DESIGN AND CONSTRUCTION OF AN AUTOMATIC POLYTHENE SEALING MACHINE

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A Thesis Submitted to the Department of Electrical and Computer Engineering, Federal University of Technology, Minna, Niger State.

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DEDICATION

This work is dedicated to my family and all hardworking staff and students of the Federal University of Technology, Minna in general and Electrical and Computer Engineering Department in particular.

DECLARATION

I, Musa Abdulwaheed A. 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.

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CERTIFICATION

This is to certify that this thesis; Design and Construction of Automatic Polythene Sealing Machine, is the original work of **Musa Abdulwaheed A.** carried out under the supervision of **Mr. A.S.Muhammed** for the award of Bachelor of Engineering (B.ENG) in Electrical and Computer Engineering Department of the Federal University of Technology, Minna.

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Praise is to Almighty Allah, the lord of the universe, the Most Gracious, Most Merciful for His love and protection. I acknowledge the incalculable and unequalled efforts of my parents Alhaji and Hajia Musa Elemosho and other members of my extended family.

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ABSTRACT

The design project is aimed at design and construction of an automatic polythene sealing machine. The essence is for safety, efficiency, convenience and effectiveness of sealing polythene materials used in packaging goods/products that are manufactured locally.

The design is based on the principle of application of electric current through a resistance wire which produces the heat required for sealing of the polythene material when a leaf switch triggers a monostable that activates an electromagnet.

An electronic timer controls the electronic machine which is made adjustable to accommodate different thickness of polythene material.

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CHAPTER ONE

INTRODUCTION

1.1 Background (Expository Introduction)

Automatic Polythene Sealing Machine is an electronic device designed and constructed for automatic sealing of polythene materials. Polythene or polyethylene material is a strong light plastic used to make water proof packaging, sheets for covering food, small containers and other related items. The dictionary meaning of the word 'seal' is to stop what something contains from getting out. [1]

Knowledge and ideas have never been produced so fast, yet the gap between our capacity to create knowledge and use it for vital causes is widening. Scientific knowledge has been key to assist humanity to develop important dreams. The dreams of a mutual construction of a better world - an old common utopia. [2]

Against this premise, developing (and underdeveloped) countries are striving very hard to build there economies in other to raise the standard of living of their citizenry. Hence to avoid waste, there is a need for companies' products which are not to be immediately consumed to be preserved. Examples of such companies are food processing company, pharmaceutical company, water contamination and damages.

For the preservation of such goods, insulating materials which are water proof are employed i.e. polythene. This accounts for the essence of a sealing machine.

The sealing machine so designed has a timer control to accommodate different polythene material Thickness.

1.2 Objective of the Project

The essence of the design and construction of the Automatic (electronic) Polythene Sealing Machine is to enhance sealing of polythene materials that are used in packaging goods and items. When heating system e.g. micro wave are properly installed, they are capable of supplying highly satisfactory heating performance. In other words, system that is not properly installed will not perform satisfactorily if it works at all. Therefore, efficiency and effectiveness of the work (system) are paramount in the design construction objective.

Furthermore, the objective of the work includes designing a highly economical system and its affordability. To this effect, maintenance cost has to be low, it has to be affordable and its (the system) use for variety of polythene materials must be enhanced.

1.3 Methodology of the Project

Basically, the project was carried out in the following order. After conceptualization of the work, the design was worked upon and developed through a thorough research on earlier academic work available. A similar circuit earlier developed was improved upon with the following modification

a. Auto-Locking Mechanism

b. Variable Timing Relay and

c. Electronic Power Control

The circuit design was then simulated. After the design work, it was tested run on bread board before the actual construction.

1.4 Feature of the Automatic Sealing Machine

The Automatic (electronic) Sealing Machine was built around three main subsystems.

a. an adjustable monostable multivibrator,

b. a solenoid actuator unit and

c. a power triac control unit.

The machine assemblage consists of two parts hinged together with a return spring as shown in the figure below

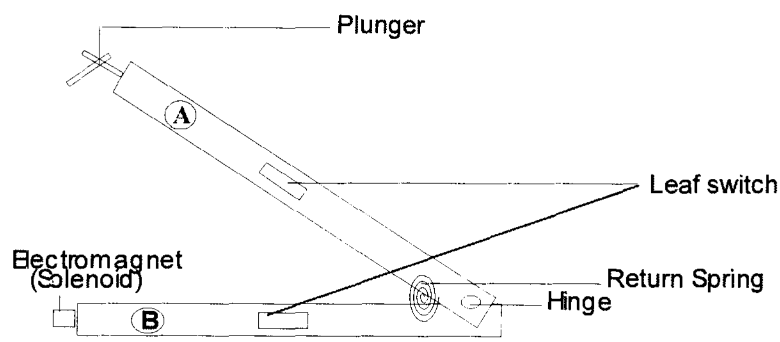

Fig 1.1 Mechanical Assemblage of the Sealing Machine

1.5 The Basic Working Principle of the Project

When the two plates A and B shown in the fig 1.1 are brought together, the leaf switch triggers a monostable and then activates the electromagnet, pressing the plunger in. At the same time, an opto –triac is switched on. This in turn switches on a high power BT139 triac controlling the heating element. The heating element is thus fed with 240AC for a period of time determined by the timing component on the monostable. The solenoid is de-energized and thereby releasing the plunger when the set time of the monostable is out. The return spring thus separates A and B.

1.6 Block Diagram Overview of the Project

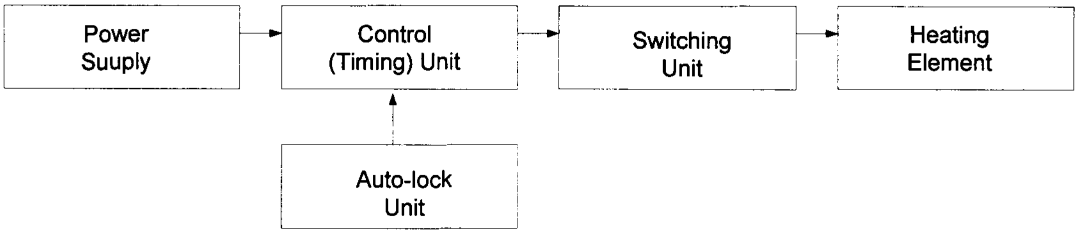

Fig 1.2 Block Diagram Overview of the Project

1.7 The Scope of the Project

As highlighted, the concept of this project spans across various situations and factories e.g. food packaging industry, electronic chips manufacturing industry e.t.c. The scope of this project is therefore to provide simple, low cost but effective sealing machine for homes, small and medium sized factories.

CHAPTER TWO

LITERATURE REVIEW/THEORETICAL BACKGROUND

2.1 Evolution of Heating System

Until the beginning of 19^{th} Century, the effect of heat on the temperature of a body was explained by postulating the existence of an invisible substance called the calorie. According to the calorie theory of heat, a body of 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 its own.

Calorie theory successively explains some phenomena of heat transfer. Experimental evidence also presented by American-born British Physicist, Benjamin Thompson 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, another British Physicist, James Prescott Joule, in series of experiment, 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.[3]

Electrical energy can be converted to heat energy by passing electric current through a resistance wire for some time, and the energy dissipated can be measured in volt-Ampere Hour. Research and implementation of heating element control only took-off seriously in the 80s when the need to automatically control heating system became very important. This explains the relatively few availability of text that discusses extensively important aspect of Electronic Engineering. However, a Scottish Professor of Chemistry, Andrew Ure, first introduced the device for controlling heating system in 1830.

The concept of packaging manufactured products in polythene bags using devices started long ago. Such practice metamorphosed into the present method of packaging products in polythene bags using automated sealing machines. The products so packaged are labeled or named differently for the purpose of standardization and improvement of such products. [3]

Electric heating is extensively used both for domestic and industrial applications. While domestic application includes hot plate for cooking, electric iron, immersion heaters for water heating etc., industrial application of electric heating includes heat treatment of metals, molding of glasses etc. [4]

2.2. Theoretical Background

The transfer of energy from one part of substance to another or from one body to another resulting from difference in temperature is referred to as Heat in physics. It is always another substance at a lower temperature thereby raising the temperature of the latter and leaving that of the former substance. [4]

2.2.1 Method of Electric Heat Production

Heat is produced due to the circulation of current through a resistance. The current may circulate directly due to the application of potential difference or it may be due to induced eddy current. There are other methods of producing heat. The different methods of producing heat for industrial and domestic purposes are classified as shown below.

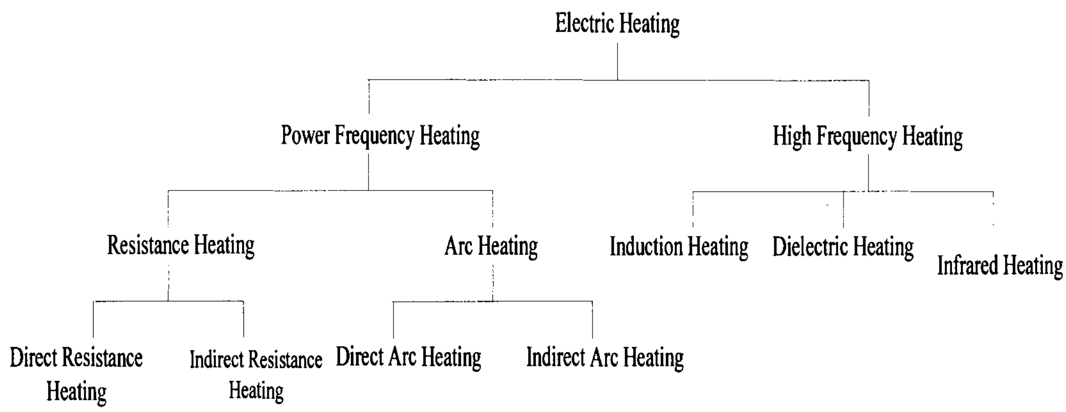

Fig: 2.1 Methods of Heat Production

2.2.2. Method of Heat Transfer

Heat can be transferred from a hot body to a cold one either by conduction, convection or radiation.

i. **Conduction:** It is a mode of heat transfer where one molecule of the body gets heated and transfers some of the heat to the adjacent molecule and so on. There is a temperature gradient between the ends of the body being heated.

ii. **Convection:** It involves the transfer of heat by the flow of hot and cold air current. This is the method of heat transfer applied in the heating of water by immersion heater or heating of building. The quantity of heat absorbed by convection 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, T_2 are the temperatures of the heating surface and the fluid in ^{o}k respectively.

iii. **Radiation:** In this process, heat is transferred 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,

$$H = 5.27eK\left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] W/m^2 \quad \text{.......(2.1)}$$

Where k is a radiating efficiency and

e is emissivity of the heating element.

If d is the diameter of the heating element and l is the total length, then its surface area from which heat is radiated is

$$\pi \times d \times l \quad \text{.......(2.2)}$$

If H is the power radiated per square meter (m^2) of the heating surface , then total power radiated as heat H_T is $H \times \pi dl$ [4]

2.2.3 Resistance Heating

Resistance heating is based on the I^2R effect. When current is passed through a resistance element I^2R loss takes place which produces heat. Two methods of resistance heating include Direct Resistance Heating and Indirect Resistance Heating.

I. Direct Resistance Heating: In this method of heating, the material to be heated is treated as a resistance and current is passed through it.

II. Indirect Resistance Heating: Here, electric current is passed thorough a resistance element placed in an electric oven. Heat produced is proportional to I^2R losses in the heating element.

The heat so produced is delivered to the charge either by radiation or combination of the two.

2.2.4 Requirement of a Good Heating Element

A good heating element is required to have the following properties:

I. High melting Temperature

II. Low Temperature Coefficient of Resistance

III. High specific Resistance

IV. Mechanical Strength

V. High Ductility and Flexibility

2.2.5 Design of Heating Element

Normally, wires of circular cross section are used as heating elements. Under steady-state conditions, a heating element dissipates as much heat from its surface as it receives the power from the electric supply. If P is the power input and H is the heat dissipated by radiation, then P = H under steady-state conditions.

Recall, equation (2.1), Stefan's law of radiation. Heat radiated by a hot body is given by

$$H = 5.27eK\left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] W/m^2$$

But $P = V^2/R$ .... (2.3)

$$\text{and } R = \rho\frac{l}{A} = \frac{\rho l}{\pi d^2/4} = \frac{4\rho l}{\pi d^2} \quad \text{...(2.4)}$$

Therefore, from equations (2.3) and (2.4)

$$p = \frac{V^2}{4\rho l / \pi d^2}$$
$$= \frac{\pi d^2 V^2}{4\rho l} \quad \text{.......(2.5)}$$

Total surface area of the wire of the element

$= (\pi d) \times l$

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

$$(\pi d) \times l \times H \quad \text{.......(2.6)}$$

Equating (2.5) and (2.6)

$$\frac{\pi d^2 V^2}{4\rho l} = (\pi d) \times l \times H$$
$$dv^2 = 4\rho l^2 H$$
$$\frac{d}{l^2} = \frac{4\rho H}{V^2} \quad \text{.......(2.7)}$$

The values of l and d can be obtained from equations (2.5) and (2.7) [4]

2.3 Merit and Demerit of Electric Heating

2.3.1 Merit of Electric Heating

When compared to other methods of heating using coal, fire e.t.c., electric heating is far superior because of the following reasons:

I. **Cleanliness**: Since neither dust nor ash is produced in electric heating, it is a clean system of heating requiring minimum cost of cleaning. Moreover, the material to be heated does not get contaminated.

II. **No Pollution**: Since no flue gasses are produced in electric heating, no provision has to be made for their exit.

III. **Ease of Control**: It is easy to control and regulate the temperature of an electric heating system. This is not possible in any other known form of heating.

IV. **Special Heating Requirement**: Special heating requirements such as uniform heating of a material or heating one particular portion of the job without affecting its other parts can be met only by electric heating.

V. **Lower Attention and Maintenance Cost**: Electric heating equipment generally will not require much attention and supervision and their maintenance cost is almost negligible.

VI. **Higher Efficiency**: Most of the heat produced electrically is utilized for heating the material itself (e.g. no waste passing through chimney or other byproducts)

VII. **Safety**: Electric heating is safe. [4]

CHAPTER THREE

DESIGN AND CONSTRUCTION

3.1 Introduction

The design of this work incorporates the basis of ac rectification in the power circuit and switching in the control circuit which involves the use of discrete components. The Automatic Sealing Machine comprises the following major sections:

I. Power Supply Unit
II. Heating Element Unit
III. The Control (Timing) Unit
IV. Auto-lock Unit

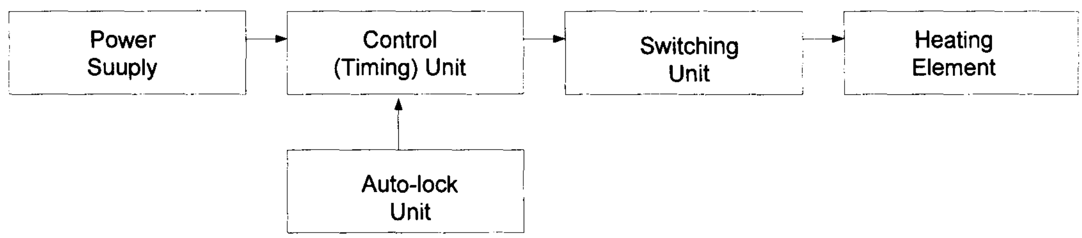

Fig 3.1: Block diagram of an Automatic Polythene Sealing Machine.

3.2 Power Supply

All electronic appliance or instruments require a source of dc power before their normal operation. At times, the source is a battery, but more often the power is obtained from a unit that converts the normal ac mains supply (240V at $50H_Z$) to some different values of dc voltages. The function of the power supply unit is to provide the necessary dc voltages and current with low ac ripples, with good stability and regulation. There are various methods of achieving a stable dc voltage from the ac mains, but only two methods are commonly used – A linear stabilizer and a switching mode stabilizer. [9]

A linear stabilizer method was considered for the purpose of this work because of its simplicity. It consists of four basic stages: a step down transformer, a full wave bridge rectifier, filter capacitor and a voltage regulator.

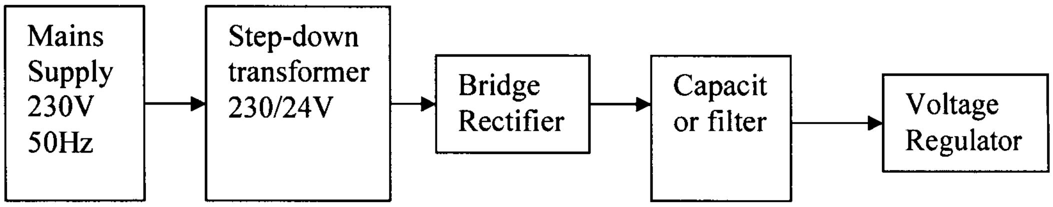

Fig 3.2 The Block Diagram of the power supply.

A regulated +9V dc supply was required for the system operation. This was realized using a step-down transformer to convert the 240V input to 24V and rectify before regulating.

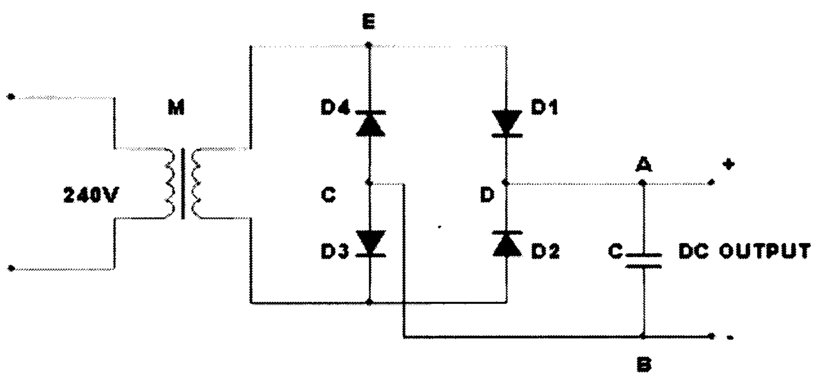

Fig 3.3 AC-DC Converter

The 24V ac voltage was peak-rectified by a full wave rectifier to produce a dc with peak voltage.

$V_{dc} = (V_{rms} \sqrt{2}) - 1.4$

For a 24Vrms input

$V_{dc} = 24\sqrt{2} - 1.4$

= 32.5V

This voltage was smoothened by a 2200uF capacitor and fed into a 7809 regulator.

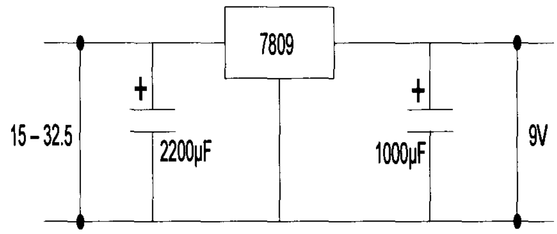

Fig 3.4 9V regulator

The 7809 is a 9volt regulator. It regulated the 32.5v input down to 9V needed for the circuit operation. The 9V output was stabilized by a 1000uF Capacitor.

3.2.1 Transformer

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. [5] For the purpose of this project, a step-down center tapped transformer was used to provide the necessary voltage required in the circuit.

Calculation

For a sinusoidal input voltage, the flux $\varnothing$ varies alternatively i.e.

$\varnothing = \varnothing_{max} \sin wt$

The instantaneous voltage in the primary side is due to Faraday's Law

$$E_1 = d\varnothing N_1/dt$$

$$= 2\pi f N_1 \varnothing_{max} \cos wt \qquad \text{———————} \qquad (1)$$

Where $w = 2\pi f$

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

$$= 4.44 f N_1 \varnothing_{max} \qquad \text{———————} \qquad (2)$$

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

$$Vs/Vp = Es/Ep$$

$$= 4.44fNs\varnothing_{s}max/4.44fN_{p}\varnothing_{pmax}$$

Therefore Vs/Vp = Ns/Np

$$Vs = (Ns/Np)\ Vp \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_} \qquad (3)$$

Where Vp = input voltage

Vs = output voltage

Np = number of turns in the primary winding

Ns = number of turns in the secondary winding

$\varnothing_{pmax}$ = maximum flux in the primary winding

$\varnothing_{smax}$ = maximum flux in the secondary winding

Ep = the e.m.f value of input voltage

Es = the e.m.f value of the output voltage

Also IpNp = IsNs

$$Is = (Np/Ns)\ Ip \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_} \qquad (4)$$

Where Ip = the input current

Is = the output current

Combining equations (3) and equation (4)

$$Vs/Vp = Ns/Np$$

$$= Ip/Is \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_} \qquad (5)$$

3.2.2 Rectification

It involves the conversion of alternating current (ac) to direct current (dc) using rectifiers. A rectifier is an electronic device that offers low resistance to the flow of current in the positive direction (i.e. forward bias) and high resistance to the flow of current in the negative direction (reverse bias) [6].

Rectifiers are used to carry out either half-wave or full-wave rectification depending on the application. Full wave bridge rectifier was considered in this project. This allows the flow of dc current in the output throughout the alternating cycle of the input signal.

3.2.3 Operation Mode

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 3.5. Diodes D1 and D3 became forward biased, while diodes D2 and D4 are reversed biased. It means current flows along the path MEDABCFN thereby charging the Capacitor C.

During the negative input half cycle of the ac voltage, secondary terminal N of the transformer becomes positive and M negative. Diodes D2 and D4 are then forward biased while diodes D1 and D3 are reverse biased. Current thereby flows along NFDABCEM charging the capacitor C.

This way, current keeps flowing through the circuit in both cycle of the ac input supply, thereby supplying a constant dc voltage. Fig. 3.4 shows the waveform of this operation.

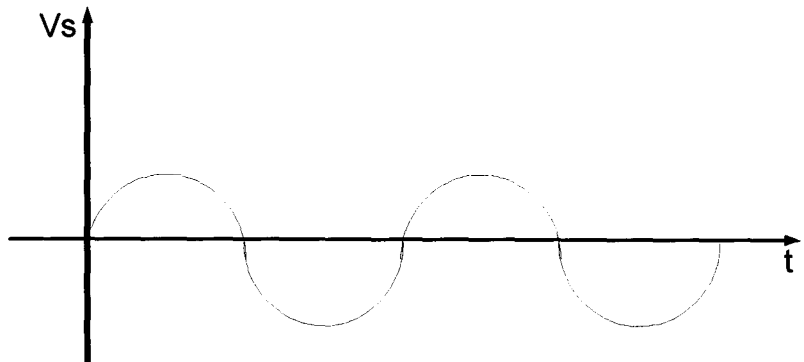

Fig 3.6 (a) input waveform

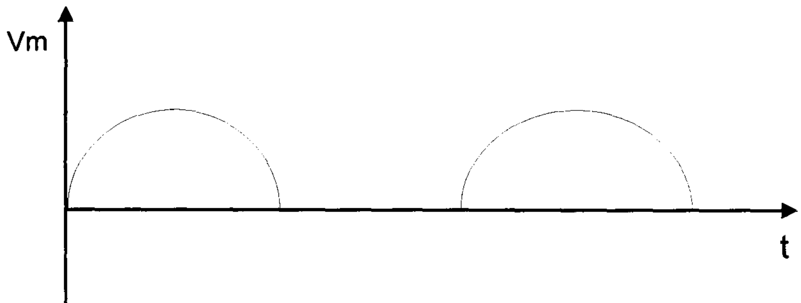

Fig 3.6 (b) Output of D1 and D2

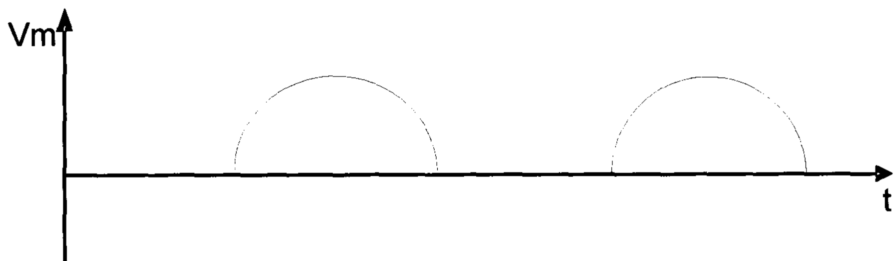

Fig 3.6 (c) Output of D2 and D4

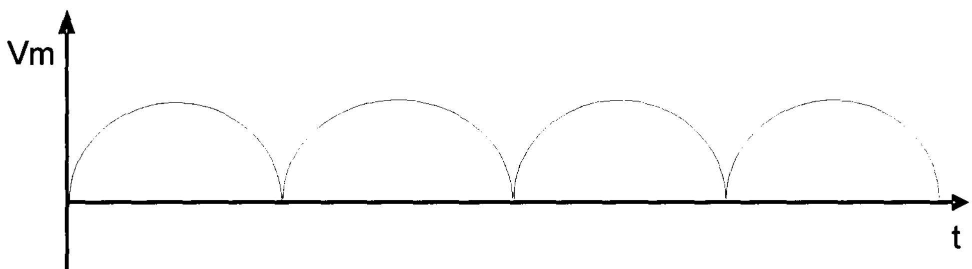

Fig 3.6 (d) full wave output

Figure 3.6 The input and output waveform of a bridge rectifier

3.2.4 Smoothening and Filtering

The filter is required to smoothen the pulsating dc output of the rectifier. Various types of filter are built using a combination of an inductor and a capacitor or with resistor.

In this work, two capacitors were employed. An electrolytic capacitor which smoothens the pulsating dc output and another capacitor which filters out noise.

The choice of a filter capacitor was based on the following equation.

$C = (I/V_{pp}) \times T$

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

I = the load current in ampere (A)

V_{pp} = the peak to peak ripple in volt (v)

T = the period in seconds (s)

3.2.5 Voltage Regulator

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 [4]. Therefore, regulated power supply can be achieved using a voltage regulator circuit. For the purpose of this work, 7809 voltage regulator IC was used to provide the regulation.

The figure 3.4 above shows the connection of the IC. 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 [5].

The percentage regulation of power is given by

% regulation = (Vmax-Vmin) / Vmax X 100%

3.2.6 Power Supply Indicator

Light emitting diode (LED) was used in this work to indicate power supply. The network has two important components: the LED and the limiting resistor. The limiting resistor used in this work has resistance value of 1KΩ to limit the amount of current flowing in the LED. The larger the value of the resistor, the lesser the brightness of the LED. The LED may however be damaged if the resistance is not large enough to limit the current flowing. [6]

3.3 The Control (Timing) Unit

It is a unit which has a monostable with resistor and capacitor as external timing components.

3.3.1 One Shot (monostable)

It is a digital circuit that is somewhat related to flip-flop (FF), one shot has two inputs (Q and $\overline{Q}$) which are the inverse of each other. Unlike the FF, one shot has only one stable state (normally Q = 0 and $\overline{Q}$ = 1) where it remains until it is triggered by an input signal. Once triggered, the monostable output switches to the opposite state (Q = 1 and $\overline{Q}$ = 0). After a time T, the monostable output returns to its stable state, until when triggered again [8]

The time constant T is given by the formula:

$$T = 0.5RC$$

Where R is the external timing resistor and

C is the external timing capacitor

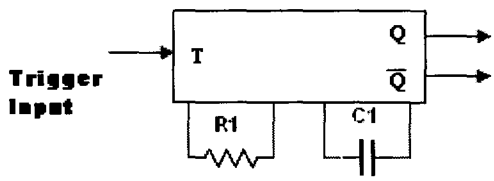

Fig. 3.7 One shot symbol

There are two basic types of one-shot: Nonretriggerable and Retriggerable one shot. For this work, the retriggerable one shot was employed.

3.3.2 Retriggerability

Most monostable e.g. the 4538 will begin a new timing cycle if the input triggers again during the duration of the output pulse. They are known as retriggerable monostables. The output pulse will be longer that usual if they are retriggered during the pulse, finally terminating one pulse width after the last trigger. [9]

3.3.3 The CD4098 Monostable

The CD 4098 monostable provides stable retriggerable/ resettable one shot operation for any fixed voltage timing application. An external resistor (Rx) and an external capacitor (Cx) control the timing for the circuit. Adjustment of Rx and Cx provides a wide range of output pulse widths from the Q and $\bar{Q}$ terminals.

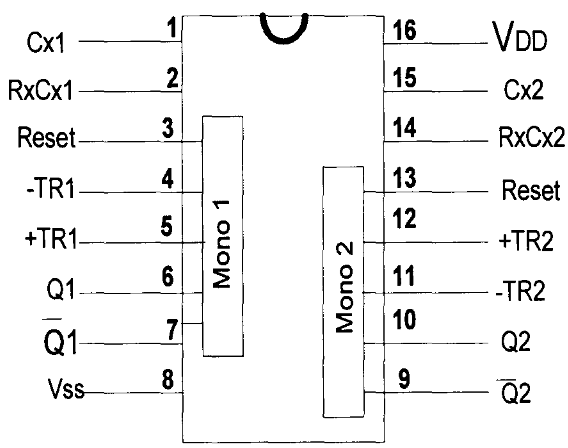

Fig. 3.8 CD 4098 Monostable Multivibrator

Leading edge triggering (+TR) and trailing edge triggering (-TR) inputs are provided for triggering from either edge of an input pulse. An unused +TR input was tied to V_{SS}. An unused –TR input was tied to V_{DD}. A RESET (on low level) is for immediate termination of the output pulse and to prevent output pulses when power is turned on. An unused reset input was tied to V_{DD}.

In normal operation, the circuit triggers (extends an output pulse one period) on the application of each new trigger pulse. For operation in the non-retriggreable mode, Q is connected to –TR when leading edge triggering (+TR) is used or Q is connected to +TR when trailing edge triggering (-TR) is used. [10]

A variable timing length to effect sealing was needed. The CD4098 monostable was used to provide the delay and the connection is as shown below.

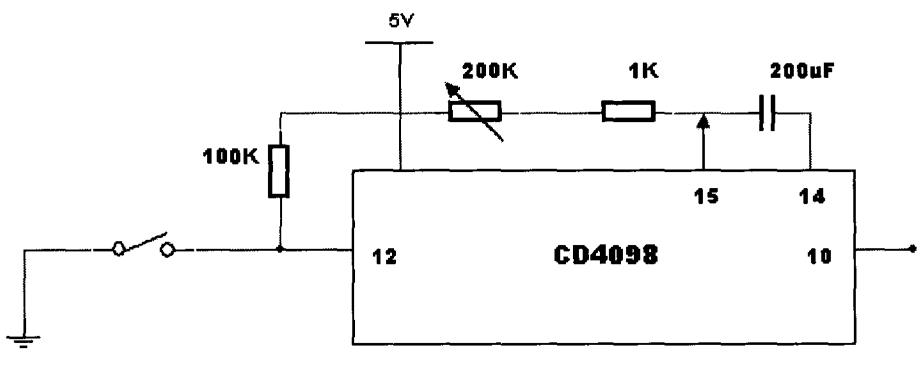

Fig 3.9 CD4098 Monostable

The CD4098 monostable produces an output pulse of width

$$T_X = 0.5R_XC_X$$

For available timing length, the value of R was made variable from 1K to 200K and the value of C was made a 220uF capacitor.

The maximum time delay was

$T_X = 0.5 \times 2 \times 10^5 \times 2.2 \times 10^2 \times 10^{-6}$

$T_X = 0.5 \times 2.2 \times 10^7 \times 10^{-6}$

$T_X = 1.1 \times 10 = 22$ seconds

The monostable was triggered whenever the leaf switch closes, generating a falling-edge trigger impulse that drives Q high for a time determined by the setting of R_X in the timing circuit.

The Q output was used to drive a power triac and a solenoid that provides latching action between the two hinged sections of the sealing machine.

3.4 Heating Element

To produce the required heat, a heating element is needed. Thus, a heating element which is a mere resistance wire was used. When voltage is supplied to the wire, it will draw sufficient current from the supply which in turn generates heat. Wire of circular cross-section or rectangular conducting ribbon was used as the heating element. Under steady state condition, a heating element dissipates as much heat from the surface as it receives the power from the voltage supply. [4]

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

$$H = 5.27eK\left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] W/m^2$$

Where T_1 = the temperature of the hot body in ^{0}K

T_2 = the temperature of the cold body (surrounding) in ^{0}K

$$P = \frac{V^2}{R}$$

and $R = \frac{\rho l}{A}$

Therefore, $R = \frac{4\rho l}{\pi d^2}$

$$P = \frac{\pi d^2 V^2}{4\rho l} \quad \text{...(1)}$$

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

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

Heat radiated per second = $(\pi d) \times l \times H$..(2)

3.4.1 Determination of Power Rating of the Heating Element

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

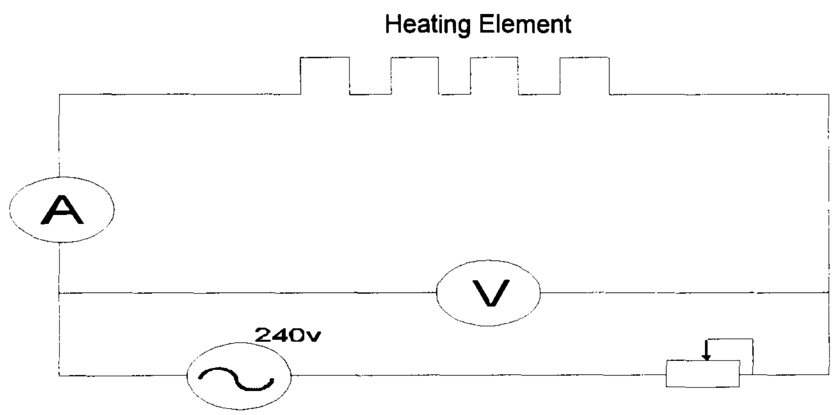

Fig 3.10 Determination of power rating of the heating element

The voltage and current rating of the heating element was determined with the arrangement shown above in fig 3.10. From the experiment, 0.35 meter length of the constantan wire cannot tolerate more than 24 volt at a current of 2.5A. This result necessitated the choice of 24 volt transformer for the element circuit and from power rating of

$$P = IV$$
$$= 2.5 \times 24$$
$$= 60 \text{ watts}$$

In essence, high specific resistance, high oxidizing temperature, positive temperature coefficient of resistance, ductility and good mechanical strength all of which are properties of good heating element were ensured in the course of the work.

3.4.2 The Switching Circuit

With the aid of the CD4098, transistor and relay, the switching operation was made possible. The transistor was used to amplify the current to the relay which in turn switched ON/OFF the heating element. In other words, the relay drives 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 was connected to the collector terminal of the transistor. The collector current I_C energized the coil of the relay and thus the relay operated.

3.4.3 The Relay

Relay is an electromagnetic element that energizes whenever there is a supply of current through its coil. It is an electromagnetic control switch, in which a coil pulls an armature when sufficient current flows. Relay is therefore capable of automatically turning on and off the circuit [7]

When the output of the CD4098 goes high, the transistor will be turned on and the relay is activated. When the output of the timer becomes low, the transistor is cut off and the relay will be deactivated. Fig 3.11 below shows the switching circuit diagram.

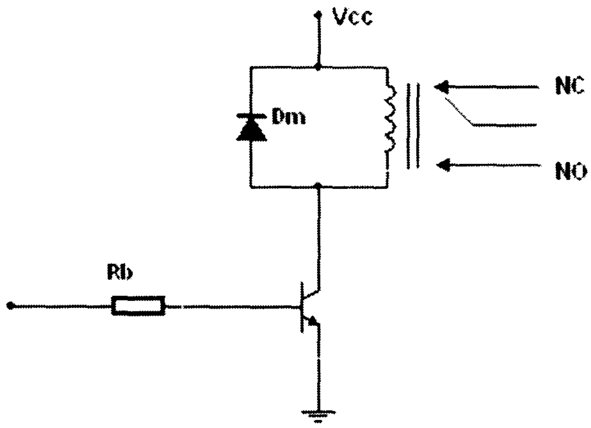

Fig 3.11 The switching circuit

3.4.4 The Relay Transistor Switch

Transistors are used as electronic switch. Such switch can be turned ON/OFF by a small signal. The power level of the control signal is usually very small and is capable of providing enough based drive to switch a transistor ON/OFF.

Two levels of control signal were employed. With OFF level, the transistor operates in cut-off region (open), whereas with ON level it operates in the saturation region. For basic operation of a transistor, its Emmiter-Base Junction (EBJ) has to be forward biased. While its Base-Collector Junction (BCJ) has to be reverse biased.

For the purpose of this work, the NPN C9014 was used to provide the switching effect for the relay. Normally, the quiescent point is first identified. In other to obtain such a value, we need to forward bias the EBJ. The base should be positive with respect to the emitter. The base resistor R_B connected between the positive supply and the base enhances this.

The transistor has the following parameters.

$I_{Cmax} = 150mA$

$V_{CE} = 60V$

$Ic = I_{LED} = 15mA$

$V_{BE} = 0.7$

$h_{fe} = 200$

The base current I_B can then be calculated using

$I_B = I_C/H_{FE}$

$= 0.015/200$

$= 0.75 \times 10^{-4}$

$= 75\mu F$

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

Where V_B is the logic 1 voltage of CD4098 = 5v

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

$R_B = (5 - 0.7) / 7.5 \times 10^{-5}$

$= (4.3 / 7.5) \times 10^5$

$= 56K\Omega$

3.4.5 Back EMF

A free wheeling diode (Dm) is usually put across relay coil connections as shown in Fig. 3.11. The diode connected in parallel with the relay coil serves the purpose of a protective device and is also called commutating diode.

When the current flows through an inductor or coil is interrupted, a higher voltage in the reverse direction called back emf is generated by the collapsing magnetic field. As coil is connected to a transistor, the back emf can be high enough to destroy the device. This same thing happens across the relay contact when connected to an inductive source. It causes contact arcing – an energy ought to have been dissipated. So, by placing a diode across the relay coil, it conducts when the magnetic field collapses and therefore effectively short circuit the voltage.

3.4.5 Auto-lock Unit

When the two plates A and B shown in the fig 1.1 are brought together, the leaf switch triggers a monostable then activates the electromagnet, pressing the plunger in. At the same time, an opto –triac is switched on. This in turn switches on a high power BT139 triac controlling the solenoid. This occurs for a period of time determined by the timing component ie the monostable. The solenoid is de-energized and thereby releasing the plunger when the set time of the monostable is out. The return spring thus separates A and B. See fig. 1.1

3.5.1 Triac and Solenoid

A BT139 power triac was used to supply/disconnect the solenoid from 240v depending on the logic level on Q.

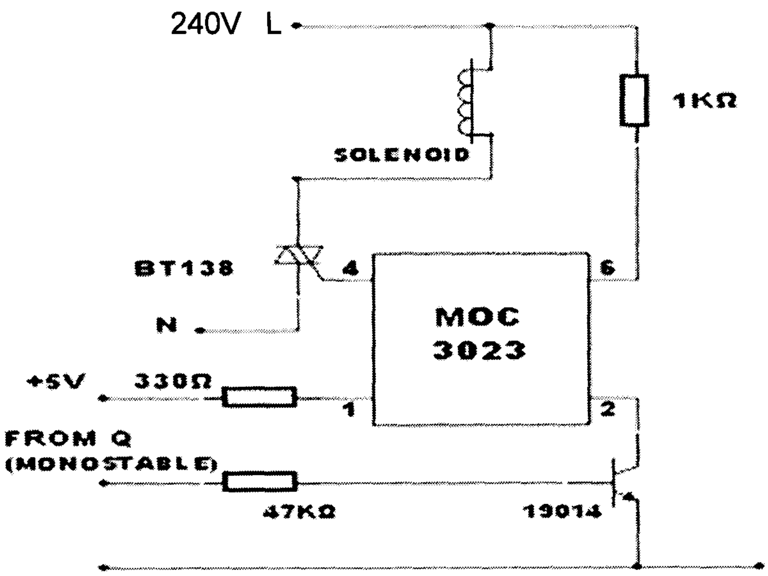

Fig 3.12 Power Triac Solenoid Driver

An MOC3023 opto-triac was used for isolation and gate triggering. The MOC consists of an internal IR diode and a light-sensitive triac.

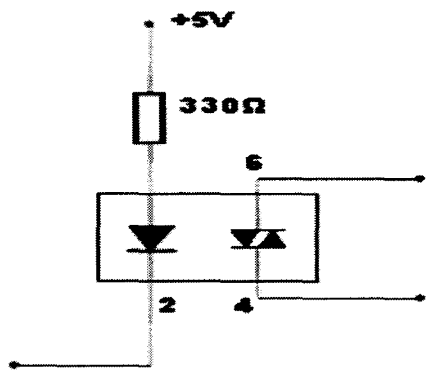

Fig 3.13 MOC 3023 internal wiring

When the integral LED in the package is forward-biased, it emits an IR radiation that causes the internal diac to switch on, causing a current flow through it. The MOC3023 was connected to the gate circuit of the power triac and controlled by Q via an NPN transistor.

When Q is high, the transistor is forward-biased, turning on the integral LED, causing the diac to source current into the gate of the power triac. The solenoid is fed with 240V supply and the heating element fed with 24V. The solenoid locks the two sections together and the heating element supplies the heat needed to effect sealing.

When Q goes low, the transistor turns off and the power triac loses gate drive. The solenoid de-energizes and the heating element is disconnected from power.

Current through LED = 15mA

$V_{cc} = 5V$, $V_B = 1.8V$

$R_S = (5 - 1.8) / 0.015$

$= 3.2 / 0.015$

$= 213\Omega$

A 330Ω resistance was used.

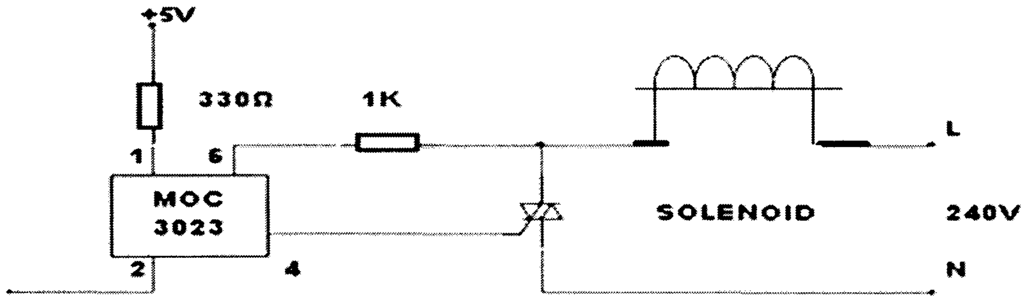

Fig 3.14 Power Triac/solenoid driver

3.5.2 Opto-Triac Transistor Switch

A C9014 NPN transistor with a gain of 200 was used to turn on the Opto-triac;

$I_{Cmax} = 150mA$

$V_{CE} = 60V$

$Ic = I_{LED} = 15mA$

$V_{BE} = 0.7$

$h_{fe} = 200$

The base current I_B can then be calculated using

$I_B = I_C/H_{FE}$

$= 0.015/200$

$= 0.75 \times 10^{-4}$

$= 75\mu F$

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

Where V_B is the logic 1 voltage of CD4098 = 5v

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

$R_B = (5 - 0.7) / 7.5 \times 10^{-5}$

$= (4.3 / 7.5) \times 10^5$

$= 57K\Omega$

A 4.7KΩ resistor was used to allow over drive.

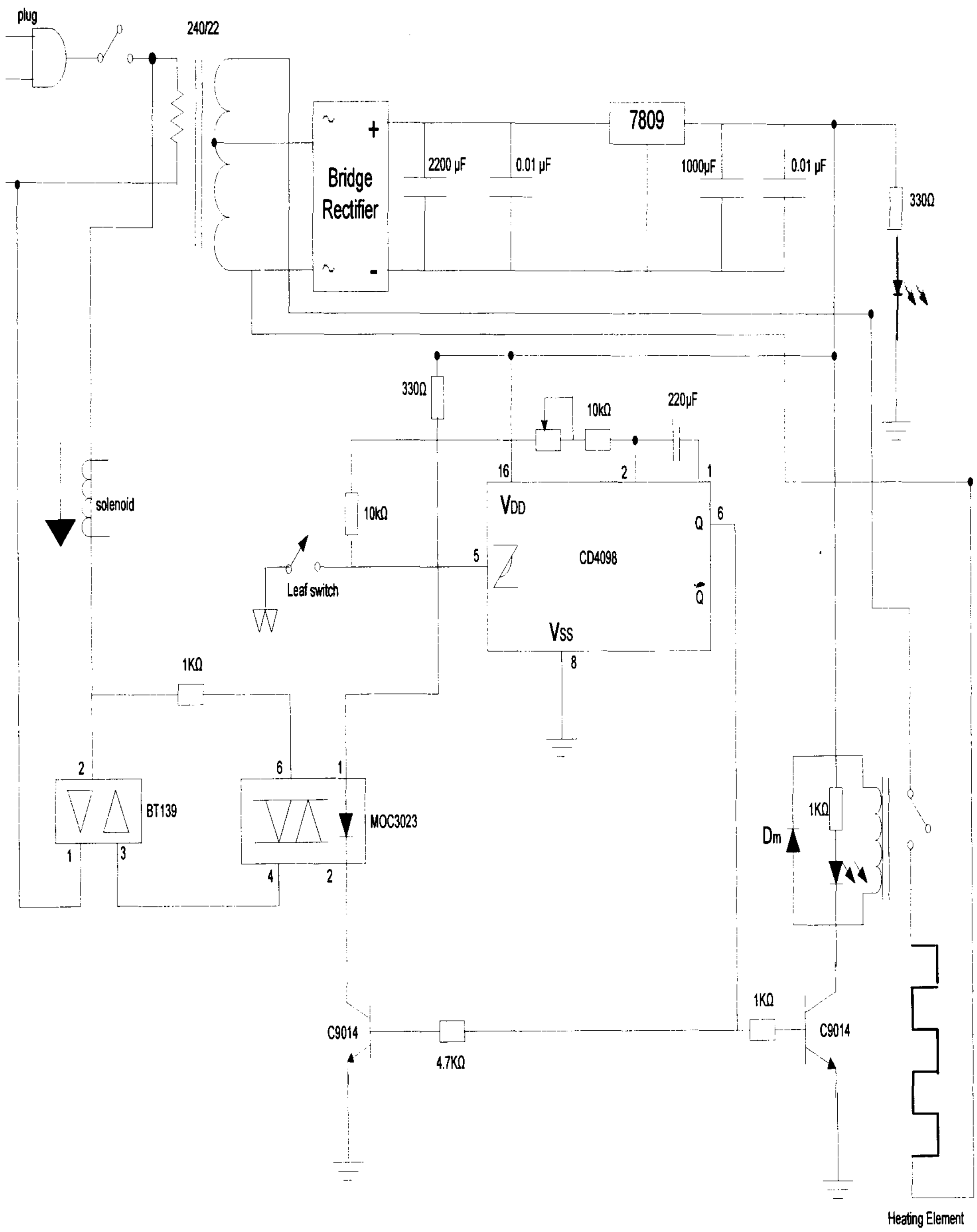

Fig 3.15 Circuit Diagram of Automatic Polythene Sealing Machine

CHAPTER FOUR

TESTS, RESULTS AND DISCUSSION

4.1 Testing

Stage by stage testing was carried out after the final assembling of the components on the board. The first test was on the transformer in which a voltmeter was connected across the output of the center tapped transformer to determine the output voltage. A dc voltmeter was connected across the output of the rectifier to ascertain that it actually converts the ac to the required dc voltage. The 11.2V dc output of the rectifier circuit was thus connected to the 7809 voltage regulator which stabilizers it to constant 9 volt that powers the control (timer) circuit.

The supply cable was then connected to the mains (240volt). The power transformer is in this way energized and the button switch controlling the electronic timer is activated. The output voltage of the regulator was checked for stability and it was found to be 9 volt which is the required voltage for the proper operation of the circuit

The CD4089 monostable multivibrator produces one shot pulse as it was triggered through pin 5, when the variable resistor was set to a desired range, thus energizing the relay coil, which completed the circuit of the heating element with 24 Volt from the transformer. This caused the element to glow. When the preset time was reached, the output of the CD4089 was low and the relay coil de-energized and the complete circuit to the heating element opened. There was no more power supply to the heating element, thus it cooled off. When another preset time was set, the circuit switched 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 thicknesses of the polythene materials to be sealed.

4.2 Soldering Method and Precautions

4.2.1 Soldering process

Soldering is a process of joining two pieces of wires or a wire and metal log together by melting an alloy of Lead and Tin (solder) through the use of soldering iron, to make an electrical 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 was thus brought close to its tip. This was already placed close to the point of connection for pre-heating to give a bright shiny and smooth surface with a strong mechanical joint.

4.2.2 Precautions taken 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 require great care. To ensure a good soldering and effective operation of the circuit, some precautions have to be ensured since a little mistake while soldering can render the whole circuit useless.

Among the precautions taken were:

- An adequate care was taken while soldering so as to avoid short-circuits on the board. Excessive heat was also avoided in order to prevent the components from being damaged.

- Also, the IC was mounted on IC socket to prevent damage due to soldering. Visual inspection was also made to ensure there is no missing joint.
- Precaution was also taken to ensure that there were no problems of insufficient solder, excessive solders, crystallized solder, dry solder etc

4.3 Discussion

The result of the test indicates that the circuit works according to design as an automatic polythene sealing device which switches on / off automatically at a prescribed preset time. The device can be used to seal any polythene material within the thickness range of 2μm – 1mm.

4.4 Operating Instruction

The fact that the circuit operates by switching on/off automatically depends on the preset time in the automation. Therefore, to use the automatic polythene sealing machine, the following procedures should be followed.

(i) Plug the power cord to the mains (240volt) supply.

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

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

(iv) Press the sealing arm on the platform and allows the plunger to get de-energized.

4.5 Troubleshooting

The Automatic Sealing Machine is a device which incorporates electronic timer to vary the required time of operation instead of being manually operated. Against this premise, various kinds of fault can occur within the system. It is however advisable that before major repair and/or maintenance is carried out on the machine, the following common trouble shooting guide should be observed.

Table 4.1 Troubleshooting Guide

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

CHAPTER FIVE

CONCLUSION

5.1 Introduction

This chapter presents summary of the work. The results obtained and the problems encountered in the process of carrying out this project are summarized. Furthermore, recommendations that will enhance possible improvement and additions to this project which could give rise to further work scheduled for the future are also presented.

5.2 Summary

The project is about design and construction of an Automatic Polythene Sealing Machine. Chapter one exposes the background knowledge of the work and the objective of the work which is to enhance sealing of polythene materials that are used in packaging items for preservation at low cost and convenient method.

In chapter two, the fundamentals of automatic polythene sealing machine are well discussed.

Chapter three explains the design and construction procedure. The different circuit stages used in the work are clearly indicated. The power supply unit, the control unit, the relay (triac), and solenoid and the heating element unit are well spelt out and explained. The chapter also indicates the principle of operation of the complete circuit. Tests, result and discussion form chapter four. In other words, the steps taken to test the work and the measurement methods are properly documented. The results obtained are also discussed as well as trouble shooting.

Chapter five presents the summary of the entire work (design, construction and the report writing).

5.3 The Constraint

Some of the constraints encountered during the design and the construction of the project include but are not limited to, unavailability of some components needed for the construction e.g. solenoid, plunger e.t.c. They were ordered; mechanical and other construction work e.g. welding e.t.c. were not readily accessible.

5.4 Recommendations

The design work will enhance students' performance especially in automation through demonstration of theoretically acquired knowledge in practice.

I also recommend this work for a large scale construction so as to boost the production and packaging goods and items being manufactured across the country at all levels.

5.5 Conclusion

Over the years, people have employed several means of packaging goods among which is knotting of strings and polymer materials. This prevailed before the advent of sealing devices.

The aim and objective of this work has largely been achieved which is to design and construct an automatic polythene sealing machine. Its principle is based on application of heat to seal a polythene material of different sizes and thickness. This was made possible by the heat produced in the heating element which is being controlled by the control/timing circuit. The combination of this as a system in this work produces the Automatic Polythene Sealing Machine.

This design consideration and specification provide easy operation of the machine, easy maintenance, low cost, reliability and especially lower power consumption. Thus, the automatic polythene sealing machine is highly economical.

The automatic polythene sealing machine is a contribution to the field of engineering and can have valuable application in many packaging industries ranging from pharmaceutical company to local water treatment factory.

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