Premature babies in NICU are likely to have retinal damage.
- So eye protection continues to be the standard procedure during phototherapy.

Temperature Control Risks

- Both Hypo & Hyper Thermias have been reported.
- Hence temperature monitoring needs to be done regularly.
- Carcinogenic & Mutagenic Risks:
- There have been unconfirmed reports of mutation (cell changes) & breaks in DNA strands due to phototherapy.
- Hence the Genital areas may need to be covered with proper pads.

Phototherapy in Dermatology

- Used in the Treatment of various skin diseases like psoriasis (peeling of skin with inflammation),
- Vitiligo (whitening of the skin),
- Eczema (inflammation of the skin with continuous itching) etc.
- When the topical treatments (treatments applied to the skin surface) fail to treat the extensive affected areas.

Operation

- When sunlight penetrates the top layers of the skin,
 - 1) UV radiation bombards the genetic material, DNA inside the skin cells & injures it.
 - 2) It also impairs the immune function in the skin, which results in wrinkles, aging disorders & skin cancers.
 - 3) These same damaging effects can also destroy the skin cells that cause the skin diseases.

Sunlight

- The sunlight consists of components **UV A** and **UV B** radiations
- **Ultra-Violet A :**
- This radiation is administered along with a light sensitizing medication called psoralen.
- This treatment is called **PUVA** (acronym for psoralen + UVA).
- Treatment range is between 320 to 400nm.

Sunlight

- **Ultra-Violet B:**
- It is an effective form of treating the various skin diseases.
- It slows the abnormal rapid growth of skin cells.
- Here the skin is exposed to artificial UV light for a set length on a regular schedule under a physician's guidance.

UVB treatment

- Two types of UVB treatment:
- **Broad band & narrow band**
- Broad band radiation is between **290 to 350nm**.
- Narrow band radiation is in between **310 to 312nm** .
- Narrow band UVB clears the skin diseases faster.

Difference between UVA & UVB:

- UVB affects the outer skin layers.
- UVA penetrates more deeply & efficiently.
- UVB is 1000 times more powerful than UVA in producing sunburns.
- UVB may be used alone while UVA requires a photosensitizing medication to be effective.
- UVA poses a higher risk for skin cancers than UVB.

SUCCESS

- The key to the success of the treatment is consistence in the treatment .
- RISK:
- Long term use can lead to skin damage, such as aging, wrinkles & even rarely skin cancers .
- SAFETY:
- People who are sensitive to sunlight, should avoid phototherapy.

Treatment Phototherapy Units

- **Whole Body Unit:** Here the patient enters the unit & the UV light is delivered based on the time entered on the control section.
- **Panel Unit:** This treats only a part of the body, which is exposed to light, and so the patient has to turn around to expose the other half.
- **Hand/ Foot Unit:** This unit is meant to treat the palms & the dorsal surface of hands as well as the plantar & dorsal surface of the feet.

COMPONENTS OF THE PHOTOTHERAPY UNIT

- Power Supply – Consists of the mains i/p, chokes & starters
- Fan – For cooling of the tube-lights during treatments to prevent over-heating.
- Light Source – Mostly consist of the tube-lights or halogen bulbs used for the treatments.
- Filter (optional) – Can be air filters for the fan as well as UV filters to filter out the harmful radiation.

Chokes or Ballasts

- an integral part of the lighting system,
- Have 3 main functions:
- To provide starting voltage because the fluorescent lights require a higher voltage to start than to operate.
- To match the line voltage to the operating voltage of the tube-light.
- Limit the lamp current to prevent immediate destruction because once the arc is struck the lamp impedance decreases.

Types of Ballasts

- **Magnetic ballast:**
- Make use of the core coil type that has 10% power efficiency improvement.
- **Electronic Ballasts :**
- Improve the efficiency by converting the standard 50 Hz i/p frequency to a higher frequency (25 k to 45 k Hz)
- while consuming 12 to 25 % less power.
- There is less audible noise, less weight & virtually no lamp flicker.
- **A starter is** like a separate starting switch used to aid in forming the arc.

MAINTENANCE OF THE PHOTOTHERAPY UNIT:

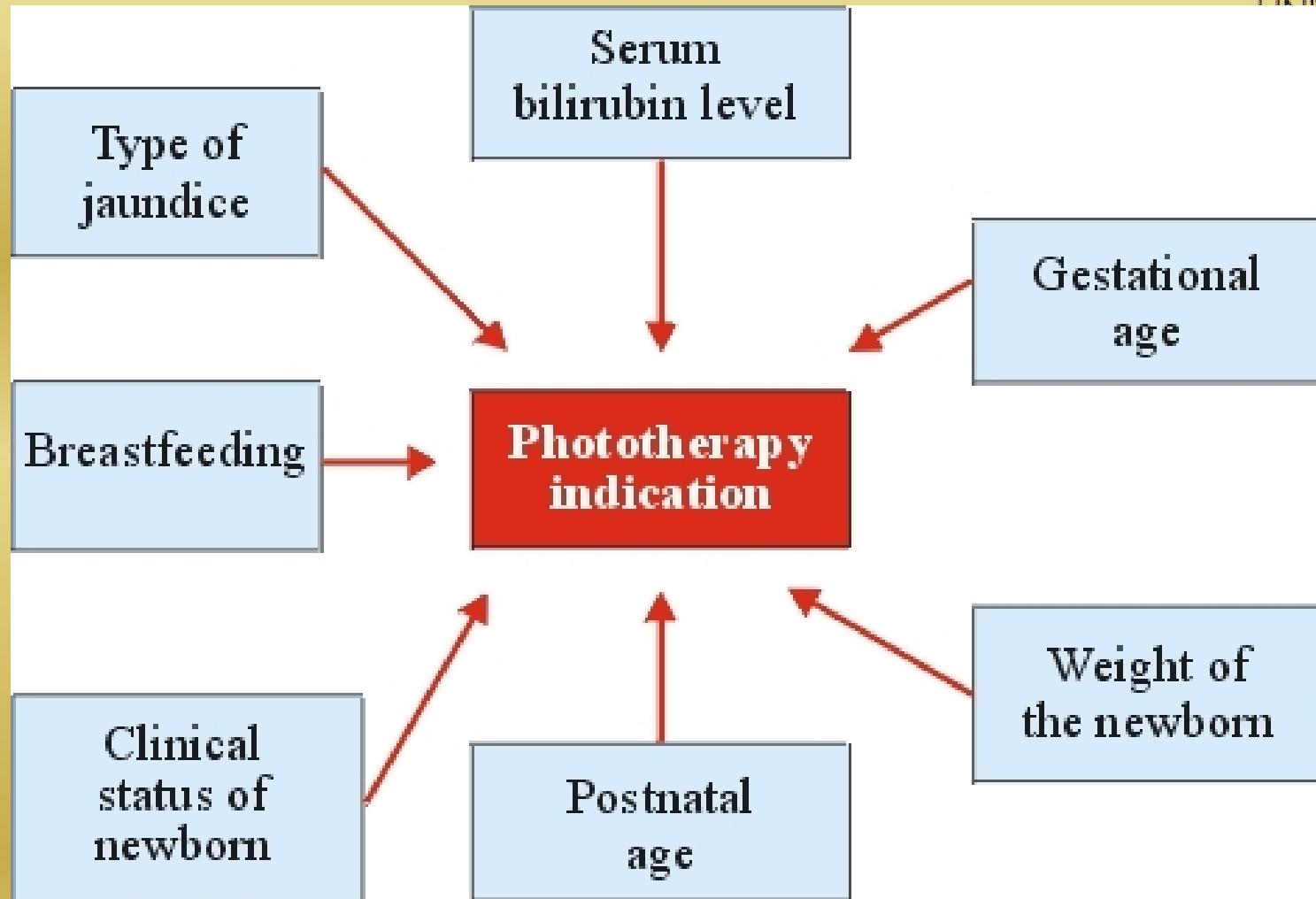
- Switch off the unit & allow it to cool before cleaning it.
- Remove the air filters & clean thoroughly.
- Clean the fan with brush to remove all the accumulated dust.
- Clean the bulbs/tube-lights, reflectors with a soft cloth.

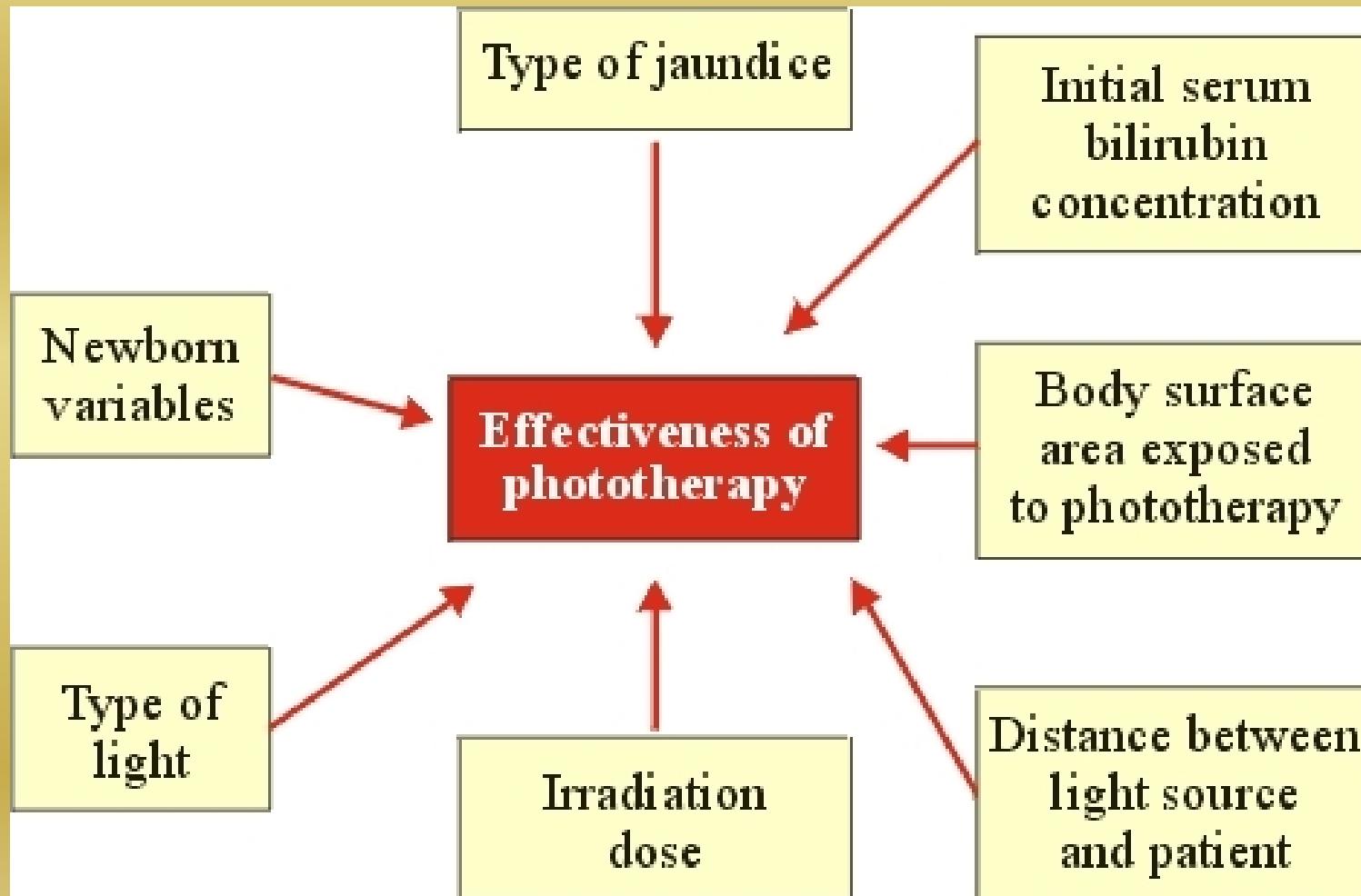
MAINTENANCE OF THE PHOTOTHERAPY UNIT:

- The external of the unit may be cleaned with a mild detergent & wiped dry with a cloth.
- See that the power plug is a standard 3 pin type & not broken.
- Periodically check the intensity of the unit using a radiometer. Irradiance should be between 8 to 25 $\mu\text{W}/\text{cm}^2/\text{nm}$. If less, replace the tube-lights.

MAINTENANCE OF THE PHOTOTHERAPY UNIT:

- Replace with the same type of rating of the previous tubes.
- In some places there have been reports of the fluorescent tube-lights being replaced with UV type in NICU units.
- This should not be done as it may cause over exposure of the infants to the hazardous UV radiation.
- If halogen bulbs are replaced, don't touch the glass surface as it may reduce its lifetime.







Thank You