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Design and Construction of a Medical Nebulizer System

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Abstract: The vaporizer can be used for both short-acting medicines (rescue medicines), which are used in cases of acute attacks, or long-acting medicines (control medicines), which are used to control symptoms and prevent their deterioration, as these medicines are available either in the form of small single-dose ampoules, Or in the form of bottles or cans with instruments to measure the required dose size. the problem of chest allergy is one of the most common health problems that can affect many children, and the use of the nebulizer for children will help facilitate inhalation in cases of chest allergies that lead to difficulty breathing. Asthma is a chronic disease, and asthma patients need to use inhalers, whether portable devices or nebulizers, as the person needs frequent sessions, and the nebulizer is more suitable for young children than nebulizers that are difficult to use at a young age, as they require a special method of use. bronchodilators are medicines used to open narrowed airways and facilitate breathing, and are often prescribed to people who suffer from asthma or chronic obstructive pulmonary disease. These medicines include salbutamol, ipratropium, formoterol (Formoterol), and others. sterile saline solutions that help open the airways, and thin the secretions in the airways and lungs, which may facilitate the process of coughing and excreting the mucus there. Vaporizers can be used to deliver some types of antibiotics directly to the lungs or airways in some severe respiratory infections.

Chapter One Introduction

1.1 Introduction

Throughout history, many scientists and doctors provided services that contributed to ridding humanity of deadly diseases and saved many human lives from death. In addition to those who succeeded in discovering vaccines and medicines, history mentions the names of people who invented machines that facilitated diagnosis and response to diseases Created by the doctor John Mudge (1). the invention of the inhaler is thanks to the combined efforts of many scientists and innovators for centuries. In ancient times, humans relied on aromatic and medicinal fumes to treat a number of diseases. In the past, humans used the process of boiling and burning to obtain gases that are used to be sent to the lungs through inhalation. one of the first splinter models is credited to the English physician and astronomer John Mudge. In 1778, Mudge invented a pewter-like device whose surface was perforated and a flexible tube was attached to it to facilitate the inhalation process. To get the treatment, the user pours hot water, which has been mixed with the medication, into the mug tank before closing the lid and inhaling the steam rising through the tube.

1.2 the nebulizer

A nebulizer is a medical device that enables a person with asthma or any other respiratory disease to take medication directly and quickly into the lungs. The inhaler turns liquid medication into a very fine mist that a person can inhale through a face mask or mouthpiece, allowing the medication to go directly to the lungs and respiratory tract immediately when needed.

1.3 two main types of nebulizers

1. A pressurized respirator to convert medication into a mist.
2. Ultrasound inhaler

1.4 the difference between Nebulizer and Inhaler

There are some similarities between a nebulizer inhaler and an inhaler both of which deliver medication directly to the lungs to help make breathing easier. However, there are some important differences.

two types of inhalers

1. A Metered Dose Inhaler (MDI)
2. Dry powder inhaler.

The most common type of inhaler is an MDI, which involves inhaling a predetermined amount of medication through a mouthpiece. The inhaler is similar to a dry powder, but the medicine is in the form of a powder, so the patient must take deep and quick breaths; To pull the medicine into the lungs.

Both types require the ability to inhale the drug deeply into the lungs, so some children and patients with acute respiratory illness find this problem.

As such, the Nebulizer tends to be a little easier to use, in terms of drug delivery. However, it may take up to 10 minutes for the medication to dispense, and the patient needs to sit still to fully inhale, making this difficult for a young child.

1.5 Medicines used with the nebulizer

1. Bronchodilators:

Are medicines that help open the airways, and facilitate breathing. It is often prescribed to people with asthma, COPD, or other respiratory disorders.

2. Sterile saline solution:

An inhaler can deliver a sterile saline solution to help open the airways and thin secretions. This may loosen the mucus in the lungs and make it easier to pass out.

3. Antibiotics:

A nebulizer can deliver some types of antibiotics directly to an inhaler can deliver a sterile saline solution to help open the airways and thin secretions. This may loosen the mucus in the lungs and make it easier to pass out.

1.6 Literature Survey

Joseph L Rau, et al [2002](2)

Liquid nebulization is a common method of medical aerosol generation. Nebulizers are of 2 types: jet (or pneumatic) small-volume nebulizer, and ultrasonic nebulizer. Jet nebulizers are based on the venturi principle, whereas ultrasonic nebulizers use the converse piezoelectric effect to convert alternating current to high-frequency acoustic energy. Important variables for both types of nebulizer are treatment time required, particle size produced, and aerosol drug output.

Thomas G O'Riordan et al [2002](3)

To deliver a drug by nebulization, the drug must first be dispersed in a liquid (usually aqueous) medium. After application of a dispersing force (either a jet of gas or ultrasonic waves), the drug particles are contained within the aerosol droplets, which are then inhaled. Some drugs readily dissolve in water, whereas others need a cosolvent such as ethanol or propylene glycol. Some drugs are delivered as suspensions, and the efficiency of nebulizers can be different for solutions and suspensions.

Solutions are delivered more efficiently with most devices.

Ding z, taylor km et al [2007

In this study, the effect of fluid physicochemical properties and the vibrating-mesh mechanism on the aerosols generated from vibratingmesh nebulizers have been evaluated using fluids having a range of viscosity, surface tension and ion concentration. Two nebulizers were investigated: the Omron MicroAir NE-U22 (passively vibrating) and the Aeroneb Pro (actively vibrating) mesh nebulizers. For both devices, the total aerosol output was generally unaffected by fluid properties.

GILL Hs, Taylor km et al [2006]

Multilamellar and oligolamellar liposomes were produced from ethanol-based soya phosphatidyl-choline proliposome formulations by addition of isotonic sodium chloride or sucrose solutions. The resultant liposomes entrapped up to 62% of available salbutamol sulfate compared with only 1.23% entrapped by conventionally prepared liposomes. Formulations were aerosolized using an air-jet nebulizer (Pari LC Plus) or a vibrating-mesh nebulizer (Aeroneb Pro small mesh, Aeroneb Pro large mesh, or Omron NE U22). All vibrating-mesh nebulizers produced aerosol droplets having larger volume median diameter (VMD) and narrower size distribution than the air-jet nebulizer.

CHAPTER TWO

Theoretical Background

2.1 use the nebulizer

1. Ensure that all parts of the device are clean.
2. The device is placed on a flat surface and connected to electricity
3. Wash hands before preparing medication.
4. Putting medicines in their designated place.
5. Connect the tube to the pressure and liquid container.
6. Place the mouthpiece between the teeth and close the lips around it.
7. Wear the mask correctly, covering the mouth and nose

2.2 Principle of Operation

The operation of a pneumatic nebulizer requires a pressurized gas supply as the driving force for liquid atomization (Fig. 1).(5–10) Compressed gas is delivered through a jet, causing a region of negative pressure.

The solution to be aerosolized is entrained into the gas stream and is sheared into a liquid film. This film is unstable and breaks into droplets because of surface tension forces. A baffle is placed in the aerosol stream, producing smaller particles and causing larger particles to return to the liquid reservoir. More than 99% of the particles may be returned to the liquid reservoir.8 The aerosol is delivered into the inspiratory gas stream of the patient. Before delivery into the patient’s respiratory tract, the aerosol can be further con conditioned by environmental factors such as the relative humidity of the carrier gas.

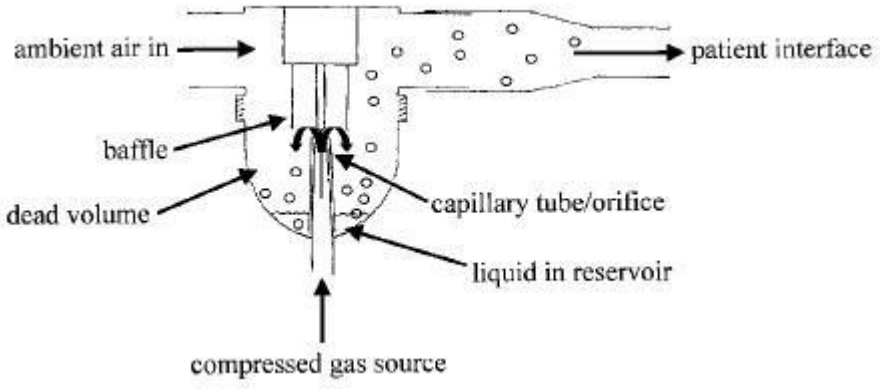

Figure (2-1) Basic components of the design of pneumatic nebulizers.

(Adapted from Reference 6.)

2.3 Technical Factors

1. Manufacturer of nebulizer
2. Gas flow used to power nebulizer
3. Fill volume of nebulizer
4. Solution characteristics
5. Composition of the driving gas
6. Designs to enhance nebulizer output
7. Continuous versus breath-actuated
8. *Patient Factors*
9. Breathing pattern
10. Nose versus mouth breathing
11. Composition of inspired gas
12. Airway obstruction
13. Positive pressure delivery
14. Artificial airway and mechanical ventilation

2.4 The advantages and disadvantages of the Nebulizer

Advantages:

1. The Nebulizer can be used by anyone of any age.
2. More than one medicine can be mixed, and they can all be taken at the same time.
3. High doses of medication may be used.
4. The medication is delivered as you breathe normally.

Defects:

1. The device is annoying and needs an electrical power source to work.
2. Compared to other inhalers, they are larger, less mobile, and have a longer treatment Tim.

2.5 The need a nebulizer

Doctors usually prescribe a nebulizer inhaler to patients who have one of the following lung conditions:

1. asthma.
2. Chronic obstructive pulmonary disease (COPD.
3. Cystic fibrosis.
4. Bronchiectasis or bronchiectasis.

2.6 Device cleaning

The nurse or pharmacist will explain how to clean and maintain the nebulizer as follows:

1. Wash your hands and work on a clean surface.
2. Detach the tube, medicine cup, and mouthpiece, and wash them well with warm, soapy water.
3. Let the pieces air dry on a clean towel.
4. Also disinfect the device according to the manufacturer's instructions.
5. A person may need to replace some of the components of a nebulizer three to four times a year, so check the instruction manual for how and how often, and also make sure not to share the parts with someone else.
6. If a person does not take good care of the device, it may become contaminated with bacteria that can cause infection which can be very dangerous especially for people with a lung disorder.

2.7 Nebulizer and corona virus

COVID-19 is a serious lung disease that is currently spreading worldwide. Being a lung disease, the nebulizer has been used in self medication to manage lung conditions along with COVID-19. However, there are some concerns about that. The nebulizer sprays lead to the formation of fine particles, which can carry bacteria and viruses deep into the lungs, increasing infection transmission.

On the other hand, medication taken in this way may be critical in managing COVID-19 symptoms and ensuring patients are able to breathe. There is also some concern about the immunosuppressive qualities of many inhaled corticosteroids that may contribute to not using nebulizer inhalers for patients with or near COVID-19. However, some other evidence suggests that inhaled corticosteroids and nebulizers can have antiviral properties by blocking viral replication of SARS-CoV-2.

Chapter Three

Design

3.1 Components of the nebulizer

1. Linear Voltage Regulator.
2. Variable Resistance.
3. Medical Compressor Nebulizer.
4. Air Filter.
5. Medical Breathing Mask.
6. Medicine Vaporizer Tube.
7. Air Tube.

3.2 Linear Voltage Regulator

Power Regulator integrated chips (IC) control single phase mains driven loads of 6V, 10V and 15V. The Solid-state phase controlled power regulator needs external 220 k or 250 k linear potentiometers (not supplied) and controls the power into a resistive load from 0% to 98%.

Applications include resistive heating elements like quartz lamps, ovens and dryers as well as some inductive loads such as transformers, fans and motors. as in the following figure.

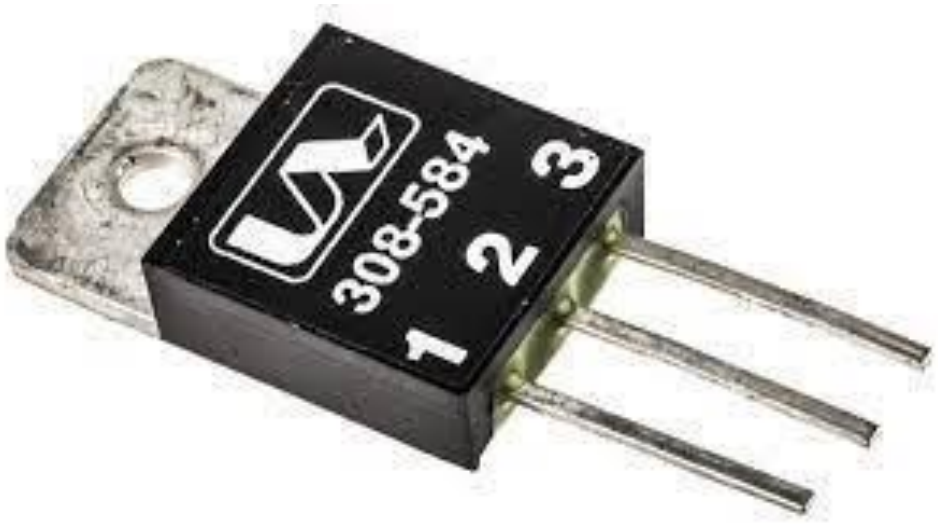

Figure (2-1) (RS 308-585)

3.3 Variable Resistance

A variable resistor is a resistor of which the electric resistance value can be adjusted. A variable resistor is in essence an electromechanical transducer and normally works by sliding a contact (wiper) over a resistive element. When a variable resistor is used as a potential divider by using 3 terminals it is called a potentiometer. When only two terminals are used, it functions as a variable resistance and is called a rheostat. Electronically controlled variable resistors exist, which can be controlled electronically instead of by mechanical action. These resistors are called digital potentiometers. as in the following figure.

Figure (3-3) Variable Resistance

3.4 Medical Compressor Nebulizer

Nebulizers can be used to deliver many types of medicines. The medicines and moisture help control breathing problems like wheezing and help loosen lung secretions. A nebulizer might be used instead of other inhalers. A nebulizer is powered by an air compressor that plugs into an electrical outlet.

Transformer specifications

Power supply : AC220V 50Hz.

Power : 130VA No more than the biggest scale line.

Droplet particle (MMAD) : 1 um 5 μm.

Machine noise : ≤65Db.

The average rate of spray : 20.2ml / min.

Working pressure range : 60kPa - 130kPa. The residual liquid : < 0.7ml Alt.

3.5 Air Filter

Nebulizer filters for nebulizer compressor machines are essential to ensure that respiratory irritations do not make their way into the lungs. Adhering to a proper schedule for filter replacements guarantees a longer life cycle for your nebulizer. as in the following figure.

Figure (3-4) Air Filter

3.6 Medical Breathing Mask

An mask provides a method to transfer breathing gas from a storage tank to the lungs. masks may cover only the nose and mouth (oral nasal mask) or the entire face (full-face mask). They may be made of plastic, silicone, or rubber. In certain circumstances, solution may be delivered via a nasal cannula instead of a mask. as in the following figure.

Figure (3-5) Medical Breathing Mas

a. Medicine Vaporizer Tube

A nebulizer is a small machine that turns liquid medicine into a mist. You sit with the machine and breathe in through a connected mouthpiece. Medicine goes into your lungs as you take slow, deep breaths for 10 to 15 minutes.

The standard length for nebulizer tubing is 7 cm. Particle size – the size of the aerosol particles. The ideal range if 5-10 microns. Anything larger or smaller will not help in most treatments. Medical Breathing Mask

Figure (3-6) Medicine Vaporizer Tube

b. Air Tube

The trachea, a bronchus, or any of its branches conveying air to the lungs.

Figure (3-7) Air Tube

3.7 Breath-Enhanced Nebulizers

The traditional nebulizer design incorporates the nebulizer side stream to the air flow of the patient. Some newer nebulizers use a mainstream design with valves. In this valved open-vent design, the patient breathes through the nebulizer during inspiration, which enhances the nebulizer output. During the expiratory phase, a one-way valve directs patient flow away from the nebulizer chamber (Fig. 8). This design has been evaluated in several studies, which have reported greater pulmonary deposition with this design than with a conventional nebulizer)11-13(A potential advantage of the open-vent nebulizer design is an improvement in nebulizer output with an increase in inspiratory flow.

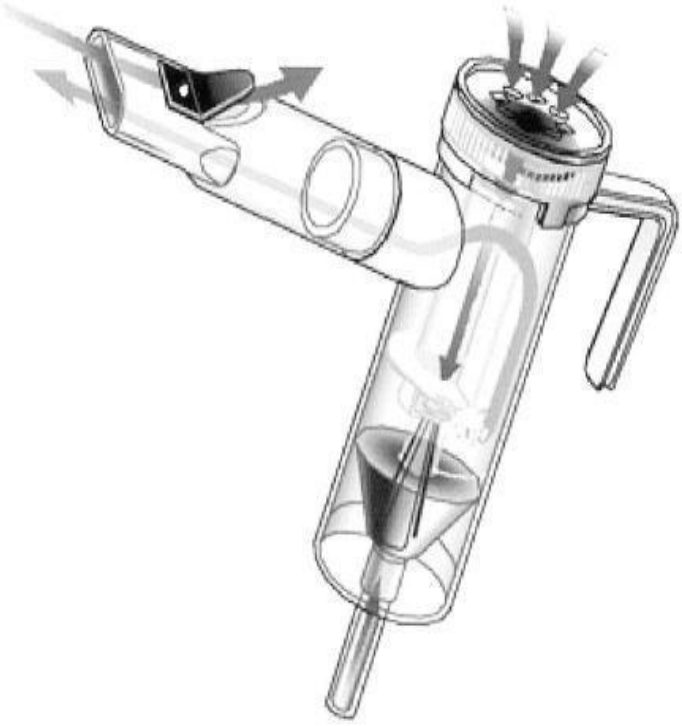

Figure (3-8) Schematic representation of the function of a breath-enhanced nebulizer. Courtesy of Pari Respiratory Equipment.

3.8 Circuit of the nebulizer

The main flowchart of the nebulizer is shown in Figure (3-9).

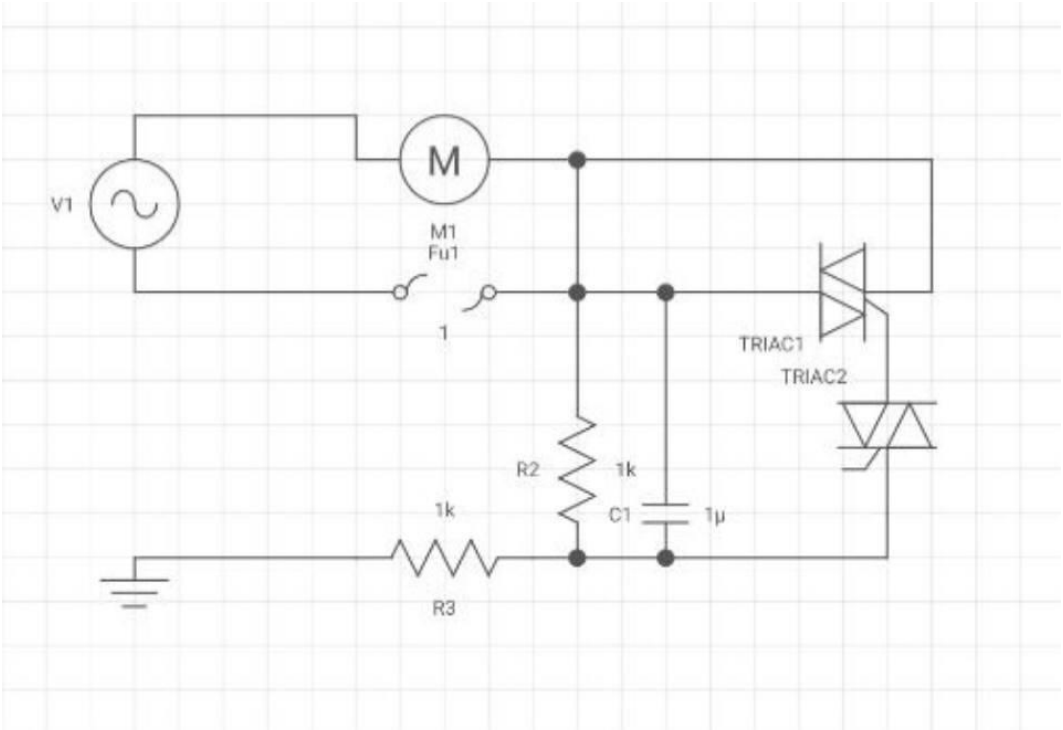

Figure (3-9) Circuit of the nebulizer

Chapter Four: Conclusions and suggestions Future Works

4.1 Conclusions

Nebulizers have been used clinically for many years. Despite the increasing use of metered-dose inhalers and dry powder inhalers, it is likely that nebulizers will con- tinue to be used in selected

patients. A number of factors affect nebulizer performance, and these should be appre- ciated by clinicians who use these devices. Several new designs have recently become available that improve the performance of the nebulizer, but their cost-effectiveness remains to be determined.

4.2. Suggestions for Future Works

Suggestions for future work We will develop the project by adding several parts that will be important and will greatly help patients. We suggested adding these parts to the machine in the future.

1. Digital clock to record the device's operating time
2. Adding the battery to continue operating during a power outage
3. monitoring system
4. Reduce device size

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