DESIGN AND CONSTRUCTION OF AN AUTOMATIC WATER LEVEL CONTROL DEVICE

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2003/15443EE

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BY

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A project report submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering (B.Eng.) in the department of electrical and Computer Engineering, school of Engineering Technology, Federal University of Technology Minna, Niger State.

NOVEMBER, 2008

DECLARATION

I, OMOZUAPO MARTINS declare that this work was carried out by me and has never been performed elsewhere for the award of a bachelor degree. I also hereby relinquish the copyright of the Federal University of Technology Minna.

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DEDICATION

My profound gratitude to almighty God have has been so merciful and taking me thus far. I dedicate this project to my loving parents, brothers and sisters and to all my loved ones.

ACKNOWLEDGEMENT

My appreciation goes to Almighty God the omnipotent God for His protection, supernatural provision and seeing me through this program.

I am forever grateful to my dearest parents Mr. and Mrs. Clement Omozuapo for their ever reliable support spiritually, financially and otherwise.

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Finally to all those i omitted their names, and to all the graduating students of the Department of Electrical and Computer Engineering of the 2007/2008 session.

ABSTRACT

This project is on the design and construction of an automatic water level control device, which is design to bring an end to the constant spillage of water leading to erratic electricity bills and the pain of frequent on and off of the pump.

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CHAPTER ONE

DESIGN AND CONSTRUCTION OF AN AUTOMATIC WATER LEVEL CONTROL FOR WATER STORAGE TANKS.

1.0 INTRODUCTION

In most developing society, the provision of portable water remains almost a mirage the search for this life supporting fluid has been unending. Thanks to borehole method where submersible pumps are fast evolving, yet the need to conserver the electric motors are used for pumping water into the tanks.

Even though the source of power supply for these pumps are sometimes erratic, which is why the choice of solar pumps are fast evolving, yet the need to conserve energy stored in the associated battery bank is still a major concern. However, regardless of the choice of pump drive employed, that is, whether solar energy or the regular electric energy, a major priority is in the area of the energy management and proper control of water storage.

This piece of work being introduced is a solution proffered to take care of the above challenges. Although, other methods of solving the underscored challenges abound, efficiency and low cost put our maiden device ahead of them all. The simplified electrical interface between the storage tank, the sensor and the pump switching network is so keen that it outweighs other brands in comparison. By the use of a special; constructed liquid sensor, this device will intelligently turn on or off a water pump (submersible electric motor) thereby controlling the level of water in a given storage tank where it has been installed. For instance, when the water level in a tank where this device is installed goes below a critical point, depending on the type of storage vessel used,(because positioning of the sensor is relevant in this case),the sensor sends signal to a decision circuit. The decision circuit is a thyristor wired in such ways that that its output drives a solid state relay technique. This technique employs transistor opto-coupler device which in turn operates the pump via a triac switching. In other works, when the tank is empty, the pump is turned on by a prompt from the combined activities of sensors and the decision circuit. The pump continues to dispense water into the storage tank until it is filled to the brim. At this point, the pump is automatically turned off. This way energy is conserved, pump's life span is extended and unwanted spillage of water is avoided.

This said device is compatible, easy to install and maintenance free. Other fields of endeavor can adapt this device for liquid level control and alarm set-up.

1.1 PROJECT OBJECTIVES

The objective of this project is to explore a new way of accomplishing the goals of water level control other than the common types, with a view to:

1. Using cheaper materials and simple techniques to achieve the said goal.
2. Bring about labor saving, since the principle of operation is based on electronics and completely automatic.
3. Eliminating completely the problem of water spillage as a result of continuous pump activities even when the storage tank is filled up.

1.2 THE AIM OF THE PROJECT

The project is aimed at using simple techniques with very low cost implication, to bring about control of the volume of water in overhead storage tanks. The device takes the responsibility of a man who goes from time to time, to turn off the water pump when the tank is filled with water or turn on the pump when the volume of water in the tank is almost empty.

1.3 SCOPE AND LIMITATION

This project is to operate only on single phase **A.C** to **D.C** mains. The project if properly installed and with available power supply, the level control device may not require any form of manual operation.

However, it is capable of detecting the lowest level of water in the storage tank and automatically turns on the motor pump to begin pumping of water into the tank. On the other hand, it can also detect the highest level of water in the tank and automatically turn off the motor pump. It also gives a visual display on the device control panel the level of water in the tank.

It must be stated here that this device is only for non-distilled water sources. Any kind of water with pH value of 7.0 is not suitable for this application.

1.4 MOTIVATION

This piece of work is chosen to proffer a permanent solution to the problem of water spillage/acute water shortage where motor pumps are used The concept is to use electric means to control and display the volume of water in a storage tank with minimum human intervention.

1.5 SIGNIFICANCE

In view of the success realized in entrusting that the water level control device performs the required functions it can thus be confidently stated that simple techniques and low cost components can be used to automatically bring about the control of water level in storage tanks.

This signifies that locally sourced materials with low implication can be harnessed to solve some basic needs in our homes and residential areas.

1.6 METHODOLOGY

The concept of using pure electronics means to control the volume of water in a tank is perhaps a bit new, considering the kinds in vogue. However the common types in use are mechanical and are most times prone to various weather problems such as wear and tear, rusting friction e.t.c.

They are not also capable of indicating the volume or level of water in a more precise way like one in this design.

The piece of work introduced here seeks to use a simple and yet cheap technique to bring about control of the volume of water in the storage tanks. Before going further it must be stated here that devices are only suitable for non-distilled water sources. Any kind water source with ph value of 7.0 is not suitable for this application. The source of water where this device can work perfectly should be slightly acidic or slightly basic where conductivity of electricity is supported the above remarks are vital and must be stated as regards the type of sensor employed by this project a D.C positive rail 9.0v volts is applied to the body of the water in the tanks. At various levels in the tanks, conductors are positioned to serve as sensors. When water level comes between the 9.0 volts rail and the conductors serving as sensors they become equip-potential and this provides useful signals that are fed into section like the decision circuit and water level indicators.

The decision circuit determines when the pump should start pumping water into the tank and when it should turn off the pump while the water level indicator gives a visual indication of the volume of water in the tank.

1.7 REPORT ORGANIZATION

In this project chapter one discussed the general introduction the aims and objectives motivation aims, scope and limitation significance and methodology. Chapter two discussed the literature review of sources of water, power supply for borehole installations, and review if some automatic water levels control devices. Chapter three is the design and construction of various circuits used to achieve this project.

Construction of various control circuits, testing and encasing is discussed in chapter four of this project. Conclusion and recommendation forms chapter five of the write up.

1.8 SUMMARY OF PRINCIPAL FINDINGS

Principal findings that make the design of this project easier are centered

On the use of thrysitor for decision makings and the use of timer based technique to intercept dry pumping.

Another finding includes the principle of biasing the sensor by applying D.C voltage to the water in the tank whose ph level must not be exactly 7.0. This shows that distilled water whose pH value is 7.0 cannot support conduction of electricity. Therefore the project can work perfectly in a water source having a pH value less than 7.0 or above.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1WATER

The substance regarded as the element that gives live. In ancient times, philosophers regarded water as a basic element typifying all liquid substances. This view held about water in ancient times was later discarded when series of experiments later conducted reveals that water originally contains two molecules of hydrogen and one molecule of oxygen, as expressed by present day formula H_2O

Water occurs at ordinary temperature in all states of matter, that is, as a solid, liquid and gas. As solid, or ice, it is found as glaciers and ice caps, on water surfaces in winter, as snow, hail and frost and clouds formed of ice crystals. It occurs in the liquid state as rain clouds in formed of water droplets, and on vegetation as dew. In addition, it occurs three-quarters of the surface of the earth in the form of swamps, lakes, rivers and oceans. As gas, or water vapour, it occurs as fog, steam and clouds.

As an element that supports life, water is known as the major constituents of all living matter. From 50% to 90% of the weight of living organism is water [2]. Protoplasm, the basic material of living cells, consists of a solution in water fats, carbohydrates, proteins, salts, and similar chemicals.

Water acts as a solvent, transporting, combing and chemically breaking down these substances. Blood in animals and plants consist largely of water and serves to transport food and remove waste materials. Water also plays a key role in the metabolic breakdown of such essential molecules as proteins and carbohydrates. This process called hydrolysis exists in living cells (2).

2.2 WATER SOURCES

As earlier shown, water can be found in rivers, lakes, seas oceans etc. Interestingly, water is found underground. This source of water is called groundwater. Groundwater is the body of water found below the surface of the land. Such water exists in pores between sedimentary particles and in tissues of more solid rocks. In arctic regions, groundwater may be frozen. In general, such water maintains a fairly even temperature very close to the mean annual temperature of the area. Very deep-lying groundwater can remain undisturbed for thousands or millions of years. Most groundwater lies in shallow depths, however, and plays a slow steady part in the hydrologic cycle. Worldwide, groundwater accounts for about one-third of one percent of the earth's water, or about 20 times more than the total surface waters on continents and islands. Groundwater is of major importance to civilization, because it is the largest reserve of may appear drinkable water in regions where humans can live. Groundwater may appear in the surface in the form of springs, or it may be trapped by wells and even where the later is readily available, groundwater is often preferable it tends to less contaminated by waste and organisms.

For both urban and rural water supply, groundwater also known as underground water has played a major role in providing portable water on a very large scale. Governments and humanitarian organizations have turned their direction towards water source available from underground, to combat shortage of portable water (4).

2.3 GROUNDWATER SOURCING:

USING BOREHOLE METHOD

Boreholes are fast becoming a major access for portable water in most communities where surface water bodies are limited. The method involves drilling a narrow hole into the earth crust down to a targeted body of water. Several methods are now in use depending on a number of factors such as depth, earth crust profile, types of drilling mechanism in place etc. The processes of drilling may sometimes become rigorous depending on geological formations, such as hard rocks and cavy materials. Once drilling is successful, and the targeted body of water is accessible, pipes are laid through the hole created from the water body to the surface. In most cases, submersible water pumps are deployed to deliver water to storage tanks (4).

Some of the drilling methods are listed below.

- Direct push method
- Auger hollow and solid stem method
- Cable tool (percussion) method
- Air percussion (Down the hole) hammers method
- Air Rotary method

2.4 POWER SUPPLY FOR BOREHOLE INSTALLATIONS

After a successful drilling process, the water must be drawn out and stored in reservoirs. The method for drawing water differs, depending on the source of power available. Some are hand pumps while majority of borehole facility nowadays are powered by electricity.

In rural areas where the supply of electricity is irregular or not available at all, it's often frustrating to rely on mains for powering water pumps. It goes to show that all-time availability in the reservoirs may not be a reality. These problems can be addressed by using power alternatives like generator sets and solar power source.

Between solar power system and generator sets, the most efficient and reliable of the two is the solar power system. Although the initial cost is somewhat huge, once installed, the solar power system can ensure a steady supply of power. Unlike the generator set that have high cost of maintenance and limited period of operation, the solar power system and run all day and ensures twenty four hours service of water pumping. Once the associated battery bank(s) are fully charged, during the day time where solar energy from the sun abundant power supply for the water pump can be available for as long as necessary. The electric energy stored in the battery, is basically a D.C quantity and may be converted into an A.C quantity in the case of A.C motor pump. This implies that a D.C to A.C inverted must be in place. The inverted is an electronic device that transforms a battery's D.C current into an A.C mains. Usually, the rate of battery discharge is always high when the battery is working. Therefore you need to conserve energy by automatically turning off the pump when the tanks are filled up. The task of controlling the volume of water in a storage tank, as well as conserving the energy used by the pumping device, is the design of an automatic system where by the above jobs can be accomplished without any human interventions(2)

2.5 REVIEW OF SOME AUTOMATIC WATER LEVEL CONTROL DEVICES.

2.5.1 MODEL NAME: MOBREY

DEVICE NAME: VERTICAL FLOAT LEVEL SWITCHES (4).

MANUFACTURE'S NAME: MOBREY TECHNOLOGIES

PHYSICAL DESCRIPTION

The vertical float level switch from Mobrey carries a stainless steel sheathed permanent magnet which rises and falls in the glandless pressure tube with changing liquid level

MODE OF OPERATION:

Switching is achieved with the unique Mobrey 3-magnet system giving snap action latch-on switching. A switching mechanism mounted inside the enclosure adjacent to the pressure tube. Vertical movement of the float magnet in the pressure tube simultaneously actuates the secondary and tertiary magnet in the switch mechanism to operate the contacts.

The 3-magnet system enables the float magnet to pass on,and actuates switch mechanisms at other levels. Switch mechanisms already actuated cannot reset until the return of the primary magnet the magnet system once again.

FEATURES:

- Up to four switch points available
- Flanged or chamber mounted
- Weatherproof

APPLICATIONS

- Alarm and shutdown duties
- Sump level control
- Large switching difference for motor control.

BENEFITS

- Simple and proven design
- Operate in most liquids
- Long and trouble free operation
- Low cost of ownership.

Automatic water level controller cum indicator is an electronic gadget called (motor controlled automatically on the basis of liquid W.R to sump and overhead tanks).

2. MODEL NAME: LIAMOCON

DEVICE NAME: AUTOMATIC WATER LEVEL CONTROLLER

CUM INDICATOR (2)

MANUFACTURERS NAME: LIAMOCON ENGINEERING

DESCRIPTION

TECHNICAL SUPPORT:

Input voltage: 230volts AC 50HZ

Power consumption: 2.5W maximum.

Working voltage: Motor trips off if voltage >250or< 160 AC.

Motor can be operated both automatically and manually.

FEATURES:

Liamocon switches on the motor if:

- The water in the overhead tank fall to prefixed value i.e. 75%, 50%, and 25%.
- Soft touch needed in case we need to switch on the motor irrespective of the water level in the tank.

2.5.3. MODEL NAME: JBJ AUTOMATIC TOP OFF SYSTEM (A.T.O)

DEVICE NAME: JBJ WATER LEVEL CONTROLLER (A.T.O)

MANUFACTURER: JOHNSON TECHNOLOGIES

DESCRIPTION:

A.T.O: Automatic top off system water level indicator is one of the most advanced water level controller system in the market today. Lifting water now is a thing of the past. A.T.O will refill as soon as the water level drops.

FEATURES:

The A.T.O is equipped with 2-float sensors that activate seconds when your water automatically refills your sump or tank until it reaches your desired set point.

BENEFITS

The A.T.O automatically stops power to your pump in your reservoir in the event that there is no water. This safety feature prevents the pump from dry and falling.

2.6 CONCLUSION AND RECOMMENDATION

In this project, the test environment was a rural settlement. And the method of sourcing for water is essential the borehole method. The borehole was constructed and fitted with submersible pump to deliver underground water into storage tanks. The entire set up was successful but however marred by a lingering problem of water spillage and continuous pump activities. The cost of constant motor activities was becoming a concern due to fat electric bills, plus the waste of water due to uncontrolled volume of water pumping. The above situation was a set back and has informed the action taken by the designer of the automatic water level control mechanism to proffer a permanent solution.

Careful studies and design principles were adopted and tried out to see the best as well as the most cost effective principle to choose. At the idea of using a calibrated sensor and the principle of Applying a positive DC voltage to the body of the water in the tank was adopted. Every other section involved in this project was adopted in the same way of careful observation and experimentation.

When the automatic water level control device was finally ready and installed, the following items were observed

1. The device takes the responsibility of a man who goes from time to put off or on the pump.
2. Saves water, protects motors live and reduces electricity bill.
3. Water reserve in the tank can be visually observed

CHAPTER THREE

3.0 CIRCUIT DESIGN AND ANALYSIS

3.1 WATER LEVEL INDICATOR

The water level indicator is one of the interesting features that s the automatic water level control device more user friendly. The level of water in a tank where it has been installed can be visually observed at anytime.

Visual indication of water level in the tank is displayed on the device's control panel by four LEDs. It could be used depending on the height of the tank and the graduation of the sensor. For this design, the sensors are sectionalized into four levels. Each LED when turned on will indicate the approximate level of water in the tank. For instance, when only the first LED counting from the top is turned on, it means that the level of water in the tank is at its highest point. On the other hand, when the volume of water in the tank is at its lowest level, the last LED counting from the top will be turned on. However, the two LEDs in the middle will indicate their respective level of water in the tank when they are turned on.

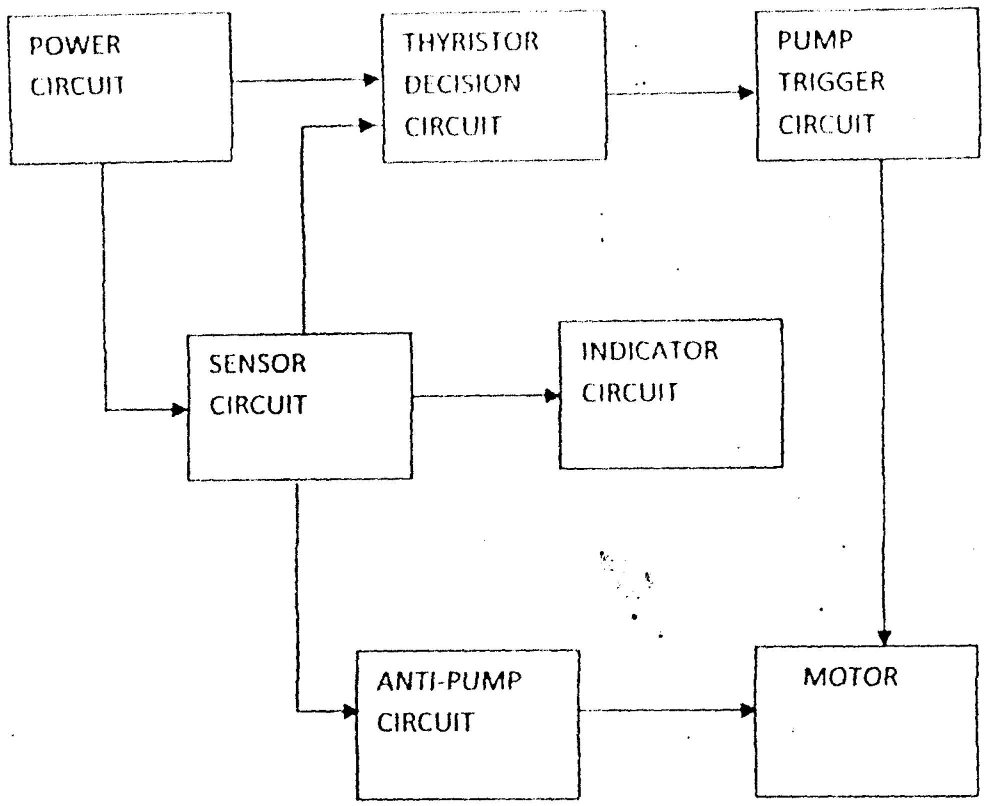


FIGURE 3.1 SIMPLIFIED BLOCK DIAGRAM OF AUTOMATIC WATER LEVEL CONTROL DEVICE

3.2 CIRCUIT DESCRPTION

The level, indicator is built around four transistors (BC945), operating at switching mode. Any medium switching general purpose transistor can work perfectly. The only active components are the four transistors and the LEDS. For proper switching operation, the transistor can be switched on independently. The LEDS are used as collector loads for a given transistor.

A 220 ohms resistor is used as the LED current limiter inserted along the emitter path of each transistor. The figure below shows the circuit of a single section of the four transistor switching network.

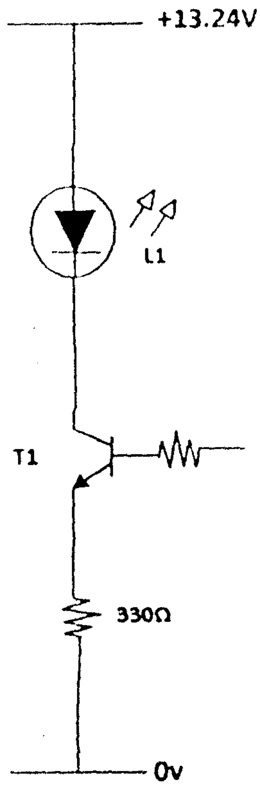


Figure 3.2 SINGLE CIRCUIT DIAGRAM OF LED LEVEL INDICATOR

From the circuit diagram in the figure (3.2) above, it is obvious that the LED used as the collector load will remain turned off as long as the transistor is operating at cut-off i.e. no current at the base terminal. The only time a base current will be available to turn on the transistor, so as to light up the LED is when the sensor attached to the base of the transistor sense the presence of water.

Once the sensor senses the presence of water, a biasing current drives the transistor into saturation and a collector current drives the transistor into saturation and a collector current is drawn by the LED. This current is however, limited to a safe value of about 25-30mA by the 330Ohms placed in the emitter to ground path.

The overall indicator containing four LEDS, four transistors and their biasing network is shown in the diagram below.

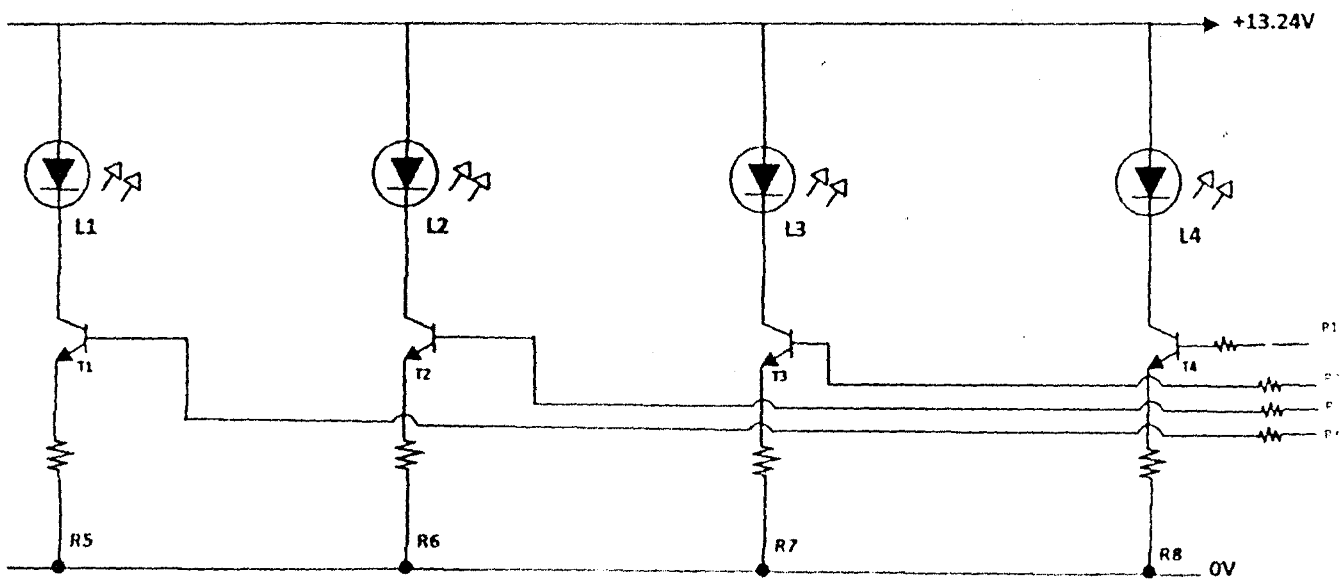


Figure 3.3 showing the complete circuit diagram of the LED level indicator

3.3 POWER SUPPLY

The entire control circuit of the water level control device is made up of discrete electronic components; I.Cs (integrated circuits). Transistors, diodes etc. these components depend on DC power source to operate. A simple AC to DC converter using a step down transformer, a bridge rectifier and capacitor filtering network, serves as the main DC supply. This main DC supply unit will provide power to sections like: the decision circuit, level indicator, anti-air pumping mechanism and pump triggering circuits.

The biasing DC voltage for all these sections is 13.24volts.Although the rams' value of the voltage from the rectified transformer step-down is 18.90volts

The other power supply is strictly used to bias the sensor network only. The 18.90volts of the main power supply is further cut down to 9.0volts this time around through an I .C voltage regulator (LM7809). The reason for putting extra effort for further stabilizing the utility voltages is that any fluctuation in the D.C power rail affects the working of the various control sections adversely.

The most sensitive part of all is the sensor network; care is taken to ensure that at all times its biasing voltage is kept at 9.0volts.

Figure (3.4) below shows the circuit diagram of the power supply for the control circuit of the water control device

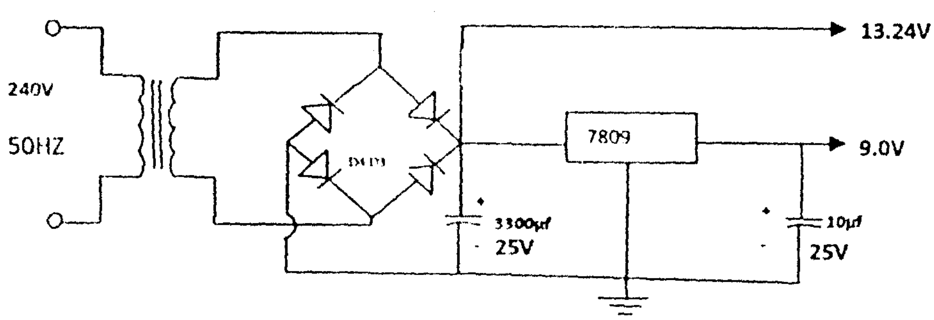


Figure 3.4 showing power supply circuit

3.4 CALCULATING FOR THE VALUE OF THE D.C VOLTAGE AFTER RECTIFICATION

Using the relations: Vdc = 1.4Vac

Where;

Vdc = rectified DC voltage from bridge rectifier

1.4 = multiplying factor for using capacitor filter.

Vac = AC voltage to be rectified.

Data:

Vac = 9.6Vac

Using the relationship

Vdc = 1.4Vac

=1.4 x 9.6

Vdc =13. 44V

3.5 PUMP TRIGGER CONTROL UNIT

The pump control unit uses a transistor inverter network build around two transistors: the H9014 and D400. H9014 is a general purpose small power transistor. Here it is used to work inversely with the D400 which is of higher power than it (H9014).

It was preferable to use the D400 which has robust current handling properties to drive a DC relay as a collector load. The DC relay used as collector load of D400 is only energized when the H9014 is biased by a positive signal and driven to saturation. The inverse mode of operation of the two transistors is to make compatible the pump's trigger circuit and the signal from the decision circuit. The signal from the decision circuit comes on only when the tank is tank is filled up with water and at that point the H9014 receive a positive signal at its base and is biased. While it conducts the collector voltage is dropped below the 0.7 volts Vbe mark required for turning on the D400. As a result the D400 is turned off. Now the D.C relay on D400's collector has one of its normally close contact s connected to live A.C mains. The other contact goes to the coil of another relay this time an A.C relay, that is, a relay whose coil operate on A.C mains . The contact of this A.C relay when close gives mains supply to the pump. This way, the D.C relay serve's as a switch to the A.C relay and the normally open contact of the A.C relay serves as a switch to the pump. This arrangement is such that when the D400 is turned off: both the D.C and the A.C relay would be de-energized thereby cutting power supply from the pump. The situation occurs only when the tank is filled up and a signal from the decision circuit triggers the H9014 on. On the other hand when the biasing signal is withdraw from the base from the H9014, because the tank is almost empty, and sensors are all reading zero, the voltage on the collector of the H9014 will equal the D.C supply voltage of 13.24volts this voltage is sufficient to turn on the D400. With the D400 on, it's collector load: the D.C relay coil is energized and so is the A.C relay.

The normally open contact of the A.C re4lay would be come normally close and the main supply is restored to the motor pump and the pumping of water resume's the process is continued without human intervention. In the figure shown below, the circuit diagram of the pump trigger units explains the connection of the two transistors working in inverted mode, and the A.C and D.C relay connection to the pump and mains supply.

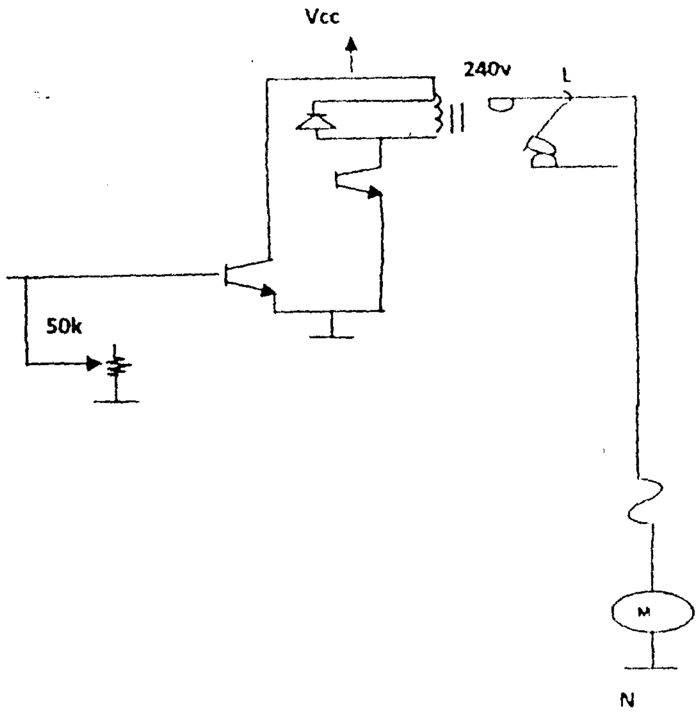


Fig (3.5) showing the circuit diagram of pump trigger unit

3.5.1 DECISION CIRCUIT

The turning off of the pump when the volume of water in the tank Is about to overflow and the resumption of power supply to the pump when the volume of water is very low, have to employ some sort of intelligence.

Although, the sensors are there to make available the information about the level of water in the tank at various points, a decision circuit is needed to determine how the goal of water level control is accomplished. The turning on of the pump is programmed in such a way that the pump comes on only when the volume of water is at the lowest level that is , when all the output of the sensors are zero which implies that they have sensed the absence of water. However, this does not mean that the tank is completely empty; it only indicates that the level of water has just fallen below the first sensor counting from the bottom. This is allowed so that the tank will not be completely empty before pumping resumes.

This strategy is one of the features of this design that ensures that energy is conserved where battery is used to power the pump. If on the other hand the pump was programmed to turn on the pump every time the first sensor from the top reads zero, there will be frequent turning on and off of the pump at short intervals and unnecessary energy use up will set in. In order to be able to manage the above information effectively, a decision circuit built around a thyristor is employed

3.6 CIRCUIT DESCRIPTION AND CHOICE OF COMPONENTS USED.

Once the level of water in the tank reaches the highest sensors point and the pump is turned off, the level control device is designed in such a way that the pump remained turned off even when the tank is being emptied.

The idea is to prevent the pump from continuous early pumping activity which occurs whenever the water level at the highest sensor point is reduced. When this happens the pump will be triggered on for only short period, which is likely to continue too often especially when the tank is being emptied frequently. This early triggering on of the pump has adverse effect such as constant pump activity which can level to pump motor failure.

By default design, the pump should only resume activity when the level of water in the tank is at the lowest sensor point. This control of pump activity is achieved by using a thyristor switching technique.

The thyristor also known as SCR (silicon control rectifier) is a very useful switching device in electronics. It is a rectifier with a third terminal for control purpose Once forward biased i.e. when the anode terminal is connected to the positive rail of the power supply and the cathode to the negative rail, the device will operate in its forward blocking mode, and will not conduct current from the anode to the cathode like the usual diode rectifier would do.

However, when a short positive pulse is applied at the gate terminal with respect to ground, the forward blocking mode is removed and the device (SCR) is turned on. The application of positive pulse to the gate terminal to turn on the SCR is called SCR firing.

Once the SCR is fired it remains in its on state regardless of the gate's voltage level thereafter, this means that even if the positive voltage that initially turned on the SCR is removed, it still continues to conduct. The SCR can only be turned off by removing the anode voltage.

This feature of the SCR plays a very important role in the design of the anti early pumping control.

The working principle is described as follows; the anode terminal of the SCR is connected to the sensor at the lowest level of the tank. The idea is that once pumping commences and the first sensor point is biased by the rising water level, the SCR is also biased but will remain in forward blocking mode, while waiting for a positive gate voltage. The gate terminal is connected to the highest sensor point which only becomes biased when the tank is filled. At this point the SCR is fired and remain latched. Even when the tank is being emptied and the highest sensor point let go it bias, the latching condition of the SCR is unaffected, hence the pump still remains turned off.

As the tank continues to be emptied, the water level in it decreases below the lowest sensor point, and the anode voltage is removed thereby turning off the SCR; when this occurs, the pump receives supply and begins to dispense water into the tank.

3.7ANTI AIR PUMPING MECHANISM

When a water pump's motor fails water and just pump only air the situation is called dry pumping and soon becomes unhealthy if allowed to continue for a long period of time.
The armature current of such a motor can increase indiscriminately as a result of under damped speed which was supposed to be provided by a load. The overshot of armature current at no-load condition has adverse effect on motors such as loss of speed control, armature temperature rise and breakdown of insulation winding and thereafter, complete motor failure.

When air pumping occurs, non-continuous rated motors are quick to come down with the associated problems. Continuous rated motors can take a little longer before insulation failure begins. Since the problem appears to be general, the only remedy is to stop motor as quick as possible, the moment dry pumping begins.

Various techniques are employed to counter dry pumping depending on the dosing of the technique. In this design, a very simple but yet cheap mechanism is used to intercept dry pumping. The components of this mechanism include; a sensor, a logic gate, a transistor relay driver and a timer. The strategy is such that once pumping of water begins; the timer is triggered on and begins to count. This period of counting is 10minutes. Once this period is elapsed and the sensor attached to the mechanism has no contact with water, the pump will automatically be turned off.

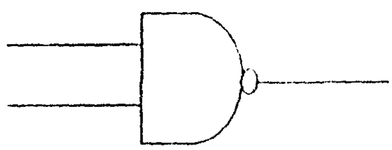
If however, before the 10minutes period expires, the attach sensor senses the presence of water, the timing cancel out and pumping continuous.

3.7.1CIRCUIT DESIGN AND DESCRIPTION

The anti air pumping mechanism is built around a CD4011BP, transistor driver, and a delay timer. The CD4011BP is a two input Quad NAND gate. The 14 pin dual in line package I.C is the 40 series CMOS version.

To make the anti air pumping mechanism simple, only one of the four NAND gates was used. The working of the NAND gate is such that one of the two inputs must be high for the output to be high.

The figure below shows the schematic diagram of a two input NAND gate and its corresponding truth table.



A	B	X
1	1	1
0	1	1
1	0	1
0	0	0

FIG 3.5 Showing both schematic diagram and truth table.

The result of the truth table in figure (3.5) gives very important information that was used to design the working of the anti air pumping mechanism. Referring to the top row of the truth table, the output of the gate, reads low when the two inputs are.high.

Applying these findings to the circuit diagram in figure (3.5), input A of the gate is kept high by a pull up resistor and input B pulled to the ground through a resistor

Once input B becomes high due to the presence of water as sensed by the sensor, the output X gives a low logic level.

The state of the gates output, determines the triggering of the timer. The timer is essentially a delay with relay coil and contacts capable of holding up to 10A at 240v A.C mains. This contact rating is capable of withstanding the breaking and making impulse during motor pump switching. The coil of the relay in the delay timer is used as a collector load of the transistor driver whose base is directly connected to the output of the NAND gate.

The contacts of the delay timer are used as a switch between the pump and the A.C mains supply.

Once pumping commence, power is supplied to the anti air pumping circuit. At this point the output of the gate is at high level, and the transistor relay driver is biased and driven to saturation, this process energizes the timer and counting begins. During the counting period if it happens that before the 10minutes is elapsed, water has pumped up to the level of the sensor attached to the input B of the NAND gate and reads a high level to it, the output of the gate goes to low logic level and pull to ground the base of the transistor driver. This development de-energizes the relay coil of the timer and the delay is cancelled and pumping continues.

On the other hand, if the 10minutes mark elapsed without the sensor reading a high signal to input B as a way of sensing the presence of water, it means that the pumping process have been dry pumping. At this point the contact of the relay is de-energized and cut off supply from the pump and turns it of

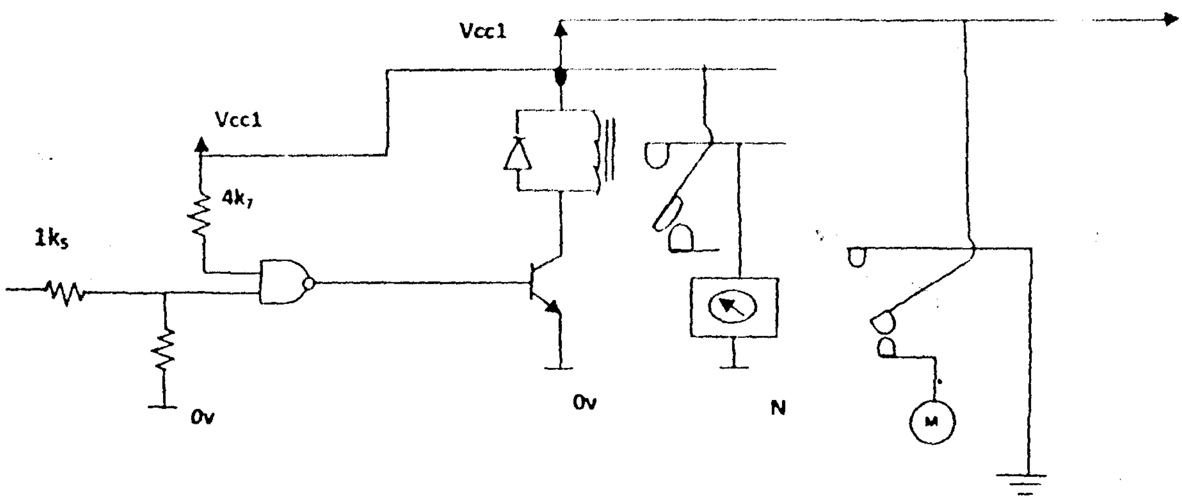
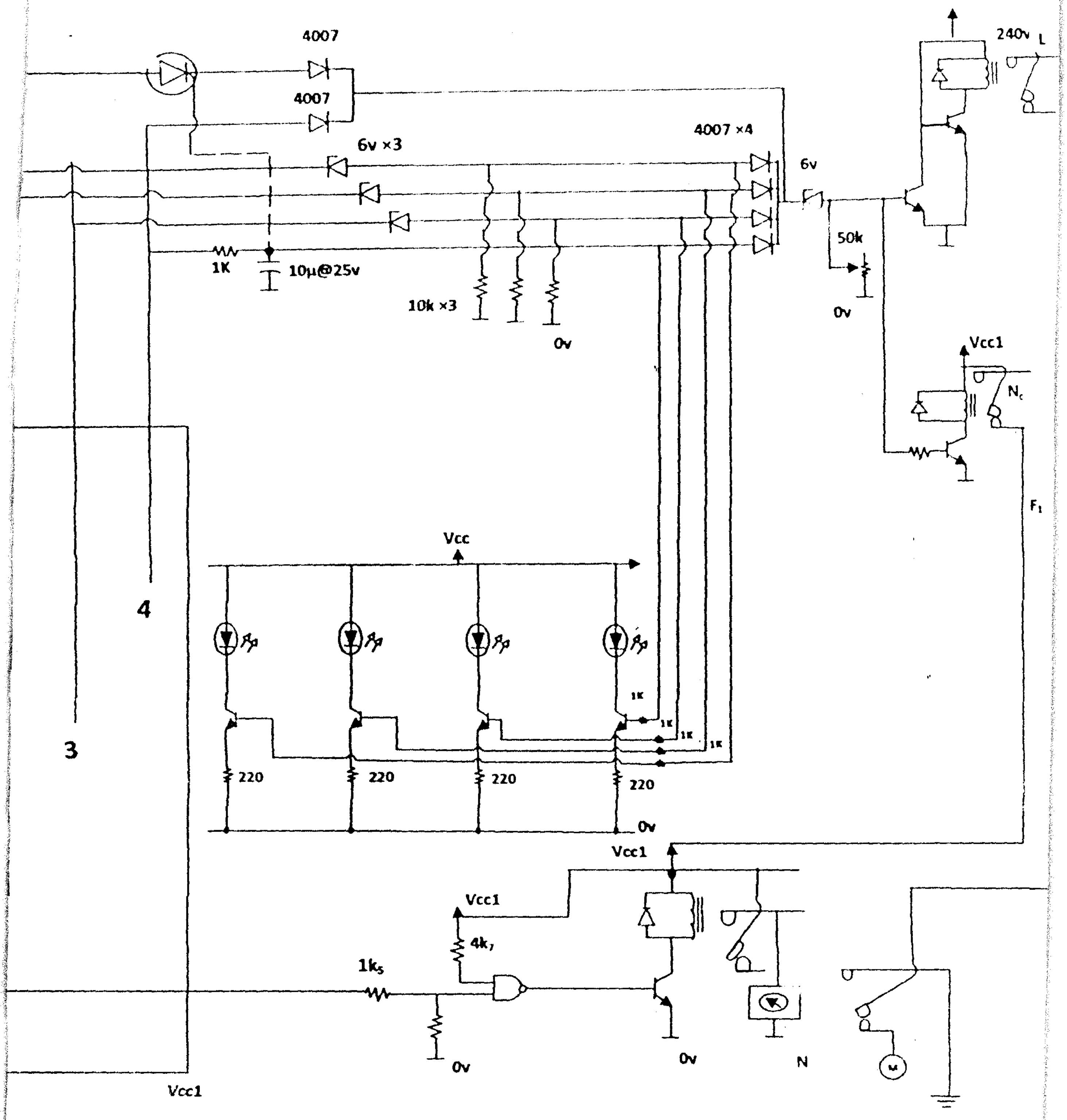


FIG 3.6 Anti-Air pumping Mechanism



PLETE CIRCUIT DIAGRAM OF AN AUTOMATIC WATER LEVEL CONTROL DEVICE

CHAPTER FOUR

4.0 TESTING AND CONSTRUTION

A number of materials committed to use during the construction this project work. It is encouraging to point out that 90% of the materials used are locally sourced.

Details on the types of materials and how they are used are explained section by section.

4.1 THE SENSOR

CONSTRUCTION AND MATERIALS USED.

The sensor is made of five enamel copper wires embedded in a three centimeter wide Perspex material of three feet long, depending on the height of the tank. The copper wires at the lower end are soldered to a pure copper strips of five millimeter square each.

Because, of the flexible nature of the rather blade like, three centimeter wide Perspex material used, a plastic channel tube was used to reinforce it. At the upper end of the copper wires, a cable connector is used to collect the bunch of wires to the control circuit.

The choice of plastic and Perspex materials are not farfetched:

A. They are perfect insulators.

B. They are materials that are not liable to rust and corrosion.

4.2 TEST AND RESULTS

For this design, the sensors are sectionalized into four levels. Each LED when turned on will indicate the appropriate level of water in the tank.

- LED 1(counting from the top) was turned on when water touched the sensor connected to it, an indication that the level of water in the tank is at the highest point.
- LED 4 (counting from the top) was turned on when water touched the sensor connected to it. This indicates the lowest level of water in the tank.
- LED 2and 3 turned on respectively when water touched the sensor connected to them. They indicated their respective level of water in the tank.

The anti-air pumping sensor is positioned at the same level with sensor No. 3 to avoid unpredicted output to the anti-pumping circuit.

During the test, the timer is set at 10minutes.

At time (t) =10minutes, the water pump automatically turn off (sensor made no contact with water).

At time (t) > 10minutes, the timing cancels and pumping continues (sensor made contact with water)

4.3 THE ENCASEMENT (CASING)

CONSTRUCTION AND MATERIALS USED

The material used as casing for the control circuit is entirely made of Perspex. Perspex is transparent, easy to cut into desired dimension, relatively chip although a bit difficult to come by. The main feature offered by Perspex is its good finish when eventually assembled. Other merits are its light weight compared to metal sheet of relative size.

The casing that housed this project is made into a box, with the following dimensions.

Length.........250mm

Breadth........200mm

Height............100mm

Perspex was preferred to any kind of metal for obvious reasons;

- The costs of per square meter of steel sheet compared to that of Perspex are unmatchable. Steel sheets are far more expensive than Perspex.
- Cutting process and finishing: it will take special cutting tools and joinery to make a good finish if metal sheets were used for constructing the case. On the other hand, a simple Perspex cutting knife, and glue were all it takes to bring out a beautiful and well finished box.
- Superior glue such as top bond super glue were used to fasten the various sheets of Perspex together, to give the final finish for both the sensor and case constructions.

4.4 CONTROL CIRCUIT

The control circuit is built on a large size Vero board. All the various sections of the control circuits were however tested on a project board and certified workable before final transfer to the permanent Vero board. Every adjustment needed was effected on the project board before component soldering on the Vero board.

Soldering process of components into Vero board was carried out using high quality soldering lead and low heating soldering iron.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

In this project, the test environment was a rural settlement. And the method of sourcing for water is essentially the borehole method. The borehole was constructed and fitted with submersible pump to deliver underground water into storage tanks.

The entire setup was successful but however marred by a lingering problem of water spillage and continuous pumping activities. The cost of constant motor pump activities was becoming a concern due to fat electric bills, plus the wastage of water due to the uncontrolled volume of water in the storage tank during pumping. The above situation was actually a set back and has informed the action taken by the designer of the automatic water level control mechanism to proffer a permanent solution.

Careful studies and design principles were adopted and tried out to see the best as well as the most cost effective principle to choose. At the end, the idea of using a calibrated sensor and the principle of applying a positive D.C voltage to the body of the water in the tank was adopted. Every other section involved in this project was adopted in the same way of careful observation and experimentation.

When the automatic water level device was finally ready and installed, the following items were observed:

1. The device takes responsibility of a man who goes from time to time to put off or on the pump.
2. Saves water, protects motor's life and reduces electricity bill.

3. Water reserve in the tank can be visually observed anytime.

5.1 RECOMMENDATIONS

The following recommendations are necessary:

- The automatic level control should be harnessed to function with other liquids art from water.
- Possible ways of introducing and widespread usage should be exploited.
- Large scale production and widespread usage should be encouraged.

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