# AUTOMATIC LIQUID LEVEL DETECTOR – Customized Model

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OCTOBER, 2006

# AUTOMATIC LIQUID LEVEL DETECTOR- Customized Model

By

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A Project submitted to the Department of Electrical and Computer Engineering, Federal University of Technology, Minna, Niger State, Nigeria.

In partial fulfillment of the requirement for the award of Bachelor of Engineering (B.ENG)

OCTOBER, 2006.

# DEDICATION

I dedicate this project to God.

# DECLARATION

I, **Igochukwu Ogunka**, 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.

Usman A. U.

(Name of Student) (Name of supervisor)

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(Signature and Date) (Signature and Date)

## ACKNOWLEDGEMENT

Endless thanks to God for His help, inspiration, and favour all through the undergraduate studies to this point. I thank and salute my parents, Dr and Mrs S. K. Ogunka for their noble support, and encouragement, my siblings too, and uncle Anosike Kwelle.

I dearly appreciate my lecturers Engr. M. D. Abdullahi, Dr Y. A. Adediran, Mr J. G. Kolo, etc. for their passionate transfer of knowledge and counsels. Also, much thanks to Mr. Abraham Usman, the supervisor of this project, whose encouragement, patience, and suggestions made the turn out easy and better; and my colleagues: Chijioke Odurukwe, Ugbede Ocheja, Kama Nnaanna, Ajibade John, and more, for their help and suggestions.

# ABSTRACT

'Automatic Liquid Level detector- customized model' is a reliable system for detecting and indicating the level of liquid a reservoir. Unlike some other kinds, it could offer an easy means of monitoring the level of the liquid to any depth of the reservoir. Its mode of indication is discrete and could be set to convenient intervals and gauged levels to suit a user's demand. It's easy to use and maintain, and suitable for various kinds of liquid, except ones that are corrosive to its transducer, which normally is in contact with the liquid. Consequently, the 'Automatic Liquid Level Detector- customized model' finds application in a wide field of works, both domestic and industrial, that require liquid level monitoring.

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# CHAPTER ONE

# 1.0 INTRODUCTION

In many industrial and some domestic course and function it is required or needful to have an appreciable knowledge of the level of liquid in a reservoir. This ends up being a wishful thought to many minds except they implore some very physical means.

"Automatic liquid level Detector- customized model" which will be well explained in subsequent Chapters, is a fair –cost, brilliant system which can meet this industrial and domestic need.

## 1.1 Objective

The sole purpose of the 'Automatic Liquid Level Detector- customized model' was to detect and indicate the levels of Liquid stored in a reservoir, so that observers had an appreciable knowledge of the level of the liquid at all time and exact at specified intervals which could be of exact interest to them.

It mainly was designed with the scope of aiding petroleum filling stations to know the levels of petroleum in their underground reservoir, so that they don't always have to open it to know, by taking off the heavy lid of the reservoir. However, it also is very suitable for other fields of liquid level indication.

## 1.2 Methodology

As against some beard methods of attaining this purpose, the functionality of the 'customized model' has no limitation to the depth (or height) it can measure or indicate, thus defends its name. Its measurement is however discrete. This was as a function of its transducer method, which is simple but reliable. The transducer technique implored simple adapted switches that the liquid closed as it rose through each level and opened as it fell, several discrete-levels could thus be implemented.

This concept was born out of the wide appreciation that in real uses and applications, that definite or approximate gauged levels are required rather than continuous/boundary-less measurement which mainly serve for experimental purposes. Thus, choice was here taken for better performance within purpose, against complexity.

The end of the transducer unit was a wired connection to its electronic circuitry where the signals were appropriately interpreted. It was designed to give a visual indication of the changing discrete levels of the liquid in the reservoir. Consequently the volumes of the liquid could be inferred. Also, as an important forewarner it had an alarm which blared at a very low level of the liquid before it finished. This was preset to alert or attract unobservant persons.

One thing that overtime might threaten to limit the efficiency of this system is the flow of the liquid in the transducer casing through the switching path. However, a good measure was taken for correction, prevention and to secure its continued efficient performance.

## 1.3 Materials used

Materials used to implement the design of this system were common and readily available in the market. They included simple PVC pipe, conductors, together with some of the basic but very useful electronic components such as diodes, relays, etc.

For sometime much effort was made towards achieving this measurement and indication using a non-contact method, with Infra-red sensors. In so doing, battled towards enhancing the sensitivity of the Infra-red (IR) sensors` transducer setup by operating it at its peak current/voltage rating and using no fewer than 3 sensors, so as to achieve a reasonable depth(or distance), but, it was unsatisfactory and futile. It was pondered upon until the use of wires was suggested by, Mr Ugbede Ocheja, a friend, of Physics Electronics Department. This resounded in my mind and stirred up shelved ideas which grew into this.

The "Customized Liquid Level Detector" is dependable and serves for a wide variety of liquid fluids like - Water, Petroleum products, and many other kinds of uncorrosive liquid.

# CHAPTER TWO

# LITERATURE REVIEW

The measurement of distance, height or depth as accorded to the world of Electrical/Electronics is aided by transducers, which are components that are set to convert physical quantities to relative electrical units. The electrical units, based on established measurements or the designers desired end, are then calibrated to suit the purpose opted.

There are several transducers that are direct aid to electronics for the measurement of displacement/depth. Among these are: Infra-red sensors, Ultrasound, gamma-rays, and other physical types such as 'linear variable resistance wire (e.g Constantine wire), linear variable transformers, other craft able ones, and, this used for the "Automatic Liquid Level Detector-customized model".

While choosing a suitable transducer in the design of this system, the following were considered:

- Aimed use
- Range: that is how far(or deep) the measurement can cover using the transducer;
- The reliability, durability and dependability of the method;
- Cost;
- Safety and health effect of the method;

* Size or complexity of the transducer unit.

These affected the choice of method to the achievement of the stated objective for "Automatic Liquid Level Detector – Customized Model".

As earlier mentioned, before adopting the method of transducer used for the "Automatic Liquid Level Detector" infra-red(IR) transducer set were tried, which included IR-emitter diode, IR-receiver diode and IC(GP1U5 0XG). This was to work by high-frequency emission and reflection, thus subsequently sensing with the receiver. It was discovered via research and brain-storming to achieve an enhanced range that the setup could not give an appreciable range of more than 16-inches [1]. Also, surface colour of substances, hence of the liquid, affects its absorption and reflection, thus varying strengths of the parametric signal. There are various ways to realize its setup, but the principle is the same, thus basic [2].

This is unlike the physical means of transducing which has been chosen for "Customized Liquid Level Detector" which can cover any desired range and is not impaired by the kinds of liquid whose level is to be measured, not to talk of the readily availability of the GP1U5 0XG in the Nigerian market. Nevertheless, I give credit to these IR (infrared) components which I have discovered, in the course of my research and pondering, find a wide use in the field of electronics.

The method used for the 'Automatic Liquid L-Detector' could simply be called "Activate as it flows method". It was justified to be very suitable after balancing the trade-offs on choices involved with the objective/aim. It doesn`t depend on *varying* strength of a particular electrical parameter (I,V,R,C,etc). as such has the added important advantage of stability in the face of power fluctuation. "Half (or Xcm) always remains half when it should be. Its features, quality, and mode of performance are well explained in the next chapter.

Other methods exist that has recorded some degree of success in the measurement of levels of liquid stored in a reservoir. They include works done using – Ultrasound waves which like the IR transducer setup described works by transmission and sensing after reflection. Ultrasound is a high frequency wave. The time lapse and strength of the received wave is measured by its sensor and 'decoded' to judge the distance it could attain. With increasing distance it is limited but, is better than the IR-setup in terms of range [5], [1]. Also, with increasing proximity of the liquid towards the sensor it offers a 'dead band', a wave region at which the liquid can not be sensed or detected [3]. Also, ultrasound can be used by transmitting high frequency ultrasonic pulse through the metallic vessel and comparing the analyzed signal to the empty and full level state via some predetermined program [4].

Also, methods exist that make use of the electrostatic (capacitance) strength between a capacitive sensor and the liquid. When power is applied to the sensor, an electrostatic field is generated and reacts to changes in capacitance caused by the presence of a target. Specific judgment is impaired in this method by the kind of liquid to be measured since varying liquid surfaces have different charge strength, thus different dielectric constant. Hence, one must know the electrostatic property/strength of the liquid to be measured to obtain reasonable judgment and better performance. A good way for this is via pre-empirical test of the setup [3].

Water is found to be better in strength, thus supports better range than other liquid. A limitation of this method remains range (distance to which it is applicable), as regions outside its sensitive zone can not be detected, but has the advantage that the level of the liquid can still be indicated even if it overflows it. It also has the problem of impaired measurement due to precipitation of residue within the liquid [3]. Partially immersed capacitive probes have been used too.

Gamma rays have also been used. This is a very sophisticated method. It makes use of emitters and detectors standing tall beside the reservoir and as high as it. The rays are then detected at levels where the liquid has not risen to. The least of the levels give the level of the liquid. An addition to the sophistication of this method is the critical disadvantage of its health danger, since uncontrolled and much exposure to gamma rays is a serious health/life threat. Also, its complexity with increasing height or depth directly implies complex emitter and detector, thus huge cost; or a less complex one- meaning that it will be moved and set manually, mainly when the depth is to be measured at any time by an individual or automated process. I also add my fear that based on my understanding of atomic physics and chemistry that this might cause mutation of the liquid in the storage, thus nutritional problems if it is liquid foods, or 'malfunction` for others. Concerned chemist or atomic physicist should look into this.

Also, according to [8]; American Society of Mechanical Engineers has lately discovered a method of liquid level detection by 'mechanical resonant vibration. This is based on the longitudinal vibration of a steel capillary, and is able to detect a liquid (even if covered). The behavior of the vibrating system is then calculated and compared with previous experimental results.

Looking at all these and other device-able means, the environment, situation and purpose for the measurement answers appreciably to the question of 'which kind of transducer is to be used?', thus justifying among other important reasons the reason for this means which is reliable.

# CHAPTER THREE

## 3.0 DESIGN AND IMPLEMENTATION OF THE SYSTEM

The entire system`s design could be divided into three main parts, each having very unique importance. They are as follows:

1. The transducer unit.
2. It's electronic circuitry ('the interpreter`).
3. It`s casing

The functional block below illustrates the operation of the system.

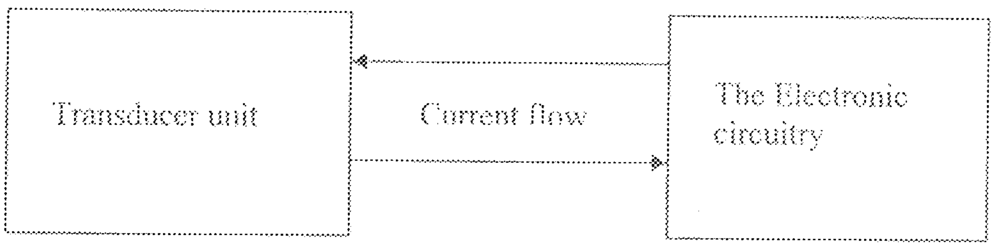


Fig 3.0 Functional block of the Automatic Liquid Level Detector

The transducer unit was solely meant to sense the levels of the liquid at preset measures, subsequently articulating with the electronic circuitry which interprets it with a visual meaning to an observer. And the casing was mainly to serve the purpose of housing the units and other important functions- view section 3.3.

## 3.1 The Transducer Unit.

The transducer unit used for the customized liquid l-detector as earlier mentioned, is a method that could simply be called "activate as it flows". Basically it functioned like switches. However the circuit's functionality altered this simple illustration, but not completely.

This unit comprised of a stem of PVC pipe projected to a desired depth of the reservoir. That is, the depth to which was to be measured dictated the length of the stem. The pipe held the simple switches along its length at designated levels and intervals. This was as illustrated in fig 3.1. below.

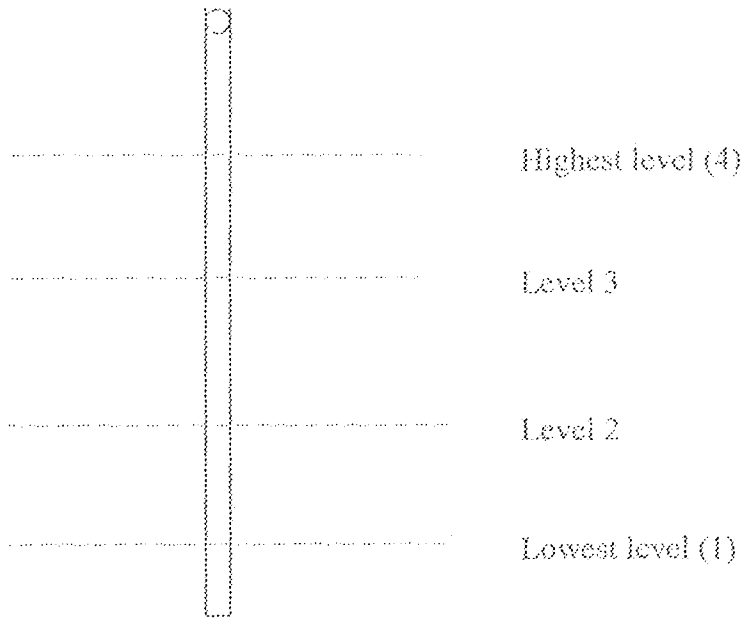


Fig 3.1a Pipe at gauged levels
for the flow switch.

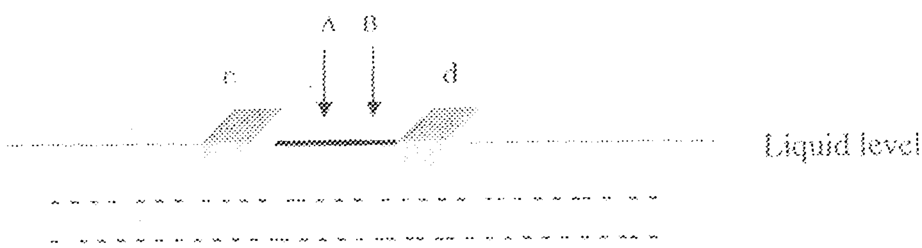


Fig 3.1b switch illustration

The pipe should be non reactive with the Liquid whose level is to be measured, as such it was chosen to be PVC for common liquids such as petroleum products and water.

The flow switch at each of the gauged levels is as shown in fig 3.1b. The connector between 'c' and 'd' had a conducting surface which bridged 'A' and 'B' whenever it contacted with them. Its conducting surface was made to be curved to prevent the settlement of the liquid on it. It was also rust resistant.

'c' and 'd' where slim plastic strips of reasonable surface area, not too large, but of $1.5x1.5cm^2$ area. It thus had sufficient buoyancy to float on the surface of the liquid. Consequently, rising as the liquid rises and drops as the liquid drops, hence closing and opening the switch.

The slit along the cross-section of the pipe along which the flow switch lever flowed was not continuous from top to bottom, this was to permit the easy location of contacts A and B (within the hollow), and the strength of the pipe which would have been weakened. As such this kind of switches were implemented at each desired level to enable its indication whenever the liquid reaches.

'A' and 'B' contact point were made to be sharp pointed to minimize the chance of smearing its surface with the liquid of any kind, so that the needed electrical contact would not be impaired. Also, they had high corrosion/rust resistance, as rust can also impair the contact.

At the ends of 'A' and 'B' conductors were connected, which in easy terms served like 'swich and feed wire in an installation'. The conductors were vanished $0.4mm^2$ copper conductors which ran within the pipe in a way that they won't disturb the flow switching at other levels through to the end of the pipe outside of the reservoir.

The conductors were chosen to be vanished so that there won't be leakage along its length to prevent short-circuit or current transfer to another switch line. Also to minimize the dc current interacting with the liquid, which nevertheless was not capable of causing any form of shock nor impairing the functioning of the circuit.

In choosing a conductor for this purpose the resistivity of the conductor was considered and the resistance of the entire length subsequently. This was in order to avoid loosing part of the little current the system was dealing with to unneeded resistances along the length of the connecting wires.

The resistivity, p, of copper is $1.7 \times 10^{-8}$ ohm.m. Consequently, the resistance, R, (where R=pL/A) of the switch conductors to a long, L, and cross-sectional area, A, could be negligible, thus serving the purpose.

At the end of the pipe the switch conductors were terminated with male port pins from which suitable female ones could be connected to the electronic circuit.

### 3.1.1 Fitting the Transducer

The transducer was to be fitted to protrude vertically at an angle of $90^0$ from the lid of the reservoir. It mustn't reach the bottom, but reached the bearest minimum level of liquid desired relative to the size of the reservoir.

Fixing it at $90^0$ to the lid, that is vertically, allows the flow switches to function very well. Also, passing it through the centre would assure the even distribution of the liquid`s pressure around it and thus its protrusion angle.

## 3.2 The Electronic Circuitry

The electronic circuitry comprised of inter-operating parts which can be sectioned and detailed into smaller modules or units which could perform unique functions. The various units were:

1. The Power Supply Unit
2. Logic Unit
3. Indicator Unit.

However, the conductors within the transducer-nit also formed part of the electronic-circuitry.

The inter-operation of the modules is as illustrated in fig 3.2 below.

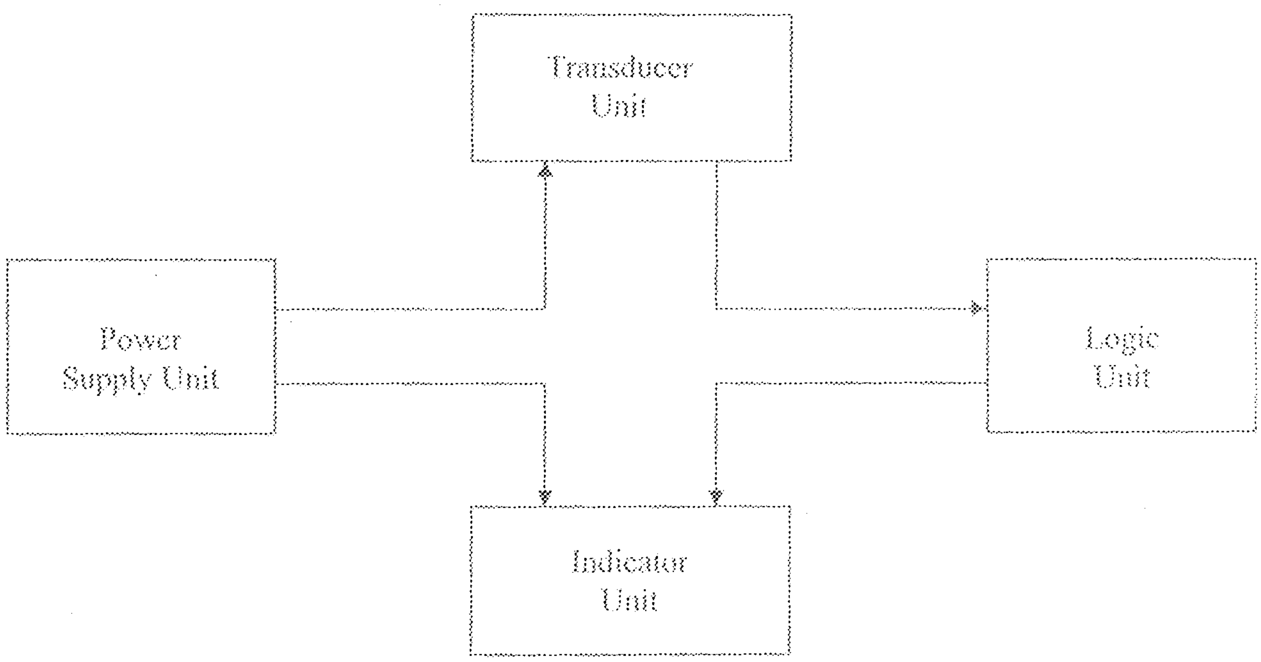


Fig 3.2 functional modules of the Electronic Circuitry

### 3.2.1 The Power Supply Unit

The Power Supply Unit was comprised of: an input line from an AC source, an induction step-down voltage transformer, a fuse, full-wave bridge rectifier, a capacitive filter, and a 5 volts regulator unit.

#### 3.2.1.1 Input Line from an ac source

Power was drawn from an external source of 220-240V ac into the (*Power*) unit using a suitable conductor. This was no challenge as there exist suitable conductors for this purpose. However for an approximate rating of 240V, 4A, 0.4mm$^2$ copper conductor was chosen. This could withstand the needed power drawn, and also maintains the interest of minimizing unnecessary cost of materials and production, as larger cross-sectional areas of similar conductor would imply larger cost and superfluity.

#### 3.2.1.2 The Transformer

The transformer used was of 240/15V, 50HZ rating and had a mass of about 3kg. It was fitted outside the circuit board. Alternating current (ac) supply at 220-240V was input to the primary side of the transformer and the output from the secondary (low voltage) side connected to the full wave bridge rectifier on board through a fuse. In the course of the design of the power supply section other tranformerless means were tried in order to cut down the net size and weight of the system but they produced low power which was not sufficient, and when appreciable, the heat generated was also much. Consequently, an induction transformer was resorted to, to provide the needed power level with a very low power loss and heating. Thus a dead voltage of $15V_{max}$ at $2A_{max}$ was tapped from the secondary terminal to the rectifier on the circuit board.

### 3.2.1.3 The Fuse.

The fuse through which the output from the secondary end of the transformer was a 2cm, 2A rated fuse. It was connected as a safe gateway of the 15Vmax, 2Amax to the full-wave bridge rectifier. It served the universal purpose of protecting the circuit from over current supply, and short circuiting within the circuit. I really enjoyed its benefit while designing and testing.

### 3.2.1.4 Bridge Rectifier

The full-wave bridge rectifier comprised of four IN4001 diodes which converted the 15Vmax AC supply from the secondary output of the transformer to DC. IN4001 which is of 50V, 1A, rating, according to specification was suitable to withstand the supplied power and subsequently output dc voltage which was however pulsating. The diodes, $D_1$-$D_4$, were connected as shown in fig 3.2.1. The bridge rectifier had an efficiency of 2/3 (that is about 67%), but was however boosted by a capacitive filter, which also greatly minimized the pulses.

### 3.2.1.5 The Capacitive Filter

The capacitive filter was a 4700µF, 16V electrolytic capacitor, which was connected in parallel across the rectifier's output terminals. It by its characteristic opposition to varying dc signals and allowance of ac signals, sifted pulsating DC components and weak AC harmonics from the rectifiers output. Thus, it provided a more stable DC supply across its terminals.

The high capacitance value, 4700μF as chosen, was suitable to achieve this, and to increase the dc output voltage of the power supply unit towards (15V,) the peak, likewise the current. [6].

3.2.1.6 5volts regulator

A parallel connection was made from the filter capacitor to a 5volts dc voltage regulator IC. The IC used is L9805. This, with supporting 10nF and 100nF capacitors, served the purpose of further regulating the supply from the rectifier unit at a steady voltage of +5V dc to feed other IC's on board which required +5volts $V_{cc}$.

The Power Supply Unit was as illustrated in the schematic diagram below.

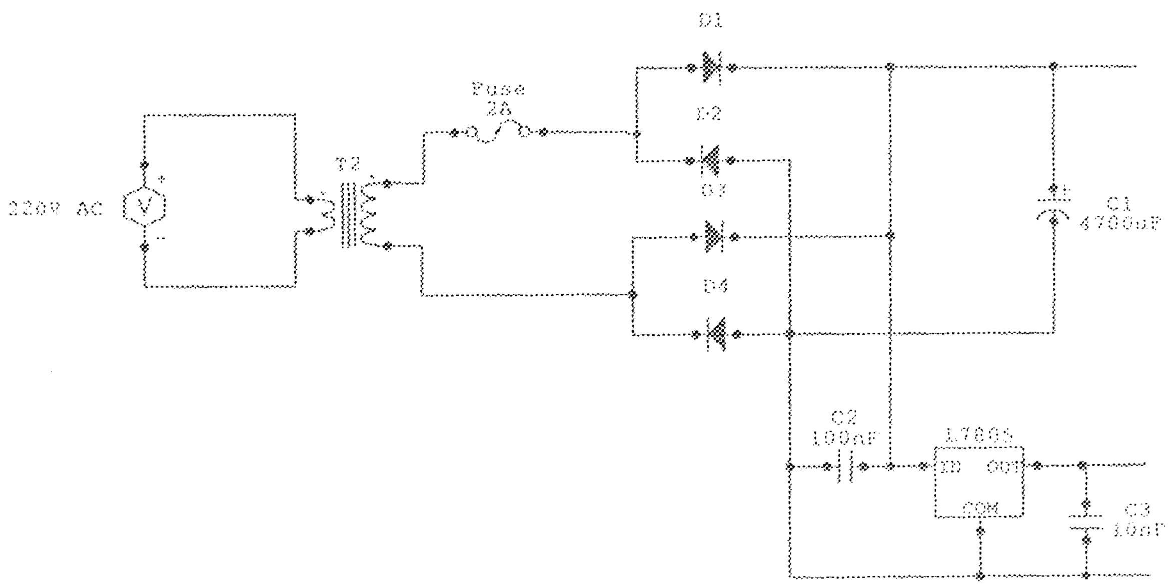


Fig 3.2.1 Schematic diagram of the Power Supply Unit

### 3.2.2 Logic Unit

This is the unit of the electronic circuit that is responsible for the selection and activation of the proper indicator. It is mainly comprised of relays an XOR gate and it's nearest aiding circuitry.

#### 3.2.2.1 The Relay Circuit

The relays used were 6V dc/10$A_{max}$ rating single-pole changeover relay. These according to the rating required pick-up excitation dc voltage of 6volts which must not be highly regulated since relays are not so sensitive to voltage or current jitters, so long as there is no drop below the pick-up point. The coil resistances of the relays were found to be approximately 98ohms each. Consequently, with the aid of a voltage divider, not less than 6volts was tapped from across the source supply filter capacitor.

This is as illustrated in fig 3.2.2.1 a and b below, with the preceding calculations-accommodating a chance-variance of 3volts less of $V_{max}$ across the rectifier`s filter.

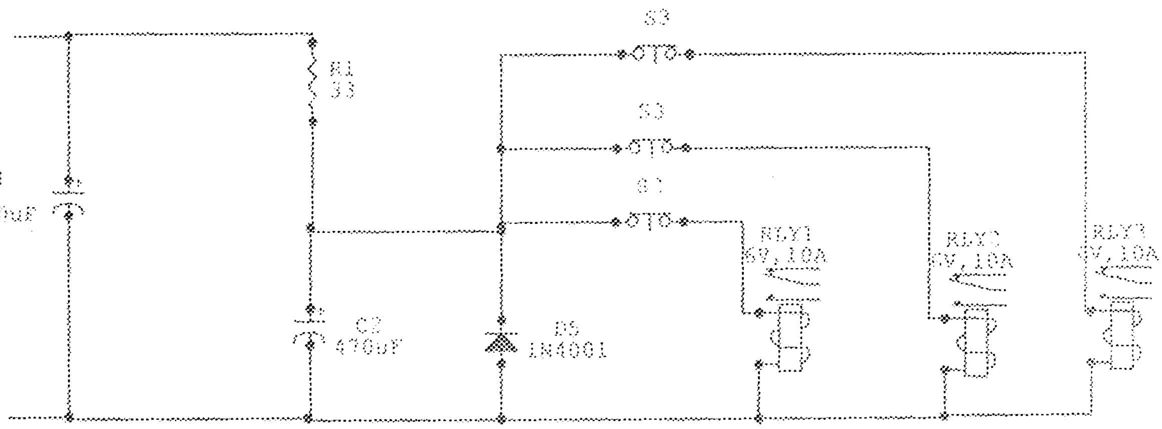


Fig 3.2.2.1a The Relay Circuit

The relays were activated one at a time per level. But, since the relays formed a parallel combination when all energized, (see fig 3.2.2.1), its design calculation was done to accommodate the equivalent Circuitry; such that the excitation signal available to its input terminals is always sufficient to operate the relays.

The equivalent resistance $R_L$ of the 3-relay coils = $[1/98 + 1/98 + 1/98]^{-1}\ \Omega$

Therefore, $R_L = 98/3\ \Omega$

$= 32.7\ \Omega \approx 33\ \Omega$

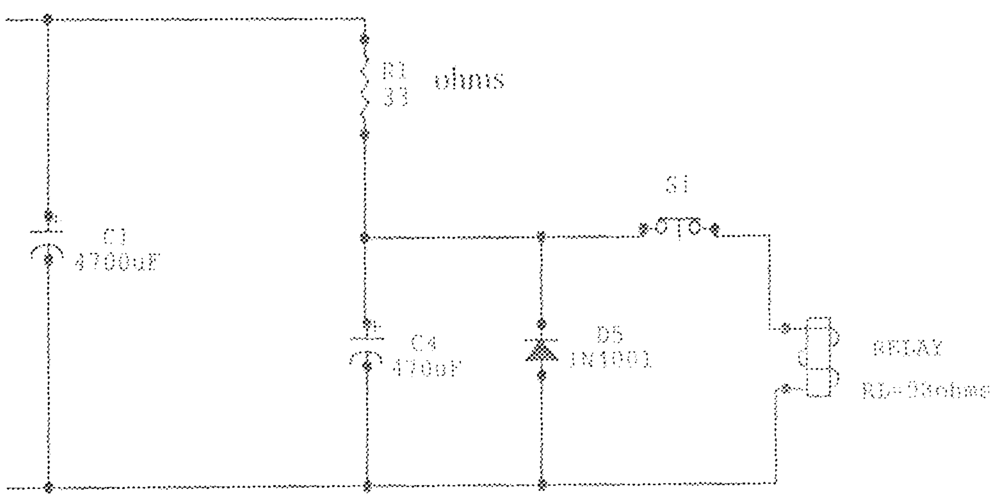


Fig 3.2.2.1 Schematic of the Equivalent circuit of the relays in the unit When all operating.

Calculations:

$R_L$ = Equivalent resistance of the 3 Relay coil when all energized = 33Ω.

Reactance due to capacitance $C_2 = X_{c2} = \frac{1}{2\pi f C_2}$

$$= \frac{470 \times 10^{6}}{2 \times \pi \times 50} >> R_L$$

Resistance due to the diode = $R_D >> R_L$

Circuit theory and principles of equivalent resistance calculation, confirms that when a small resistance and a very large resistance is connected in parallel, the equivalent resistance's value tends to that of the small one.

Hence: $R_l \approx 33\ \Omega$.

Thus, applying voltage divider principle:

$$V_{dc} = \frac{V_{dc}}{(R_1 + R_L)} \times R_L$$

$$6V = \frac{(15\text{-}13)V}{(R_1 + 33)} \times 33$$

$$6R_1 + 6 \times 33 = 12 \times 33$$

$$6R_1 = 396 - 198$$

$$R_1 = \frac{198}{6}\ \Omega$$

$$R_1 = 33\ \Omega$$

Consequently, $R_1=33\Omega$ was used in series with the equivalent resistance across $R_{L}$, which is very close to the estimated value.

$C_2$ of 6.3V rating was connected across the relay's excitation input to enhance a stable 6volts across. The remaining relays were also connected in parallel across $C_2$. View fig 3.2.2.

Maximum operating current, $I_R$, through the relay:

$$I_R = V_{dc(rated)} \div R_L$$

Therefore: $I_R = 6/98\ A$

$= 0.061A$

Diode $D_5$, an IN4001, was connected in reverse bias across the relays. This served as a free-wheeling diode to short-circuit the back emf generated in the relay coils by the opening of its supply switch $S_i$ {i = 1,2,3,4 }. Thus de-energizing the coil at such moments, thereby protecting other components within the circuit from damage due to reverse flow of current and p.d. from the relay.[7].

Haven satisfied these; whenever the relays were operated its pole contacts were switched thus changed-over. Subsequently, Indicators were connected to the contact terminals of the single pole changeover relay; thus defining a logical order of operation for the indicators. The logical control operation of (the indicators by) the relays was as drawn up in table 3.2.2 below. Also the Schematic illustration is as shown in section 3.2 .3, fig 3.2.3.

Table 3.2.2 Logical operation and control by the Relay and Gate Logic.

| Flow switch ON(1)/OFF(0) Combination | | | | Active Relay(RL) (operating) | LED Indicator ON(1)/OFF(0) | | | | Levels |
|---|---|---|---|---|---|---|---|---|---|
| $S_4$ | $S_3$ | $S_2$ | $S_1$ | | R (deep) | R (bright | Y | G | |
| 0 | 0 | 0 | 0 | None | 1 | 0 | 0 | 0 | Too Low |
| 0 | 0 | 0 | 1 | None | 0 | 0 | 0 | 0 | Low |
| 0 | 0 | 1 | 1 | $RL_1$ | 0 | 1 | 0 | 0 | $2^{nd}$ |
| 0 | 1 | 1 | 1 | $RL_1$, $RL_2$ | 0 | 0 | 1 | 0 | $3^{rd}$ |
| 1 | 1 | 1 | 1 | $RL_1$, $RL_2$, $RL_3$ | 0 | 0 | 0 | 1 | Highest |

### 3.2.3 Indicator Unit

This consists mainly of LEDs used to give a visual signal when a set gauge has been reached by the liquid stored within the reservoir. It also included an Alarm Driven by a 555-timer circuit.

The set of LEDs were of different colour, each implying a level, when turned on. Four definite levels of equal intervals up to the fullest were preset. Consequently, four LEDs of different colours were used. The deep Red LED signified that the Liquid had gone below the barest minimum: an alarm sounded with it, then the Yellow, next the Green and on more could be implemented.

The LEDs were connected and controlled as shown in table 3.2.2.

The deep Red LED and alarm was driven by a 555-timer clock.

3.2.3.1 The 555-timer circuit

The main essence of the 555 circuit is to drive the deep Red LED to produce a blinking scintillation at a set frequency, and the alarm (buzzer). The circuit was as shown in fig 3.2.3.1. The frequency of the driving signal from the timer circuit could be adjusted using variable resistance R4. $R4=20k\Omega$.

$$\text{Frequency of the 555 drive at any instant} = \frac{1}{0.693(R_3 + 2R_4)C6}$$

$$= \frac{1}{0.693(10k + 2x20k)x100E\text{-}6}$$

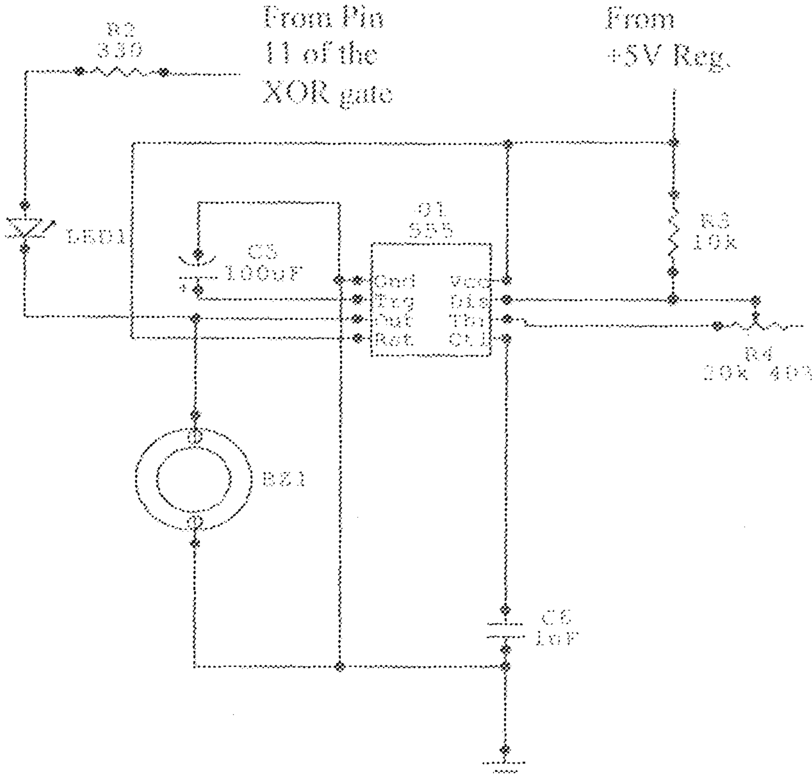


Fig 3.2.3.1. The 555-Circuit.

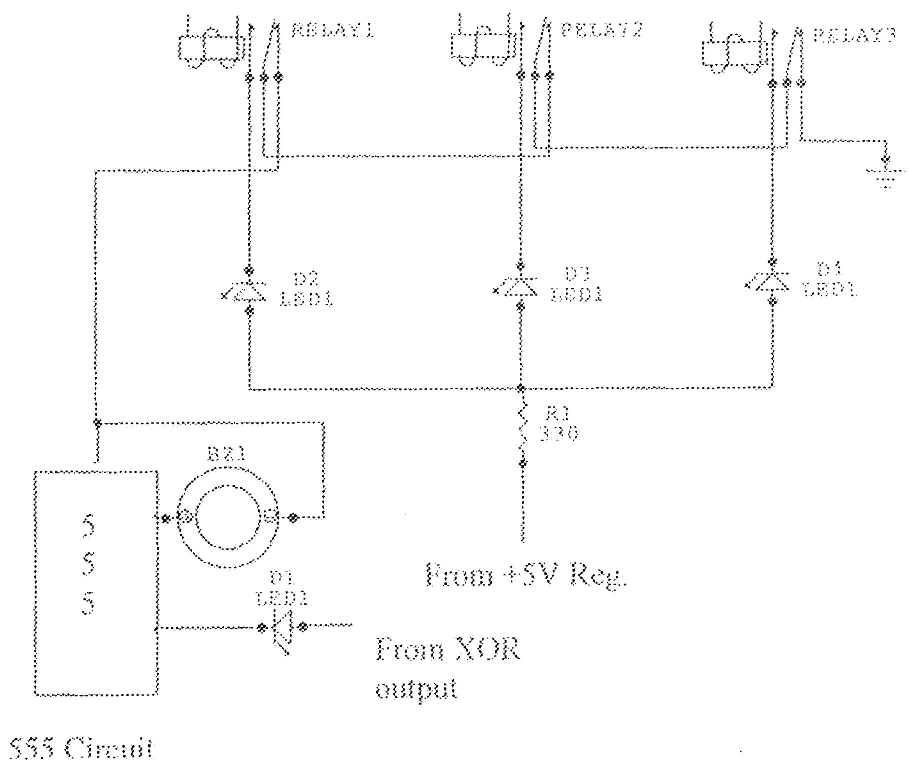


Fig 3.2.3 The Indicator unit schematic

Fig 3.2.3 above illustrates the indicator unit.

When the Signal through LED1 is high, it lights and the alarm blares, as there was a continuous ground path through the normally closed terminal of the changeover relay-1, 2 and 3, for the ground terminal of the 555-circuit.

LED-2, 3, 4, where fed from the +5V regulator, through a common 330Ω resistor.

When flow-switch $S_2$ was closed and relay-1 energized, the ground path for the 555-cicuit was broken, but connected for LED2. Consequently, LED2 came on, while all others remained low and the buzzer likewise.

When $S_3$ was closed, relay-2 was energized, thereby turning on LED2 and disengaged all others.

Also, when $S_4$ was closed relay-3 was energized, thence LED4 and all others disengaged.

## 3.3 Casing

This in other words is the housing of the electronic circuit within which it was packaged. More than just a housing, it was designed and constructed to serve the following important functions.

- It allowed the attachment of electrical connections to its ports with ease.
- It had a colour that formed a background on which the colour (visual mark) of each stage could be easily seen from a distance.
- It was perforated such that it permitted cross ventilation within, and propagation of the buzzer-alarm sound.

- To protect the circuit from harsh environmental conditions and human disturbance.
- It was made such that it could be hung on a wall with the aid of a slim protruding support or cord.

It was noted that packaging serves an indispensable role in acceptance, as such the case was made such that yet serving the above important functions had an aesthetic look.

# CHAPTER FOUR

## 4.0 TESTS, RESULTS AND DISCUSSION

During and after the implementation of the design tests were carried out to test the performance of individual components, unit and subsequently the entire system. The tests covered areas that could possibly affects its Physical and Electrical strength and performances.

### 4.1 Physical tests

Since the transducer method of the detector was quite physical, necessary tests which were mechanical and chemical related were performed on the level transducer, likewise on a few of the electronic component. This provided useful utility feedback and proved the extent of its dependability.

4.1.1 Mechanical related tests

(a) Weight.

The weights of materials used for the transducer were considered, consequently its net weight. It had a fair weight of about 1kg, as such it was quite portable and easy to install.

Also, the weight of the electronic circuitry was considered and found to be relatively appreciable. 'Appreciable', in the sense that a lighter weight would ease carriage and easy placement on the wall, or any desired place of convenient visibility.

The circuit transformer was the major weight of the circuit, consequently to achieve the said convenience it was fitted outside the main electronic circuit board in a different chamber, and, connected with a reasonably long cord to permit movement.

(b) Ease of flow-switch

The operation of the flow-switch was tested for consistence, and was found to be 80% reliable. This however should be due to chance inaccuracy in manual implementation of it.

4.1.2 Chemical related tests

These in order words are tests that were carried out to investigate effects of the environment or medium within which the transducer was operating on it.

Water and kerosene, a petroleum product, are the commonest kind of liquid this device could be used for. Consequently, conductor used at the contact points was put in water and kerosene, for a day and more to investigate its reaction with them. Hence, the silver contact points were found to be non reactive, nor rusted.

This was done to guarantee that there will be electrical continuity when the discrete levels were reached.

## 4.3 Electrical tests

These were tests carried out with the bias of the working design of the electronic circuitry; that is they were done with the aim of confirming its operation and possible troubleshooting. Digital multimeter was very handy in doing this.

Resistance of resistors acquired, likewise properties of other components were tested before being fitted on board. Some of the components though presumed new were found to be far from the expected. A low resistance from a high coded band once caused malfunctioning and braking of the fuse, because it caused short circuiting. This was discovered via test and rectified.

The input and output voltages of the transformer were tested and consequently its efficiency evaluated. It had a percentage loss (in-efficiency) of 3.177%, that is 96.823% efficient. This, in addition to appreciated variations in **ac** power supply, influenced the design of power supply to the relay unit.

Also, the ambient temperature while the circuit functioned with some other circuit specifications was considered. This prompted further analysis for alternative designs, thus this. And creation of air vents in the casing.

# CHAPTER FIVE

# CONCLUSION

The 'Automatic Liquid Level detector- customized model' proved to be a simple and reliable means of sensing and indicating the levels of liquid at gauged levels and intervals. Such levels and intervals could easily be made to suit the desired use.

## 5.2 Important challenges

It is worth mentioning here that the use of relays to implement the logical selection of a single, unique indicator per level implies additional weight for more number of levels, thus making the circuit a little more complex and heavy. Nevertheless, logic gates can also be manipulated to achieve this.

The number of relays that could be used for 'n' number of unique levels, not excluding the too-low to empty state, was n-1.

## 5.2 Possible improvements

Instead of relays, which appreciably require more power than ICs, it was realized that gates can be well manipulated to implement the circuit. This will vividly help to cut-down weight and power consumption when it is needed to be used for an appreciable number of discrete level indications.

Also, the current through the flow-switch feeds, that is the conductor from the flow-switch into the circuit, can be linked to a network of resistors; each switch level having a unique resistance. This afterward, would be input to an analog to digital converter and decoded to drive a seven segment display. This is an alternative to using unique LEDs.

Each level, especially the highest and the least level can be linked to automate a desired function, e.g a pump system. This can be done by connecting a thyristor to the unit from the least switch-level through which the live terminal of the pump would be connected like a switch. Subsequently, the pump would operate. And, at the highest level, with the aid of an AND gate, with one input from the switch enable and the second held constantly high from a supply. Thus its output can be used to operate a relay through which the pumps live terminal is also connected.

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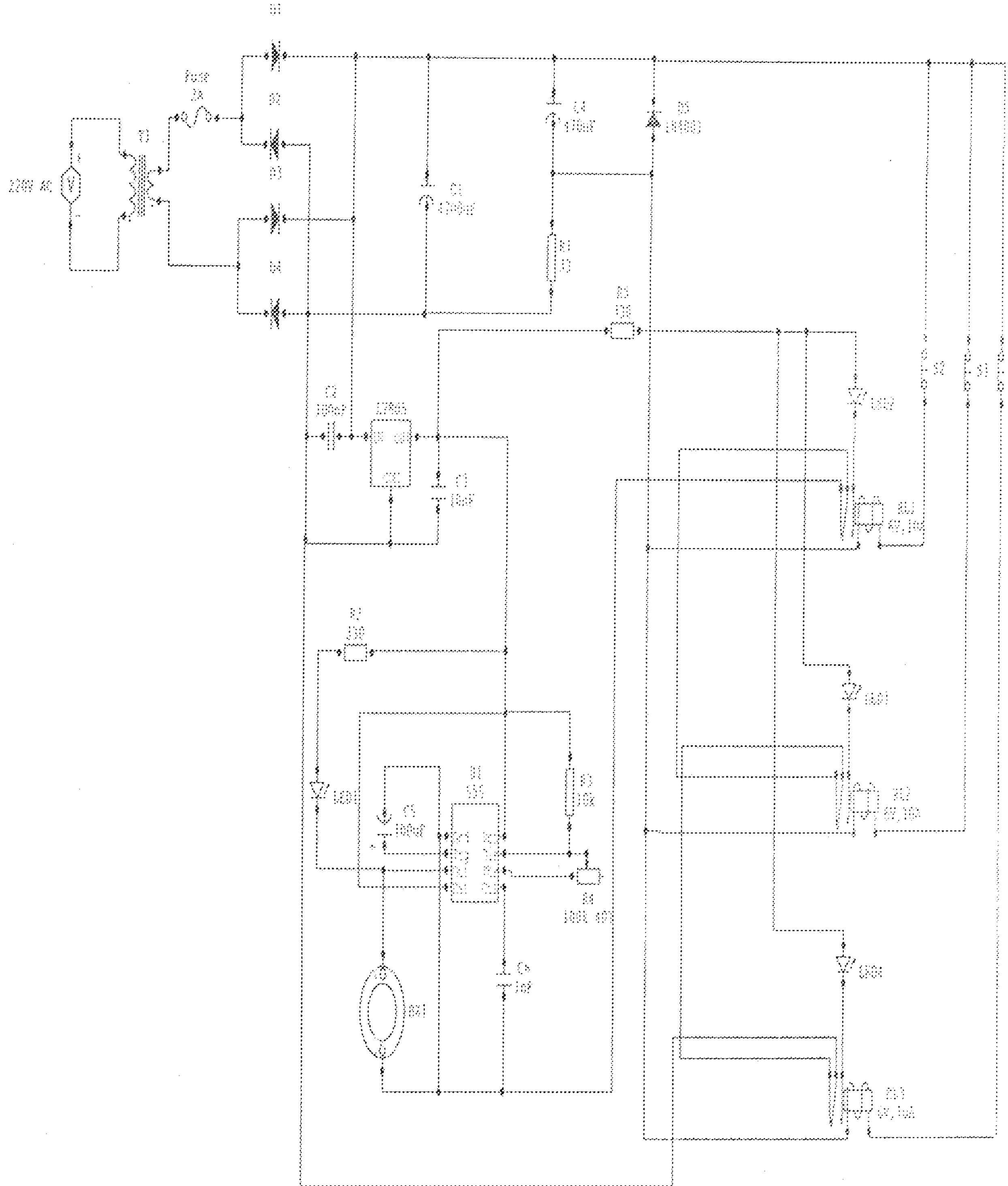
## APPENDIX



Circuit Diagram of the 'Automatic Liquid Level Detector- '