DESIGN AND CONSTRUCTION OF AN AUTOMATIC POLYTHENE SEALER

OLATOMIWA, L. JOSEPH
2001/13931EE

DEPARTMENT OF ELECTRICAL/COMPUTER ENG'G,
FEDERAL UNIVERSITY OF TECHNOLOGY,
MINNA.

OCTOBER, 2006.

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A thesis submitted to the Department of Electrical and Computer Engineering, Federal University of Technology, Minna Niger state.

October, 2006.

DEDICATION

This Project work is dedicated to Almighty God, the beginning and the end, for His love, guidance, protection and inspiration throughout the course of the program.

DECLARATION

I OLATOMIWA, L. JOSEPH, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

Olatomiwa L. Joseph

(Name of student)

06/10/06

(Signature and date)

Mr P.O Attah

(Name of Supervisor)

6/10/06

(Signature and date)

Engr. M.D Abdullahi

(Name of H.O.D)

(Signature and date)

(Name of External Examiner)

(Signature and date)

ACKNOWLEDGEMENT

I am grateful to my Heavenly Father, the Almighty God for taking care of all aspects of this project work, and for His unquantifiable assistance for my studies and life. I return all glory to His name.

My profound gratitude goes to my beloved parents; Deacon and Mrs. E.B Olatomiwa for all the support they have rendered throughout my life, may you live long to enjoy the fruits of your labour. Also, I am grateful to my brothers and sisters for their encouragement and prayers. I love you all.

My special thanks and appreciation goes to my supervisor Mr. P.O Attah, for his kindness, useful suggestions and advice. My gratitude also goes to the Head of Department of Elect/computer Engineering, Engr. M.D Abdullahi, and all the lecturers that taught me in one way or the other, may God reward you all. Credit also goes to my all friends and colleagues for their advice and concern for the successful realization of this work.

This work is not complete without appreciating my fiancée, Miss. Oluwafunmilayo Owa. Indeed you surely brought joy in to my life. Thanks for the encouragement and care, with you beside me the sky is the beginning.

Finally to those who in different ways have been instrumental to my achievement, I remain forever grateful.

ABSTRACT

This project is all about the design and construction of an automatic polythene sealant. It is carried out to enhance the safety, efficiency and convenience of sealing the polythene materials used for packaging of goods/products manufactured locally. The design is based on the principle of application of electric current through a resistance wire, which thus produces the heat required for the sealing of the polythene material. An electronic timer controls the polythene sealant, which is adjustable to enable sealing polythene material of thickness range 2μm-1mm. The design adopted in this project involves three different stages: The power supply unit, the control (timing) circuit and the heating element (output) unit. All these work together to achieve the purpose of the design. The method of procedure has been well arranged into chapters, such that each chapter deals with an indispensable part of the design.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDIES

An automatic polythene sealant is an electrical appliance exclusively constructed to enhance the sealing of polythene material automatically, thereby increasing the level of production and reduce labour. Generally, sealant is something that seals a place where there is a leak. And polythene itself is o plastic material widely used for waterproof packaging, insulation etc. thus it is a generic name for certain thermoplastic polymers of ethylene.

More so, as nations nowadays are struggling in order to improve the industrial sector of their economy, which will lead to real development as well as to raise the standard of living of the nation. Thus, some companies have to preserve the products that are not immediately consumed. For example, food processing companies, pharmaceutical companies etc. in which their product will be packed and preserved for long period of time in order to prevent it from damaging or being contaminated. In order to preserve such good, there is a need to make use of insulating material capable of resisting water. This leads to the invention of polythene sealant, such machine is only meant for polythene wrappable goods/commodities. Hence this project is set to address the construction of a polythene-sealing machine, which is incorporated with automatic control.

This is based on the principles of application of current through a fairly constant resistance wire connected across a considerable voltage supply, which develop the heat energy required for the sealing of the polythene material. If the circuit is complete the power that will be generated is (I^2*R). Generally, heat would be gradually increasing until it get to a

1.2 PROJECT LAYOUT

This project write-up is divided into five chapters for easy comprehension. Chapter one dealt with the introduction, where also the basis for the design and construction were said to include production of more cheaper and convenient method of sealing polythene material for efficient packaging and preserving of those goods/product manufactured locally.

Chapter two dealt with the literature review and fundamentals of automatic polythene sealant. Chapter three dealt with the design procedure and construction, here different circuitry stages applied in the project were clearly indicated. This includes the power supply unit, the control (timing) unit and the heating element output unit. This chapter also includes how the components are assembled on the Vero board, and also the principle of operation of the complete circuit. Chapter four includes the testing, the result and the discussion, it also contain the operating instruction of the polythene sealant and the troubleshooting analysis.

Finally, the last chapter (five), which is the conclusion, summarizes the whole project and recommendation to further improvement on the design.

1.3 PROJECT OBJECTIVES AND MOTIVATION.

The main purpose of this project is to design and construct a polythene sealer with an automatic control, for sealing polythene material use for packaging goods. All type of modern heating system, such as microwave oven, electric furnace, room heater and incubator are capable of supplying highly satisfactory heating performance when saturation point in short time, therefore heat produced is fairly constant irrespective of the period of time. The heat energy derived is purposely to seal the polythene material of different chemical formula and sizes.

Moreover, there are two major type of polythene sealant based on their mode of operation. Namely:-

(i) **Manually operated polythene sealant:** This type of sealant is normally operated by switching ON and OFF the machine during the period of operation when the desired level of heat has been attained to seal the polythene material.

(ii) **Automatic polythene sealant:** The incorporated automatic control circuit is operating this type automatically. This indicates that the control circuit is capable of switching OFF the machine when the preset time is attained.

Out of the above-enumerated types, the automatic polythene sealant is employs in this project, in which the circuit is incorporated with the control and timing sub-circuit (regulator), which allow the operator to preset the time for the sealing of the polythene material of different thickness. This sealant consist of two major sections, namely:

(i) Mechanical section, and

(ii) Electrical section.

The mechanical section consists of the upper and lower jaw, with the incorporated items such as insulators, Dunlop, fasten tape etc. it also consist of an iron rod, pedal, frame, bolts and nuts etc. the lower jaw is fixed while the upper jaw is movable. The electrical section consists of Transformer, relay, heating element 555 timer, and some other basic electronics components.

properly installed. Conversely, any system can be rendered useless if not properly designed or installed, hence the major objective of this project is design highly effective and economical system that can suit the purpose for which it was intended

However, to achieve this aim, the objectives considered to incorporate the entire system design and development are:

(i) The control system should be easily interfaced with variety of heating equipment.

(ii) The project should have low installation cost.

(iii) The project should require low maintenance cost.

(iv) It should be generally used to seal polythene nylons.

1.4 FEATURES OF THE SEALING MACHINE

This project, "automatic polythene sealing machine" which was designed and constructed, has the following features:

- The seal width ranges from 2µm-1mm.
- It is equipped with a plug –in electronic timer.
- The timer control the sealing time needed for different polythene material thickness

CHAPTER TWO

LITERATURE REVIEW/THEORETICAL BACKGROUND

2.0 LITERATURE REVIEW.

Heat in physics, is the transfer of energy from one part of substance to another or from one body to another by virtue of difference in temperature. Heat is energy in transit; it is always from a substance at a higher temperature to another substance at a lower temperature, raising the temperature of the latter and lowering that of the former substance. [2]

Until the beginning of the 19^{th} century, the effect of heat on the temperature of a body was explained by postulating the existence of an invisible substance or form of matter termed calorie. According to the calorie theory of heat, a body at a higher temperature contains more calorie than one at a lower temperature; the former body loses some calorie to the latter body in contact, increasing that body's temperature while lowering it's own. Although, the calorie theory successively explain some phenomena of heat transfer, experimental evidence was presented by American-born British physicist Benjamin Thompson (later known as Count Von-Rumford) in 1798 and the British chemist Sir Humphrey Davy in 1799 suggesting that heat like work, is a form of energy in transit. Between 1840 and 1849, the British physicist James Prescott Joule, in a series of highly accurate experiments, provided conclusive evidence that heat is a form of energy in transit and that it can cause the same changes in a body as work.[2]

Basically, electrical energy can be converted to heat energy by passing electric current through a resistance wire for some period of time, and the energy dissipated can be measured in Volt-Ampere Hour. It is on record that research and implementation of heating element control did not seriously take-off until in the 80s, when the needs to automatically control for heating systems become very important. Hence there are still relatively few text that deals extensively with important aspect of Electronic Engineering. However, the device for controlling heating system was first introduced in 1830 by Andrew Ure, a Scottish professor of chemistry.

For the purpose of this project a number of text was consulted, one of these texts is Merit student Encyclopedia by William Hasley and Emmanuel Feiedman where J.J. Jaklitsh dealt with the kind of thermostatic control for heating system and give the operation of their functional parts. [9] He however, did not delve into the process of designing the device. In a text of science and invention by Cornelius Dreddel, dealt extensively on the type and essential features of thermostats and went further to say that resistance-based thermostatic control is extremely accurate when connected to an electronic equipment. [10]

The idea of packaging manufactured goods in polythene bags using machines started long ago. It is this practice that has metamorphosed into the current method of packaging goods in polythene bags using automated sealing machines with different kinds of labels/trade names. This, of course is aimed at standardization and improvement of quality of goods. [7]

2.1 ELECTRIC HEATING

Basically, heat is produced due to the circulation of current through a resistance wire. The current may circulate directly due to application of potential difference or due to induced eddy current. Electric heating is extensively used both for domestic and industrial application. Domestic application includes; room heater, immersion heater for water heating, hot plate for cooking, electric pressing iron, electric ovens for baking, electric sealing of polythene material etc. while industrial application of electric heating includes; melting of metals, heat treatment of metals, moulding of glass, enameling of copper wire etc.[2]

2.1.1 Method of electric heating.

Different methods of producing heat for general industrial and domestic purposes is classified below:[2]

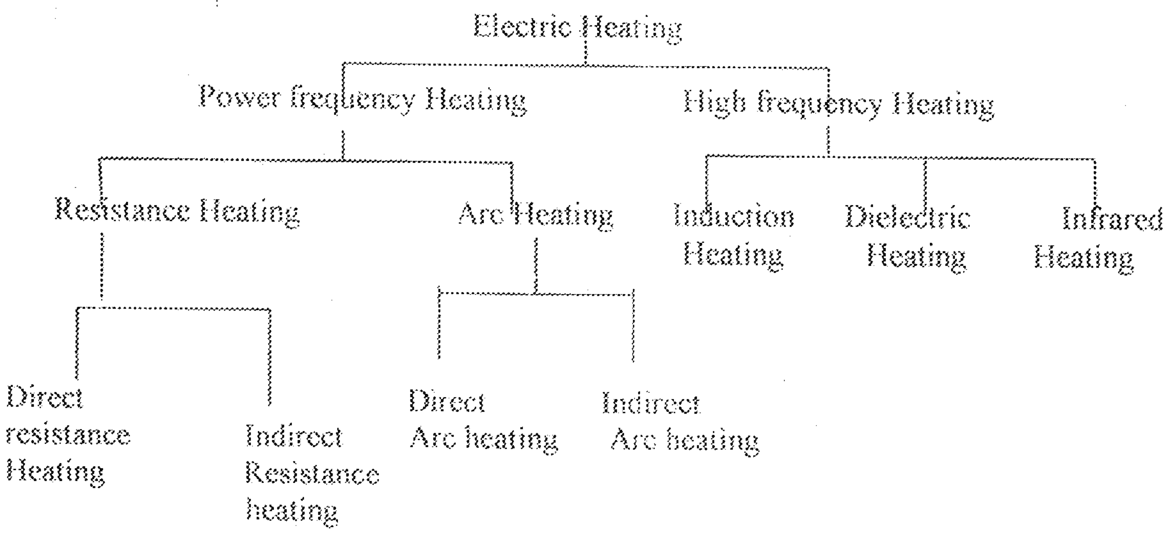

Fig.2.1 Method of Electric Heating

2.1.2 Resistance heating

This method of heating is based on the I^2R effect. When current is passed through a resistance wire, I^2R loss takes place, which produce heat. There are two method of resistance heating, namely:

(a) Direct Resistance Heating: in this method, the material to be heated is treated as a resistance and current is passed through it.

(b) Indirect Resistance Heating: in this method of heating, electric current passed through a resistance element, which is placed in an electric oven. Heat produce is proportional to I^2R loses in the heating element. The heat so produced is delivered to the material either by radiation or convention.[2]

2.1.3 Method of heat transfer

The different methods by which heat can be transferred from a hot body to a cold body are as follows:

(i) **Conduction**: In this mode of heat transfer, one molecule of the body gets heated and transfers some of the heat to the adjacent molecule and so on. There is temperature gradient between the two ends of the body being heated.

(ii) **Convention:** In this process, heat is transferred by the flow of hot and cold air current, this process is applied in the heating of water by immersion heater or heating of building. The quantity of heat absorbed by convention process depends mainly on the temperature of the heating element above the surrounding and the size of the surface of the heater. The amount of heat dissipated is given by:

$$H = a\,(T_1 - T_2)$$

Where "a" is a constant, and T_1 and T_2 are the temperature of the heati surface and the fluid in ^{o}K respectively.

(iii) **Radiation**: This is the transfer of heat from a hot body to a cold body in a straight line without affecting the intervening medium. The rate of heat emission is given by Stefan's law according to which, heat dissipated,

$$H=5.72eK[(T_1/100)^4 - (T_2/100)^4]\ W/m^2$$

Where K= radiating efficiency

"e" =emissivity of the heating element.

If "d" is the diameter of the heating element, and "l" is total length, then its surface area from which heat is radiated is $=\pi * d * l$

If "H" is the power radiated per square meter (m^2) of the heating surface, then total power radiated as heat is= $H * \pi dl$.

If "P" is the electrical power input to the heating element, then

$P=\pi dl * H$.

2.1.3 Property of good heating element

(i) High specific Resistance

(ii) High melting temperature

(iii) Low temperature coefficient of Resistance

(iv) High oxidizing temperature

(v) High ductility and flexibility

(vi) Mechanical strength. [2]

CHAPTER THREE

DESIGN ANALYSIS AND IMPLEMENTATION

3.0 INTRODUCTION

This project was design with readily available component, so as to reduce cost and still maintain its economic values. The design of this project incorporates the basis of ac rectification in the power circuit and switching in the control circuit, which involves the use of discrete components and integrated circuit (IC). It consist of three major sections, namely:

(i) Power supply unit

(ii) Control (Timer) unit.

(iii) Heating Element unit.

The block diagram in figure 3.0 give a clear picture of layout and details of each stage are explained in this chapter.

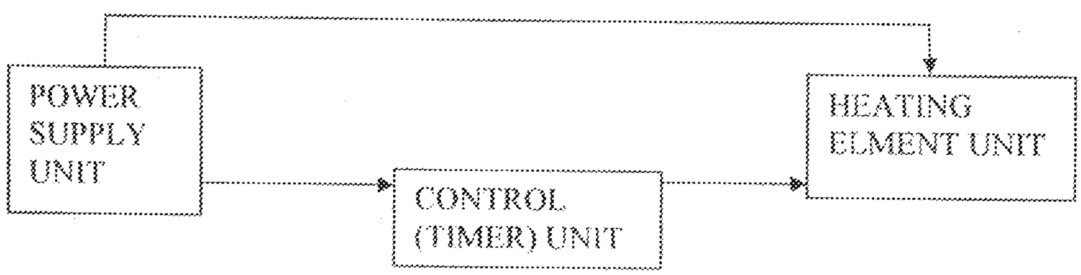

Figure 3.0 Block Diagram Of An Automatic Polythene Sealant.

3.1 POWER SUPPLY UNIT.

Actually all electronic appliance or instruments require a source of dc power before their normal operation. Sometimes, the source is a battery, but more usually the power is obtained from a unit that converts the normal ac mains supply (230V at 50Hz) to some different values of dc voltages. The function of the power supply unit is to provide the necessary dc voltage and current with low ac ripples, with good stability and regulation. In other words, it must produce a stable output, irrespective of variation in the mains input voltage.

There are various methods of achieving a stable dc voltage from the ac mains, but only two methods are commonly used. Namely;[1]

- A linear stabilizer.
- A switching mode stabilizer.

However, for the purpose of this project a linear stabilizer was adopted, because of its simplicity and relative cheapness. A linear stabilizer consists of four basic stages, namely; a step-down transformer, a full-wave bridge rectifier, filter capacitor and a voltage regulator. The block diagram of this unit is shown in figure 3.1, however the supply to this unit is from the mains (PHCN) supply of 230v, 50Hz.

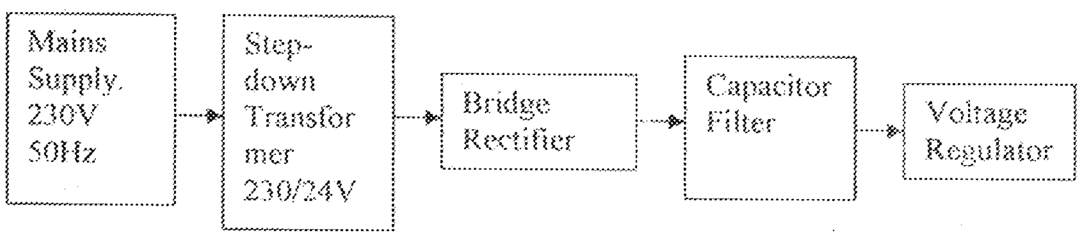

Figure 3.1 Block Diagram Of Power Supply Unit.

3.1.1 TRANSFOMER

A transformer is an electrical device made up of coils wound around a magnetic core, it makes use of the principle of electromagnetic induction to transform electrical energy from one coil to another at different voltage level. [1] Thus, a step-down center tapped transformer of 24volt is use in this project which provide the necessary voltage require in the circuit.

<u>**Calculation**</u>

For a sinusoidal input voltage, the flux, ϕ varies alternately i.e

$\phi = \phi_{max}$ Sinwt

The instantaneous voltage in the primary is due to Faraday's law.

$E_1 = d\phi N_1/dt \quad = 2\pi f N_1 \phi_{max} coswt$.......................................(1)

Where $w = 2\pi f$

Thus, $M_{ead} = 2\pi f N_1 \phi_{max}$

$E_{rms} = 2\pi f N_1 \phi_{max}/\sqrt{2}$

$= 4.44 f N_1 \phi_{max}$..(2)

Neglecting the losses in the coil, the flux is the same for the primary and the secondary winding. Thus, the secondary voltage and current could be derived from;

$Vs/Vp = Es/Ep$

$= 4.44 f Ns \phi_{smax} / 4.44 f Np \phi_{pmax}$

Therefore, $Vs/Vp = Ns/Np$

Thus $Vs = (Ns/Np)Vp$...(3)

Where, Vp = Input voltage

Vs = Output voltage

Np = Number of turns in the primary windings

Ns = Number of turns in the secondary windings

ϕ_{Smax} = maximum flux in the secondary windings

ϕ_{Pmax} = maximum flux in the primary windings

Es = the emf value of output voltage

Ep = the emf value of the input voltage.

And,

$$IpNp = IsNs$$

Or

$$Is = (Np/Ns)\, Ip \qquad \ldots\ldots(4)$$

Where Ip = the input current

Is = the output current

Combining equation (3) and (4)

$$Vs/Vp = Ns/Np = Ip/Is \qquad \ldots\ldots(5)$$

The transformer used has the following parameter:

Primary voltage = 240Volt

Secondary Voltage = 24Volt

Secondary Current = 5Amp

From equation (5)

$$Ip = (Vs/Vp)\, Is$$

Therefore, $Ip = (240/24)*5$

$= 50A$

The transformer ratio can be calculated as

$$Vs/Vp = Ns/Np = 240/24 = 10$$

3.1.2 RECTIFICATION

Rectification involves the conversion of alternating current (ac) to direct current (dc) with the application of rectifiers. A rectifier is an electronic device that offers low resistance to the flow of current in the positive direction (forward bias) and high resistance to the flow of current in the negative direction (reverse bias). [4]

Rectifier may be used to carry out either half-wave or full-wave rectification depending on the application. In this project, we shall concerned only with full-wave bridge rectifier, which in essence allow the flow of dc current in the output throughout the alternating cycle of the input signal. The common type of bridge rectifier is made of four discrete diodes arranged in a bridge form.

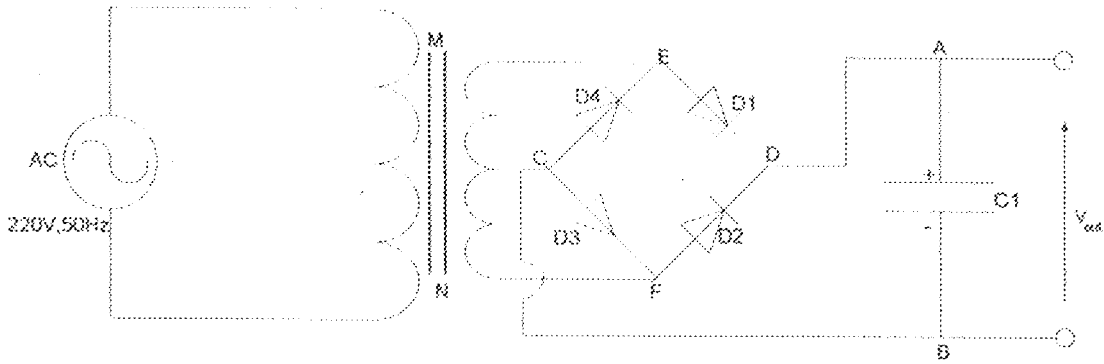

Figure 3.12(a) Full Wave Bridge Power Supply

Mode of operation

During the positive half cycle of the ac supply, terminal M of the secondary side of the transformer is positive and N is negative as shown in figure 3.12(a). Diode D1 and D3 became forward biased, whereas diode D2 and D4 are reverse biased, hence current flow along the path MEDABCFN, thereby charging the capacitor C1 to maximum value, V_{out}.

While during the negative input half cycle of the ac voltage, secondary terminal N of the transformer becomes positive and M negative, diode D2 and D4 are then forward biased and diode D1 andD3 are reverse biased, hence current flows along NFDABCEM charging capacitor C1 to maximum voltage V_{out}. This way, current keeps flowing through the circuit in both cycle of the ac input supply, thereby supplying a constant dc voltage. The waveform of this operation is shown in figure 3.12(b).

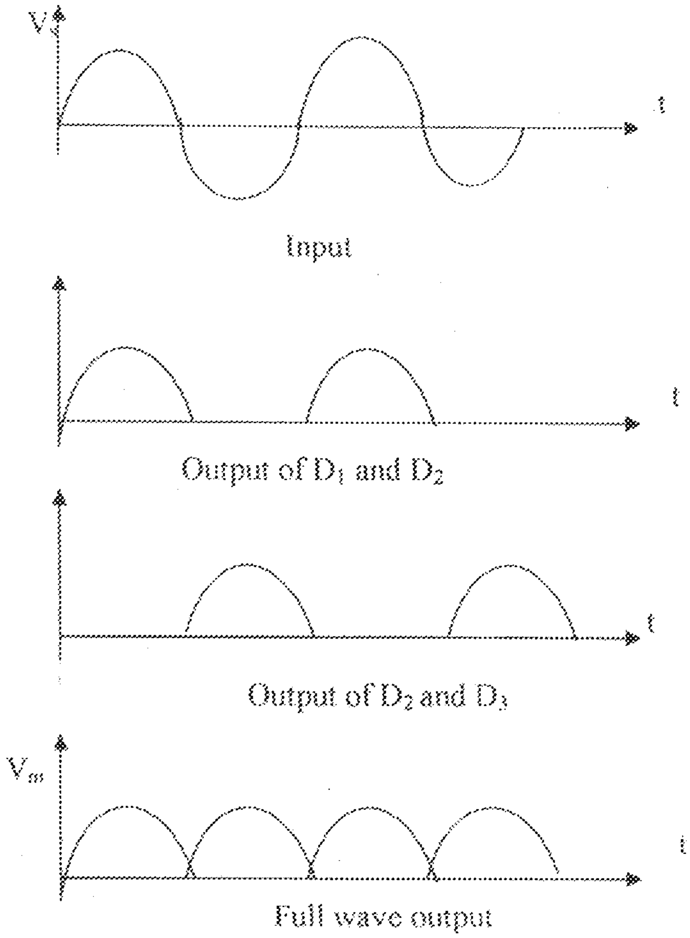

Figure 3.12(b). The Input And Output Waveform Of A Bridge Rectifier

3.1.3 FILTERING/SMOOTHING

The filter is required to smoothen the pulsating dc output of the rectifier. Various type of filter is built using a combination of an inductor and a capacitor, or in combination with resistor. However, a single capacitor in parallel with the output of the rectifier (as shown in figure 3.12(a)), perform the filtering action. The capacitor stores energy during the conducting period and deliver it to the load during the non-conducting period, hence the time of flow of current through the load is prolonged. [1]

In this project, a single capacitor is used as a filter, the capacitance of the capacitor is large enough to store sufficient amount of energy in order to provide a steady supply of current, and otherwise the output will drop as the load demand more current. The approximately output waveform can be represented by figure 3.13(c), below.

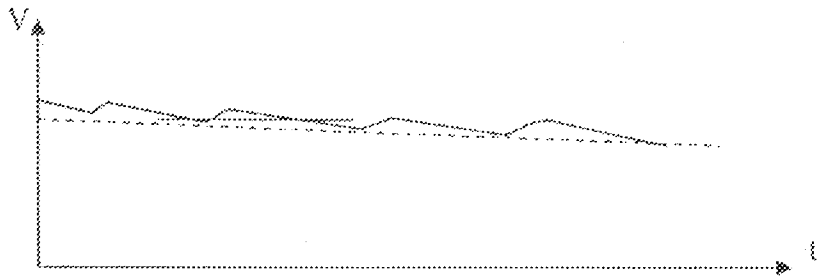

Figure 3.12c. Filtered Waveform.

The choice of a filter capacitor is based on the following equation:

$$C = (I/Vpp)*T$$

Where C = the capacitance of the capacitor in farad (f)

I = the load current in ampere (A)

Vp-p = the peak-to-peak ripple in volt (v)

T = the period in seconds (s)

Note $T = 1/f$

The capacitor used in this design is 50v, 3300µf, thus its peak-to-peak ripple voltage can be calculated as

$$Vp\text{-}p = (I/C)$$

3.1.4 VOLTAGE REGULATOR

Regulated power supply can be achieved by using a voltage regulator circuit or a Zener diode. A regulator is an electronic control circuit, which is capable of providing a nearly constant dc output voltage, even if there are variations in load or input voltage. [2] In this project LM7812 and LM7805 voltage regulator IC are use to provide the regulation.

The figure 3.13 below shows the connection of the IC. It is supplied in a To-220 case and has three terminals; the IC provides 12Volts at a load current of 1.5A The regulator is mounted on a heat sink with a mica insulator and a nylon washer around the mounting screw, in order to dissipate the heat away from the regulator.

The percentage regulation of power is given by;

$$\% \text{ Regulation} = \frac{(Vmax\text{-}Vmin)*100\%}{Vmax}$$

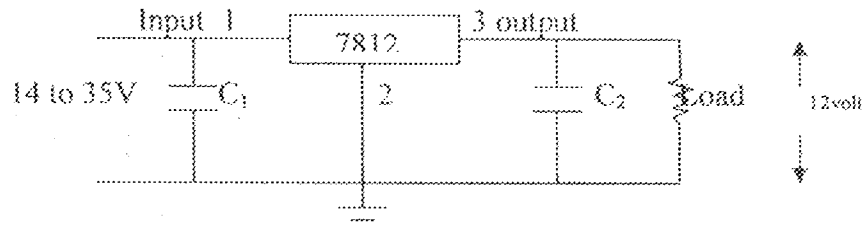

Figure 3.13 Integrated Circuit Voltage Regulator.

3.15 SUPPLY INDICATOR NETWORK (LED)

The purpose of the Light Emitting Diode (LED) use in this construction is to indicate the power supply. This network has two components, namely; the LED and the limiting Resistor. The limiting resistor of resistance value 1KΩ is used to limit the amount of current flowing in the LED. The larger the value of the resistor, the less the brightness of the LED, but if the value of the resistor is not large enough to limit the current, the LED could be damage.[4]

The voltage across silicon diode is 0.7, the current in the network is therefore;

$$I = (Vcc\text{-}0.7)/R$$

$$I = 11.3mA$$

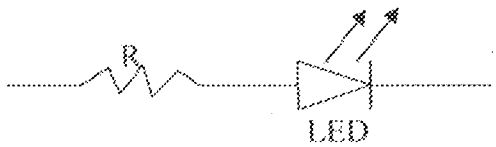

Figure 3.14 Supply Indicator Network

3.2 THE HEATING ELEMENT

To produce the required heat, a heating element is needed. Thus, a heating element which is mere a resistance wire is used, in which when voltage is supply to the wire, it will draw sufficient current from the supply which in turn generate heat. Wire of circular cross-section or rectangular conducting ribbon is used as the heating element. Under steady state condition, a heating element dissipates as much heat from the surface as it received the power from the voltage supply.[2]

If "P" is the power input and "H" is the heat dissipated by radiation then,

$P = H$ (under steady state condition)

As per Stefan's law of radiation, heat radiated by a hot body is given by

$H = 5.72eK[(T_1/100)^4 - (T_2/100)^4]$ W/m^2

Where T_1 is the temperature of the hot body in °K

T_2 is the temperature of the cold body (surrounding) in °K

Now $P = V^2/R$ and $R = \rho l/A$

$\therefore R = 4\rho l/\pi d^2$

$P = \pi d^2 V^2/4\rho l$ ……………………………………………………(1)

Total surface area of the element = $(\pi d)*l$

If H is the heat dissipated by radiation per seconds per unit surface area of the wire, then

Heat radiated per second = $(\pi d)*l*H$ ……………………………………(2)

Equating (1) and (2) we have

$P = (\pi d)*l*H$

Or $P = \pi d^2 V^2/4\rho l = (\pi d)*H$

3.2.1 DETERMINATION OF POWER RATING OF THE HEATING ELEMENT

Among the various preliminary experiments that were carried out in the process of constructing this project, is the determination of the voltage and current rating of the 0.35meter length of the heating element and its power rating.

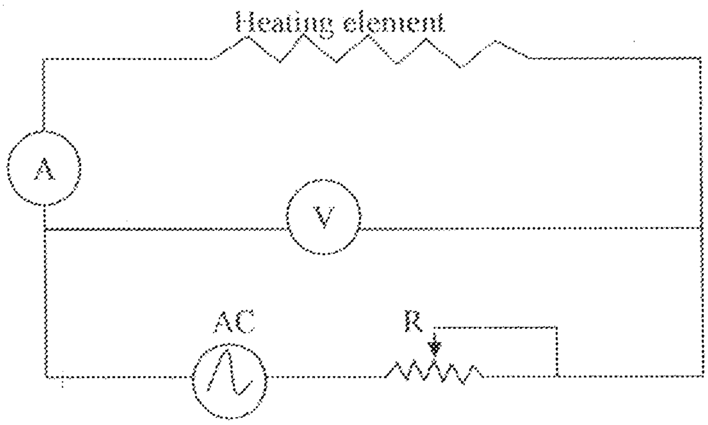

Figure 3.21. Determination Of Power Rating Of The Heater Element

The voltage and current rating of the heater element was determined with the arrangement shown in fig 3.21. It is shown from experiment above that the 0.35-meter length of the constantan wire cannot tolerate more than 24 volts at a current of 2.5 amps.

This result warrants the choice of 24-volt transformer for the element circuit and from power rating of

$$P = IV$$
$$P = 2.5 * 24 = 60 \text{ Watts}$$

Thus, in the course of this project, properties of good heating element were ensured among which are: high specific resistance, high oxidizing temperature, positive temperature co-efficient of resistance, ductility and good mechanical strength.

3.3 THE TIMING CIRCUIT (CONTROL UNIT)

This section consists of a one-shot (SN74121) Multivibrator with external timing components (resistor and capacitor), a transistor switch and a relay.

3.3.1 ONE-SHOT (MONOSTABLE) SN74121

This is a digital circuit that is somewhat related to Flip-flop (FF), one-shot has two inputs (Q and $\bar{Q}$), which are the inverse of each other. Unlike the FF, one-shot has only one stable state (normally Q=0 and $\bar{Q}$=1), where it remains until is triggered by an input signal. Once triggered, the monostable output switch to the opposite state (Q=1 and $\bar{Q}$=0), it remains in his quasi-stable state fixed period of time t_p, which is usually determined by an RC time constant which result from the value of the external components connected to the multivibrator. After a time t_p, the monostable output return to its stable state, until triggered again. [6]

The time constant t_p, is given by the formular:

$$t_p = 0.7 R_T C_T$$

Where R_T = external timing Resistor and,

C_T = external timing capacitor.

In practice, t_p can vary from several nanoseconds to several tens of seconds.

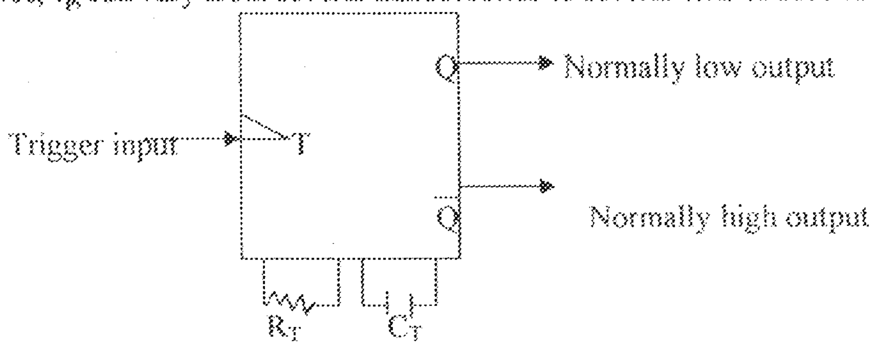

Figure 3.30 One-Shot Symbol

3.3.2 Types of one-shot

There are two basic type of one-shot available in IC form, namely;

(i) Nonretriggerable one-shot

(ii) Retriggerable one-shot

(1) Nonretriggerable one-shot

This is a one-shot in which the output pulse is independent of further input transitions during the output pulse. The waveform below illustrate the operation of a nonretriggerable one-shot that triggers on positive-going transition at its trigger(T) input.

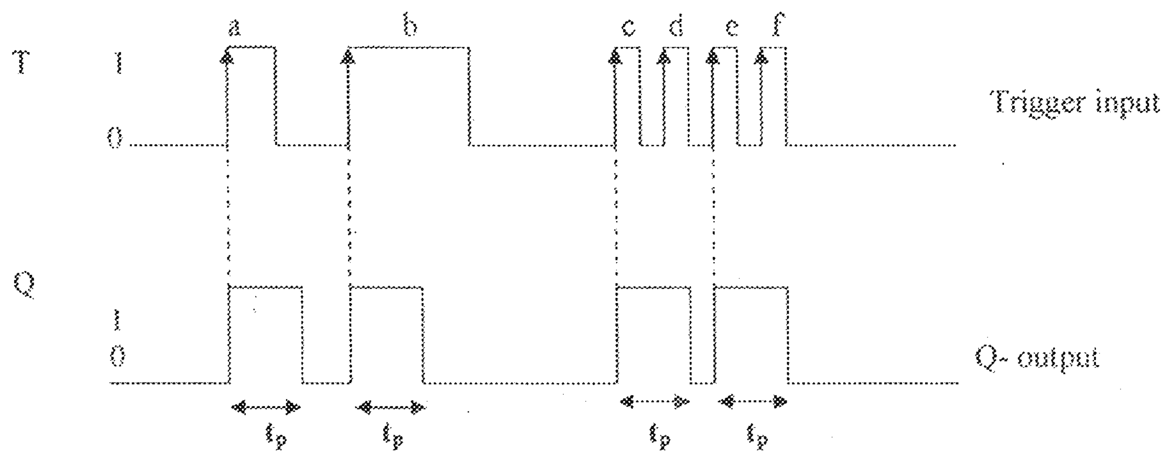

Figure 3.31 Typical Waveform For Nonretrigerable Operation

The following points need to be noted in the operation of nonretriggerable one-shot.

- The positive-going triggers (PGTs) at point a, b, c and e will trigger the one-shot to its quasi-stable state for a time t_p, after which it automatically returns to the stable state.
- The PGTs at point d and f, have no effect on the one-shot because it has already been triggered to the quasi-stable state. This means that the one-shot must return to the stable state before it can be triggered.
- The one-shot output pulse duration is always the same regardless of the duration of the input pulse.[6]

(2) Retriggerable one-shot

This type of one-shot operate much like the nonretriggerable one-shot except for one major difference, that is, it can be retriggered while it is in the quasi-stable state, and it will begin a new time interval. Most one-shot IC e.g. 74121, 74223 and NE555 timer will begin a new timing cycle if the input triggers again, during the duration of the output pulse. That is why they are referred to as retriggerable monostables. This means that the output pulse will be longer than usual, if they are retriggered during the pulse, finally terminating one pulse width after the last trigger. [5]

Out of the above-enumerated types of one-shot, nonretriggerable one-shot is employed in this design because of its characteristic that it ignores input transition during the output pulse.

3.3.2Features of nonretriggerable one-shot IC (SN74121)

Several one-shot ICs are available in both the retriggerable and nonretrigable version. The SN74121, which is a single nonretiggable one-shot, is employed in this design. The figure below illustrate the traditional symbol of the 74121 nonretrigeable one-shot IC. [5]

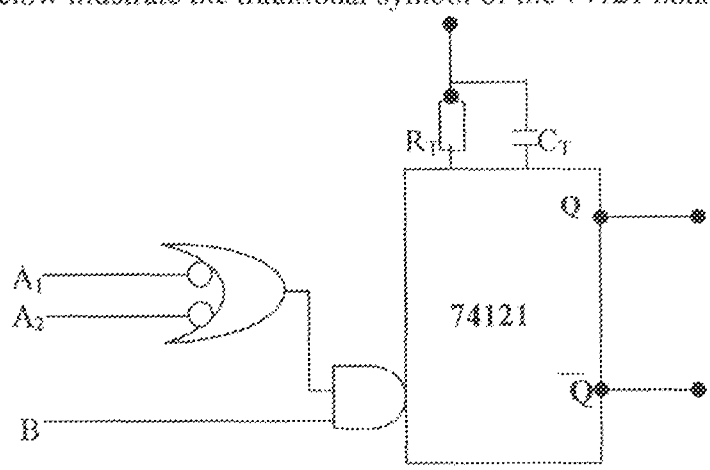

Figure3.32 Logic Symbol Of The 74121 Nonretriterable One-Shot

3.3.3 The input characteristic of 74121

One-shots are triggered by a rising or falling edge at the appropriate inputs. The only requirement on the triggering signal is that it has some minimum width, typically 25ns to 100ns. It can be shorter or longer than the output pulse. In general, several inputs are provided so that several signals can trigger the one-shot. The following are type of trigger used in one-shot multivibrator:

(i) Positive edge trigger input (low-to-high transition)

(ii) Negative edge trigger input (high-to-low transition)

74121 has three inputs with a combination of OR and AND logic gates, these internal logic gates allow input A_1, A_2 and B to trigger the IC in a variety of ways. 74121 IC was configure to triggers when one of the A inputs makes a High-to-Low transition (i.e negative edge), if the B input and the other A input are both high, as shown in the truth table below.[5]

Table 3.0 Function Tables of 74121

INPUT			OUTPUT	OUTPUT
A1	A2	B	Q	$\bar{Q}$
L	X	H	L	H
X	L	H	L	H
X	X	L	L	H
H	H	X	L	H
H	↓	H	⊓	⊔
↓	H	H	⊓	⊔
↓	↓	H	⊓	⊔
L	X	↑	⊓	⊔
X	L	↑	⊓	⊔

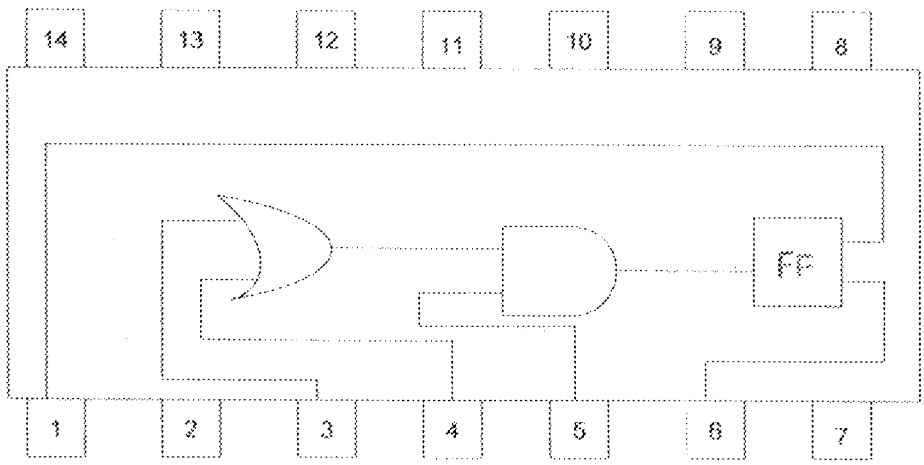

Figure3.33 Schematic Diagram of 74121

The B input is a Schmitt-trigger type of input that is allowed to have slow transition times and still reliably trigger the IC. The pin labeled R_{int}, R_{ext}/C_{ext} and C_{ext} are used to connect an external Resistor and Capacitor to achieve the desire output duration. The output pulse width of a 74121 one-shot is given by the formula: [6]

$$t_{p} = 0.7R_TC_T$$

Where R_T = external timing Resistor and,

C_T = external timing capacitor

For the purpose of this design, we employed two type of resistor i.e a variable resistor (potentiometer 0-50kΩ) and a fixed value resistor of 3.3kΩ. While the capacitance value of 470µF was chosen to obtain the required pulse duration. The fixed resistor and the potentiometer are connected in series between the R_{ext}/C_{ext} pin and Vcc, while the capacitor is connected between the C_{ext} and R_{ext}/C_{ext} pins.

Calculation

R_1 (fixed resistor)= 3.3kΩ

R_2 (variable resistor) =0-50kΩ

C_T (capacitance) = 470μF

For minimum duration of pulse:

$$T_{p(min)} = 0.7R_1C_T$$
$$= 0.7*3.3*10^3*470*10^{-6}$$
$$= 1.1\text{seconds}$$

For maximum duration of pulse:

$$T_{p(max)} = 0.7(R_1+R_2)C_T$$
$$= 0.7*(3.3+50)*10^3*470*10^{-6}$$
$$= 17.5\text{seconds}$$

Note that, once the74121 one-shot is triggered and the timing capacitor is charging through the combined resistor, no additional triggering will begins a new timing cycle

3.3.4 THE SWITCHING CIRCUIT

The switching operation is achieved with the aid of a transistor and a relay; the transistor is used to amplify the current to the relay, which in turn switches ON/OFF the heating element. When the output of the timer is fed to the base of the transistor, the transistor goes into saturation, thereby making the current to flow through the relay coil that is connected to the collector terminal of the transistor. The collector current I_C, energized the coil of the relay, thereby operating the relay.

3.3.5TRANSISTOR SWITCH

Very often most transistor are used as electronic switch, with the help of such switches, a given load can be turned on/off by a small signal. The power level of the control signal is usually very small and it is capable of providing enough base drive to switch a transistor on/off, hence the transistor is made to switch the load.

Using transistor as a switch, two levels of control signal are employed. With OFF level, the transistor operates in the cut-off region (open), whereas with the other level it operates in the saturation region and act as a short circuit. For basic operation of a transistor, its emitter-base junction (EBJ) has to be forward biased, while its base-collector junction (BCJ) has to be reversed biased. Hence a transistor under saturation (NO) condition could be switch off by mere making its base voltage equal or less than that of the emitter-base junction.[3]

For the purpose of this project, the NPN type of 2N222 is used for current amplification, and provides the switching effect for the relay. Normally, given the transistor, it is the practice to first select a quiescent point. In order to obtain such a value, we require to forward bias the EBJ, i.e. been an NPN transistor, the base should be positive with respect to the emitter. The base resistor, R_B connected between the positive supply and the base achieves this.

The NPN 2N222 has the following parameters:

$I_{Cmax} = 0.8A$

$V_{CE} = 40V$

$V_{BE} = 0.6$

$h_{fe} = 200$(typical)

The base current I_B of the transistor can be found from the equation:

$I_C = \beta I_B$

Therefore $I_B = I_C/\beta = 0.8/200 = 4mA$

But, $I_B = (V_B - V_{BE})/R_B$

Where, V_B is the output voltage at pin 6 of the IC (3.5V)

$V_{BE} = 0.6$ (for silicon npn transistor)

Therefore $R_B = (V_B - V_{BE})/I_B = (3.5-0.6)/15*10^{-3}$

$= 150\Omega$

3.3.6THE RELAY

This is an electromagnetic element that energizes whenever there is a supply of current through its coil. Thus it is an electromagnetic control switch, in which a coil pulls an armature when sufficient current flows. Hence it is capable of turning on and off the circuit automatically. [3]

The type of relay employed in this project is 12Volt dc relay, which has two contacts, i.e. the normally close (NC) and the normally open (NO) contact. When the output of the 74121 IC goes high, the transistor will be turn on and the relay is activated, this cause the normally open (NO) contact to close as the armature clicks downward, thus complete the circuit of the heating element. When the output of the timer becomes low, the transistor is cut off and the relay will be deactivated, the armature springs upward to its normally open (NO) position, thus breaking the circuit of the heating element. The resistances of the relay coil R_C is 400Ω.The figure below shows the diagram of the switching circuit

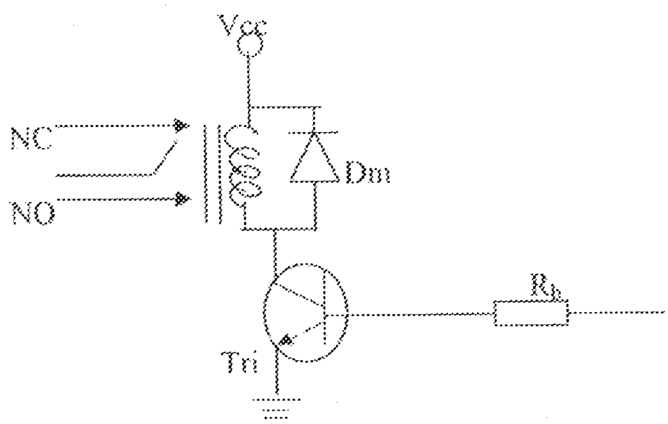

Figure 3.33. The Switching Circuit

EMF suppression

In most cases, a diode (Dm) is usually connected across the relay coil, as shown in Fig 3.33. Depending on the type of the relay, it can be a 1N4148 for a very small relay (reed) or a 1N4001 for a normal miniature relay like the one employed in this design. The diode IN4001, connected in parallel with the relay coil is called the Freewheeling diode or a Commutating diode; it is use as a protective devices.

When the current flowing through an inductor or coil is interrupted, a higher voltage in the reverse direction is generated by the collapsing magnetic field. This voltage can be as high as ten times the Vcc (source voltage). As coil is connected to a transistor, the back 'Electro Magnetic Force' (EMF) can be high enough to destroy the device. Anyways, the same happens across the relay contact when connected to an inductive source. This creates contact arcing, which is energy that must be dissipated somehow. One way of doing that is to place a diode across the relay coil (or contacts) which conducts when the magnetic field collapses and so effectively short circuit the voltage. The decision to use a diode or not depends on the voltage and currents involved. Also, placing a diode across the inductor causes current to flow longer and lengthens the hold-in time of the relay.. Since the coil of the relay has a large amount of inductance when the transistor is operating in cut off mode, this generate a very large voltage spikes (arching), the diode thus block the voltage spikes from hitting the rest of the circuit, i.e. prevent the high voltage inductive kickback from the relay coil.

3.4 COMPONENTS ARRANGEMENT ON THE VERO BOARD

Before the components were assembled on the Vero board, all components were tested with a multi-meter, to ensure that they are in good operating condition. When this is satisfied, the laying out of components was then made on a breadboard as temporary circuit layout to ascertain that the circuit works as expected. Some corrections were made before final transferring of the component to the Vero board for permanent connections and soldering. The fixing of all components was done with great care to ensure that all leads were fixed in line with the circuit diagram and well soldered

The components were arranged sequentially according to the specification in the circuit diagram, the power supply unit, follow by the control and switching circuit. In the power supply unit, the output of the transformer is connected to the bridge rectifier, which convert the ac input to dc output. Then a filter capacitor is used to filter out the ripple, before it is connected to the voltage regulator, which stabilized the voltage (12volt and 5volt dc) that is used to power the control and the switching circuit .The 74121 IC is connected with an 14-pin IC socket, in order to allow for easy replacement of the IC in case of damage, the associated external components (the variable resistor and the capacitor) of the timer were also connected.

The Q-output pin of the 74121 (pin 6) is connected to the base of the transistor and the collector terminal of the transistor is connected to one terminal of the 12v dc relay coil, which serves to switch the heating element on/off automatically. A diode (IN4001) called free wheeling diode is also connected across the relay coil in order to prevent the circuit against kickback voltage.

The choice of material used for the construction of the casing was based on cost, mechanical strength and reliability of the material; therefore the casing was constructed from a metal sheet.

3.5 SOLDERING METHOD AND PRECAUTIONS

3.5.1 Soldering process

Soldering is a process of joining two pieces of wires or a wire and metal lug together by melting an alloy of lead and tin (solder) through the use of soldering iron, to make an electrically continuous and sound connection.

Soldering iron and solder (lead and tin) are used in low temperature and non-heating appliance. Having heated the soldering iron to its operating temperature, the soldering lead is thus brought close to its tip, which is already place close to the point of connection for pre-heating. Thus, down to give a bright shiny and smooth surface with a strong mechanical joint.

3.5.2 Precautions taking during soldering

In engineering, safety precautions are measures taken to prevent accident to operators, as well as the components and materials used. In electronics, these precautions are imperative, which requires great care and which are always dealt with. To ensure a good soldering and effective operation of the circuit, some precaution has to be ensured since a little mistake while soldering can render the whole circuit useless. Among the precaution taken are:

- Adequate care was taken while carrying out the soldering, so as to avoid short-circuits on the board.
- The IC was mounted on IC socket to prevent damage due to soldering.
- Turning and tinning of the soldering iron bit was ensured throughout.
- Visual inspection was also made to ensure there is no missing joint, no problems of insufficient solder, excessive solders, crystallized solder, dry solder etc.

CHAPTER FOUR

TESTS, RESULTS AND DISCUSSION.

4.1.0 STAGE BY STAGE TESTING

Stage by stage testing was done after the final assembling of the components on the board. The first test was carried out on the transformer in which a voltmeter was connected across the output of the center-tapered transformer to determine the output voltage, and approximately 24volt and 12volt ac was obtained. This is confirmed because the transformation ration of the transformer is 10 thus when the input voltage from the mains is 220V, the output gives 22V and 11V, which is also within the range. A dc voltmeter is connected across the output of the rectifier to ascertain that it actually converts the ac to the required dc voltage. The 12V dc output of the rectifier circuit is thus connected to the LM7812 and LM7805 voltage regulator, which stabilizes it to constant 12V and 5V that powers the relay and control (timer) circuit respectively.

A test was also carried out on the control section, the output of the 74121(pin6) was tested with an oscilloscope to determine the pulse width as the variable resistor is being varied and various calibrations were made. Also an ammeter is connected in series with the output (collector terminal) of the transistor to determine whether the current is sufficient to energize the relay.

4.1.1 FINAL TESTING OF THE CIRCUIT /OVERALL TESTING

The supply cable (power cord) was connected to the mains (220/230volt), thus the power transformer is energized and the push button (trigger) controlling the electronic timer is activated, the output voltage of the regulator was checked for stability and this gives exactly 12V and 5V for the proper operation of the circuit. The 74121 produces one-shot pulse as it is triggered through pin 6,while the variable resistor (potentiometer) was set to a desired range, thus energizes the relay coil, which complete the circuit of the heating element with 24volt from the transformer, this cause the element to glow. When the preset time has reached, the output of the 74121 goes low and the relay coil de-energized and the completed circuit to the heating element was opened, there was no more power supply to the heating element, thus it cools off. When another preset time is set, the circuit switch-on again for normal operation, this was repeated for different range of potentiometer values, and it was discovered that as the resistance increased the time taken for the heating element to switch-off increased. Thus, various calibrations were made for various thickness of the polythene nylon to be sealed, precisely 2μm-1mm thickness.

4.20 DISCUSSIONS

The result of this test shows that the circuit works as it has been designed to work, as an automatic polythene sealant which swicthes on/off automatically at a prescribed or preset time. Thus, this can be used to seal any polythene material within the range of (2μm-1mm) thickness.

4.30 OPERATING INSTRUCTION

The automation here is the principle that, the circuit operates and switch off automatically depending on the preset time. To use this automatic polythene sealant the following procedure should be followed.

(i) Plug the power cord to the mains (220/230volt) supply.

(ii) Adjust the time knob (potentiometer) according to the thickness of the polythene

(iii) Place the top of the polythene nylon on the sealing work place.

(iv) Press the sealing arm on the platform until the indicator lamp goes off

4.40 PROBABLE FAULTS, CAUSES AND REMEDIES (TROUBLES SHOOTING)

An automatic sealing machine is a machine that incorporates an electronic timing system for varying the required time of operation instead of manually operating the machine. Fault of various kinds can occur within the system. But, before maintenance or repair is carried out on the machine, the following are the common troubleshooting guide.

Table 4: Faults and Remedies

S/N	TYPE OF FAULT	PROBABLE CAUSES	SOLUTION
1.	The machine fails to operate	(i) Power supply failure (ii) Open-circuit in the supply/heating element. (iii) Switch fails to close	(i) Check if there is supply from the mains (ii) Test for open circuit in the heating element circuit using an ohmmeter. (iii) Replace the switch with good one
2.	Power indicator lamp on and off continuously	(i) Loose socket/plug, resulting in possible loss of contacts	(i)Replace the socket/plug and make sure it is firmly fixed
3.	Fuse or circuit breaker goes off on load	(i) Short circuit in the cable (ii) Earth fault	(i) Test for short circuit within the cable (ii) Test for earth fault on the transformer
4.	Control circuit fails to operate	(i) Failure of supply to the control input (ii) Relay coil fails to energize (iii) Open circuit in the control circuit	(i) Restore the supply to the input (ii)Replace the relay (iii)test for open circuit and clear the fault.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 INTRODUCTION

This chapter deals with the summary, conclusion, and the recommendations of the project. It also includes some observation and problems encountered in the cause of carrying out the project work.

5.1 SUMMARY

This project basically dealt with the design and construction of an automatic polythene sealant. This was however clearly indicated in chapter one of this write-up, where also the basis for the design and construction were said to include production of more cheaper and convenient method of sealing polythene material for efficient packaging and preservation of wrappable goods/product manufactured locally.

Chapter two dealt with the fundamentals of automatic polythene sealer, and the concept of component used. While Chapter three dealt with the design procedure and construction, here different circuit stages applied in the project were clearly indicated. This includes the power supply unit, the control (timing) unit and the heating element output unit. This chapter also includes how the components are assembled on the Vero board. It also indicates the principle of operation of the complete circuit.

Chapter four includes the testing, the result and the discussion, it also contain the operating instruction of the polythene sealant and the troubleshooting analysis while the last chapter contains the summary of the work, the conclusion and the recommendation.

5.2 CONCLUSIONS

The aim and objectives of this project work has largely been achieved, that is to design and construct an automatic polythene-sealing machine, which is a contribution to the field of engineering. Its principles is based on the application of heat to seal a polythene material of different sizes and thickness, this was achieved by the heat produced in the heating element, which is being controlled by the timing circuit, and timing a relay of magnetic type whose operation is electromagnetic in nature. All these were combined to work as a system, thereby producing the automatic controlled polythene sealer.

This venture in the field of advance circuit theory can also serve as a stimulant for others who consider undertaking topic related to it. However, not only relatively cheaper and easier to maintain, this automatic polythene sealant is also highly economical and safer to operate.

5.3 RECOMMENDATIONS

It is recommended that this project work should be constructed in large scale in order to boost the production and packaging the goods manufactured in the country. This design will also help the students to practically demonstrate the theoretical knowledge they have acquired in classroom on the principle of automation.

5. 4 PROBLEMS ENCOUNTERED AND PREFERRED SOLUTION

In the course of carrying out the design and construction of this project, some problems were encountered, to which solution were proffered. Some of the problems are; breaking down (damage) of some components as a result of careless handling and subjecting the components to excessive heat during soldering. Thus extra care was taken in handling some of this sensitive component and IC socket were used in order to prevent subjecting IC to excessive heat during soldering. Scarcity of components also form part of the problem encountered, especially the transformer used is not very easy to come by, because the current rating of the transformer to be use must be a bit be higher, which is unavailable in the market but the available one is 24volt with output current of 5Amp, that is why a 12volt regulator is used to regulate the voltage to 12v that is suitable for the operation of the control circuit. Also in order to avoid time wastage, an equivalent component was also used for some other component that are not available in the market.

False triggering of the One-shot (IC), as a result of the IC being triggered by too shot an input pulse. Since most one-shot are prone to false triggering from glitches in the Vcc line or ground, this problem was overcome with the design of a delay circuit, that delayed the triggering time by 0.3second.

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APPENDIX 1

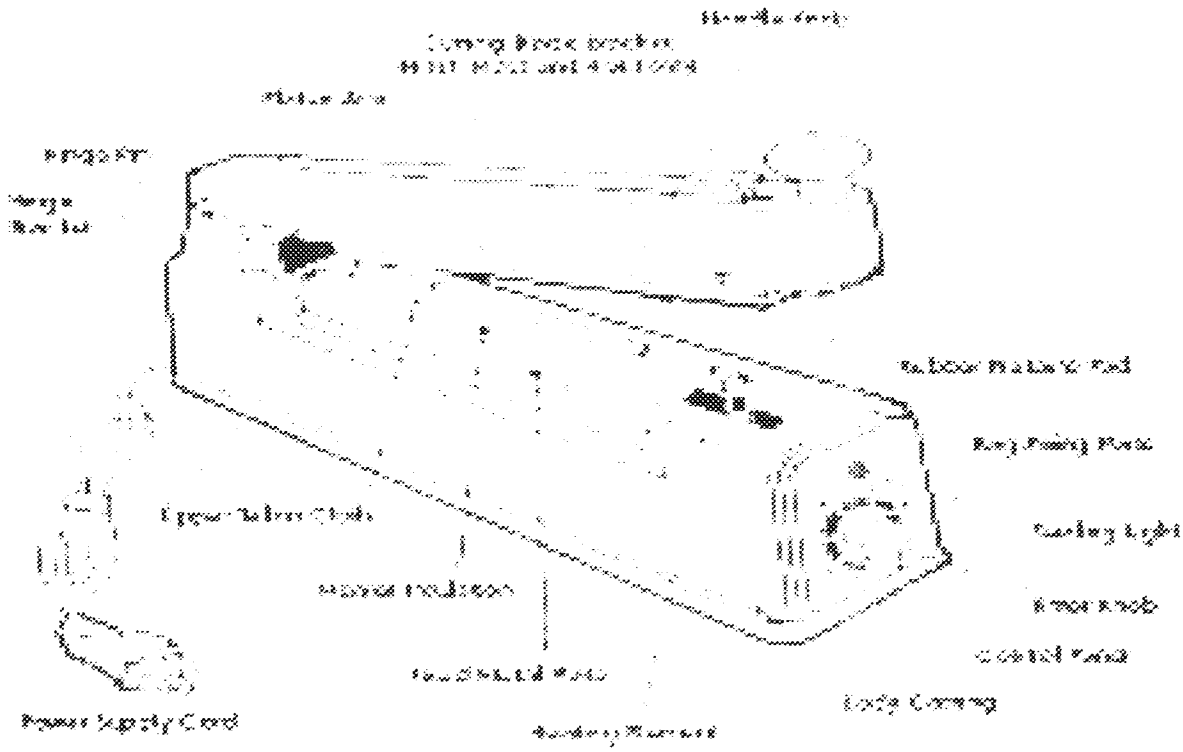
TABLE 1.0
COMMOM RECTIFER DIODE RATING

Device	Peak Inverse Voltage (V)	Average Rectified output current (A)	Non repetitive peak surge current (A)
IN4001	50	1	30
IN4002	100	1	30
IN4003	200	1	30
IN4004	400	1	30
IN4005	600	1	30
IN4006	800	1	30
IN4007	1000	1	30
IN5400	50	3	200
IN5401	100	3	200
IN5402	200	3	200
IN5404	400	3	200
IN5406	600	3	200

TABLE 2.0
DIODE RATING FOR VARIOUS SUPPLY CIRCUIT

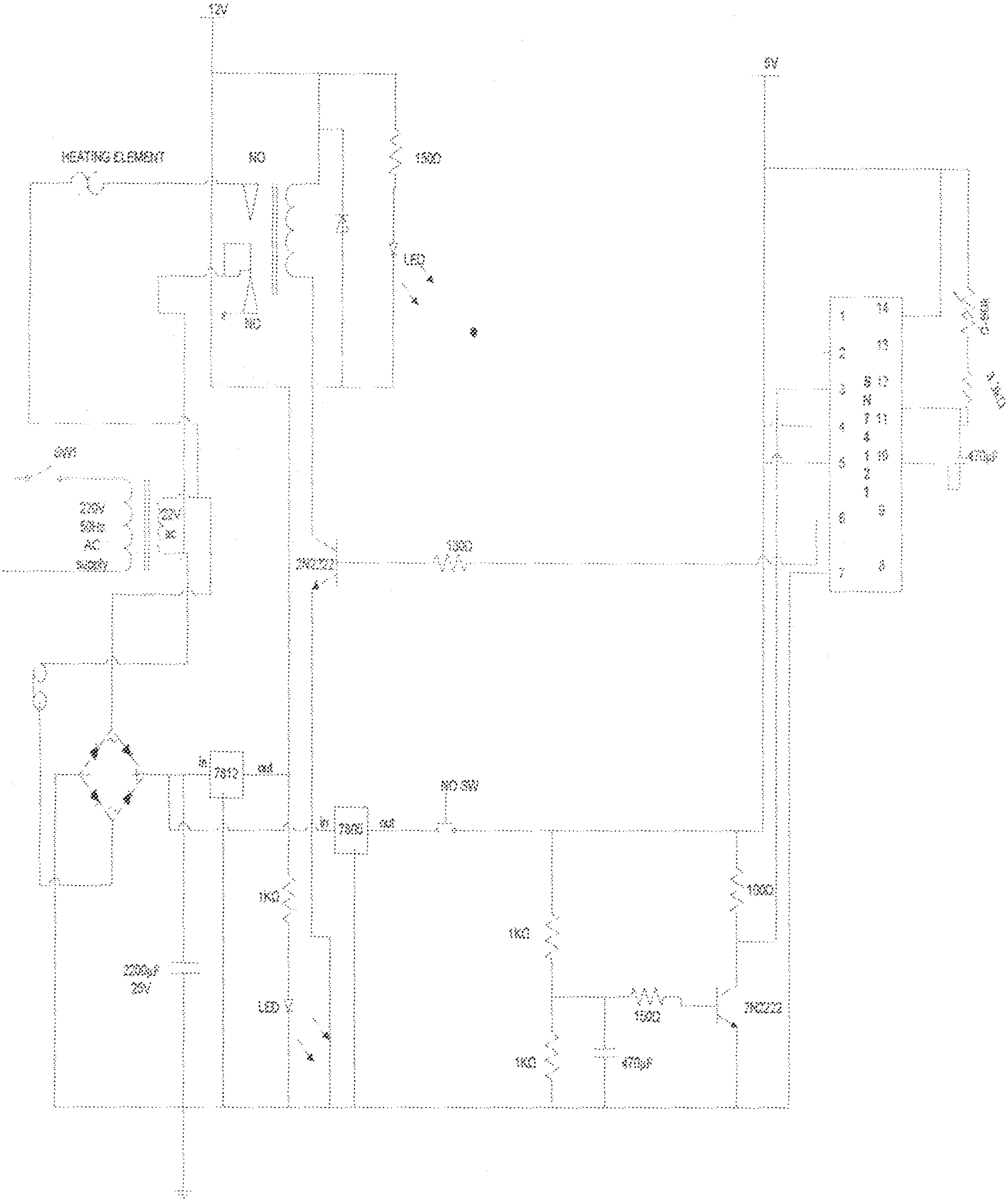
Schematic	Name	PIV per diode	PIV per diode with capacitor filter	Diode current
	Half wave Rectifier	$1.41V_{rms}$	$2.82V_{rms}$	I_{dc}
	Full wave Rectifier	$2.82V_{rms}$	$2.82V_{rms}$	$0.5I_{dc}$
	Bridge Rectifier (Full wave)	$1.41V_{rms}$	$1.41V_{rms}$	$0.5I_{dc}$

APPENDIX 2



AUTOMATIC POLYTHENE SEALER

APPENDIX 3



CIRCUIT DIAGRAM OF AN AUTOMATIC POLYTHENE SEALER