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Research Article

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Development of Electrophoresis Machine using Locally Sourced Material

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Abstract This research was to develop an electrophoresis machine using locally sourced material, whose main objecting is used to determine the genotype patients, the develop a genotype machine with easy operation and cheap. Electrophoresis machine is a medical equipment used in conducting a blood test to detect the genotype of a human being which primarily is AA, AS and SS. This paper overtly succeeded in showing how some different component of electronics namely resistors, capacitor, diode can correctly be put together or assemble to realize and efficient genotype machine. All the equipment was assembled after locally soured in other to build the machine. After fixing the material, the machine was tested and it performance was optimally. Before now, electrophoresis machine was built without resistor but now, owing to development in electronic chips, this machine has become an advanced device with the capacity to separate blood and group them into types eg. AA, AS, SS.

Keywords Electrophoresis machine, Genotype.

1. Introduction

Electrophoresis machine is a medical equipment used in conducting a blood test to detect the genotype of a human being that primarily is AA, AS or SS. In the past, a lot of people died of unknown diseases neither could the cause of death traceable to any common diseases of the time. This led to uncertainties in the minds of people as to the mystery surrounding the deaths.

Several couples experienced serial abrupt demise of their newly-born babies, children and adolescent without any idea of the cause of death or how to prevent it. It was the knowledge of electrophoresis that removed the veil off people's eyes and revealed the genotypic constitution of cells. This knowledge also made it possible for the causes of different diseases and deaths to be diagnosed or detected and determined in the laboratory such as sickle cell diseases etc.

Furthermore, the knowledge and use of electrophoresis machine to detect anomalies in the constitution of the genotype paved way to interventions leading to the development of cure or medical advice for intending couples to make informed decisions based on the genotypic result before them. Electrophoresis describes the technique used in separating super molecules mainly nucleic acid or protein based on electric charge, physical properties and size. The motion of polar particles as a result or consequence of an electric field is known as electrophoresis [1]. Modern understanding of the protein composition of serum and plasma derives from, the electrophoretic techniques introduced by Tiselius. He separated proteins dissolved in an electrolyte solution by [2] application of an electric current through a U-shaped quartz tube that held the protein solution, There exist dual negative implications when not using resistors to construct or fabricate electrophoresis machine. It can lead to the

destruction of the junction rectifier by means of high voltage or it tears the cellulose acetate paper, the support matrix in the tank where separation occurs. Imported electrophoresis machines today come with resistors in use thereby negatively affecting the demands for locally or homemade electrophoresis machine especially those without resistors. The advantages the Nigerian produced genotype machines have over the imported ones include the fact that they are cheaper as the components of the locally made device are sourced within the locality and are cost-effective.

2. Literature Review

Currently, the study of micrometer-scale biological particles from 10 nm to 100 mm as cells, proteins, viruses and DNA intensified considering its application in various fields. For the detailed knowledge of the physical properties of DNA and for the awareness of a variety of novel devices. Such as an integrated lab-on-a-chip, the capability to stretch, orient or sort DNA molecules is a key prerequisite [3]. Chou et al., (2002) They developed the potential electrostatic power using electrophoresis, di-electrophoresis, electroosmosis and electrofusion. [6];[5]. Proposed a Di-electrophoresis, a method that utilizes non-uniform force field to induce a dipole in the polarization particle Di-electrophoresis is usually used for large cells whereas DNA fragments of smaller size can be more easily concentrated using electrophoresis. This method works in a pushing motion of neutral particles, but can be used on charged particles like DNA that normally uses electrophoresis. Several studies have shown that DNA can be collected on the metal electrode on di-electrophoresis. [7]; [8] Proposed an Electrophoresis and di-electrophoresis possible increasing need for the use of DNA, proteins and viruses along with the discovery microelectrode. Although this technique encourages neutral particle motion, but can be utilized on the charged particles. DNA molecules can accumulate on the electrode metal on di-electrophoresis. [9] studied the frequency dependence of the di-electrophoretic movement of DNA and compared with the predictions of theory and the motion of polystyrene beads under identical conditions. Since di-electrophoresis works out too in field Alternating Current (AC), reducing small ions trapping and electrochemical effects on the electrode, it tends to be used only for large DNA fragments in deionized water and Tris Ethylene diamine tetra acetic acid (EDTA) [10]. The tool design uses a combination of di-electrophoresis phenomena and electrophoresis to gaining better visualization of large and small DNA bands.During this time, qualitative tests for DNA visualization commonly used agarosa and polyacrylamide gel. These assays decide the size of DNA band based on comparisons with a known concentration marker. Sometimes it is used for measuring DNA concentration which is highly subjective and less scalable. Measurements of an accurate concentration of DNA is usually done using a spectrophotometer UV / VIS.

3. Materials and Equipment Used

Materials used to produce the electrophoresis device and for construction of tank include:

i. Power switch
ii. Cord and Cables
iii. Rectangular metallic casing/box
iv. Resistors
v. Rectifiers or diodes
vi. Regulator
vii. Pilot lamp
viii. Two-winding transformers
ix. Filter capacitor
x. Outlet
xi. Verso board
xii. Fuse and holder
xiii. Soldering apparatus
xiv. Paint
xv. PVC plastic
xvi. Cutter
xvii. Adhesive e.g., Super glue
xviii. Audio Visual (AV) port
xix. Soldering lead, etc

4. Methodology

Construction Procedures

Carrying out the under listed actions in sequence brings about the production of a genotype machine or device.

Production of Machine

i. Have a well-studied electrical drawing
ii. Calculate and demarcate desired sizes of metal sheet and verso-board ie. Mark out.
iii. Assemble the parts needed
iv. Insert all component parts on the verso-board.
v. Connect the Circuit
vi. Coupling of devices
vii. Paint and give a final finishing touch

To construct the tank, do the following:

i. Mark out
ii. Cut
iii. Join
iv. Finishing touch/smoothening

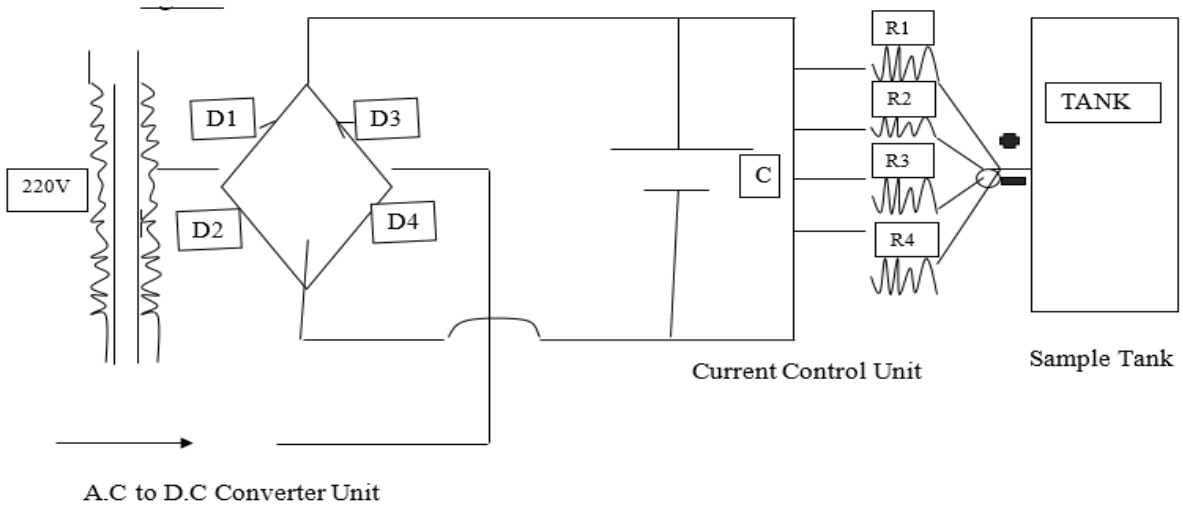

Figure 1: circuit diagram

An electrical drawing shows in details how the inter-connection between component parts on the electrical panel are to be carried out.

Marking Out: Marking out means using marking out instruments such as measuring tape, ruler, scriber etc. to ascertain and mark any wanted dimension on the verso panel.

Insertion of Component parts: This means the placing, putting or inserting of the essential parts into the verso panel as appeared in the electrical drawing.

Assembling of component parts: Assembling of component parts means the gathering or bringing together of the component parts needed.

Connecting the Electrical System: It involves using connector cables to link the different units together as appeared in the electrical drawing for unhindered movement of electric current.

Coupling of Device: Coupling is the bringing together or joining of the cubic boxes when all the connections have been made.

Painting: Painting is the coating of the equipment with paint to protect and stop it from corroding.

For Tank

Marking Out

Marking out means using marking out instruments like scribes to measure out the needed dimension of the polyvinyl chloride (PVC) plastic.

Cutting: Cutting is the act of using a slicer to slit the PVC material into desired size and dimension.

Joining: Here, the earlier cut parts are put or joined together using an adhesive.

Smoothening: This means using soft items such as clothes to smoothen the device.

Power Source: Virtually, every electronic circuit ranging from basic Op-amps and transistor circuit to digital microprocessor systems require a source of constant voltage.

A dual-winding transformer same as auto-transformer in role is recommended and a voltage not below 200V is desirable for this research work. The transformer output if rectified by means of a bridge rectifier produces instable D.C voltage and this is moved past a filter capacitor. And the yield electrical energy from the filter is therefore passed into a straight-lined regulator whose rating is concordant to handle this current.

Operational Theory

If the switch is closed to supply current to the electrical system, the diodes D1 to D4 changes A.C to D.C. The electrical energy from the D.C yield will contain certain gradation of waves or ripples. Those waves are additionally taken away by the capacitor during current flow via the transformer. This gets fed into the current controller that decreases the ultimate yield of the electrical energy supply and ensures it is retained constant thereby making it appropriate for good functioning of the separation tank.

Tank's working and Contents

i. Tank's contents include
ii. Cellulose acetate paper
iii. Filter
iv. Buffer solution of 8.7pH

Tank Operation

For genotypes, human blood samples are required for the process while syringes are needed to get blood samples from an individual.

Also 'AS' genotype sample will serve to regulate the test. The 'AS' lifeblood specimen or sample is the determiner. 8.7pH tris buffer solution is emptied into the chamber called separation tank containing the soldering lead and cellulose acetate paper is then left to immerse in the buffer for 10minutes and cleaned to prevent excessive drenching with buffer. The unknown blood samples are positioned in a straight-line arrangement alongside determiner sample 'AS'. The samples migrate from anode to cathode terminal. The 'AS' sample linearly gets positioned resting on the cellulose acetate paper alongside the 'unknown' or unidentified samples. Once power is supplied to the device, separation takes place from the anode terminal to the cathode terminal where the 'S' travels quicker trailed by the 'A', the determiner. The 'unknown' samples will then migrate as required. On the occasion that the 'unknown' sample lies lower than the 'A' band, the genetic constitution is 'AA', and should the unidentified sample lie lower than the 'S' band, the genetic constitution is 'SS' while when the unidentified sample lies lower both 'A' and 'S' bands, the genotype is 'AS'. The flow of electrons from the electrical system allows the movement of negative and positive charged particles in the separation tank thus triggering separation of samples.

The method used to achieve the design. First, evaluation of the existing machine was examined and it was observed that the existing machine used foreign material which was costly and it consumed large electricity. Then this work was locally designed and fabricated (i.e., The materials were sourced locally). Secondly the materials after sourcing, were assembled in order. The electrical drawing was developed. The equipment was fixed and assembled in an attempt to achieve the objectives of the work.

Implementation

Layout Design: Layout design means the gathering of interconnected components arranged to transmit or modify force so as to perform useful work. It is the layout, diagram or picture made in somewhat arrangement with any method to demonstrate how the integrated circuit is formed up

Components Assembly: Assembling or soldering of components is done after bread boarding. A process of making up short-term circuits for testing or to try out an idea is called bread boarding. At the moment, no soldering is needed so that it is not difficult to alter connections and replace components. Parts are not spoiled and can possibly be re-used afterwards.

Insertion and Soldering of Components: Thoroughly clean the board before inserting any components into it. Components insertion is usually done from the non-components side after proper cleaning and drying of board. Ensure to observe the orientation of components, the components that have polarity and lead conformation ought to be put in the right direction. Soldering means the joining together of two metals using an alloy or another metal usually with lesser melting point when compared with the two metals joined. Soldering basically affords a suitable joint to guarantee electrical connection or deal against leakage.

Dimensions of the Machine The Device is designed in a four-sided shape with dimensions as given below.

Length $=10^{1/2}$ inches

Width $= 6^{3/4}$ inches

Height =5 inches

The tank has a rectangular design with the dimensions shown below.

Length =7 inches

Width $= 4^{1/2}$ inches

Height$=1^{1/2}$ inches

Testing and Troubleshooting: To confirm the functioning or working condition of a device, a test will be conducted. If the device fails the test, findings will be made to ascertain the causes with the view to correcting them.

Testing and troubleshooting a device, require a four-step process as given below:

i. Primary or pilot testing
ii. Operational test
iii. Troubleshooting will start and if after troubleshooting the device begins operation
iv. Performance tests will be done for confirmation.

If the device scales through performance tests, it is confirmed efficient.

Pilot testing is carried out first. It is done before the device is coupled to source of power. It is aimed at detecting errors that can cause severe problem if incorrect voltage and current are allowed to get to critical components.

If the device successfully gets through the pilot tests, then operation test is conducted. In this phase of testing, power is supplied to the device for the very foremost time and key device functioning will be determined and if all is well then performance testing comes next. If any problem is encountered or there is malfunctioning of the device, it then undergoes troubleshooting exercise, Troubleshooting is performed to determine, locate and localize the problem with any device and to proffer solution to the problem. After troubleshooting is concluded, performance test is conducted to check if the device is working and whether it can be trusted to work whenever in use. To do this, the device is exposed to adverse conditions such as high voltage of 200-220V for two-hours.

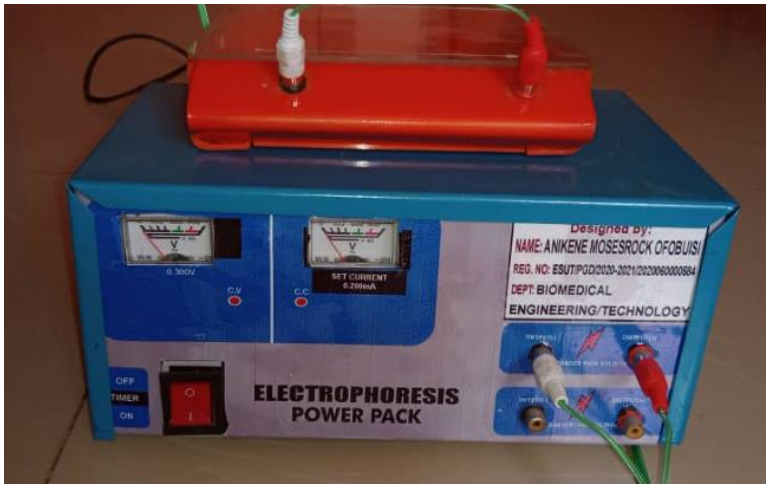

Figure 2 developed electrophorese machine

Troubleshooting: It is hard to make a broad statement concerning components failures. The most likely components prone to failure include diodes, capacitors and transformer while the very unlikely components to fail are resistors.

In the event of any problem with the device, troubleshoot the device by doing the following.

i. If the indicator does not turn on, examine the energy supply unit. Assess the yield of the controller to ensure yield electrical energy of 200-220V should no voltage be noticed while checking out the polarities of both regulator and rectifier. If the problem persists, examine the 220V A.C outlet.
ii. If the diode does not pass current, evaluate the diode using multi-meter to ascertain its condition. And if good, then examine the soldering to know whether all the parts are well linked.

If every other thing is okay yet the device is not working, the capacitor should be checked for a possible voltage damage

7. Conclusion

This research piece has clearly shown and demonstrated how some different components of electronics namely, diode, capacitors, resistors etc, can be assembled to give an efficient electrophoresis (genotype) machine. However, this is not the only way to achieve the result of designing and constructing a genotype device, electrophoretic machine than can have low demand for energy with much less equipment operation challenges. In Africa and Nigeria to be exact, there are issues of non-steady power supply, inadequate equipment care workers and non-qualified operator in-charge of hi-tech genotype machines hence, the decision to use available and cheap materials to produce a low energy supply compliant and user-friendly genotype device totally ideal and suitable for Africa and developing countries. Electrophoretic or genotype apparatus is a medical device or equipment used in conducting a blood test to detect the genetic constitution of a person that primarily are AA, AS and SS. Before now, electrophoretic machine was built without a resistor but now, owing to development in electronics, this machine has become an advanced device with the capacity to isolate blood and grouping them into AA, AS and SS types. Electrophoresis machine locally made comprises of a large plastic or three-dimensional metal box cut to have a partition separating the chamber called separation tank from the energy source or dual three-dimensional boxes, one serves as the separation tank while the other serves as the engine. Largely, homemade electrophoretic machines have no resistors and it causes a big harm to the device. First, it can lead to the destruction of the diode resulting from power surge or a high electrical energy and secondly, it can cause the tearing of the cellulose acetate paper in the separation tank where separation takes place. The major advantage of a locally constructed genotype device is its cheap production cost because all the essential components can be sourced locally.

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