DESIGN, CONSTRUCTION AND TESTING OF AN EMERGENCY LIGHTING SYSTEM

BY

ETIM-IDEKPE DANIEL

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DECLARATION

I hereby declare that this thesis, presented in partial fulfillment of the requirement for the award of Bachelor degree in Electrical and Computer Engineering (B. Eng.) is a complete handwork of Etim-Idekpe Daniel.

Information obtained from both published and unpublished works of others have been acknowledged accordingly.

CERTIFICATION

This is to certify that the project work titled "Design, Construction and Testing of an Emergency Lighting System" was carried out by Etim-Idekpe Daniel, under the supervision of Mr. I. A. Danjuma, and submitted to the Electrical and Computer Engineering Department of the Federal Uiversity of Technology, Minna, in partial fulfillment of the requirements for the award of Bachelor of Engineering (B. Eng.) Degree in Electrical and Computer Engineering.

MR. I. A. DANJUMA
Project Supervisor

Signature and Date

DR. Y. A. ADEDIRAN
Head of Department

Signature and Date

External Examiner

Signature and Date

DEDICATION

This project work is dedicated to Almighty God for His protection and guidance throughout the period of my research work, and my dear parents, Mr. P.D. Etim-Idekpe and Mrs. Maria Stella Etim-Idekpe

ACKNOWLEDGEMENT

My gratitude goes firstly to God Almighty, whose infinite mercy, love and patience saw me through this programme.

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ABSTRACT

The aim of this project is to design, construct, and test an emergency lighting system that serves as an alternative source of lighting to be used in special places and other sensitive locations when light from the main power supply fails. Special places like libraries, hotels, hospitals, bank vaults, and sensitive locations like theatre rooms, stadiums, public corridors and exits used at night. All these are required by law to have this kind of lighting systems.

The system was designed using rechargeable battery, which receives sufficient charge from the a.c. main source of power to maintain them in a fully charged state. But usually, they are not operatively connected to the emergency circuit, except in a power failure. At this condition, an automatic switch disconnects the emergency circuit from the normal supply and connects the battery. As soon as power is restored to the main source, an automatic reconnection back to the main source is made and automatic recharging of the battery also follows, preparing for another case of emergency lighting supply.

CHAPTER ONE

GENERAL INTRODUCTION

1.1. AIMS AND OBJECTIVES

In the course of providing light in an environment or in a specified location, electric lamps have been used as mediums for producing light that makes it possible to carry on all forms of human activities far outside the sunrise to sunset time limitations faced by earlier societies. The make our streets and highways safer after dark, and they decorate and illuminate all manner of public places. The form of supply to these electric lamps has been from the main power supply unit, that is, the National Electric Power Authority, NEPA. In this concept, failure of power supply to these electric lamps has resulted in accidental effects on some special places like libraries, bank vaults, recreational centers, as well as some sensitive locations like hospitals, theatre rooms, electrical control rooms, stadiums, public corridors and exits etc. this has brought about the design of an alternative emergency lighting system.

An emergency lighting system have been introduced as an alternative supply of light when there is power failure from the main supply unit. Mostly, in this part of the world, or other third world countries where constant supply of power cannot be generally ensure, the need, by saw or ordinance, for such places and locations mentioned above to have emergency lighting systems is not supposed to be taking at a low ebb, because of the number of lives usually involved in accidents due to power failures.

Thus, this emergency lighting system is supposed to be planned, installed and maintained to the highest standard of reliability, so that it will operate satisfactorily wherever automatically called into action, no matter how frequent it may be. Considering the type of lighting system in use from its origin, we have three different types of fittings now in existence, namely:

(a) Single point fitting: These are maintained unit with continuous lighting all the time; that is the battery takes over as soon as the main source fails. The change over process here is faster and it displays the emergency qualities compared to others

(b) Standby lighting (Non-maintained): This is the commonest basic method used to provide an emergency lighting. In this method, light is not normally lit, but illuminated via an ON/OFF switching device when the main supply fails. In this continuous system, the lights are a.c./d.c fed. Alternating current is produced from a step-down transformer via a change over relay, and the same light is battery-fed through the change-over relay when the mains supply fails.

(c) Sustainable unit: This use two or more lamps, and operates on the effect of a double pole switch, with one lamp main-powered and the other battery-powered when the main fails.

Emergency luminosity should be made to satisfy the necessary standard especially its fittings conversion packs and ensuring that the battery is shielded from excessive heat from the lamp. But nowadays, high frequency fluorescent fittings which offer around 30% energy is more common. Apart from the mounting method which is usually used in the above mentioned locations, a handy self-contained emergency system is now being designed by many electronic companies, for instance, Binatone, Teledyne Big Beam etc.

1.1 METHODOLOGY

This project has been designed in a form of showing the block diagrams of each unit and sub-units, and how they interrelate with one another in other to produce the lighting system mentioned. The main supply voltage is the alternating sinusoidal line voltage, which is too high for some of the electronic devices and then making use of a step-down transformer commonly used in almost all electronic equipments to achieve the low voltage needed.

The type of charging unit used in the connection of diodes in full-wave rectification mode, which enhances the conversion of alternating current (a.c.) to direct current (d.c.) in the circuit. The processes that take place here are as follows:

(i) Receiving and rectifying a.c. power supplies

(ii) Controlling the amount of the current going into the battery

(iii) Determining when the battery is charged.

In the design is an invented circuit, which acts opposites to rectifier by converting the direct current from the battery to alternating current. The main reason for this is for current amplification to the maximum value required in the next stage. Also is the switching with normal open and close contact. The device used in this system is called relay, which operates in the ON and OFF state. The current goes into this unit in such a way that when the current energizes the relay coil, a magnetic field is set up with magnetic coil terminal and current flows into the lead acid battery via the fuse. Again, when the power from the main source fails, this time, the relay de-energizes and there is a change-over to the emergency lamp, this time the battery which was charging before supplying the current to the lamp for emergency lighting. And so goes on the process of emergency which was designed in this project.

1.3 LITERATURE REVIEW

LIGHTING DEVICE

One major priority of human consciousness is "visibility". Once men struggled to break the blanket of night with a flickering torch or the small fluttering flame of an oil lamp. Even so , it was not always easy to have light. Lighting or artificial illumination as opposed to the natural illumination of the sun or moon, was probably first furnished by campfires and by torches made of dried rushes or resinous wood. Crude stone lamps in which light came from a flaming work lying in a pool of oil or melting grease, were used by prehistoric peoples.

Candles and oil-burning lamps remained the chief source of artificial illumination until the middle of the 19^{th} century, when kerosene lamps with flat, woven wick and glass chimney came into common use. A few of these first artificial source are discussed below.

1.3.1 EARLY ARTIFICAIL ILLUMINATION

The Torch

The earliest lighting of all came from wood fire. If a man needed to have light away from the fire, he picked up one of the burning sticks and had a "Torch". Men learned that torches dipped into animal fats lasted longer and threw a stronger light. Torches were used for many years.

About the year A.D. 450, tarred torches were used to light the streets of Antioch. Torches like these were still used in the middle Ages.

Oil Lamps

Along side with men development on torches that last long when dipped into animal fat, the first oil used in these early lamps came from animals. The first "oil lamp" were "open stone dishes" with wick reeds or plant fibre. These lamps gave the light used by the caveman when they painted pictures deep in caves.

Lamps have been found from as long ago as 3000 B.C.. Some of these early lamps were from shells or from the skull of small animals. They have a perfect shape for holding a good amount of oil and for supporting a wick.

Candles

The "candle" was not used as early as torches, lamps and bush light. The first candles were apparently reed or stalk filled with tallow or with beeswax from beehives. The ancient Egyptians had wickless candles made of lumps of tallow wrapped with rags to keep them from melting apart as they burned. The Romans used candles made with wicks.

Candles were made in decorative styles and colours. Some, in glass containers, were used for religious purposes. These were three or four inches in diameter and burned for hours. Some candles were as tall as ten feet and lasted for years.

Lanterns

In the 5^{th} century B.C., protective cases for light "lanterns" were commonly used. They were lit with candles or oil lamp. Lanterns were designed in many different shapes. Cylindrical lanterns and square types with conical tops were popular. The were made of many materials such as: metals, wood, pottery and even leather.

Kerosene Lamps

Before 1859; the best lamp oil that money could buy was "whale oil". Unrefined petroleum had been used in lamps for many years, but it gave a feeble and dirty flame. In that same year, great quantities of petroleum oil were discovered in Pennsylvania. Shortly before this, it had been learned that kerosene could be separated out of petroleum.

At first, kerosene was burned in open lamps. The open flame flickered and was dangerous to use. Then, glass chimney were made for kerosene lamps. The flame became steady and gave more light. With a glass chimney to protect it from the wind and a little roof to protect it from the rain, kerosene lamps could be used outdoors for street lights.

Kerosene gave a better light than had ever been known before. People could more easily read by it in the evening. Oil refining became an active business, supplying kerosene around the world. Kerosene lamps have flat wicks. By the turn of a small knob, the wick could be raised and lowered and the lamp's light could be adjusted. This was a great advantage over other lighting.

1.3.2 ELECTRIC LIGHTING

In the emergence from the stone age, electric lighting have been developed in so many ways that it plays a part in nearly every activity of man. The study and practice of electric lighting has become a profession in itself. The first electric lights are discussed below.

Incandescent Bulb

During the 1840s, many experiments aimed at the development of a workable electric "Incandescent Lamp" were conducted. No practical advances took place, however, until 1879, when the American Inventor, Thomas Alva Edison, developed a successful carbon filament incandescent lamp. Edison passed an electric current through thin filament of carbonized threads that were tightly sealed inside a glass bulb from which all air had been removed by a vacuum pump. "Edison's invention marked the birth of electric lighting and the electric age".

Electric Arc Lamps

Electric arc lamps consist of electrons drawn between two carbon electrodes were one of the earliest lighting devices to make use of electrical energy.

Invented around 1801[3] arc lamps, and not used to commercially, until 1858, after one had been successfully in a "LIGHTHOUSE" in England.

Discharge Tubes

Fluorescent light belong to the group of lighting devices known collectively as discharge tubes; glass tubes filled with metal vapour, with electrodes at both ends. Electric current that is passed between the electrodes eventually ionizes the vapour which begins to glow, producing light. Discharge tubes are widely used for street lighting. Some discharge tubes emit flashes of high intensity light and are used in lighthouses and for directional beacon of various kind [3].

1.3.1 PRESENT DAY LIGHTING DEVICES

In the emergence from electric lighting, the electric utility industry was born and this was to set the tone for man's incredible progress of the last one hundred years. In this saga, Thomas Alva Edison perfected the electric bulb in 1897 and his technical genius created the central power station concept in about 1880 [4]. Also, Frank J. Sprague worked with Edison and produced efficient electric generators as a means of supplying his lamps with current. George Westinghouse and William Stanley, believed in the alternating current concept and developed the commercial practical transformer between 1885 and 1856 [4].

For over a century, humankind had depended on electric lighting which is driven by current from electric power generation, to the extent that he can now hardly withstand life or survive without it.

More so, electric lighting had been used everywhere. It is estimated that half of the people of the world suffer the inconsistency of these electric generators due to their failures. As a result of this, an alternative method for generating this electric current for the lighting system was developed. Thus, a storage facility (battery) was used to provide electricity for use at night and also when there is failure of these electric power- generating systems (Emergency Lighting Systems). These batteries were able to store large amounts of electrical energies when charged and discharges when put into action.

This enhancement has led to the designing of buildings so that the people working in them have abundant light without glare. Also, due to this constant supply of light between the power-generating process and its alternative method (battery) has permitted good lighting system for all sorts of tasks to be done at anytime under easy seeing conditions, such as:

(a) A surgeon can operate, if necessary, in the meddle of the night as easily as in the daytime.

(b) An accountant can still do his day's account at night in a bank vault with good lighting system provided.

(c) It can as well ease reading at night, and people can thread needles, paint pictures, and walk upstairs in safety.

(d) One can go outside to a floodlighted stadium and watch any game, and also participate, depending on the situation.

With all the above instances sited, emergency tasks can be done at night when light is available.

CHAPTER TWO

SYSTEM DESIGN

This chapter reveals the detailed explanation of the general principle of the theory and design of this project. Before the design of this project, several things were taken into consideration, the most important of which is the theory and design of each unit.

The principle of operation of emergency lighting system can be divided into the following parts:

(a) The power (main) supply unit

(b) The rectifier unit

(c) The filtering unit

(d) The charger's unit

(e) The battery unit

(f) The switching/control unit

(g) The indicator unit

(h) The inverter unit

(i) The lighting unit

2.1 THE POWER (MAIN) SUPPLY UNIT

This is where the main supply from the NEPA gets to the circuit. The voltage that comes from the main source is a single phase 220/240 volts, with frequency of 50 Hertz (HZ), which needs to be stepped down before further usage of the electronic equipment in question.

The main supply unit also consists of a 220/240 V step-down transformer which serves two purposes. It isolates the equipment d.c. power lines from the main supply, and also changes the level of a.c. main voltage (220/240V) to the lower d.c. voltage (9V) required.

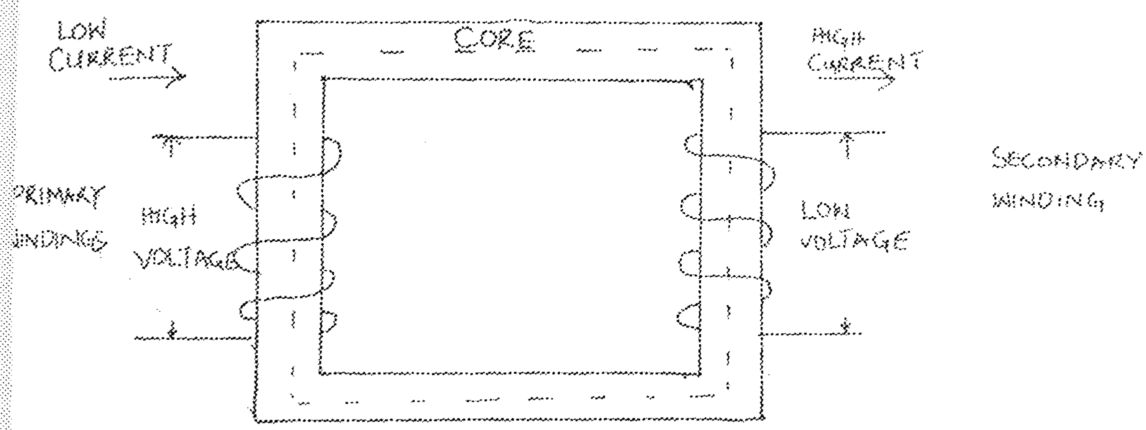

FIGURE 2.1: Structure of a Step-down Transformer.

2.2 RECTIFIER/FILTERING UNIT

The term rectification is defined as the process of charging a pulsating a.c. voltage from secondary windings of the transformer to a d.c. voltage. Regardless of the type of rectifier used, the function of all rectifiers is the same, that is, they allow current to flow in one direction only. But in this project, the full wave bridge rectifier was applied to the system designed.

The full wave bridge rectifier follows immediately after the transformer, with four diodes encapsulated. Their major operation is the removal of traces of a.c. voltage from the transformer's secondary windings into pulses of non-directional currents.

DIAGRAM

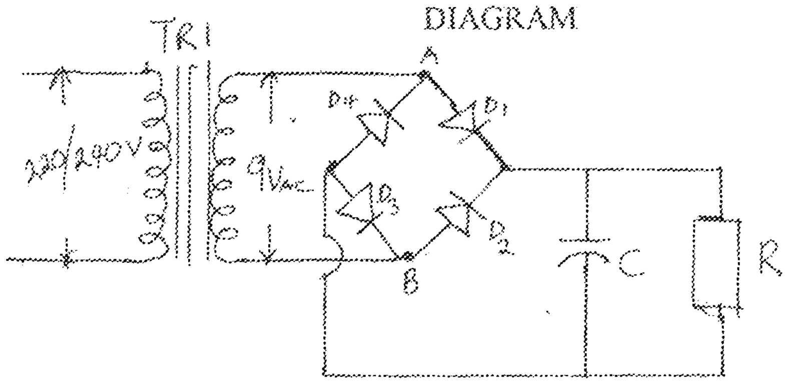

FIGURE 2.2: Rectifier Unit.

The four encapsulated diodes are labeled D1, D2, D3, and D4, and the transformer's secondary terminal across which the step-down 9V a.c. flows is donated by points A and B. During the first-half cycles of the (9V) input that makes point A positive with respect to point B, diodes D1 and D3 are conducting and diodes D2 and D4 are non-conducting. Current therefore flows from point A to B through D_1 into the charger unit and back through D3, then to the transformer input terminal. When point A is negative relative to point B, D2 and D4 are conducting and D1 and D3 are non-conducting. Current then flows from point B to point A through D2, the charger unit and D4. Both current pass through the load in the same direction and so a fluctuating unidirectional voltage is developed across the load, having the wave form shown in Fig. 2.2 below. The full wave bridge rectifier gives a much higher efficiency in the rectifying process.

DIAGRAM (WAVE FORM)

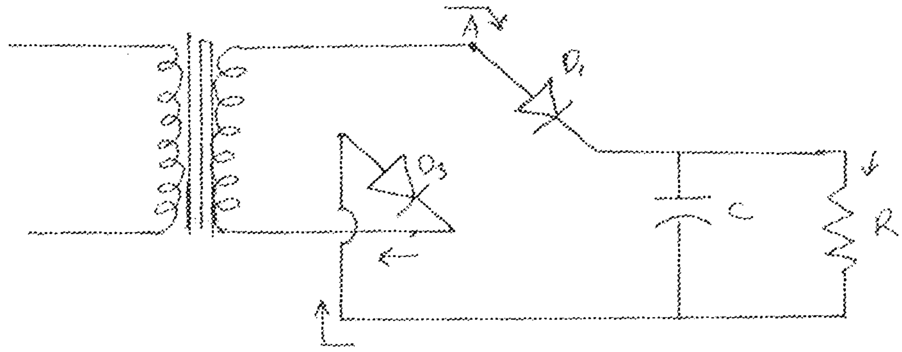

Figure 2.2a Rectifier Unit showing Diode D1 and D3 conducting when point A is positive with respect to point B.

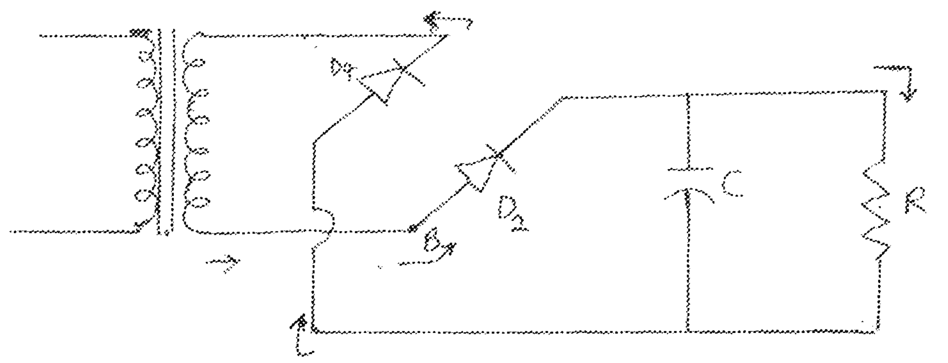

Figure2.2b Rectifier unit showing Diode D2 and D4 conducting when point B is positive with respect to point A.

The output of the full-wave rectifier is a pulsating d.c. voltage. Before it can be applied to the other circuit, the pulsating must be reduced. A more pure d.c. voltage is needed. This was obtained in this project using capacitor C1 (16V, 1000uF) as a filter network. It was connected as a shunt across the rectifier to provide some filtering action.

When the diodes or rectifier is conducting, the capacitor charges rapidly, storing electrons at peak voltage. Similarly, it discharges the stored electrons to the charger's unit when the rectifier is non-conducting. Also, the charging and discharging effect of the electrolytic capacitor (C1), helps to smoothen out the pulses (a.c. ripples) from the rectifier out.

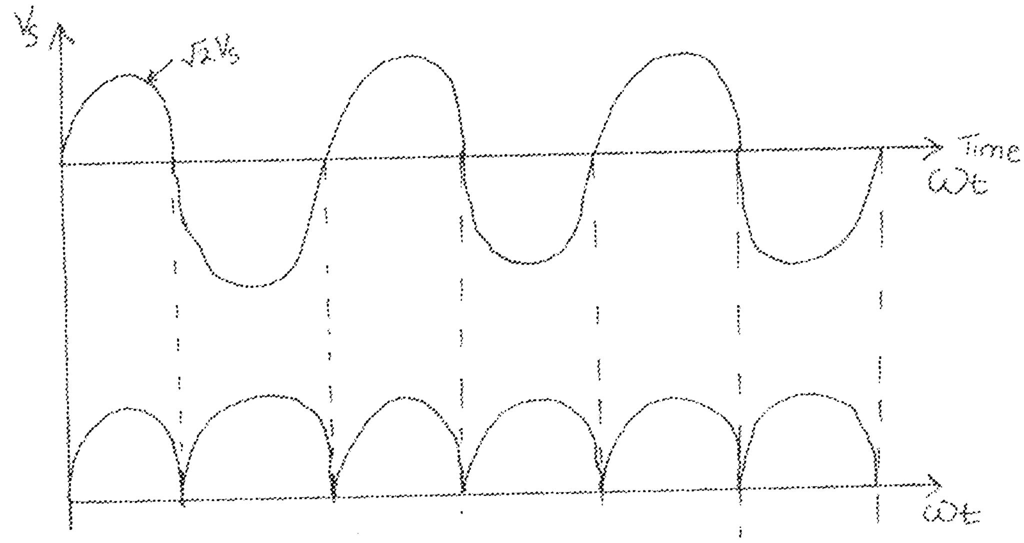

Figure 2.3a The full wave rectifier output wave form.

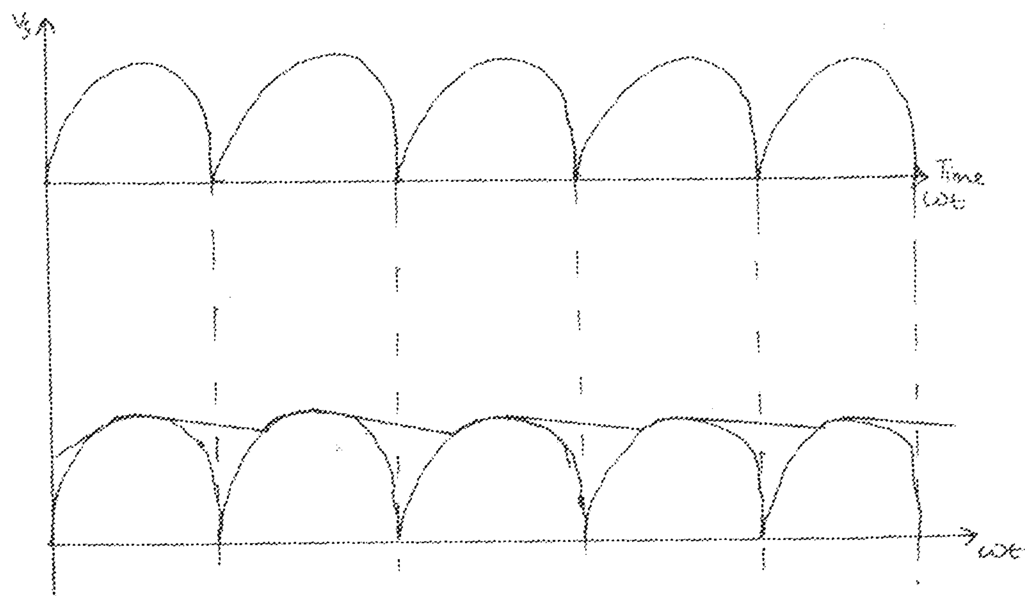

Figure 2.3b The filtering action of the capacitor.

2.3 Charger's Unit

There follows the principle of operation of charger for lead acid approximately 6V rechargeable battery. Input supply is 220V a.c. main. This voltage, is stepped down by a 9V step-down transformer. Four D4001 silicon diodes are connected in a bridge to each other on the positive and negative terminals of the step-down transformer, and are used as a full wave bridge rectifier to rectify the oncoming current into an unidirectional current.

An ammeter may be connected in series with the positive terminal to measure the current. The cathode of diode D1 and D2 are connected to the anode of SCR1 (silicon controlled rectifier) while the cathode of SCR1 is connected to the output terminal of the battery charger. This terminal is the positive higher potential of the charger.

The negative terminal of the battery charger is connected to the anode of diodes D3 and D4 in which also the cathode of D3 and the anode of D2 are hence connected to the negative terminal of the transformer, which connects also the negative terminal of the 6V battery for charging operation. In order to vary the output voltage of this charging circuit, a 500n variable resistor is connected between the positive and negative terminal of the charger.

Operation:

Operation of this charging circuit takes place when the voltage of the battery falls below 6V. The electrolytic capacitor, C1, connected in-between the positive and negative terminals of the rectifier output is used as a filtering capacitor for removal of ripples for the d.c. supply to the two 390n resistor and diode, D5. When this happens, voltage is applied to the gate of the thyristor SCR1, through diode D5, connected in-between tow 390n resistors, to trigger it on in a forward-biased mode. The source voltage from the rectifier output is applied to the anode of the thyristor SCR1, which is now more positive than that of the cathode voltage Since the gate voltage is now greater than the cathode voltage, the thyristor is then triggered on. This sends the 6V dc. set by the variable resistor to appear at the output of the charger.

While the first thyristor is in the "on" state, the second one, SCR2, is in its "off" state. This is because the gate voltage of SCR2 is at the same potential compared to the anode. A pre-set (reference) voltage at which the charger will stop charging is determined by the Zener diode connected in conjunction with the variable resistor.

Also, an electrolytic capacitor,C2, (25V, 470uF) is connected to the cathode of the first thyristor which, when charged, sets up voltage across itself while the charging operation is on. When the voltage at the output of the battery charger is 6V, the battery is then charged , then the voltage across the capacitor will be almost two-third of the battery voltage. Therefore, the voltage at the cathode of the first thyristor (SCR1) will be higher than that of the anode, hence it goes off. At this instance, the output voltage will be applied to the gate of the second thyristor (SCR2), through the potential drop across the 1Kn resistor (R3), therefore triggering it on. Since the anode voltage is now greater than the cathode voltage and at the same time, the gate current pulse has a higher voltage than that of the cathode of the second thyristor (SCR2), it trigger's on and biases in the forward direction.

Also, the second thyristor (SCR2), is connected as a shunt with respect to the negative terminal of the circuit designed. Hence, this cuts off the voltage supply to the first thyristor, that is, puts it in an off state. The triggering "on and "off" of both thyristors help in sustaining the life cycle process of the battery. Since SCR1 triggers on when the load voltage drops and SRC2 triggers on when the load voltage has reached its maximum output voltage, which is now regulated with the help of the variable resistor and the Zener diode DZ (7.5V), the charging process of the system is thus maintained with the aid of the above procedure.

2.4 SWITCHING UNIT / RELAY OPERATION

This is the unit that operates ON and OFF of the relays. It also connects and disconnects some lines. It can act as a bypass switch and also connects the load to the inverter. It is also the control link between the battery and a.c. main supply in this project design. The alternating current looming from the supply unit is first rectified using bridge wave rectification and an extra diode which is shunted before the current goes into the relay coil to energize it and avoid sparks from developing across the coil when energized.

This unit operates in such a way that, when the current energizes the relay coil, a magnetic field is set up which magnetizes the coil terminal and current flow into the lead acid battery with the switching pole connected to the positive terminal of the battery closed, and when the power from the mains fail, the relay de-energizes and thereby changes over to the emergency lamp this time. By so doing, it implies that when the main supply is ON, the relay unit switches on the charging process of the battery, and when the main supply fails, it switches off the charging process and at the same time, connects the battery to the inverter unit which drives the emergency light to come on. Hence, the battery which was charging before now supplies the current to the fluorescent lamp.

Relay itself is an electromechanical switch by design, a moveable spring armature is mounted above the core of an electromagnet. When the core is energized, the armature is altered and the contact points open or close by responding to a change is some physical quantity as current, voltage, frequency, light sensitivity, temperature, pressure, etc. When energizing potential is removed, the spring action returns and the armature returns to its original state. Switch point may be set to several contact for double pole and more complicated switching operations.

One of the major advantages of rely includes the rapid and positive switching control of machinery and device from remote locations. This provides safety for the operator. Since the relay operating voltage and current can be relatively small when compared to levels required for running the machine.

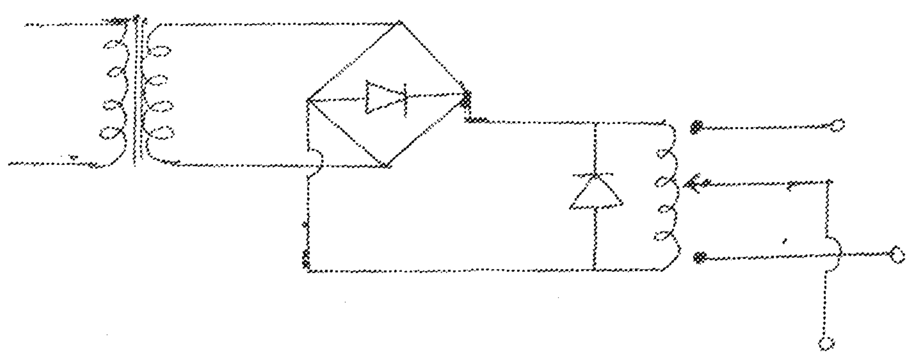

Figure 2.9: The Switching / Control Unit.

2.5 BATTERY UNIT

The battery unit in this system designed is lead acid cell, a secondary cell which possesses the characteristic of irreversibility and storage of electrical energy. The voltage and current ratings of the battery are not constant, due to the effect of charging and discharging processes that occur within the battery itself. So, at maximum, the charging current is rated at 1.30A, while the voltage regulation consist of two stages namely: cycle voltage: 7.35V – 7.50 and standby voltage: 6.75V – 6.85V. It also consists of two terminals (plates), positive and negative terminals. The positive terminal of the bettery is connected to the switch / control unit (relay), while the negative terminal is connected to the anode of D3 and D4 (rectifier unit).

The connections of the lead-acid cell (battery) describes its operations. When the supply is on, the charger unit charges the battery to its maximum for a period of time, about some hours, and when it is off, the switch / control unit connects the charged battery to the inverter unit, which gradually discharges and acts as an in-built power supply source to the lighting unit.

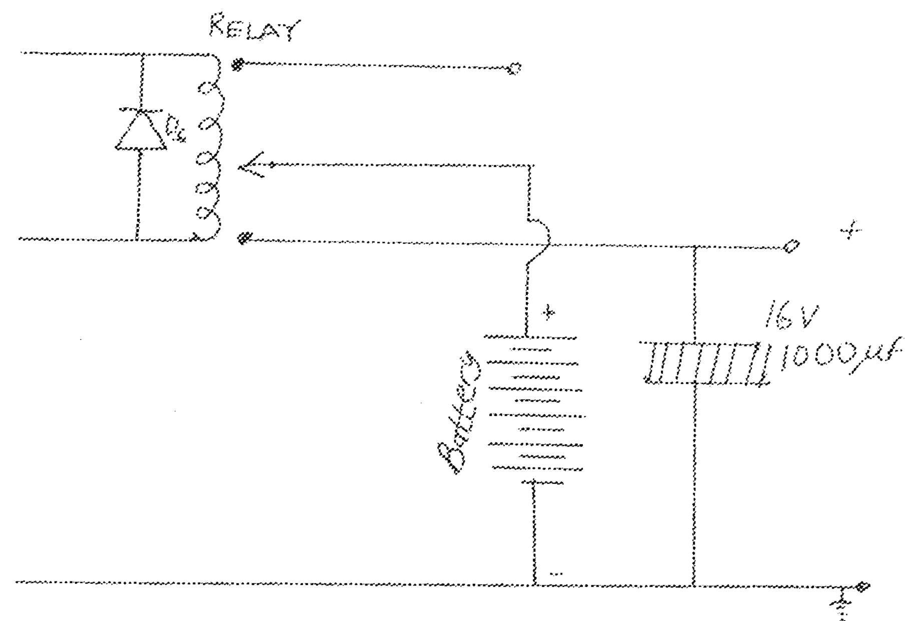

Figure 2.5: The Battery Unit.

2.6 INDICATOR CIRCUIT

The connection of the indicator circuit in this design is made by connecting the two light emitting diodes (LED) – red, green, and blue – in series and a

1kilo ohm resistor connected in parallel to both LEDs, which serve as current limiting to the LEDs. The red LED indicator lamp has its anode connected to the output of the rectifier and glows when main supply is on, indicating that the battery is on charge, and goes off as soon as the main supply fails, while at this instant, the green Led indicator comes on, with the help of a normally closed push button (switch), connected at the input to the inverter. This describes the indication of the green Led as an emergency state. Also, these signify the presence of an in-built source, that is, a battery, which is called into action with the help of the relay. The LEDs connected are made in such a way that, the red LED takes its source from the a.c.main supply and the green LED takes its own source from the d.c. (battery) supply.

These LEDs are composed of the conventional filament lamps operating from significantly smaller voltage and current. Most LEDs, when forward current between 5mA and 20mA is applied, provide a reasonable level of output. LEDs are available in various formats, with the round type being most popular.

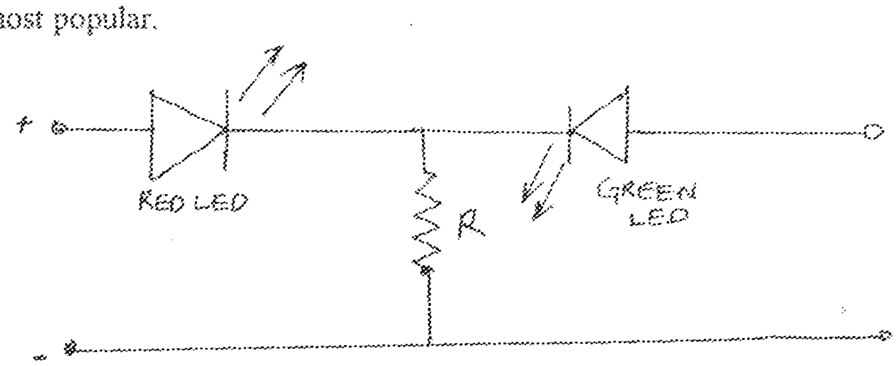

Figure 2.6: An Indicator Circuit.

2.7 INVERTER UNIT / OPERATION

This is the heart of the emergency lighting system. It is the major determinant of the magnitude and frequency of the output current and voltage.

In the event of an outage, the battery supply sufficient power to the inverter to maintain its output for a specified time, usually fro minutes to hours, depending on the duration taken by the battery to discharge to a predetermined minimum voltage before it turns off.

The type of inverter used in this design is meant to carry out the purpose of conversion of direct current (d.c.) to alternating current (a.c.). The circuit is of two modes: current amplification and impedance marching.

The power transistor in the unit helps in generating a better substantial amount of electric current through alternating conduction and step-up transformer is employed to transform the impedance of the device to optimum impedance required. Also, in the inverter circuit, connection of the capacitors and inductor from an oscillator and frequency composition. This circuit was designed to produce an alternating electromotive force (emf) of known frequency and output voltage of sinuosoidial wave form. The frequency response is such that at low oscillating frequency, low voltage is induced in the transformer corresponding to low gain and vice-versa.

<u>**Operation**</u>

When all switches are closed, the resulting surge d.c. current flows into the inverter circuit through connection point P into inductor L2, part of the step-up transformer, and induces an emf at the frequency, into the transformer. The capacitor C4 (NIS 223SG) in this circuit is connected parallel with respect to inductor L2 to give an oscillating frequency (resonant frequency), and also serves as d.c. input blocking capacitor into the inverter unit. This capacitor and inductor connection produces one half-cycle of the alternating current (sinuosoidal).

Also to the transistor base is capacitor C5 (224H) connected, to help the transistor in the amplification of oscillation and also serves as d.c. input blocking capacitor into the transistor base terminal. The transistor now introduces 1800 phase shift between base and collector. Its amplitude is built up until a point is reached when the transistor is driven into saturation in one half-cycle and into cut-off in the other half. The current, after 1800 phase shift flows through inductor L2 to make the second half-cycle and an emf is also induced into the transformer. The transistor can be observed to be operating in ON and OFF mode. In the first cycle, the positive half-cycle is clipped because the transistor is driven into saturation and the negative half-cycle is clipped when transistor is driven into cut-off.

The step-up transformer couples both halves of the alternating current as a result of its oscillation and produces a step-up voltage output of about 220/240V (a.c.) to the lighting unit, but with a small amount of current present at its output due to the type of lighting system in use.

DIAGRAM BELOW

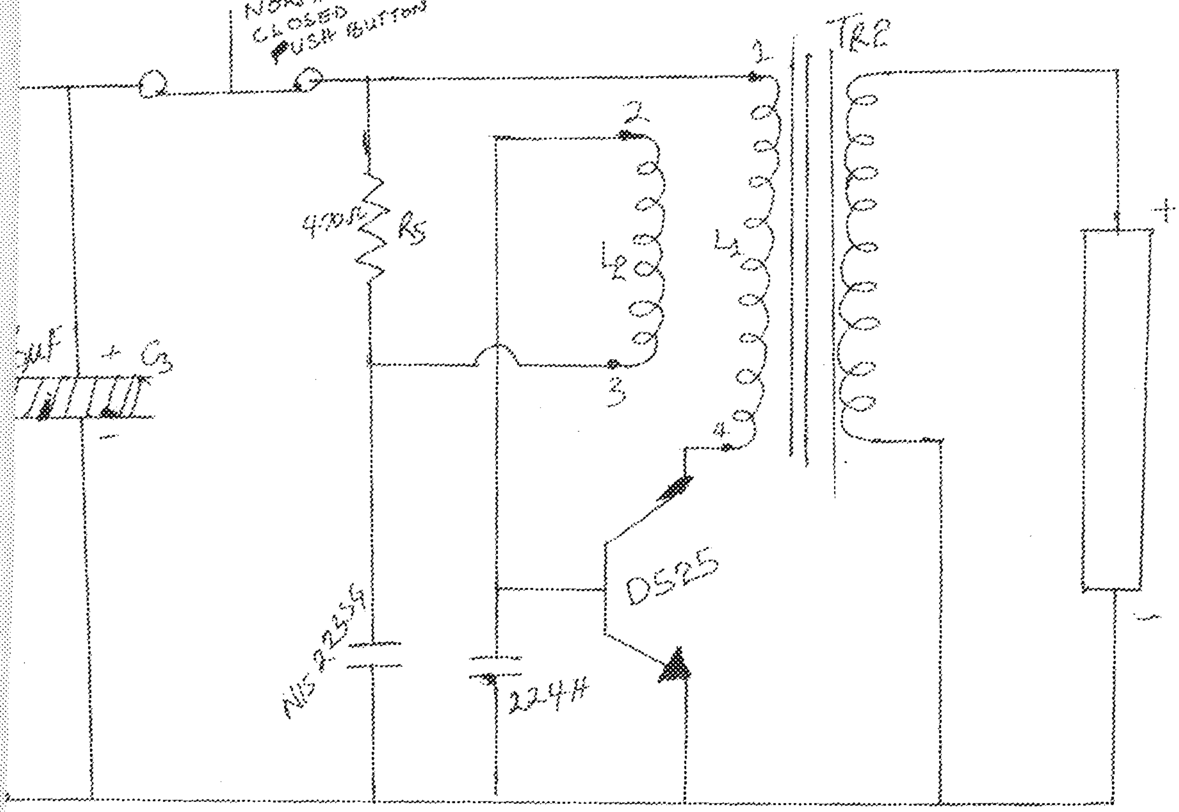

Figure 2.7: An Inverter Unit.

2.8 LIGHTING UNIT

Since the output of this design is mainly emergency lighting, the unit comprises of only a fluorescent lamp, which has much to share with the inverter circuit, which rendered its use of starter unnecessary, hence, behaves like an instant starting lamp. This makes the lamp to light instantaneously when the circuit switch is closed.

No automatic starter switch is employed due to the amplification work of the inverter circuit coupled with the step-up transformer and heating effect on the lamps cathode electrode. Since cathode is capable of emitting electrons, especially when heated, like in this case where it is used as a filament in a vacuum tube, it emits radiation called light. It should also be noted that at the transformer output, the voltage is about 220/240V and the current within the range of 0.01mA and 1A.

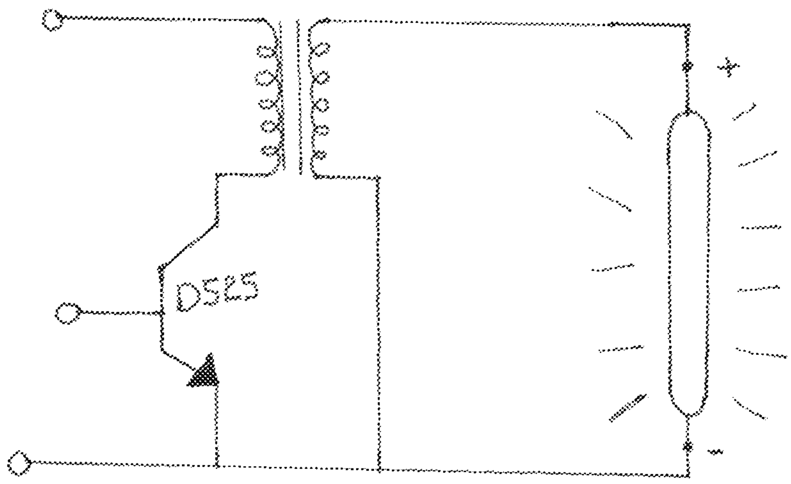

Fig 2.8: The lighting unit.

In order to obtain the amount of voltage required by the electronic components to operate functionally in the design, a step-down transformer was used in which the number of turns of its windings (primary and secondary); the primary and secondary voltages and currents; and also, the electromotive force (E.M.F) induced in the coil were determined.

It shows that $V_p = -N_p \, d\emptyset/dt$

$$V_p = -N_s \, d\emptyset/dt$$

Where $d\emptyset/dt$ is the rate of change of flux linkage

while V_p = primary voltage

V_s = secondary voltage

N_p = number of turns in the primary winding

N_s = number of turns in the secondary winding

Hence, $d\phi/dt = V_p/N_p = V_s/N_s$

Since we want to determine the ratio of input voltage to the output voltage, the equation would simply be:

$$V_s/V_p = N_s/N_p$$

Thus, the input and output voltages of the step-down transformer in this project design were 220/240V to 9V, which implies that, $V_s = 9V$, V_p = 240V

$$V_s/V_p = Ns/N_p = 9/240 = 1/26.6 \approx 1/27$$

Hence, the ratio of secondary voltage to primary voltage is 27:1, which defines the turns ratio of $N_p:N_s$.

But for current, $Is/I_p = N_p/Ns = 27/1$

That is, $I_p:I_s \approx 1:27$

These results shows that, in a transformer, when you step-down a voltage, you equally will be stepping up the current and vice-versa, but the frequency remains unchanged.

Also, in the course of testing the waveform output after rectification, it was understood that the rectified V d.c. voltage is less than rms input voltage, due to the drop across the diodes. From the calculations, the V d.c. was found to be:

$$V_s(t) = (2)^{1/2} V_s \sin wt$$

$$= (2)^{1/2}\, 9 \sin wt$$

The 9V a.c. is the step-down secondary voltage going into the rectifier.

Hence, V_o (d.c.) =

$$= \frac{T}{2}\int_0^{T/2} V_s(t)\, dt$$

$$= \frac{1}{\frac{2\pi/\omega}{2}}\int_0^{\frac{2\pi}{2}} \sqrt{2}\, V_s \sin \omega t\, dt$$

But T = 1/F = 1 / [2π/w]

And w = angular frequency (omega),

Also dt = d(wt) /w

$$V_o\,(d.c.) = \frac{w}{\pi}\int_0^{\pi} \sqrt{2}\; V_s\; \sin \omega t\; \frac{d(\omega t)}{\omega}$$

$$= \frac{1}{\pi}\int_0^{\pi} \sqrt{2}\; V_s\; \sin \omega t\; d(\omega t)$$

Which is equivalent to

Vo(d.c.) = 2 * $(2)^{1/2}$ Vs/π

Recall Vs = rms value (ie 9V a.c.)

Vo(d.c.) = 2 * $(2)^{1/2}$ * 9 /π

= 8.1V

but the PIV (peak inverse voltage) = $(2)^{1/2}$ Vs

= $(2)^{1/2}$ * 9

= 12.73V

Hence, for the full wave bridge rectifier, the output voltage after voltage drops across the diodes is 8.1V . Also, with the peak inverse voltage (PIV) value, one should be able to know the type of diode to choose for a particular output.

Considering the d.c. component of full wave rectifier, the current is given by:

$I_{d.c.} = \frac{1}{2\pi}\int_0^{2\pi} i(t)\, d\omega t$

Where $I(t) = I_s \sin wt$

Also, $I = V/R$

$(2)^{1/2} V_s \sin wt/R$

$I_{d.c.} = \frac{1}{2\pi}\int_0^{2\pi} \frac{\sqrt{2}\, V_s \sin\omega t}{R}\, d(\omega t)$

$= \frac{2\sqrt{(2)}V_s}{2\pi * R}$

$= \frac{2(2)^{1/2} V_s}{\pi * R}$

$\approx V_{d.c.}/R$

Where R = load resistance = 390 ohms.

$I_{d.c.} = \frac{8.1V}{390\Omega}$

$= 0.021A \approx 21mA$

Due to the charging and discharging effects of capacitor C1, a ripple voltage has been produced. Now the output voltage of the rectifier is the sum of the Vd.c. and ripple voltage (Vr). Hence, calculating it will result to:

$V_{ripple} = \frac{I_{d.c.} T}{C}$

$= \frac{V_{d.c} * T.}{R_L\ C}$

But T = 1/f, where f = 50HZ and C = 1000uF

$$V_{ripple} = \frac{V_{d.c.} * 1 * 1}{R_L \times F c \times 2}$$

$$= \frac{I_{d.c.}}{2fc}$$

$$= \frac{21mA}{2 * 1000 * 10^{-6} * 50}$$

$$\frac{21 * 10^3}{2 * 50 * 1000} = \frac{0.42}{2}$$

$$= 0.21V$$

The above value shows the amount of ripple voltage present in the output, hence, when choosing capacitors and diodes, they should be able to reduce the amount of ripples in a circuit output of voltages and currents.

$$\text{Hence, ripple factor } (r) = \frac{V_{rms}}{V_{d.c.}} * 100\%$$

$$\% \text{ ripple factor } (r) = \frac{9}{8.1} * 100\%$$

$$= 111\%$$

In the conclusion of the circuit design, that is, the inverter unit, the resonant frequency and impedance matching were determined. That is:

$F = 1/2\pi (LC)^{1/2}$

(general formular for resonant frequency)

where $L_1 = L_2 = 10mH$ (inductor)

$C_1 = 500uF$ (Capacitors)

$C_2 = 500uF$

Since both capacitors C_1 and C_2 were connected in parallel;

$C = C_1 + C_2$

Hence, $C = 1000uF$

Now, substituting these values into the equation:

$$F = \frac{1}{2 \times \pi \times \sqrt{L_2 \times C}}$$

$$= \frac{1}{2 \times \pi \times \sqrt{10 \times 10^{-3} \times 1000 \times 10^{-6}}}$$

$$= \frac{1}{2 \times \pi \times \sqrt{0.00001}}$$

$$= \frac{1}{2 \times \pi \times 0.00316227}$$

$$= 50.32Hz$$

$$\approx 50Hz$$

Now considering the impedances with respect to power input and output of the inverter unit:

$Pp = Ps$

$I^2Rp = I^2Rs$

$Vp^2 / Rp = Vs^2 / Rs$

Where $Is^2 / Ip^2 = Rp / Rs$

Which is equivalent to:

$$Rp / Rs = (Np / Ns)^2 = (Vp / Vs)^2$$

Where $Vp = 6V$ from the battery source, and

$Vs = 240V$ secondary output

$$Rp/Rs = (6 / 240)^2 = (1 / 40)$$

$$Rp / Rs = 1 / 1600$$

Hence the ratio of the primary impedance to the secondary one would be:

$$Rp : Rs = 1 : 1600$$

The above shows that when a voltage in a transformer is stepped up, the current in it is reduced

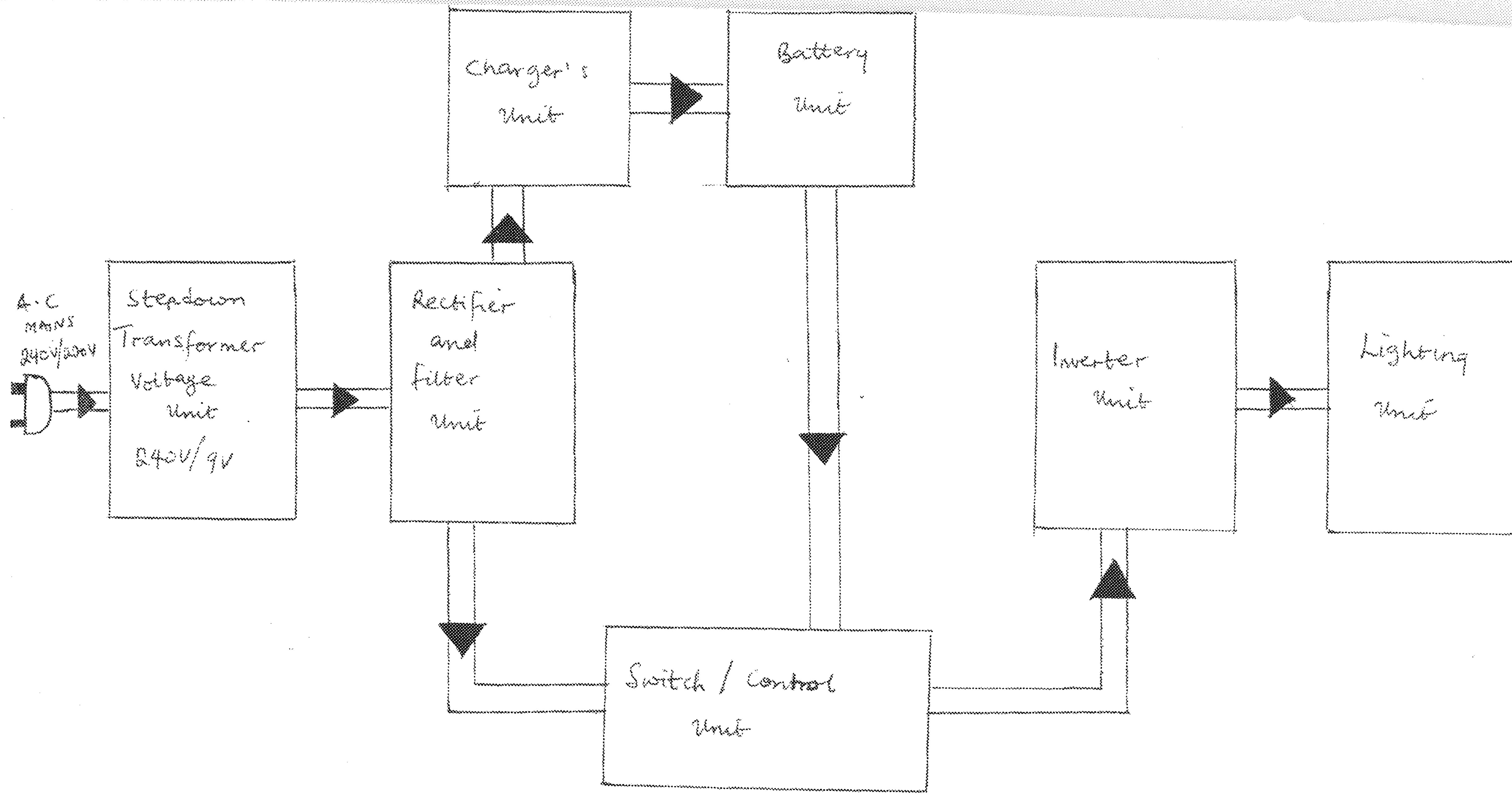

Fig 2.9 BLOCK DIAGRAM OF AN EMERGENCY LIGHTING SYSTEM.

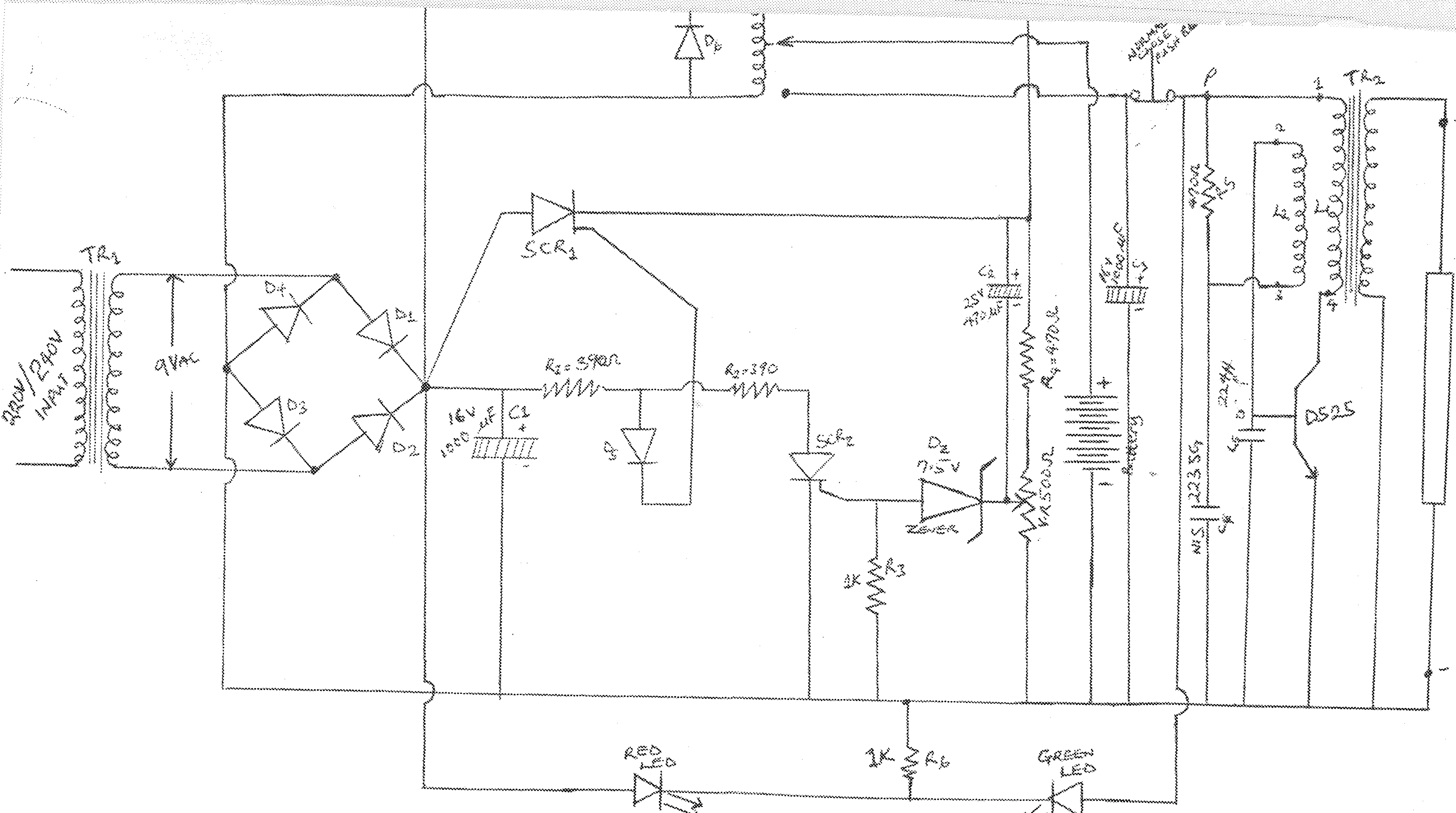

Fig 2.10 CIRCUIT DESIGN OF AN EMERGENCY LIGHTING SYSTEM

CHAPTER THREE

CONSTRUCTION, TESTING AND RESULTS

3.1 CONSTRUCTION

The construction of this project work brought to light the theory and design as explained in the chapter. Before the construction of this project, several things were taken into consideration of which most important, the theory and design of each stage.

First and foremost, the circuit was built on a solder less breadboard showing the different stages, as explained in the design. This made it possible to make changes when the need arose and made it easier to locate bugs and trouble-shoot the circuit design. It was later transferred onto the Vero board, where careful component soldering was done. All components lead were kept at a minimum to prevent accidental short circuiting. The circuit was carefully planned, minimizing errors and making trouble-shooting easier. Finally, the entire connection was carefully housed in a stainless aluminium steel box (compartment), in which the in-built power source (battery), was mounted inside and the lighting fluorescent bulb mounted by the side as shown below.

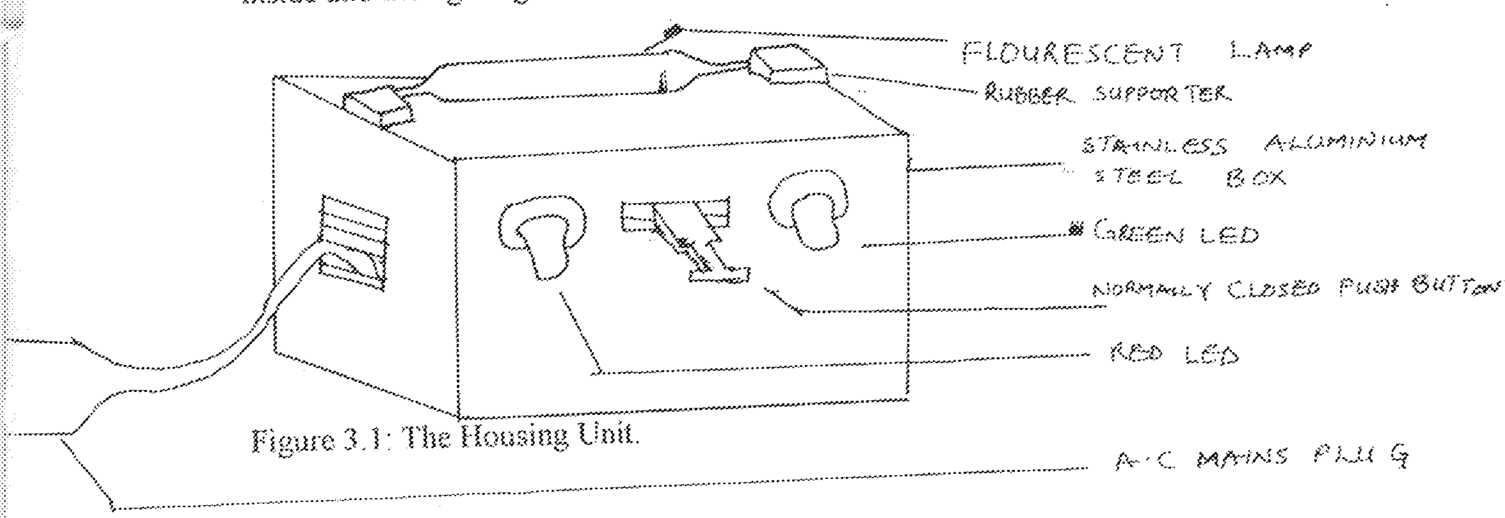

Figure 3.1: The Housing Unit.

3.2 TESTING

During the construction, the waveform was tested using an oscilloscope after rectification and filtering and the required output waveform of the applied voltage was displayed on its screen other components were also tested to confirm their values before being put to use in the construction. Outputs at each stage were also tested.

Finally, the construction work was plugged into a socket-receiving source from a.c. main. The socket was put for charging operation to commence and this automatically puts off the fluorescent light, and later, when it was switched off to serve for sudden power failure, the light came on defining its emergency state. The ON and OFF process of the fluorescent light was aided by a normally closed pushed button (switch), and also it assisted the battery voltage from a complete discharge.

3.3 RESULTS

After carrying out the different test on the components that made up the design of this project, the results were graded on the minimum and maximum possibility of the system operation. This was noticed on the input and output stages of the in-built power supply source (lead acid-cell rechargeable battery) and also the luminous intensity of the lighting source. With the battery undergoing a charging and discharging process which also affects the luminosity of the fluorescent lamp. The rating of the battery was made on cycle voltage: 7.35v-7.50v and standby voltage 6.75v-6.85v and its maximum was 1.3A. Also the fluorescent lamp on the other hand has a voltage of 220v an a current range of 0.01-0.1mA at its output.

The results obtained after the test operation was that, the battery could charge up to maximum for about 12-14 hours on an approximate value of voltage; 6.85v-7.21v, and a current of 875mA (0.875A). Hence the luminous intensity of the fluorescent lamp explains the charging and discharging effect possessed by the battery. After charging the battery to its maximum voltage as mentioned above, it discharges immediately when there is failure from the main power supply and the brightness of the fluorescent lamp shows that the battery is fully charged. Undermining the charging period, a state would reach when the luminous intensity of the lighting source reduces (i.e. the light dims) this implies that the battery has discharge to its minimum voltage required

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

This design, construction and testing of emergency lighting system is a big success. The fundamental of its design, that is, of its components and the basic of its operation are now well comprehended. It was also observed that, at the end of this project work, the gap between the theoretical work and the practical application has been bridged.

Also, in the course of this design, it was understood that power supply can be stored for a certain amount of time and later distributed by a storage device to its load through other means of supply. It was shown too, that electronic components are not meant to be connected directly to any supply unit, due to the fact they are called to operate with a small amount of current. The lighting system can be on for about sixteen hours when the battery is a in good charged condition.

4.2 RECOMMENDATION

Having completed the project construction, I hereby make the following recommendations for its improvement:

(i) The inverter system should be improved to give a higher power rating for outdoor illumination, eg 1000 watts halogen lamp.

(ii) The school should stand up to assist students at least materially-wise, in future project constructions to alleviate the financial burden it incurs.

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Table 3.1: **LIST OF COMPONENTS USED AND THEIR VALUES**

	Name	Quantity Value	Voltage/Current Rating
1	Step-down Transformer	1	240V/9V
2	Step-up Transformer	1	6V/220V
3	Encapsulated Diodes (Bridge rectifier)	4	IN 4001 (each)
4	Thyristor (SCR)	2	
5	Rectifying diodes (1/2 wave rectifier)	2	IN 4001 (each)
6	Electrolytic Capacitors	3	16V,1000uF,25V,470uF
7	Ceramic Capacitors	2	NIS 223SG, 224H
8	Zener diodes	1	7.5V
9	Relay	1	6Vd.c/240Va c.
10	Normal close push button switch	1	
11	Resistors	2	390Ω
12	Resistors	2	470Ω
13	Resistors	2	1KΩ
14	Variable resistor (Potentiometer)	1	500Ω
15	Battery	1	6 volts
16	Light Emitting diode (LED)	2	
17	Transistor	1	D525
18	Flourescent tube	1	
19	Connecting wires		