DESIGN, CONSTRUCTION AND TESTING OF AN AUTOMATIC SHUT-OFF AC MAINS TIMER WITH AN AUDIOVISUAL ALARM.

BY

KAKWAGH S.S
(95/4521EE

BEING

A PROJECT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A BACHELORS DEGREE IN ELECTRICAL AND COMPUTER ENGINEERING.

DECEMBER 2000.

DECLARATION

I hereby declare that this project is an original concept wholly investigated by me, and submitted to the Department of Electrical and Computer Engineering, Federal University of Technology, Minna, in partial fulfillment of the requirements for the award of the Bachelor of Engineering.

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KAKWAGH SHATSE.S. **DATE**

CERTIFICATION

This is to certify that this project titled "AUTOMATIC SHUT-OFF A.C MAINS TIMER WITH AN AUDIO-VISUAL ALARM", was carried out by Kakwagh S.S. (95/4521), under the supervision of Mr. Pinne K.K. and submitted to the Department of Electrical and Computer Engineering, Federal University of Technology, Minna in partial fulfillment of the requirements for the award of the Bachelor of Engineering.

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Mr. Pinne K.K DATE

PROJECT SUPERVISOR

....16/1/01.........

Dr. Y.A. Adediran DATE

(H.O.D.)

....17/1/01........

EXTERNAL EXAMINER DATE

DEDICATION

This project is dedicated to my whole family for their encouragement and support, especially my Dad and Mum.

ACKNOWLEDGEMENT

I wish to thank the almighty God for His guidance and protection throughout the duration of this course.

I wish to thank my parents, for their unflinching support at every point in my life. You have always encouraged me to strive harder. I hope I never let you down.

A special thank you to my supervisor, Mr. Kenneth Pinne, your encouragement, advice and tireless resolve for perfection led to the successful implementation of this project.

To my sisters Ngunan, Iember, Alueshima and my little brother Gandepuun, thank you, for always being there for me.

I wish to thank my friends Obiora, Tony, Chris, Adigwu, Joseph, Bem, Babi, Kola, Amemo and Philip.

Lastly, I wish to thank my H.O.D., Dr. Y.A. Adediran and all my lecturers for their hard work and perseverance.

Thank you all.

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ABSTRACT

This project puts into perspective the peculiar power situation in this country and it effect on our appliances. It also puts into view the negative consequences of leaving our appliances to run for long unsupervised periods at a time, with consequent danger of fire outbreaks/damage to the appliance.

This device will shut-off mains power supply to a device connected to it after a preset time duration, saving energy (thus, power cost) and prolonging the life span of such appliances.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION:

In order to sustain the life span of equipment/appliances we use in our homes and work places, we need to adhere strictly to manufacturers instructions on everyday use and maintenance.

We often neglect to switch off our appliances when we are not using them, thus allowing them to run unsupervised for long periods of time thereby exposing their internal components to strain. This reduces their durability and results in frequent system breakdown, and in extreme cases, fire disasters.

In Nigeria today, the provision of stable utility power supply can only be a future plan. Protection equipment are therefore needed for electronic appliances.

This project seeks to design, construct and test a power protection device that will automatically switch off appliances connected to mains after preset time periods.

1.2 MAINS POWER SUPPLY PROBLEMS IN NIGERIA.

The frequent power outages and fluctuations from Nigeria's utility power supply company (NEPA) are a hazard to home appliances.

Power supply from NEPA is supposed to be 240V, but the situation is so bad that the supply voltage varies dangerously around the country.

1.3 **THE SYSTEM**:

This system is designed to automatically shut off mains power supply to connected appliances after a preset period of time. It also has a display unit that tells the state of operation at any particular period of time and alerts the user through an audio-visual alarm system.

Appliances like heaters, fans, radio sets, television sets, etc are often intended to run for certain periods of time. This requires the user's supervision, which is often not reliable. With an automatic shut off system, such operations can be carried out successfully and the user will be alerted through an audio-visual alarm system.

1.4 **PROJECT AIMS**:

This project aims at;

1. Reducing the occurrence of domestic fire outbreaks caused by appliances left unsupervised for long periods of time.
2. Prolonging the life span of appliances by ensuring optimum use.
3. Conserving power and consequently reducing power costs.

1.5 **PROJECT LAYOUT**:

This project report is contained in four chapters for clarity. Chapter One gives a general introduction, defining the problem and proffering a solution. Chapter Two details the system design analysis from the very beginning.

The system construction, testing, results and modifications are contained in Chapter Three. Chapter Four deals with conclusions and recommendations. A list of references is given in this Chapter Four.

CHAPTER TWO

SYSTEM DESIGN

2.1 SYSTEM DESIGN OVERVIEW:

The automatic shut-off AC timer with audio-visual alarm system is an electronic device which switches off the mains supply to a device connected to it after a preset time duration.

If a device, say an electric heater, is connected to this device, one can set the timer to ten minutes; which means one can heat water for exactly ten minutes after which the power supply to the heater is shut-off automatically. Optionally, this device will sound an alarm. This audio alarm can be disabled since it can be a nuisance, say at night when a quiet shut-off is required. However a visual OFF display will be flashing at shut-off. In a like manner, an ON display will flash when the connected device is supplied with power.

This system is powered by a +12V regulated DC supply. Below is the block diagram of this system.

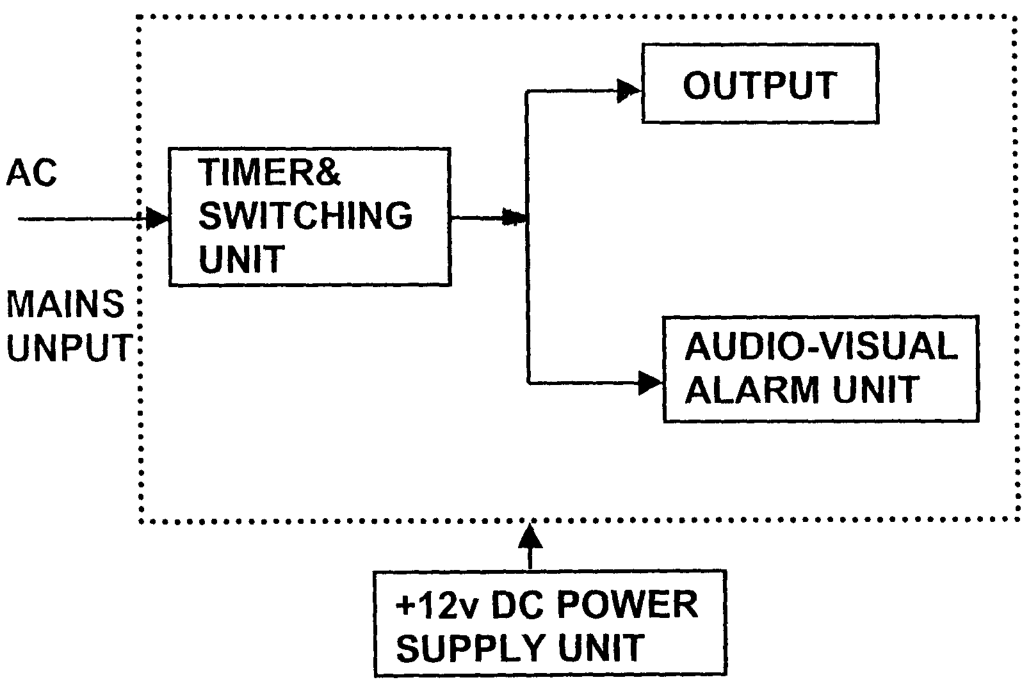

FIGURE 2.1 BLOCK DIAGRAM OF AN AUTOMATIC SHUT-OFF AC MAINS TIMER WITH AN AUDIO-VISUAL ALARM.

2.2 POWER SUPPLY DESIGN.

The power supply considered in this project is a +12V regulated power supply that has an output current of about 1A. This power supply is adequate to power the various components and devices to be used in this design. Standard procedures are used in the design of this power supply.

THE TRANSFORMER

The transformer considered is a step down 220V/12V power transformer rated to deliver about 1A current. Under test, this transformer gives a secondary voltage of about 14.5V AC. This transformer is readily available in electronic parts shops at reasonable prices.

THE RECTIFIER.

A bi-phase full wave bridge rectifier is considered for its high output current. This following parameters are recommended for this arrangement.

$$\text{Output DC current} = I_{ac}$$
$$= 1A$$

For this design, rectifier diodes of Peak Inverse Voltage (PIV) greater than 12V are used. To avoid damage to the diodes.

THE FILTER CAPACITOR

A large capacitor is used for filtering/smoothening the rough rectified voltage. The recommended value of this electrolytic capacitor is

$$C = 2200 \times \text{output current}$$

(TOOLEY M, 1990)

$$= 2200 \times 1$$

$$= 2200\ uF$$

The minimum voltage rating recommended is

2 x voltage supply (ie 12V)

A nearest preferred value (npv) of 2200 uF is chosen with a voltage rating of 25V. The values are therefore very suitable.

THE VOLTAGE REGULATOR

These are integrated circuits commonly employed in stabilized power supplies. They are basically a three terminal device usually encapsulated like power transistors. They commonly incorporate two very useful characteristics;

1. Internal current limiting
2. Thermal shutdown.

The regulator considered here is a +12V regulator (7812). It is also recommended that, two capacitors of about 0.1uF be connected as close to the regulator as possible to ensure unconditional high frequency stability.

THE POWER INDICATOR.

A typical Light Emitting Diode (LED) indicator is in the power unit above. In order to limit the forward current flowing to an appropriate value, a resistor is connected in series to the LED. The LED used here is the round standard type with a quoted typical forward current of 12mA, which should not exceed 20mA. The resistor value is calculated as follows;

$$R = \frac{V - V_f}{I}$$

V_f is the forward voltage drop produced by the LED and V is the applied voltage. It is recommended that V_f will be about 2 volts. The value of R can therefore be calculated as;

$$R = \frac{12 - 2}{12mA}$$

$$R = 833\ \Omega$$

However, a nearest preferred value of 1000 Ω is chosen for use in this circuit.

Below is the circuit diagram of the +12V DC regulated power supply.

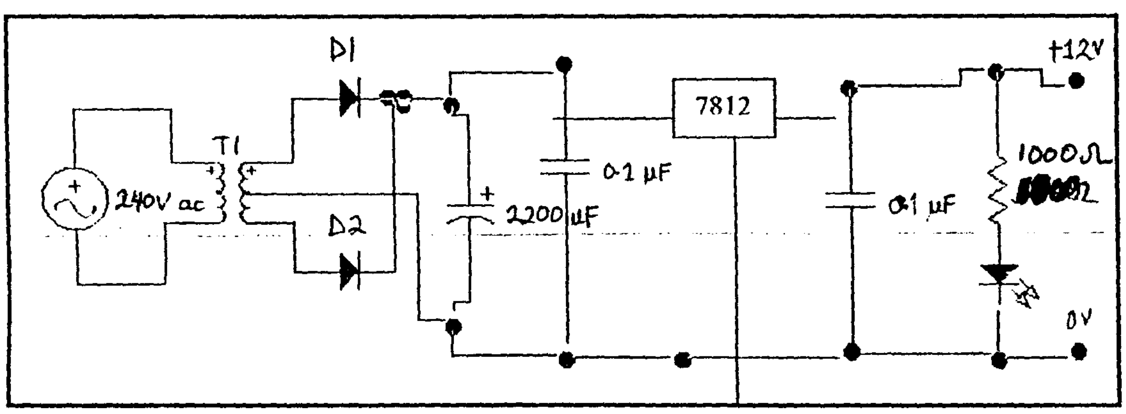

Figure 2.2 +12V regulated DC power supply.

2.3 TIMER AND SWITCHING UNIT:

This unit switches the AC mains input to the output based on the preset output of a timer device. This unit is based on the 555 timer IC connected as a one shot multivibrator (i.e. monostable multivibrator). This means that an the output is high for a time duration determined by the time constant,

$$t = R \times C \text{ seconds.}$$

The maximum amount of time considered in this design is approximately two hours. This time specification is considered adequate for most timing requirements. This is achieved by,

Setting two capacitors of 3300uF nearest preferred value in parallel and using a 1MΩ variable resistor in an RC circuit,

R = 1M Ω

C = 6600Uf

Therefor

t = R x C

That is, t = 1MΩ x 6600uF

= 5500secs

= 6600 / 60 mins

= 110 mins

= 1hr 50 mins

with the values of R and C obtained, the 555 timer is connected in the standard monostable mode.

greater than 12V, and hfemin greater than 0.15 is most suitable. On consultation with a data book, BC107 was chosen for its availability and specifications which are;

Type	=	NPN
Icmax	=	100mA
Vceo	=	45V
Hfemin	=	110
Hfemax	=	450

The value of a base resistor to limit the current flowing into the base of the transistor and avoid damage is calculated as;

$$Rb = \frac{V_{in} - V_{be}}{Ib}$$

But Vbe is 0.6V for silicon devices, and

For the chosen transistor

$$Ibmax = Icmax/hfemin$$
$$= 100/110$$
$$= 0.91mA$$

therefore,

$$Rbmin = \frac{(12 - 0.6)V}{0.91mA}$$

$$Rbmin = 12.5K\Omega$$

However, the nearest preferred value is, 15KΩ is chosen

A diode with PIV greater than 12V is connected across the coil of the relay to protect the transistor from damage due to back e.m.f. The diode 1N4001 is used. Below is the circuit diagram of the timer and switching unit.

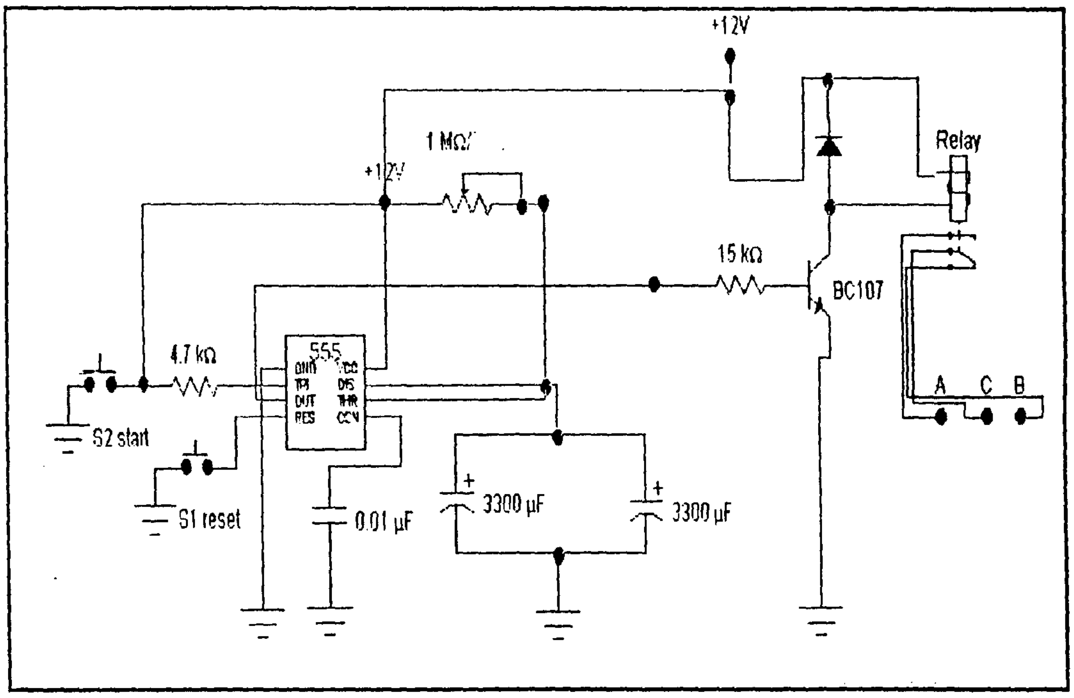

FIGURE 2.3 CIRCUIT DIAGRAM OF THE TIMER AND SWITCHING UNIT

2.4 **OUTPUT UNIT**:

This unit is simply a mains voltage socket that has the normally closed contacts (B and C in figure 2.3) as its only switch. When the system is operating, any appliance connected to this socket works units the preset time duration is elapsed. At this point, the timer output goes high activating the transistor BC107 to drive the relay. With the relay energized the normally closed contacts become open thereby switching OFF the appliance.

AC SOCKET

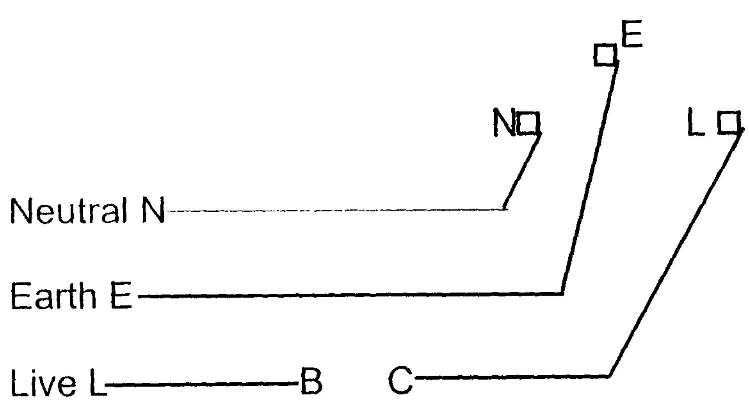

FIGURE 2.4 THE OUTPUT UNIT CONNECTION.

2.5 THE AUDIOVISUAL DISPLAY UNIT.:

This unit combines an audio alarm a visual light indicator.

The two will be analyzed separately as follows

THE LIGHT INDICATOR

A typical Light Emitting Diode (LED) indicator is used here. In order to limit the forward current flowing to an appropriate value, a resistor is connected in series to the LED. The LED used here is the round standard type with a quoted typical forward current of 12mA, which should not exceed 20mA. The resistor value is calculated as follows;

$$R = \frac{V - V_f}{I}$$

V_f is the forward voltage drop produced by the LED and V is the output voltage from pin 3 of the 555 timer. It is recommended that V_f will be about 2 volts. The value of R can therefore be calculated as;

$$R = \frac{9 - 2}{12mA}$$

$$R = 583\ \Omega$$

However, a nearest preferred value of 560 Ω is chosen for use as shown below

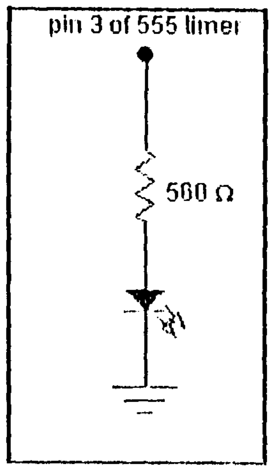

FIGURE 2.5a THE LIGHT INDICATOR CIRCUIT

THE AUDIO ALARM

This alarm is connected to the normally open contacts (A and C) of the relay. When the time set for a connected appliance is over, pin 3 of the 555 timer goes high, thereby energizing the relay. When energized, the normal open contacts, which form the switch to the alarm circuit close, thereby sounding the alarm. The 555 timer IC is wired as an astable multivibrator as shown below to generate continuous pulses at an audio frequency equal to 510.6 Hz as shown in the calculation below.

$$\text{Frequency} \qquad f = \frac{1.44}{(R_1 + 2R_2)C}$$

Setting $R_1 = R_2 = 4.7K$ Ohms

And $C = 0.2$ uF

Therefore,

$$f = 510.6\text{Hz}$$

This timer circuit generates a tone of 510.6Hz as shown above.

The output of the timer circuit feeds an 8 ohms speaker through a coupling capacitor. Thus an audible alarm is heard. The diagram is shown below.

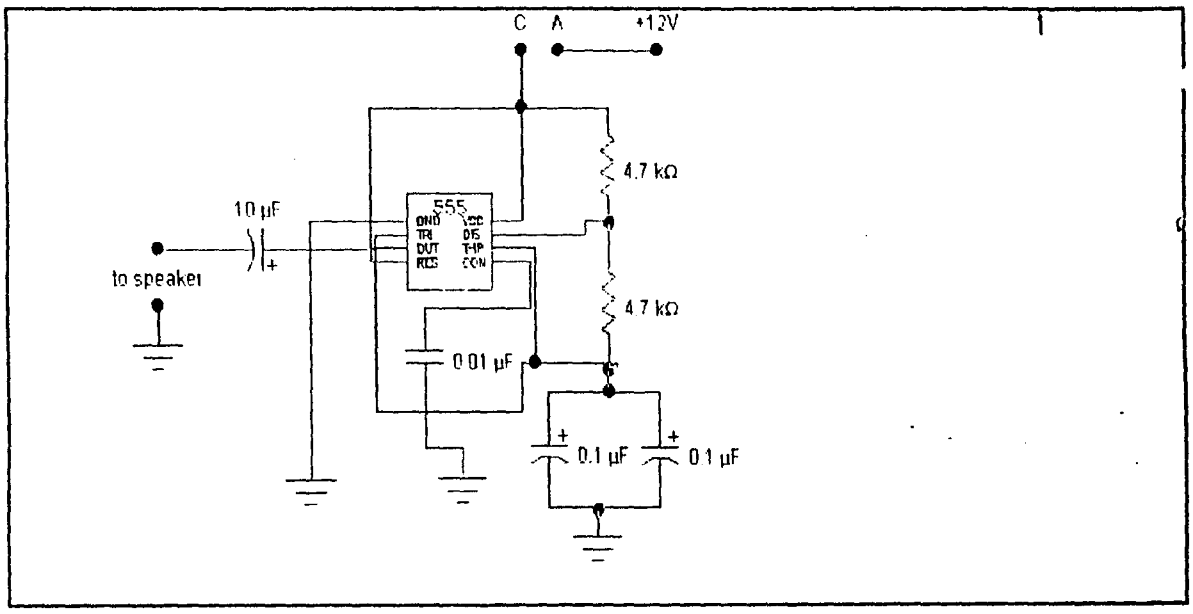

FIGURE 2.5b THE AUDIO ALARM CIRCUIT

CHAPTER THREE

CONSTRUCTION, TESTING, RESULTS AND MODIFICATIONS.

3.1 INTRODUCTION.

Every unit designed was first mounted on a breadboard, which can be easily dismantled. After mounting, the units were then tested individually before they were transferred to the veroboard and permanently soldered.

The following construction techniques and precautions were observed.

1. On the breadboard, good connecting wires were used and care was taken to make good contacts.
2. Care was taken to isolate the mains voltage wiring from accidental touch and from other units.
3. On the veroboard, high quality lead was used to ensure strong solder joints.
4. Components, especially the timer IC were handled with care to avoid damage from static electricity.

3.2 POWER SUPPLY CONSTRUCTION.

The power supply, being the source of power for the circuit, was first designed, mounted on a breadboard and tested with a digital multi-meter and then transferred to the veroboard and soldered unto it.

3.3 TIMER AND SWITCHING UNIT CONSTRUCTION.

This unit was constructed on the veroboard after testing on the breadboard. During soldering care was taken to protect the IC and transistor from excessive heat of the soldering iron. This can easily result in damage. Care was taken to avoid any bridging of circuit points. This can result in a short circuit.

Above all, general construction precautions were taken.

3.4 THE OUTPUT UNIT CONSTRUCTION:

This unit involves mains voltage and care was taken to properly insulate the wires in this unit from any contact. This is necessary to avoid electric shock and damage to life and equipment. The wire type used is that recommended for ac mains wiring as a lower type may result to damage of the entire system. An appropriate socket was chosen.

3.5 THE AUDIOVISUAL ALARM UNIT CONSTRUCTION:

Here, holes were punched into the casing to accommodate the light indicator and the speaker. Provision was also made for extensions of the legs of the light indicator and the wire for the speaker so that the can be moved and mounted on the casing without strain to the wiring. This protects the wiring from an open circuit.

3.6 TESTING:

The power supply was tested on a digital multi-meter and a steady + 12V DC was read shown in the diagram below.

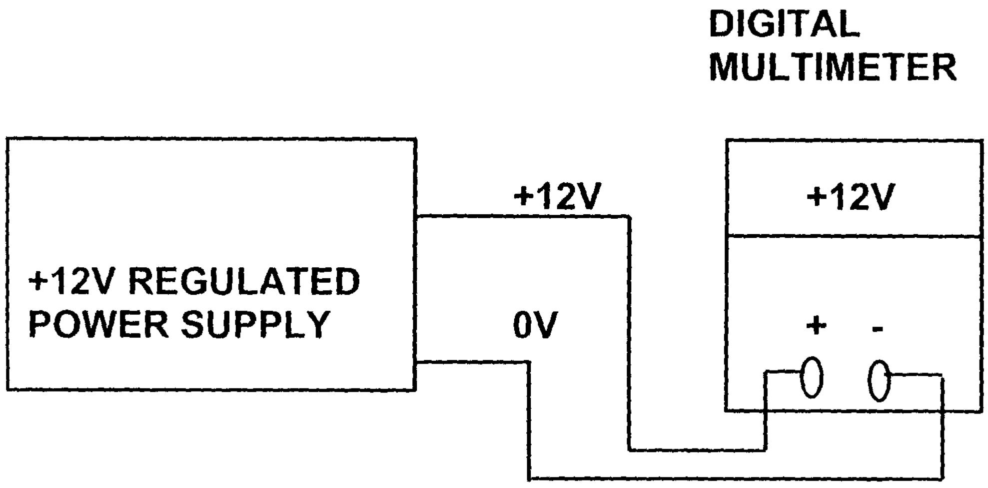

FIGURE 3.6 TESTING OF THE POWER UNIT

With the voltage supply connected, the timer and switching unit were tested, at first, there was no response, on a careful check, the variable resistor was found to be set to zero ohms. I t was then slightly adjusted and at about 7 minutes, the relay clicked. This click indicates that the relay was energized. The variable resistor was again adjusted, the reset switch pressed and at about one hour, another click was heard.

The output and audiovisual unit then connected and the above test procedure was repeated. The alarm sounded and a light was displayed.

3.7 <u>RESULTS</u>.

The following procedures were observed during this testing.

1. The use of a digital multi-meter to test voltage levels.
2. The use of electronic workbench to simulate the circuit modules thereby avoiding possible damage to equipment, components and self.

The final results of the various units and the entire system after test were remarkable. A prolonged and intensive test which involved repeating the above test procedures over and over was then embarked upon and the results made the following modifications necessary.

3.8 **MODIFICATIONS**.

During prolonged testing, the voltage regulator started heating up. This problem was finally overcome by mounting it on a large heat sink.

Time calibration was also done to show a range of about 5 minutes to about two hours after prolonged testing and intelligent guessing.

APPENDIX A

REFERENCES

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