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Design and Manufacture of A Smart and Portable Multi-Purpose Newborn Incubator

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Abstract: The incubator device is considered as a closed box that provides the environment required to maintain the condition of the child in the incubators, such as the environment in his mother's womb, and it depends on providing three basic variables, namely (temperature: it is 37C), (Oxygen O2: where it needs The child needs to double the percentage that the average person needs, which is 20% of the air for normal conditions, while in the incubator needs to provide a ratio of approximately 40%), (Moisture: It is an important factor because if the child inhales dry air with a temperature of 37, it will affect the mucous cells, where a percentage must be provided Humidity appropriate with the proportion of temperature).

Also an incubator is described in which an infant can be kept at the proper temperature and humidity, with proper ventilation and, to facilitate respiration, in an atmosphere containing a known and controlled mixture of oxygen and helium. Several Incubator devices are specifically advertised for use with expensive and complicated devices. However, a review of the health problems information, as a review, and the limited literature on performance, to suggest that no device on the market meets evens the most basic requirements of being small, lightweight, rugged, and less cost with an accurate performance.

Design and manufacture of portable multi-purpose incubator will serve as monitoring of the newborns conditions and treat Jaundice by phototherapy and solve many problems by being low cost, portable, easy to assemble, lightweight so can be carried around and also easy to use.

Chapter one

Introduction

1.1 Introduction

Infant incubators maintain a healthy environment for newborn babies. They are used for premature babies who are still small and weak as well as for some sick full-term babies. [1]

Incubators are used in the primary care department of a hospital or in the **neonatal intensive care unit**, NICU (pronounced "Nickyoo").[1]

Infant incubators should not be confused with laboratory incubators, which are used to keep reagents or samples warm.

1.2 Purpose

The incubator consists of a transparent cabinet in which the baby is kept in a neutral environment for medical care. Neutral means, that the surrounding air has the optimal temperature and moisture and the baby only needs minimum of energy to maintain normal body temperature [2].

Figure 1.1 an infant incubator

The infant incubator

- ✓ controls the temperature
- ✓ controls the humidity
- ✓ can deliver additional oxygen
- ✓ protects against infections and diseases
- ✓ protects against noise

In order maintain the body temperature of the baby (36 - 37.2°C) the incubator must be able to create an ambient air of 34 - 38°C with a humidity of 40 - 80%.

1.3 Reasons of use

There are many reasons why a baby may need to be inside an incubator. These can include:

1.3.1 Premature birth

Babies born prematurely may need additional time to develop their lungs and other vital organs. (Their eyes and ear drums may be so sensitive that normal light and sound would cause permanent damage to these organs.)[3]

Also, babies born extremely early will not have had the time to develop fat just under the skin and will need help to keep them warm and toasty.

1.3.2 Breathing issues

Sometimes babies will have fluid or meconium in their lungs. This can lead to infections and an inability to breathe well. Newborns may also have immature, not fully developed lungs that require monitoring and extra oxygen [4].

1.3.3 Infection

Incubators can reduce the chance of germs and additional infection while a little one heals from an illness. Incubators also offer a protected space where it's possible to monitor vitals 24/7 when your baby also needs multiple IVs for medication, fluids, etc. [5].

1.3.4 Effects of gestational diabetes

Many doctors will briefly incubate a baby if the mother had gestational diabetes, so that the baby can be kept nice and warm while they take time to monitor their blood sugars [6].

1.3.5 Jaundice

Some incubators include special lights to help reduce jaundice, a yellowing of a baby's skin and eyes. Newborn jaundice is common and can occur when babies have a high level of bilirubin, a yellow pigment produced during normal breakdown of red blood cells [7].

1.3.6 Long or traumatic delivery

If a newborn baby has experienced trauma, they may require constant monitoring and additional medical supports. The incubator can also offer a safe womb-like environment where a baby can recover from the trauma [8].

1.3.7 Low birth weight

Even if a baby is not premature, if they are extremely small, they may not be able to stay warm without the additional help an incubator offers.

Additionally, very small babies may struggle with many of the same vital functions premature babies do (i.e. breathing, and eating), benefiting from the extra oxygen and controlled environment an incubator offers [9].

1.3.8 Recovering from surgery

If a baby needs to have surgery for a complication following their birth, they'll need to be monitored and in a controlled, safe environment afterwards. An incubator is perfect for this [10].

1.4 Terminology

The branch of medicine that deals with the medical care of newborn infants, especially with the ill or premature newborns, is called **neonatology**. The medical practitioner who specializes in this area is known as a **neonatologist**.

Pediatrics is the branch of medicine that deals with the medical care of all children in general, from birth up to 18 years of age. The medical practitioner in this area is known as a **pediatrician**.

A new born baby (or infant) is also called **neonate**[11].

Chapter Two

Infant Incubator

2.1 Introduction

Infant incubators made in various types, product description and principle of operation must be understood, operating steps as well, knowing the design helps with addressing reported problems, and numerating the components and controls assists in cleaning, maintenance and replacing with spare tools.

2.2 Types

In a typical infant incubator the baby lies on a mattress in a closed, transparent cabinet. The ambient air is fully controlled by the incubator. The cabinet has portholes so that the nurse has access to the baby without opening the cabinet.

Under the cabinet is the compartment with the technology and the control panel. The whole incubator is mounted on a trolley[12].

In general there are several types of infant incubators, the open incubator, the closed incubator, and the transport incubator. Each is designed slightly differently with different advantages and limitations.

2.2.1 Open incubator

This is also sometimes called a radiant warmer. In an open incubator, a baby is placed on a flat surface with a radiant heat element either positioned above or offering heat from below.

The heat output is automatically controlled by the temperature of the baby's skin. While you may see lots of monitors, the incubator is open above the baby.

Open incubators are also called Radiant heater and it's preferred over closed incubator.

Sometimes the closed construction is not desired. When the baby needs special care (e.g. controlled ventilation, pulse oximetry, ECG) and nurses and doctors need fast and easy access it is better to have an open system. In this case the baby is warmed by a radiant heater, mounted over the cradle with the baby[13].

Figure 2.1 open incubator

Because of this open air space, open incubators do not provide the same amount of control over humidity as closed incubators. However, they can still monitor a baby's vital functions and warm them. It is easier to achieve skin-to-skin with a baby in an open incubator ,since it's possible to directly touch the baby from above.

Open incubators work well for infants who primarily need to be temporarily warmed and have their vital statistics measured. The inability to control the humidity and guard from airborne germs means that open incubators are not ideal for babies requiring a more controlled environment and germ protection.

2.2.2 Closed incubator

Figure 2.2 closed incubator

A closed incubator is one where the baby is completely surrounded. It will have portal holes on the sides to allow IVs and human hands inside, but is designed to keep germs, light, and other elements out. A closed incubator is like living in a climate controlled bubble, One of the biggest differences between

A closed Incubator and an open one is the way that heat is circulated and the temperature controlled. A closed incubator allows warm air to be blown through a canopy that surrounds the baby [14].

The temperature and humidity can either be manually controlled using knobs on the outside of the incubator or adjusted automatically based off skin sensors attached to the baby. (Incubators that automatically adjust like this are called servo-control incubators.)

Closed incubators are truly their own microenvironments. This means that they are ideal for babies who need extra germ protection, reduced light/sounds, and humidity control.

Some closed incubators have two walls to help prevent heat and air loss. These are commonly called double-walled incubators.

2.2.3 Transport or portable incubator

As the name implies, these types of incubators are typically used to transport a baby between two different locations.

One might be used when a baby is transported to a different hospital to get services not offered at their current location or access to doctors who specialize in areas they need additional care.

Figure 2.3 transport or portable incubator

A transport incubator typically includes a mini ventilator, a cardio-respiratory monitor, an IV pump, a pulse oximeter, and an oxygen supply built in[15].

Because transport incubators are typically smaller, they fit well in spaces that regular open and closed incubators might not.

2.3 Takeaway

While incubators can seem scary, they are important medical equipment that provides controlled environments for premature and ill babies. Without incubators fewer babies would be able to survive tough beginnings!

Incubators really are like a second womb or a safe bubble surrounding a baby. Although it can produce some anxiety to be surrounded by incubators in the NICU visiting the baby, comfort may come in knowing the hum of the electrical equipment means your baby is getting the oxygen and heat they need [16].

2.4 Health problem addressed

At birth, an infant's core and skin temperatures tend to drop significantly because of heat loss from conduction, convection, radiation, and water evaporation. Prolonged cold stress in neonates can cause oxygen deprivation, hypoglycemia, metabolic acidosis, and rapid depletion of glycogen stores [17].

2.5 Product description

Bassinets enclosed in plastic with climate controlled equipment and hand-access ports with doors that are intended to keep infants warm and limit their exposure to germs [18].

2.6 Principles of operation

These devices provide a closed, controlled environment that warms an infant by circulating heated air over the skin. The heat is then absorbed into the body by tissue conduction and blood convection. Ideally, both the skin and core temperatures should be maintained with only minor variations [19].

2.7 Operating steps

The neonate lies on a mattress in the infant compartment, which is enclosed by a clear plastic hood. Incubators have hand- access ports with doors that permit the infant to be handled while limiting the introduction of cool room air. The clinician can raise or remove the plastic hood or open a panel to gain greater access to the infant.

2.8 Reported problems

Deaths and injuries to neonates in incubators have been linked to thermostat failure that caused incubator overheating and infant hyperthermia and to malfunctions or design defects that produced fires and electric shock hazards. Inadequate control over the amount of oxygen delivered in an incubator can cause hyperopia or hypoxia [20].

2.9 Design

All infant incubators work on the same principle. A fan blows filtered ambient air over a heating element and a water container. Through a control valve additional oxygen can be supplied to the air. The moistened, heated and enriched air now flows into the above cabinet with the baby. One part of the air escapes from the cabinet through vent holes, another part gets back into the air processing [21].

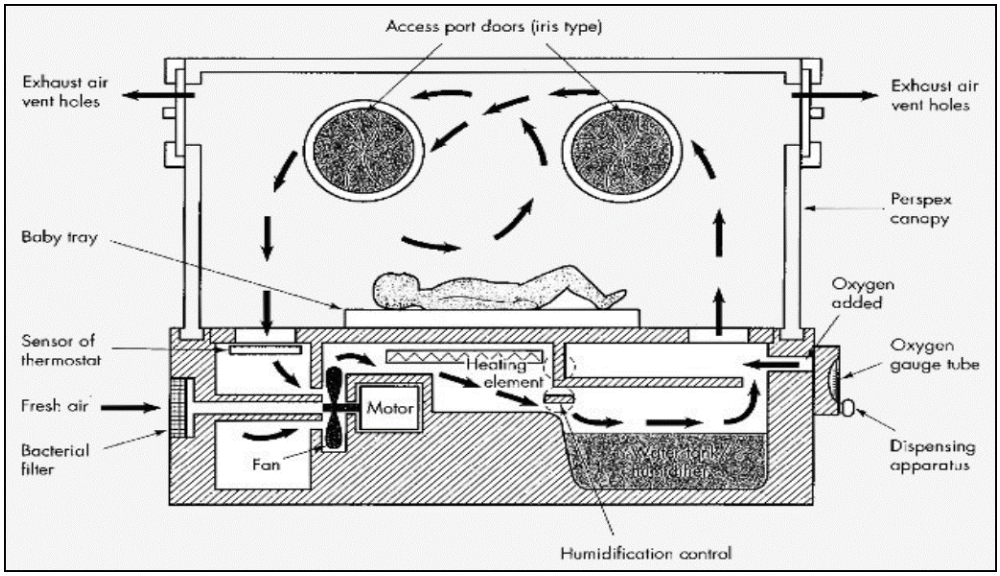


Figure 2.4 shows design and working of an infant incubator

The cabinet is made out of transparent Plexiglas (Perspex). A hinged hood can be opened to put the baby in or take it out. Through portholes in the front the nurse has easy access to the baby without letting out the warm air by opening the hood.

After the desired temperature is set by the nurse, it is kept stable automatically by the incubator. Humidity and oxygen concentration are usually controlled manually.

Furthermore the incubator has a safety switch-off function when the temperature increases 40°C. Also an alarm is given when the fan does not turn in case the power fails.

2.10 Components

The components which are used vary. Older incubators work with electrical controls, newer ones is electronically controlled and the newest generation is microprocessor controlled. But the result is the same - and the old ones are as reliable and precise as the newest ones [22].

2.10.1 Fan

The fan takes the filtered room air and blows it over or through the heating element and the humidifier. Without the fan the heat cannot be conducted away from the heating element and the heating element and thus the incubator would overheat [23].

2.10.2 Filter

Simple incubators are equipped with washable foam filters. After washing and drying they can be reused. Modern incubators however usually have disposable bacterial filters. They cannot be cleaned and have to be renewed [24].

2.10.3 Heater

A heating element made from coiled resistance wire as known from hair dryers or the tube type (flat or coiled) as seen in autoclaves are used to heat up the air. But unlike in autoclaves, the heater has much less power and thus does not get so hot. The power rating is between 100 W and 300 W.

The heater is controlled by an electronic temperature control unit via a relay or trial or simply by a thermostat [25].

2.11 Controls

2.11.1 Temperature control

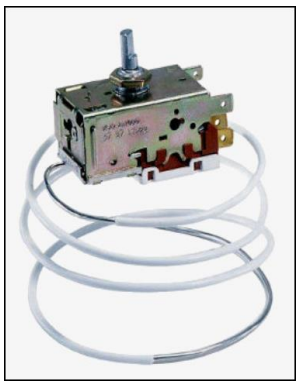


Figure 2.5 thermostat consists of a sensor and a pressure can

Simple incubators are controlled by a thermostat

which consists of a sensor and a pressure can.

The sensor is a thin capillary tube which leads

into the pressure can (or expansion chamber).

This chamber has a moveable metal lid or

diaphragm. This closed system contains a liquid

or gas which expands when getting warmer.

The lid moves and activates a connected electrical switch.

The thin capillary tube is often rolled up. This is correct. Do not cut it. It is not a wire. Also avoid bending the tube. It can get kinks and will then not work anymore.

Electronic controlled systems have a cable sensor. The output controls a relay (on-off) or a dimmer (infinitely variable control).

The electronically controlled type has the advantage that an additional temperature sensor can be used. This sensor is taped on the skin of the baby and measures the baby's body temperature [26].

The temperature display or thermometer should be separate from the temperature control unit. It can be a digital display or an alcohol glass thermometer. For safety reasons mercury thermometers must not be used in infant incubators. Mercury is toxic.

2.11.2 Humidity control

The heated air flows over the water in the water container and gets moistened. The humidity can be regulated by closing and opening a deflector plate over the container. Other incubators have a water heater which creates more humidity the warmer the water gets. The humidity should be adjustable between 40 and 90%.

The humidity is measured by a hygrometer, a digital or a traditional dial instrument.

The humidifier should be filled up only with distilled water only in order to avoid corrosive damage to the incubator [27].

2.11.3 Oxygen control

Most of the infant incubators have a hose connection for applying additional oxygen from an external cylinder, oxygen concentrator or from the central gas supply. In this case the warmed and moistened air gets also enriched with the oxygen. Alternatively the baby gets the additional oxygen directly via a nasal cannula [28].

2.12 Alarms and safety features

For safety reasons all electronically controlled infant incubators monitor all functions and an alarm is generated when something does not work properly.

In case of a failure the following alarms are given:

- Overheating; when the air in the cabinet gets too hot.
- Fan failure; when the fan is not turning any more.
- Power off; when the power supply fails. For this to work an additional alarm battery is needed.

Additionally all incubators, even the older non-electronic controlled ones have an over-heating protection. The heater is switched completely off when the temperature in the cabinet reaches 40°C [29].

2.13 Consumables

Some newer infant incubators do not have washable air inlet filters but special bacterial filters. These filters have to be exchanged after 3 or 6 month and cannot be cleaned [30].

2.14 Installation requirements

Infant incubators should be placed in a quiet environment with no exposure to direct sun light. Noisy oxygen generators should not be placed beside the incubator. Oxygen cylinders have to be protected against falling over.

Note: In case of a power cut the incubator does not work anymore. A small UPS as used for computers is no solution because the power consumption (of the heater) is too high [31].

2.15 Usage

The usage of an infant incubator is not difficult and the functions should be self-explanatory. Nevertheless the technician and the user have to read the user manual carefully before usage.

A missing user manual should be available from the manufacturer or from the Internet.

In addition to the instruction of the manufacturer here some general hints:

- ✓ Always preheat the incubator and wait for half an hour until temperature and humidity are stabilized.
- ✓ Babies are kept in the incubator undressed apart from a nappy.
- ✓ Check and record the temperature every 5 hours and hourly in a critical care stage.
- ✓ Default air temperature in the incubator is 35°C.
- ✓ The setting for the humidity for small babies is 70 - 80% in the beginning, later 40%.
- ✓ Use distilled water only. It has to be drained and renewed every day.
- ✓ Do not place equipment on top of the canopy [32].

2.16 Cleaning

Some manufacturers suggest cleaning the incubator every day with a mild soap water solution, some don't. But at least the incubator has to be cleaned and disinfected thoroughly

- ✓ after each change of infant
- ✓ at least once a week.

Therefore all inserts have to be removed and cleaned with hot soapy water added with antiseptic.

Then the inserts and the cabinet have to be dried and ventilated before they can be reused.

The disinfection products which can be used or should not be used are noted in the user manual.

The humidifier reservoir has to be cleaned and the water changed every day.

The air inlet filter should be changed or washed according to the user manual or every 3 months [33].

2.17 Maintenance

Start the maintenance with a visual check. Ensure that the hood is free of cracks and the hinges move smoothly and all switches and knobs are OK. Check all probes, cables, and tubes for cracks and the port sleeves for tears. Check or replace also the alarm battery, if there is one.

Continue with a test run with a function test and a temperature check and a calibration if needed. The temperature check and the calibration procedure are described in the service manual.

When the service manual is not present, a typical temperature check can be performed as follows:

- Use a reference thermometer with an accuracy of 0.5° or better and place it in the center of the mattress.
- Set the temperature to 36°C, wait at least 30 min and then check the temperature for 6 hours. The temperatures should not differ more than 1°.

When the temperature differs more, the control unit has to be calibrated. In electronic controls there is always is a trim-pot for doing the adjustments. Mechanical thermostats usually do not have a calibration point. But here the knob or the pointer can be twisted.

The safety thermostat or over-temperature cut-off can be tested by bypassing the main thermostat. Then the temperature will rise above 40°C, an alarm should be given and the safety function has to switch off the heater. It is also possible to use a hair dryer to warm up the sensor, or to move it closer to the heating element.

Check also the humidity. The incubator should be able to create up to 80% humidity. On the other hand it should be possible to reduce the humidity down to 40%.

An important task during the maintenance is the thorough cleaning of the technology compartment under the cabinet.

A vacuum cleaner helps a lot to clean the inside of the incubator but it is not essential. A brush will also do. Plastic parts and everything that is water resistant should be washed with hot soapy water added with antiseptic. Do not forget the air inlet filter.

A dusty fan can be cleaned easily with a brush, but this should not really be needed because of the inlet filter [34].

2.18 Special tools

A calibrated (electronic) thermometer with an accuracy of 0.1°C is needed. A clinical (fever) thermometer cannot be used because it only shows the maximum temperature.

A hygrometer is also needed when the humidity has to be checked.

2.19 Typical problems

- Burned heating elements can be replaced against other types as long as the wattage is the same. Some heating elements are protected by a thermal fuse. Consider this when you diagnose a 'blown' heating element.
- Also, a blown heating element or thermal fuse has a reason. Check the fan operation.
- When replacing a defective thermostat do not only look only at the temperature range but also at the accuracy and the hysteresis. Hysteresis is temperature difference between switching off and switching on. For an incubator a hysteresis of 1°C is needed.

- Be careful with thermostats. The thin capillary tube is usually rolled up. This is correct. Do not cut it. It is not a wire, but a fine tube. Also avoid bending the tube. It can get kinks and will not work anymore.
- Lubrication also helps when the fan gets noisy. Axial computer-type fans have a label in the center which can be lifted up a bit for lubrication.

One drop of oil is enough.

- Broken hood thermometers should never be replaced against mercury glass-thermometers. The glass can break and mercury is toxic.
- The sleeves of the ports are often torn, filthy or missing, but you can find the material for replacement easily in every town.
- Casters and brakes are often damaged and spares are difficult to find. But often the incubators are not moved anyway and the casters are not needed. In this case it is a good idea to remove them completely to ensure the incubator is standing stable [35].

2.20 Spare parts

Modern incubators use disposable bacterial filters that cannot be reused. Make sure you have some spare filters in stock. Broken or disappeared.

Chapter Three

Jaundice and Phototherapy

3.1 Introduction

Jaundice in newborn babies is common and usually harmless. It causes yellowing of the skin and the whites of the eyes. The medical term for jaundice in babies is neonatal jaundice.

3.2 Symptoms

Yellowing of the skin can be more difficult to see in brown or black skin, It might be easier to see on the palms of the hands or the soles of the feet, other symptoms of newborn jaundice can include:

- ✓ Dark, yellow urine (a newborn baby's urine should be colorless)
- ✓ Pale-colored poo (it should be yellow or orange)

The symptoms of newborn jaundice usually develop 2 days after the birth and tend to get better without treatment by the time the baby is about 2 weeks old [36].

Figure 3.1 newborn with jaundice

3.3 Treating newborn jaundice

Treatment for newborn jaundice is not usually needed because the symptoms normally pass within 10 to 14 days, although they can occasionally last longer.Treatment is usually only

recommended if tests show very high levels of bilirubin in a baby's blood, this is because there's a small risk the bilirubin could pass into the brain and cause brain damage.

There are several treatments for jaundice like giving fluids to the newborn to prevent dehydration, exchange blood transfusion, intravenous immunoglobulin (IVIg) and Phototherapy (which we'll focus on) [37].

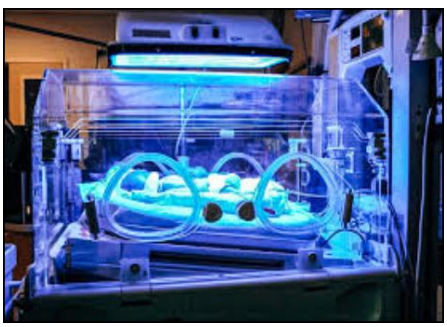


Figure 3.2 and figure 3.3 shows newborn inside infant incubator taking phototherapy

3.3.1 Phototherapy

A special type of light shines on the skin, which alters the bilirubin into a form that can be more easily broken down by the liver, An exchange transfusion – where your baby's blood is removed using a thin tube (catheter) placed in their blood vessels and replaced with blood from a matching donor; most babies respond well to treatment and can leave hospital after a few days.

Phototherapy is treatment with a special type of light (not sunlight). It's sometimes used to treat newborn jaundice by making it easier for the baby's liver to break down and remove the bilirubin from the baby's blood [38].

Phototherapy aims to expose the baby's skin to as much light as possible. The baby will be placed under a light either in a cot or incubator with their eyes covered, it will usually be stopped for 30 minutes so the mother can feed the baby, change their nappy and give them a cuddle. If the baby's jaundice does not improve, intensified phototherapy may be offered. This involves increasing the amount of light used or using another source of light, such as a light blanket, at the same time.

Treatment [39] cannot be stopped for breaks during intensified phototherapy, so the mother will not be able to breastfeed or hold her baby. But she can give her baby expressed milk.

During phototherapy [40], the baby's temperature will be monitored to make sure they're not getting too hot, and they'll be checked for signs of dehydration. Intravenous fluids may be needed if your baby is becoming dehydrated and they are not able to drink enough.

Table 3.1 Indicative levels for phototherapy in preterm newborns [41]

Age	Consider photography	Start photography	Exchange transfusion
≤ 24 h	-	-	-
25 - 48 h	12 mg%	15 mg%	≥ 20 mg%
49 -72	15 mg%	18. mg%	≥ 25 mg%
>72 h	17 mg%	20 mg%	≥ 25 mg%

The bilirubin levels will be tested every 4 to 6 hours after phototherapy has started, to check if the treatment is working. Once the baby's bilirubin levels have stabilized or started to fall, they will be checked every 6 to 12 hours. Phototherapy will be stopped when the bilirubin levels fall to a safe level, which usually takes a day or two.

The amount and time of exposure of the child to light is determined based on the decision of doctors and specialists.

Phototherapy is generally very effective for newborn jaundice and has few side effects.

The short-term side effects of phototherapy include interference with maternal-infant interaction, imbalance of thermal environment and water loss, electrolyte disturbance, bronze baby syndrome and circadian rhythm disorder. In addition, phototherapy may be associated with some long-term side effects such as melanocytic nevi and skin cancer, allergic diseases, patent ductus arteriosus and retinal damage.

Therefore, it is necessary to develop evidence-based guidelines, new light devices and alternative agents, as well as individualized treatments, to minimize the side effects of phototherapy.

Chapter Four

Manufacturing an infant incubator

Monitoring and alarm system

4.1 System build

This system built to monitor the incubator humidity, Temperature, and oxygen level It also have an alarm system In case the oxygen level went high or dropped low it will alarm the patient,

As well as the humidity and temperature device when they reach the level that makes the infant feel the heat due to the higher temperature which makes them feel uncomfortable and cause a lot of side effect, and the high humidity leads to make the infant sweat which makes them loss a lot of fluids and leads to accumulation of bacteria and viruses,

When the temperature drops very low this will lead to make the infant body cold and cause a lot of side effects as well as when the humidity drops low it will cause a respiratory disease.

So this device designed to alarm the nurse in case the humidity and temperature went high so she can take proper measurements.

Another device designed to monitor the oxygen level and alarm the nurse in case the level went high or dropped low.

The EPA recommends keeping relative humidity between 30% and 60%. Some baby experts suggest keeping humidity slightly higher than for adults, around 55% RH. Some experts also suggest slightly higher temperatures too, between 68°F and 70°F (20°C to 21°C).

4.2 Temperature and Humidity device using dht22 sensor

The DHT22 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It’s easy to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds, so when using our library, sensor readings can be up to 2 seconds old.

4.2.1 Hardware

The components of the device are:

- ✓ Microcontroller type Arduino Nano.
- ✓ Oled display.
- ✓ Dht22 sensor.
- ✓ Wires.
- ✓ Buzzer.
- ✓ Small Breadboard
- ✓ Buzzer

- ✓ Small box
- ✓ 9 volts batteries
- ✓ Switch on, off

4.2.2 The connections of the device

- ✓ Oled display connections
- ✓ Scl to A5
- ✓ SDA to A4
- ✓ A means (Analog)
- ✓ Gnd to Ground
- ✓ Vcc to 5 volts
- ✓ The DHT22 sensor connections
- ✓ Ground to GND
- ✓ Vcc to 3.3 volts
- ✓ Data to Digital 2
- ✓ Buzzer connections
- ✓ Ground to ground
- ✓ And the positive pin to Digital 8

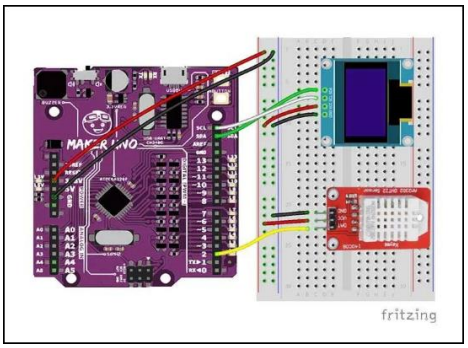


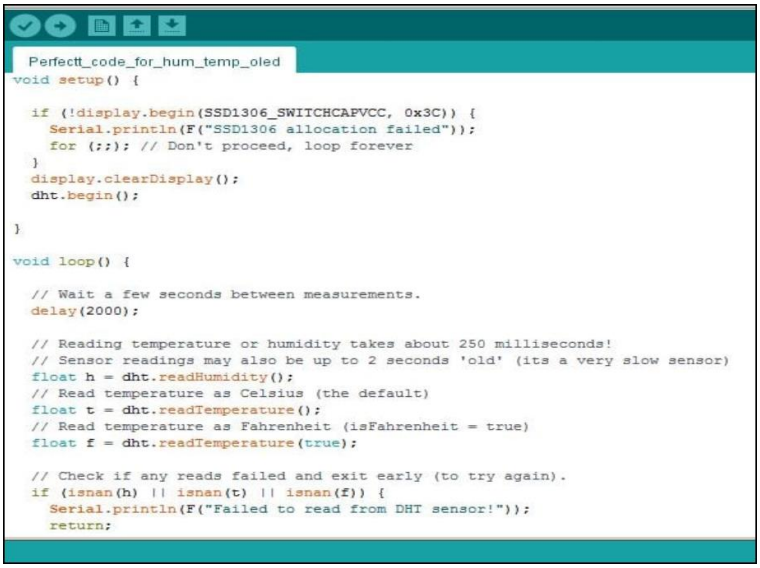
Figure 4.1 Device connections

4.2.3 Software

Perfectt_code_for_hum_temp_oled

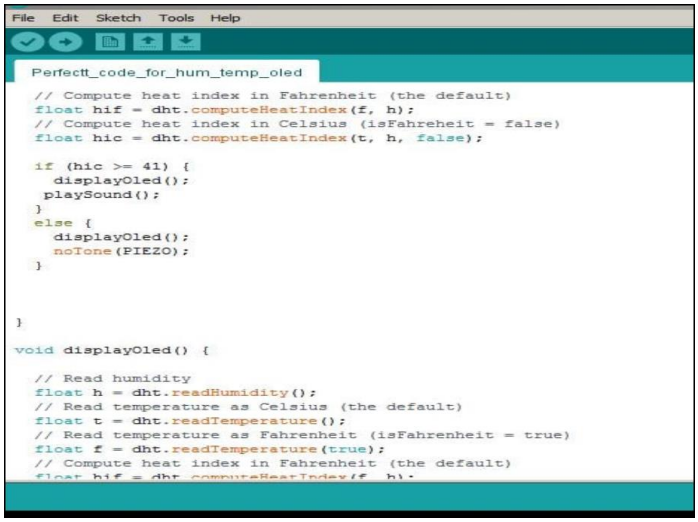
```
#include <SPI.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#include "DHT.h"

#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels

// Declaration for an SSD1306 display connected to I2C (SDA, SCL pins)
#define OLED_RESET     4 // Reset pin # (or -1 if sharing Arduino reset pin)
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);

#define DHTPIN 2
#define DHTTYPE DHT22   // DHT 22  (AM2302), AM2321
DHT dht(DHTPIN, DHTTYPE);

#define PIEZO 8

#define ALARM  1000

int Sound[] = {ALARM, ALARM};
int SoundNoteDurations[] = {4, 4};

#define playSound() playMelody(Sound, SoundNoteDurations, 2)

char inChar;
String inString;
```

Code 1.1



```
Perfectt_code_for_hum_temp_oled
void setup() {

  if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
    Serial.println(F("SSD1306 allocation failed"));
    for (;;); // Don't proceed, loop forever
  }
  display.clearDisplay();
  dht.begin();

}

void loop() {

  // Wait a few seconds between measurements.
  delay(2000);

  // Reading temperature or humidity takes about 250 milliseconds!
  // Sensor readings may also be up to 2 seconds 'old' (its a very slow sensor)
  float h = dht.readHumidity();
  // Read temperature as Celsius (the default)
  float t = dht.readTemperature();
  // Read temperature as Fahrenheit (isFahrenheit = true)
  float f = dht.readTemperature(true);

  // Check if any reads failed and exit early (to try again).
  if (isnan(h) || isnan(t) || isnan(f)) {
    Serial.println(F("Failed to read from DHT sensor!"));
    return;
```

Code 1.2



```
File  Edit  Sketch  Tools  Help
Perfectt_code_for_hum_temp_oled
  // Compute heat index in Fahrenheit (the default)
  float hif = dht.computeHeatIndex(f, h);
  // Compute heat index in Celsius (isFahreheit = false)
  float hic = dht.computeHeatIndex(t, h, false);

  if (hic >= 41) {
    displayOled();
   playSound();
  }
  else {
    displayOled();
    noTone(PIEZO);
  }


}
void displayOled() {

  // Read humidity
  float h = dht.readHumidity();
  // Read temperature as Celsius (the default)
  float t = dht.readTemperature();
  // Read temperature as Fahrenheit (isFahrenheit = true)
  float f = dht.readTemperature(true);
  // Compute heat index in Fahrenheit (the default)
```

Code 1.3

```
Perfectt_code_for_hum_temp_oled
// Compute heat index in Fahrenheit (the default)
float hif = dht.computeHeatIndex(f, h);
// Compute heat index in Celsius (isFahreheit = false)
float hic = dht.computeHeatIndex(t, h, false);

display.clearDisplay();
display.setTextColor(WHITE);
display.setTextSize(1);
display.setCursor(5, 15);
display.print("Humidity:");
display.setCursor(80, 15);
display.print(h);
display.print("%");
display.setCursor(5, 30);
display.print("Temperature:");
display.setCursor(80, 30);
display.print(t);
display.print((char)247); // degree symbol
display.print("C");
display.setCursor(5, 45);
display.print("Heat Index:");
display.setCursor(80, 45);
display.print(hic);
display.print((char)247); // degree symbol
display.print("C");
display.display();

}
```

Code 1.4

```
File  Edit  Sketch  Tools  Help

Perfectt_code_for_hum_temp_oled
  display.setCursor(5, 30);
  display.print("Temperature:");
  display.setCursor(80, 30);
  display.print(t);
  display.print((char)247); // degree symbol
  display.print("C");
  display.setCursor(5, 45);
  display.print("Heat Index:");
  display.setCursor(80, 45);
  display.print(hic);
  display.print((char)247); // degree symbol
  display.print("C");
  display.display();

}

void playMelody(int *melody, int *noteDurations, int notesLength)
{
  pinMode(PIEZO, OUTPUT);

  for (int thisNote = 0; thisNote < notesLength; thisNote++) {
    int noteDuration = 1000 / noteDurations[thisNote];
    tone(PIEZO, melody[thisNote], noteDuration);
    int pauseBetweenNotes = noteDuration * 1.30;
    delay(pauseBetweenNotes);
    noTone(PIEZO);
  }
}
```

Code 1.5

4.2.4 Packaging and testing of the device

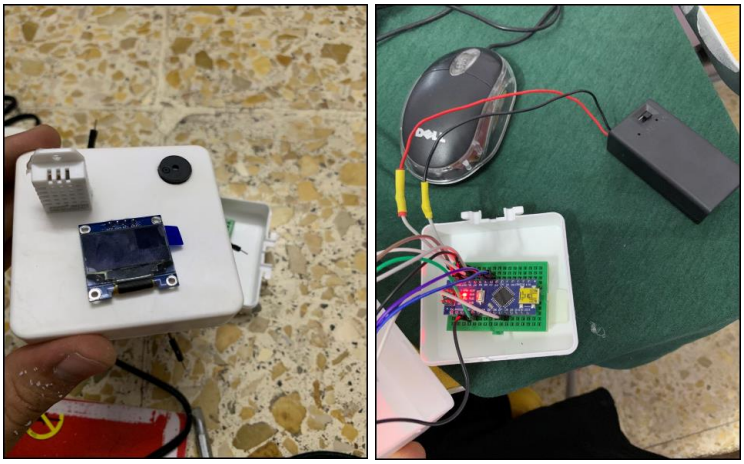


Figure 4.2 and figure 4.3 Shows the packaging process

Figure 4.4 device testing

As we can see the device works perfectly and gives an output of three readings

- ✓ Humidity
- ✓ Temperature

- ✓ And heat index

The heat index, also known as the apparent temperature, is what the temperature feels like to the human body when relative humidity is combined with the air temperature. This has important considerations for the human body's comfort. When the body gets too hot, it begins to perspire or sweat to cool itself off.

So the device designed when the heat index gets higher than 39 degrees the buzzer will work to alarm the nurse to take a proper measurement and control the situation.

4.3 Oxygen level monitor using MQ2 Sensor

This device monitors the oxygen level of the infant incubator and alarms the nurse in case any leakage occurs or if the oxygen drops low.

4.3.1 Hardware

The components of the device:

- ✓ Microcontroller Type Arduino Uno
- ✓ LCD screen
- ✓ MQ2 sensor
- ✓ Wires
- ✓ Buzzer
- ✓ Led
- ✓ Small Breadboard
- ✓ Small box
- ✓ 9v batteries
- ✓ Switch on, off

4.3.2 Connections of the device

1. -The LCD connections

- ✓ Ground to GND
- ✓ Vcc to 5 volts
- ✓ Scl to Analog 5
- ✓ SDA to A4

2. -The Sensor connections

- ✓ GND to ground
- ✓ Vcc to 5 volts
- ✓ Data to Analog 0

3. -Buzzer and led connections

- ✓ Ground To GND
- ✓ Positive To Digital pin 13

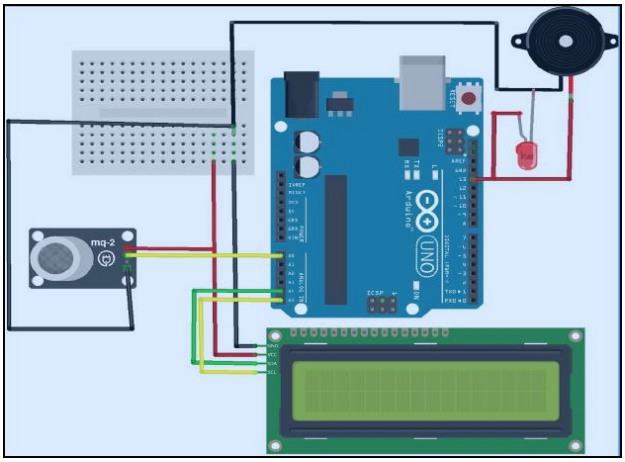


Figure 4.5 device connections

4.3.3 Software

```
File  Edit  Sketch  Tools  Help
abd_rahman
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);  //for 16x2 lcd display

int buzzer = 13;
int GASA0 = A0;
int gasvalue;


void setup() {

 lcd.init();     // initiate the lcd
 lcd.init();
 lcd.backlight();
 Serial.begin(9600);
 pinMode(buzzer, OUTPUT);
 lcd.setCursor(3,0);
 lcd.print("welcome to");
 lcd.setCursor(1,1);
 lcd.print("OXYGEN MONITOR");
 delay(5000);
}

void loop() {
  int analogSensor = analogRead(GASA0);
  int gasvalue=(analogSensor-50)/35;       //gas module sensitivity

  lcd.setCursor(0,0);
  lcd.print("O2 Level:");
```

Code 2.1

```
File  Edit  Sketch  Tools  Help
abd_rahman
void loop() {
  int analogSensor = analogRead(GASA0);
  int gasvalue=(analogSensor-50)/35;       //gas module sensitivity

  lcd.setCursor(0,0);
  lcd.print("O2 Level:");
  lcd.setCursor(10,0);
  lcd.print(gasvalue);
  lcd.setCursor(12,0);
  lcd.print("%");

  // Checks if it has reached the threshold value
  if (gasvalue >= 10)              //gas percentage alert
  {
    lcd.setCursor(0,1);
  lcd.print("DANGER");
    tone(buzzer, 1000, 10000);
  }
  else
  {
  lcd.setCursor(0,1);
  lcd.print("NORMAL");
    noTone(buzzer);

  }
  delay(500);
  lcd.clear();
}
```

Code 2.2

4.3.4 Packaging

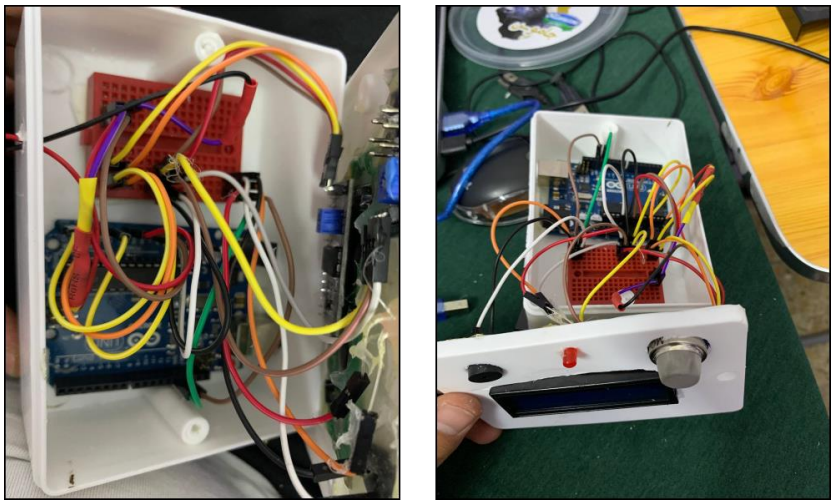


Figure 4.6 and figure 4.7 Shows the Packaging Process

Figure 4.8 the device work perfectly

Figure 4.9 shows a dangerous level of O2

As we can see in figure 4.9 the Led alarm is working as well as the buzzer to alarm the medical staff so they can take a proper measurement.

4.4 Phototherapy

As in phototherapy of Jaundice, we used a special light source that emits light in the blue-green spectrum we imported it from China, a high-efficiency device and materials suitable for safe use, (figure 4.10 and 4.11).

This light changes the shape and structure of the bilirubin molecules in such a way that the body can eliminate them with urine and feces.

During treatment, the child wears only a diaper and patches (blindfolds) to protect the eyes, (figure 4.12).

Light therapy may be enhanced with a light-emitting bed or pillow.

Figure 4.10 and Figure 4.11 shows phototherapy device

Figure 4.12 shows blindfolds to protect baby's eyes

Chapter Five

Device Components and Assembling

5.1 Introduction

A portable baby incubator that works inside and outside the home was designed and manufactured.

An incubator is designed for the baby in addition to the treatment of jaundice Portable, easy to run, quick to work, and low cost.

Home treatment is available through a small and easy-to-operate portable battery-powered bag.

And avoid the danger of leaving the house, in addition, it is possible in villages and in the countryside that incubators are not available, so this device will be very important.

This incubator maintains, through sensors and alerts, an ideal temperature, humidity and oxygen.

It is possible that we develop the incubator by adding oxygen and heat generation devices

As for the jaundice treatment device, we imported it from China, a high-efficiency device and materials suitable for safe use.

5.2 Components

It consists of several parts in general, and in short, this incubator consists of:

1. A bag in which the child is placed: - It is a rectangular bag of a suitable size to protect the child during movement and movement by the mother. It is made of plastic materials.
2. Supporting structure: - To cover the bag.
3. Plastic wrap: It is curved and lightweight to isolate the child from the outside atmosphere.
4. A special light device for phototherapy treatment of child with jaundice.
5. Temperature sensor: - Some experts suggest higher temperatures, between 68°F and 70°F (20°C to 21°C).
6. Humidity eagle: - Maintaining relative humidity between 30% to 60% representative organization experts suggest.
7. Sensors for oxygen and gases.
8. Rechargeable battery: - Jakon and it has a voltage of 9v.
9. Additional pockets for baby supplies (such as breastfeeding, milk, baby clothes and other baby supplies).

Parts and components are shown in figures below:

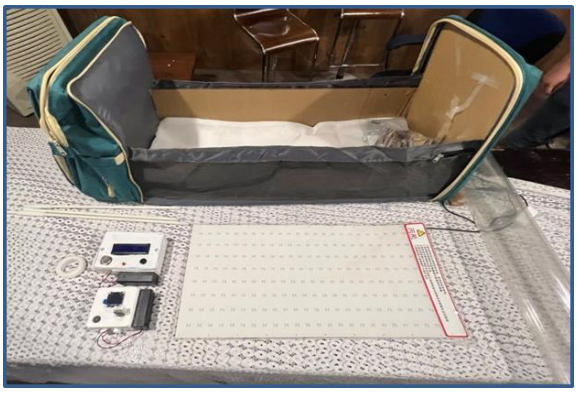


Figure 5.1 shows components of the device

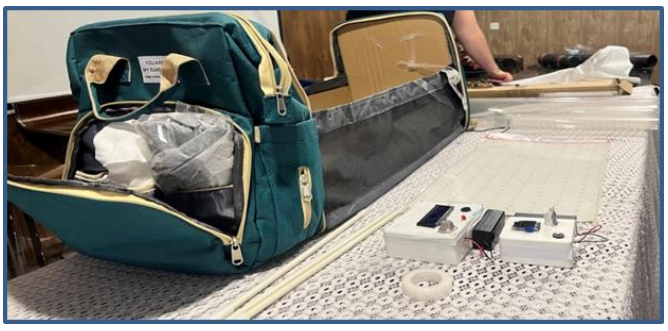


Figure 5.2 shows components of the device

5.3 Assembling

All parts of the incubator can be folded and reused, and all materials are available and light in weight, as through the components and sensors you feel heat, moisture, and oxygen, and also. In this incubator, a jaundice treatment device was added to the child and kept from any causes of health problems in order to treat the child safely inside the incubator.

The incubator device has proven being a wealth in the field of medicine for the benefit and treatment of newborn children.

Figure 5.3 device assembled and turned on

Figure 5.4 device assembled and turned off

5.4 Features:

One of the characteristics of the device, which made it suitable for home use,

1. Is cheap, the price of its manufacture does not exceed $150,
2. It is easy to install.
3. It is light in weigh.
4. It is foldable, and it does not occupy an area.
5. Portable.
6. Treats jaundice.

5.5 Feedback:

Sensors are programmed based on:

The sensors calculate the temperature, humidity and oxygen after performing the calculations which blood was originally entered,

As a result of these resulting values, if these values are higher than the safe and permissible limit, two things will be given.

The first is writing the word danger in red color on the screen in large font,

The second is to issue a warning at an appropriate height to alert the persons responsible for the matter.

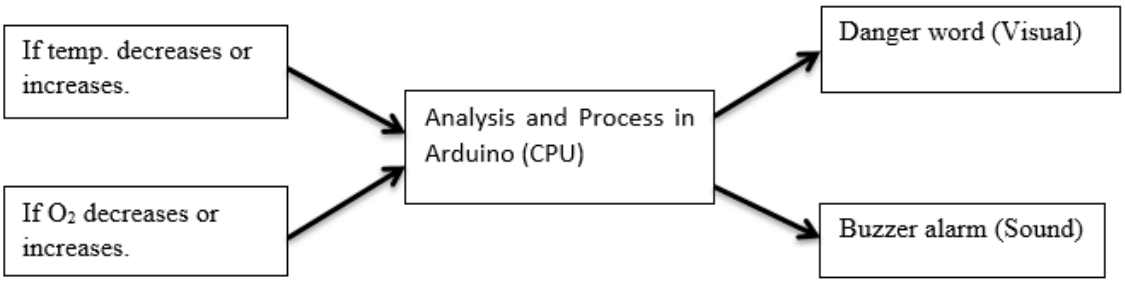


Figure 5.5 Shows the Feedback Process.

Chapter Six

Conclusion and Recommendations

6.1 Conclusion

In the end, we would like to recall the most important features of this work where it can be considered as an effective invention to serve both the mother and the child in addition to the beneficiaries as a treatment device as well.

This device was made according to what was recently covered by the events around the Corona virus and the observed momentum and the danger of hospitals that may affect the mother and a young child who does not have immunity to be treated in a place that may expose him to infection with any virus.

Based on these priorities, this portable incubator was manufactured for use inside and outside the home. It is easy to carry and from safe materials that do not pose a danger to the child and do not pose a burden to the mother. This incubator operates on a movable battery, Close to ideal.

As for being a phototherapy device, we have also imported a device from China with high efficiency and appropriate materials, In addition to a special type of glasses that are worn over the child's eyes while operating the light device to treat jaundice.

6.2 Beneficiaries

1. General hospitals: as they reduce the overcrowded on the existing incubators.
2. Private Pay Hospitals: treating emergency cases.
3. Parents of the infant, because it is easy to use, low in cost, and can be carried wherever the mother goes. With a high probability that the child will not suffer any disadvantages because he was born prematurely and his autoimmunity is very weak during this time.
4. Some local medical clinics can benefit from it for critical and emergency cases because it is available near them.

6.3 Recommendations

Device development:

The device that has been manufactured now is very suitable to keep the child in an appropriate position and treat jaundice

It can be developed through some additions to make it more practical (these additions may cause some extra weight and difficulty in moving), so please pay attention to this topic.

The additions are:

1. Oxygen generating device: We have previously mentioned that among the components of the device is a sensor to the percentage of oxygen and gases to alert the parents if something goes wrong. A device that generates oxygen can be added to treat these problems, as well as to treat the child’s symptoms of shortness of breath or other matters, and his work is

calculated according to a specific algorithm by adding quantities when needed and stopping when enough

2. Thermostat device: With the same idea and application of the oxygen generating device, a thermostat is placed to automatically equalize the heat and humidity when needed.
3. A densitometer: serves to determine the composition of the gaseous mixture within the chamber and to make certain that this composition remains constant during its use.
4. A small canister of helium: to mix with the oxygen creating a controlled mixture in the atmosphere of the chamber.

It must be precise made to avoid possible problems, and it is preferable that it be of small size and light in weight additions.

References

1. International Journal of Entrepreneurial Venturing The International Journal of Entrepreneurship and Innovation Journal of Supply Chain Management 56 (2), 3-6, 2020.
2. Sonia Tassone, Riccardo Fortina, Pier Giorgio PeirettiAnimals 10 (5), 775, 2020.
3. International Journal of Entrepreneurial Behavior & Research14 (4), 219-241, 2008 ,
4. Candace Campbell, David N Allen Economic Development Quarterly 1 (2), 178-191, 1987.
5. Roberto Antonucci, Annalisa Porcella, Vassilios Fanos Walter de Gruyter 37 (6), 587-598, 2009 , International Journal of emerging trends in electrical and electronics 11 (5), 65-72, 2015.
6. Brian Fugate, Mark Pagell, Barbara FlynnJournal of Supply Chain Management 55 (2), 3-5, 2019.
7. MT Coughlan, K Oliva, HM Georgiou, JMH Permezel, GE Rice Diabetic Medicine18 (11), 921-927, 2001, Martha Lappas, Kirin Yee, Michael Permezel, Gregory E RiceJournal of endocrinology186 (3), 457-465, 2005, Caitlyn Nguyen-ngo , Jane C Willcox, Martha Lappas Molecular nutrition & food research 63 (19), 1900224, 2019.
8. Charles L Pickens, Sam A Golden, Tristan Adams-Deutsch, Sunila G Nair, Yavin Shaham Biological psychiatry 2009 Ambika G Bajpayee, Mohiuddin A Quadir, Paula T Hammond, Alan J Grodzinsky65 (10), 2009, 881-886.
9. Brendan Galbraith, Rodney McAdam, Stephen Edward Cross IEEE Transactions on Engineering Management 68 (1), 265-271, 2019.
10. José L Barbero, José C Casillas, Alicia Ramos, Susana Guitar Technological Forecasting and Social Change 79 (5), 888-902, 2012.
11. David N Allen, Richard McCluskeyEntrepreneurship theory and practice 7 (3), 286-307, 2015.
12. José L Barbero, José C Casillas, Mike Wright,Alicia Ramos GarciaThe Journal of Technology Transfer 39 (2), 151-168, 2014.
13. Baker, Jeffrey P. The machine in the nursery: incubator technology and the origins of newborn intensive care. JHU Press 42 (9), 334-11, 1996.
14. Malviya, S. Congratulations to the New SPA Officers and Directors 13 (22), 67-714, 2001.
15. Bauchner, H., Fontanarosa, P. B., & Livingston, E. H. (2000). Conserving supply of personal protective equipment—a call for ideas. Jama , 323(19), 1911-1911.
16. Donn, S. M., & Gisondo, C. M. (2022). Transport of ventilated babies. In Manual of Neonatal Respiratory Care (pp. 807-817). Springer, Cham, 61 (98), 45-112 2015.

17. Deorari, A. K. Basic Equipment for Thermal Protection. Journal of Neonatology, 15(1), 64-71 2001.
18. Health problems addressed Bissinger, R. L., & Annibale, D. J. (2010). Thermoregulation in very low-birth-weight infants during the golden hour: results and implications. Advances in Neonatal Care 10(5), 230-238.
19. Sessler, D. I., & Todd, M. M. (2000). Perioperative heat balance. The Journal of the American Society of Anesthesiologists, 92(2), 578-578.
20. Antonucci, R., Porcella, A., & Fanos, V. (2009). The infant incubator in the neonatal intensive care unit: unresolved issues and future developments.43 (28), 1999 483-23.
21. ÖZDEMIRCI, Emre, et al. Reliability assessments of infant incubator and the analyzer. Gazi University Journal of Science, 2014, 27.4: 1169-1175.
22. Gurbeta, L., Izetbegović, S., & Badnjević-Čengić, A. (2018). Inspection and Testing of Pediatric and Neonate Incubators. In Inspection of Medical Devices (pp. 221-249). Springer, Singapore.
23. J. G. Kassakian, H.-C. Wolf, J. M. Miller and C. J. Hurton, "Automotive electrical systems circa 2005", IEEE Spectr., vol. 33, no. 8, pp. 22-27, Aug. 1996.
24. K. Koscher et al., "Experimental security analysis of a modern automobile", Proc. IEEE Symp. Security Privacy, pp., 2010.
25. CAN Specification Version 2.0, 32 (34) 1991.
26. S. Checkoway et al., "Comprehensive experimental analyses of automotive attack surfaces", Proc. USENIX Security Symp, 2011[online].
27. C. Miller and C. Valasek, "Remote exploitation of an unaltered passenger vehicle" in , Black Hat USA 447-462, 2010.
28. R. Akhtar, S. Leng, I. Memon, M. Ali and L. Zhang, "Architecture of hybrid mobile social networks for efficient content delivery", Wireless Pers. Commun., vol. 80, no. 1, pp., 85-96, 2015.
29. H. J. Jo, W. Choi, S. Y. Na, S. Woo and D. H. Lee, "Vulnerabilities of android OS-based telematics system", Wireless Pers. Commun., vol. 92, pp1511-1530, 2017.
30. Memon, "Authentication users privacy: An integrating location privacy protection algorithm for secure moving objects in location based services", Wireless Pers. Commun., vol. 82, no. 3, pp 1585-1600, 2015.
31. I. Memon and Q. A. Arain, "Dynamic path privacy protection framework for continuous query service over road networks", World Wide Web, vol. 20, pp, 639-672, 2017,
32. Memon, L. Chen, A. Majid, M. Lv, I. Hussain and G. Chen, "Travel recommendation using geo-tagged photos in social media for tourist", Wireless Pers. Commun., vol. 80, no. 4, pp, 1347-1362, 2015.
33. OSHA Technical Manual (OTM) Section III: Chapter 2; TED 01-00-015, 1999.
34. Freshney, R.I. Culture of Animal Cells. John Wiley & Sons: Hoboken, N.J., 2010.
35. Esser, P. and Weitzmann, L. Evaporation from cell culture plates. Thermo Scientific 2011; TILSPNUNCBU02 0111.
36. Kaplan M, Muraca M, Hammerman C, et al. Imbalance between production and conjugation of bilirubin: a fundamental concept in the mechanism of neonatal jaundice.
37. Maisels MJ, Kring E. The contribution of hemolysis to early jaundice in normal newborns. Pediatrics 2006.

38. AAP Subcommittee on Neonatal Hyperbilirubinemia. Neonatal jaundice and kernicterus. Pediatrics 2001.
39. Newman TB, Escobar GJ, Gonzales VM, Armstrong MA, Gardner MN, Folck BF. Frequency of neonatal bilirubin testing and hyperbilirubinemia in a large health maintenance organization. Pediatrics 1999-12
40. Eggert LD, Wiedmeier SE, Wilson J, Christensen RD. The effect of instituting a prehospital-discharge newborn bilirubin screening program in an 18-hospital health system. Pediatrics 2006.
41. Bhutani VK, Johnson LH, Schwoebel A, Gennaro S. A systems approach for neonatal hyperbilirubinemia in term and near-term newborns. J Obstet Gynecol Neonatal Nurs 2006.
42. Article on Research gate by Manoel de Carvalho OBJECTIVE To review the recent medical literature on the treatment of neonatal jaundice Aug 2001