SIMPLIFIED GROUNDWATER ABSTRACTION MODEL USING FORCE-LIFT TECHNOLOGY IN OPEN WELLS

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF A BACHELOR OF ENGINEERING (B.ENG.) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

FEBUARY, 2010.

DECLARATION

I hereby declare that this project work is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any university or institution. Information derived from personal communications, published and unpublished work were duly referenced in the text.

21 / 02 / 2010 ______________________ 21 | 02 | 2010

Danjuma, Emmanuel Date

CERTIFICATION

This project entitled "Simplified Groundwater Abstraction Model Using Force-lift Technology in Open Wells" by Danjuma Emmanuel, meets the regulations governing the award of the degree of Bachelor of Engineering (B.ENG.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This project work is solely dedicated to late Mrs Ladi Danjuma, my sweet loving mother who brought me up in the way of the Lord and the motherly advice she gave me when she was alive and also to late Mr.Istifanus Tokan, my friend, may soul rest in peace. Unfortunately, Mother I have completed my (B.ENG.) in your absence but your words of advice still lives in me.

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ABSTRACT

The groundwater abstraction model mechanism was constructed for the simplified conveyance of ground water from open wells to the surface by whirling effect from the spur gears by using manual means. The mechanism was inserted into the transparent rubber container which serves as the real system with the spur gears producing the rotary effect to the flywheel or pulley to the reciprocating movement of the piston in the pressure pipe thereby transmitting water into the delivery tube via non-return valve to the spout level where water is collected. From the design performance evaluation 6.83liters of water was discharged per minute for every 44 turns to the corresponding 440 turns to the flywheel from the spur gear which generates 86.7% efficiency. To obtain more water output at the spout level electric motor drive can be use and also the pressure can be increase between the piston and the pressure pipe.

TABLE OF CONTENTS

CHAPTER FOUR

CHAPTER FIVE

Lists of Figure

List of Table

List Of Plates

1.1.1 Groundwater Abstraction

The term groundwater is the water that is found below the surface of the land. Such water exists in pores between sedimentary particles and in the fissures 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 at shallower of depths, however, and plays a slow but steady part in the hydrologic cycle (Microsoft Encarta, 2009).

Worldwide, groundwater accounts for about one-third of one percent of the earth's water, or about 20 times more than the total of surface waters on continents and islands. What distinguishes groundwater from the rest under groundwater is that its pressure is greater than atmospheric pressure. Hence the water moves freely under the force of gravity into wells. It sometimes refers to as gravitational water. Groundwater is of major importance to civilization, because it is the largest reserve of drinkable water in regions where humans can live. Groundwater may appear at the surface in the form of springs, or it may be tapped by wells (Microsoft Encarta, 2009).

During dry periods it can also sustain the flow of surface water, and even where the latter is readily available; groundwater is often preferable because it tends to be less contaminated by wastes and organisms. Well water can be brought to the surface by a primitive method by using bucket and rope to scooped water out of wells or modern method by using pumping machinery of high efficiency. Old dug wells can be found along the Wadis of Middle East the cradle of our civilization. Some of the ancient wells and tunnels in Iran and Hawaii are still in use (WHO 1977).

1.1.2 Groundwater Movement

The rate of movement of groundwater depends on the type of subsurface rock material in a given area. Saturated permeable layer capable of providing a useable supply of water are known as aquifers. Typically, they consist of sands, gravel, limestone, or basalt. Movement of groundwater or it flow potentials depends on important properties such as porosity, permeability, specific yield and specific retention of an aquifer. An aquifer is a body of rock or soil that is sufficiently porous and permeable to store and transfer significant amounts of groundwater (Microsoft Encarta, 2009).

An aquiclude is a body of relatively impermeable rock. An aquifer is called confined when it is bounded above and below by aquiclude or unconfined when there is no aquuiclude above it. A perched aquifer is a body of ground water that lies above the regional water table because it is underlain by a small aquilude. The small zone of saturation is known as a perched water table. Some aquifers are confined under pressure. These aquifers are called artesian systems. Sufficient pressure results in free flowing water, either from the spring or and also ability of the water to seep freely. (Microsoft Encarta, 2009).

1.2 Statement of Problem

The stresses that experience in bowing or bending up to about 90^0 or less than 90^0 trying to scooped water from wells with containers and ropes gradually affects human anatomy, physiology and psychology. Ergonomics as science has a role to play in the optimizing human performance as a power source in the abstraction of ground water (well water) by using simple machine so as reduce fatigue and improve the comfort in water abstraction in our local and modern environment.

Most open wells are not cover with lid and thereby lead to the falling of contaminant into wells, making water in un-kept wells polluted and unfit for domestic uses. The need for protecting groundwater from the increasing threat of surface and subsurface contamination cannot be over emphasized if it is to continue to play an important role in the development of world water resources potential.

Wells are liable to pollution by following means:

(i) Water spill from hands, feet and part of cloths back into the well by well-users.

(ii) Throwing of domestic household utensils into the well.

(iii) Surface or an underground oil spillage into the well.

(iv) Seepage water from dirty and untreated surface water well.

(v) Falling-off of vessels/ containers used in scooping water into the well.

(vi) Falling of walk-animals into the well.

(vii) Seepage of agro-allied chemicals and soap into the well.

1.3 Objectives

(i) To design and construct a reciprocating pump for lifting groundwater via whirling effect.

(ii) To prevent frequent open well pollution and contamination from materials and animal waste.

(ii) To lift groundwater to the surface level with a minimum effort using spur gears.

1.4 Project Justification

The research project is all about devising an improved means of groundwater abstraction from shallow or deep open wells, using manual hand whirls, non returnable valves and pump to force-lift underground water to the surface. This technology, if adequately strategies and harnessed would not only prevent groundwater surface contamination but also argument the water supply of scarce surface water.

15 Scope of Study

This project will be centered on manual means of abstraction of groundwater using the forced-lift pump powered by whirl mechanism to abstract water manually with minimum effort via pressured pipe, piston, non-returnable valves connected to the delivery pipe. The presence of the pulley is to give a provision for belt for electric motor to be fit in if needed.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Water Wells

Water wells can be defined as an excavated hole or shaft usually vertical in the earth for bringing groundwater to the surface. Wells can also be use for subsurface exploration and observation, artificial recharge, and disposal of waste water. Many method exist for constructing wells, selection of particular method depends on the purpose of the wells, the quantity of water required, depth of groundwater, geological condition and economic factor (Todd, 1980).

Open wells are regarded as the most simplest and cheapest method of lifting groundwater and water can be lifted up by manual or mechanical means, such as Pumps, Persian, Archimedean Screw e.t.c. Where electric energy or diesel is not available, animal power such as buffalo are used to lift water from wells. Open wells are prominent in rural and urban areas in which water are lifted manually by using rope and bucket in a wide shallow well. Open wells can be operated up to a depth of 100metres, although they really exceed 45metres and can last for very long time without maintenance (Kennedy and Rolgers 1985).

2.1.1 **Artificial Groundwater Recharge in Wells**

The artificial recharge of groundwater basins is put into practice due to the increasing scarcity of high quality of water and increasing demand on limited water resources. Artificial groundwater recharge has been primary employed for three purposes: to maintain or increase ground water levels; Protect underground freshwater in coastal aquifers against sea water instrusion; and to store surplus surface water, such as storm water, for future use (Asono and Cotruvo, 2004).

The two type of groundwater recharge used with municipal waste water are surface spreading (percolation) and direct aquifer injection. With surface spreading, municipal waste waters percolate from spreading basin through unsaturated soil. This method offer additional treatment to the percolating water through the soil. Direct aquifer injection involves the pumping of the highly treated reclaimed water into a well-confined aquifer (Asovo and Cotruvo, 2004).

The major health concerns regarding aquifer recharge are the same for those involving drinking water drawn from polluted or partially contaminated surface sources. In particular, infectious pathogens are considered the primary risk from waste water recharge of aquifers, as they may be present even when the water meets microbiological standards for drinking water. Risk assessment for groundwater aquifer recharge is very similar to those undertaken for surface water sources (Asono and Cotruvo, 2004).

2.1.2 **Development of Well**

Well development is the process of removing clay, silt, fine sand, drilling mud and other material from the vicinity of the well screen and from behind the gravel pack. This operation increases the permeability of the material surrounding the screen, thus increasing the well efficiency. Developing of wells is almost as important as drilling a new wells. Wells can be developed by increasing the permeability of the formation through which water moves toward the well. The primary purpose of developing of well is to increase the water yield while the secondary purpose of developing of well is to determine the water supply available and the needed characteristic of pump and power unit to be installed.

Materials blocking the water bearing can be remove by means of bailer or sand pump the material into the well and settles to the bottom during the developmental operation. Great care should be taken into consideration in the developing a well in order not to remove excessive quantities of find materials. If excessive amounts of fine sand are removed, there is considerable danger that the over bearing layers might cave in and crash the well, making it completely in operative (Michael and Ojha 2003).

2.1.3 **Methods of Developing a Well**

The most commonly used methods for well development are as follows:

(i) Surging: This is the commonest and most effective method of developing a well in and gravel formation. The plunger is move up and dawn opposite the perforated casing causing water move up and down opposite the perforated causing the water to move alternatively into and out of the well. Surging is started slowly at first and increase in speed as development proceeds and surging action remove fine materials thereby improving water yield.

(ii) Backwashing: Backwashing is used to develop a well by the process of injecting forced air into a capped well until the water level is lowered to the top of the perforations. Then suddenly air released causing a reversal of flow within the well.

(iii) Compressed Air: Developing well with air is best suited to small type wells. The depth of water in the well should be at least two-third the depth of the well. The power available from the compressor should be not less than power require summing the maximum capacity from the well. The most development with air is a combination of surging and pumping.

(iv) Pumping: This requires a variable pump of large capacity. A new pump should not be used because of the damage and lowering of efficiency that it will is caused by the wearing action of the sand at it moves through the pump.

2.2 Types of Well

There are different types of well which are commonly used requirement and the nature of the geological formation, and the method in which it is use to construct these wells.

2.2.1 Dug well

A "dug well" is the oldest type of water well. It is a hole dug in the ground using a shovel or backhoe until the incoming water exceeds the digger's bailing rate. Typically, hand-dug wells range from 1 to 2 meters in diameter (large enough for a person to work in), and are much more shallow than boreholes, usually around 5 to 30 meters deep. Traditional hand dug wells are often contaminated with bacteria and dry up during the dry season. They are not considered a safe source of drinking water. Modern hand dug wells have an improved design and make decisions and provide sustainability for projects. Hand dug wells are inexpensive and can be constructed using local skills and materials; community participation is easy to organize. Further, the operation of hand pumps requires no external power and few skills, and the pumps may be maintained by local technicians (Michael and Ojha 2003).

2.2.2 **Tube well**

This are well that water is tapped from lower depth, smaller diameter pipes are used, 6cm to 30cm diameter pipes are used for tube well. Tube wells can also be installed in perennial rivers, making use of the natural filtering properties of sandy beds of the rivers by drawing water through the river beds instead of from the rivers themselves. The wells constitute a good means of obtaining water from areas with relatively coarse sand.

2.2.3 **Drilled well**

This method of drilling, a cable tool of percussion method of drilling is based upon the principle of applying sufficient energy to pulverize the soil or rock by percussion. The energy applied is varied by controlling the length of the stroke and the weight of the drill stem and bit. The bit is connected to a cable and, by means of a rocker arm on the drill rig; it is raised and released to exert its energy on the bottom of the hole.

2.2.4 **Bored well**

This is done by auger manually or by mechanical mean. The soil usually remains in the auger which is rained and cleaned periodically.

2.2.5 **Driven well**

In this method a driving point is attached to a strainer to perforated section of a driving pipe. The drive friction may be obtained by making the point layer than the casing. During construction care should be taken that the well holes remain vertical and straight.

2.3 **Lift of a Pump**

Domestically pumps can be classified into two, the lift pumps and the forced pumps. The lift pumps are designed to pump water from the source to the level of the pump spout only while forced pumps are designed to pump water from a source and to deliver it to a higher elevation or against pressure.

Theoretically pumps will raise water a distance equal to the height that atmospheric pressure will balance a column of water in a perfect vacuum. Experience and experiment however, have demonstrated that pump will raise water only about 0.75ft (0.2286m) of the theoretical height. The difference between the theoretical and the actual lift of a pump is due to the loss of head cause by friction imperfection in the pump and connections, air in the pump and the vaporization of the water (Cosgrove, 1996).

The constant 0.75ft (0.2286) holds true, however, only for water at ordinary temperature. Any appreciable rise in the temperature of the water will cause a corresponding lost of lift. This is due to the fact that in vacuum water vaporize at lower temperature than when under temperature, when air is exhausted from the suction pipe of a pump connected with a hot water tank or receiver, the water instantly flashes into vapour and fills the suction pipe, prevention the formation of vacuum. Water with temperature higher than 180^0F (82.2^0C) cannot be raised by suction but must flow into a pump by gravity. Water at lower temperature but over 100^0F (37.8^0C) are much easier to handled when they flow by gravity into the pump cylinder. The suction lift of the pump for water of about 160^0F (71.1^0C) not over 1feet (0.3048m) gives a perfect rise (Cosgrove, 1996).

Atmospheric pressure varies with the elevation that is the distance above or depth below sea level; hence on the top of a mountain, the atmospheric pressure and consequently the lift of the pump will be less than the sea at sea level. Also, the atmospheric pressure and lift of the pump will less than at sea level. Also, the atmospheric pressure and the lift of the pump in a deep pit or more will be greater than at sea level (Cosgrove, 1996).

2.4 Net Positive Suction Head (NPSH) of a Pump

The term NPSH is the amount of pump energy in the water at the pump's inlet. The require NPSH is a characteristic of the pump and depends on the pump design, size and operation conditions. The required NPSH is determined the pump manufacturer. The available NPSH must equal or exceed the require NPSH. The available NPSH is a characteristic of piping system (Bankston and Baker, 1994).

$$Net\ positive\ suction\ head = \frac{Atmospheric\ pressure - Vapour\ pressure}{2.3} - h - f \qquad (2.1)$$

Where,

f = Friction lost in pipe (ft);

h = Height (ft);

2.3 = Constant.

Before installing or selection of pumps that will fit the required needs, the following must be consider; the total head or pressure, the desire flow rate, the suction lift and the characteristic of the fluid. The total head, suction lift and flow rate are depending on the piping system and pump characteristic. The piping system and the pump interact to determine the operating point of the pump flow rate and pressure (Bankston and Baker, 1994).

As the flow rate increase the work to move each unit of water or total dynamic head of the pump must also increase. In order to obtain a pumping system that will meet the needed requirements, and meets the piping system and the flow rate (Bankston and baker, 1994).

2.5 Pump Efficiency

The term efficiency can be defined as doing something well with no waste of time and money. To improve the overall efficiency of a pump the lift of the pump must be reduce. Surface sources of water usually require much less lift than pumping from wells. Two common types of pumps designed primarily for low lift operations are the propeller axial flow pumps and the horizontal PTO driven centrifugal pump. Axial flow propeller pumps have very high efficiencies and capable of pumping large volumes of water. Horizontal centrifugal PTO driven pumps are less efficient but still maintain the capability of pumping large volumes of water.

The pumping requirement of an efficient pumps includes; priming, flexibility, useful life, net positive suction head, corrosion resistance, easy maintenance, quality pumped, pumping head, power source and economic factor (Bankston and Baker 1994).

A correct pumping plant not only will conserve valuable energy supplies but also will reduce total yearly pumping costs. Inefficient pumping part can increase costs dramatically. The efficiency of a pump is a measure of the degree of its hydraulic and mechanical perfection. Pump efficiency is a ratio of the output water horse-power to the input shaft horse-power expressed in percentage. The term horse-power is defined as the power require to raise a weight of 33,000 pounds (14968.8kg) a vertical distance of 1ft. (0.348m) in 1minute (60s). The rate of work performed by a pump (hp) is proportional to the weight of the water its delivers per minute multiplied equivalent vertical distance in feet through which it moved (Bankston and Baker, 1994).

$$Pump\ efficiency = \frac{GPM \times Total\ head}{Input\ HP \times 3960}\ 100\% \qquad (2.2)$$

Where;

GMP = Gallons per minute

2.6 Losses in Pump Efficiency

Several reasons for loss in efficiency in pump exist, such as the pipes being too small or having many bends, discharging water considerably above necessary level, when some bowls are not set properly in turbine type pump and also efficiency can be reduced via elevation, heat, accessories, and continuous operation. Energy losses occurs as a result of lower efficiency which are cause by friction in bearings that support pump shaft, friction between the shaft and the packing in the stuffing box unavailable leakage between areas of high pressure (Bankston and Baker, 1994).

2.7 Types of Water Lifting Devices

Many types of water lifting devices are in use in various parts of the world for irrigation, domestic supply or livestock watering. Those which may be envisaged in rangeland areas can be classified as follows:

2.7.1 **Man or Animal Powered Water Lifting Devices**

Traditionally water drawing in pastoral areas, a skin or rubber bucket is hung on a rope and operated either manually or with the help of an animal (usually bullock or camel). Traditional water lifting is suited to large diameter dug wells where 5 to 6 people or animals can draw water at the same time provided that the well supplies enough water. Well cisterns associated with a nearby drilled well are built with the intention of being exploited by traditional water drawing, mainly by animal powered water lifting (Michael and Ojha, 2003).

The methods used are:

(i) Traditional devices for dug wells

(ii) Hand or foot pumps for drilled wells

2.7.2 **Motor Driven Pumps**

The important progress represented by hand or foot pumps when compared with the simple drawing of water, since one or two people operating a hand or foot pump can produce as much water as 5 to 6 people or 3 to 4 animals drawing water with a bucket·

The methods used are:

(i) Diesel engine and vertical turbine pump

(ii) Generator and submersible pump

2.7.3 **Wind Powered Pumps**

This is the mean of lifting groundwater by using the power of wind energy. The prices of windmills may also be very misleading since the actual cost of the equipment on the well site including tank construction, transport and installation may be much higher than the price claimed by the manufacturer. The following examples should therefore be considered with care if prices have to be extrapolated to real situations in remote areas of developing countries (Michael and Ojha, 2003).

2.7.4 **Solar Pumps**

The use of solar energy in developing countries is now seen as a serious and worthwhile endeavour. Various governmental and international agencies as well as commercial firms are involved in research and development, including water lifting of the various methods for harnessing solar energy; the most promising is the photovoltaic system, which directly converts solar energy into electricity.

The main limiting factor to the utilization of solar energy was the excessive investment required but it cannot be excluded that a technological breakthrough similar to that of microprocessors in electronics may be achieved and that thereby solar powered devices may become highly competitive in water lifting at least for irrigation. When water is to be used for watering livestock in remote areas, an additional constraint is the maintenance requirement of such sophisticated devices (Michael and Ojha, 2003).

2.8 Pumping Plant Efficiency

A pumping plant is the combination of a pump and power unit. Overall efficiency of pump is calculated as the product of both pump's and the power unit's efficiency. For electric motors, the efficiency ranges from about 85-92%. Typical thermal efficiency of a combustion engine ranges from 5-37%. Typical efficiency of an individual pump will vary between 25-85%. Thus the greatest theoretical efficiency for a good pumping plant seldom exceeds 70% (Bankston and Baker 1994).

2.9 Operation and Maintenance

The operation and maintenance of pumps varies depending on the type and complexity of the pump. Attempts at designing a reliable pump which can be maintained at the village level continue. Experimentation with these Village Level Operation and Maintenance (VLOM) schemes are shifting gradually to focus on institutional-level operation and maintenance. Preventative maintenance operations carried out by villages and institutions include greasing moving parts (taking care not to contaminate the water supply with oils and greases), tightening bolts, replacing seals (for some pumps), and cleaning the surrounding.

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Model Design construction

Model is termed as a particular design or a copy of something usually smaller than the original object. This particular model design is analyses conceptually as a working model in which its parts move to produce the same effect as the real system. The process that is involved in producing a model depends on modeling techniques which are the efficiency of the model and the cost effectiveness. Other factors also can be use for model design consideration, which are:

(i) Cost of material used.

(ii) Availability of material locally.

(iii) Structure strength of material.

(iv) Type of material used.

(v) Durability of the material.

(vi) Load bearing capacity.

(vii) Corrosive resistance of the material.

(viii) Ability to be serviced and maintenance.

Reasons for using a model are based on; providing a systematic approach for solving problems, broadening the scope of understanding of problem, providing a standardized way of analyzing problem, to be specific about objective, serving as a consistent tools for evaluation, easy to use and less expensive, it require quality information for further investigation and it enable the user to bring the power of mathematics to bear problems.

3.2 Model Component Description and their Functions

3.2.1 Piston and Connecting Rod

The piston is made up of short solid molded plastic which will be meant to move up and down in the pressured PVC pipe. The piston will help in the transmission of air/water pressure through the PVC pipe during the downward stroke.

The connecting rod is a long piece of rod that will be use to connecting the piston to the shaft from the whirls mechanism. The connecting rod serves as a medium of transmitting power from the shaft to the piston.

3.2.2 Pulley

This is a piece of equipment consisting of a wheel over a rope or chain which is used to pull or lift heavy things. The pulley is positioned to generate a uniform and smooth movement of the shaft via belt drive. The pulley also serves as a flywheel which helps in maintaining constant rotary movement and keeps the pulley to run even in an idle stroke.

3.2.3 Shaft

The shaft is a long piece of metal and has the ability to turn and passes on power or movement to another parts of the whirl mechanism. The shaft helps in supporting other parts such as pulley, bearing, connecting rod and piston.

3.2.4 Spur Gears

The spur gears are simple mechanism use in the transmission of rotary motion between two parallel shaft gears. This shaft gears are made up of teeth ratio of 12:1 that is, the driven gear teeth over the driving gear teeth are 130 and 11 respectively. The spur gears are responsible for the transmission of large amount of power with a minimum effort.

3.2.5 PVC Pipes:

These are two parallel pipes with internal diameter 4.7cm and 2.0cm respectively. They are meant to be inserted into the real system eg. Wells or cistern or the model transparent rubber container which is used for abstraction of water through the PVC pipes from the pressured pipe to the delivery pipe at the spout point.

3.2.6 Bearing

The bearing is the part of the mechanism that help in the turning of other parts, or in which the turning part is held. Bearings are used to sustain shocks and fatigue during turning, balancing and smooth motion.

3.2.7 Transparent Rubber Container

The transparent rubber container represents the real system (well or cistern). This containier houses water, non returnable valves, pressure and delivery pipes in which it's volume, diameter and height was accurately measured.

3.2.8 Non-returnable Valve

The non-returnable valve allowed the movement of water in one direction up to the spout point. The valve help in retaining water not to flow in the opposite direction of its original direction.

3.2.9 Bolts and Nuts

The bolts and nuts were meant to fastening metal parts or wood parts together in a firm position.

3.3 Model Construction Procedure

The following operations were involved in the construction of the model of groundwater abstraction mechanism.

(i) Measurement and marking out according to specific size.

(ii) Cutting out the desired size after an accurate measurement.

(iii) Welding and assembling of the parts.

3.4 **Material Specification and Cost**

	Material	Specification	Quantity	Cost (₦:K)
i	Non-returnable valve	3/4inch	3	1500.00
ii	Spur Gear mechanism	1	1	1000.00
iii	Transparent rubber	25ltr	1	500.00
iv	PVC pipes	2.5 & 1 inch	1	100.00
v	Metal pipe	3.0 inch	1	800.00
vi	Connecting rod and piston	1	1	50.00
vii	Bearing and Shaft	1	1	100.00
viii	Bolts and nuts	1 inch	8	100.00
ix	Green Paint	1/2ltr	1	250.00
x	Pulley	1	1	150.00
		Total material cost		**4550.00**
		Labour cost		**1000.00**
		Total cost		**5550.00**

3.5 **Mode of Operation**

The model mechanism is operated manually by rotating the handle of the whirl mechanism either clockwise or anticlockwise direction in order to provide the piston stroke which pushes air/water pressure through the pressure pipe up to the delivery pipe via non-returnable valve. The piston moves up and down as a minimum effort is applied on the handle of the whirl connected to the spur gears which produces higher rates of strokes.

The model work in accordance with the principles of a reciprocating pumps. It involves the movement of piston or plunger which moves vertically to and fro movement in a close fitted cylinder which is rightly connected to the pressure, suction and the delivery valves respectively in the connected pipes.

During the suction stroke, when the piston or the plunger moves outwards, a partial vacuum is created in the cylinder, which enables the atmospheric pressure acting on the liquid surface in the sump to force the liquid into the suction pipe via the suction valve under gravity and both the delivery and the pressure valves will be closed at that moment.

When the inward movement of the piston or the plunger was made, the liquid in the sump will be forced up by air pressure from the pressure pipe which pushes water out the sump to the delivery pipe. During this process the suction valve will be closed while the delivery valves opens for the discharge of water up to the spout level which can be collected into a collectable container.

3.6 Testing Procedure

The simple mechanism will be operated by a single person. The operator will hold the handle of the spur gear machine and supply force either clockwise or anticlockwise direction in order to rotate the shaft and thereby transmitting power to the connecting rod down to the piston by the rotating effect of the which is transmitted into reciprocating movement. The piston will stroke 11 times for every 1 turn of the handle of the whirl mechanism and this will lead to the production of more output power during the process.

3.7 Design Calculations

3.7.1 Area of the Pressure and the Delivery Pipes

The areas of both the pressure and delivery are calculated using the area of a cylinder which is; $A = \frac{\pi d^2}{4}$

The area of the pressure pipe;

$$A_1 = \frac{\pi d_1^2}{4} \quad \textbf{(3.1)}$$

Where;

A_1 = Area of the pressure pipe (m^2);

d_1 = Diameter of the pressure pipe (m);

d_1 = 0.045m.

$$A_1 = \frac{0.045^2 \pi}{4}$$

A_1 = 0.0016 m^2

The area of the delivery pipe;

$$A_2 = \frac{\pi d2^2}{4} \qquad \textbf{(3.2)}$$

Where;

A_2 = Area of the delivery pipe (m^2);

d_2 = Diameter of the delivery pipe (m);

d_2 = 0.02m.

$$A_2 = \frac{0.02^2 \pi}{4}$$

A_2 = 0.0003m^2.

3.7.2 **Pressure Displacement Volume per Minute of Piston Stroke**

$V_d = A_1 ln$ (Michael A.M. and Ojha T.P, 2003) **(3.3)**

Where;

A_1 = area of the pressure pipe (m^2);

l = piston displacement in pressure pipe (m)

n = Number of stroke per minute.

V_d= Pressure displacement

$l = 0.06m$;

n= (40X11) = 440 turns.

V_d = 0.0016 x 0.06 x 440

V_d = $0.042m^2$

3.7.3 **Piston Speed**

$P_s = 2lN$ (Michael A.M and Ojha T.P, 2003) **(3.4)**

Where;

P_s= Piston speed.

$N = 440rpm$

$l = 0.06m$

$P_s = 2 x 0.06 x 440$

P_s= 52.8m/min or 0.88m/s

3.7.4 **Pressure Exerted in both Pipes**

The pressure exerted in the pressure pipe;

$$P_{r1} = \frac{\rho_w \cdot v_d\, g}{A_1}$$ **(3.5)**

Where;

ρ_w = Density of water (kg/m^3);

V_d = Volume of air/water displaced in the pressure pipe (m^3),

g = Acceleration due to gravity (m/s^2);

$\rho_w = 1000\ kg/m^3$

$g = 9.81 m/s^2$

$V_d = 0.042 m^3$

$$Pr_1 = \frac{1000X0.042X9.81}{0.0016}$$

$Pr_1 = 257513 N/m^2$

The pressure exerted in the delivery pipe;

$$P_{r2} = \frac{\rho_w V g}{A_2} \quad \textbf{(3.6)}$$

V = Volume of water that is discharge or collected (m^3);

$V = 6.83X10^{-3} m^3$

$P_{r2} = 223341 N/m^2$

3.7.5 **Efficiency of the Pump**

$$\text{Efficiency} = \frac{\text{Pressure exerted in the delivery pipe}}{\text{pressure exerted in the pressure pipe}} \; X\ 100\%$$

From the equations 3.5 and 3.6;

$$\text{Efficiency} = \frac{Pr_2}{Pr_1} \; X\ 100\%$$

$$\text{Efficiency} = \frac{223341 N/m^2}{257513 N/m^2} \; X\ 100\%$$

Efficiency = 86.7%

3.7.6 **Power to be Generated at Various Heights in One Minute**

To determine the power to be generated at various heights in one minute by using this formula;

$$P_n = \frac{mgh}{t} = \frac{\rho_w V_d\, gh}{t} \quad \text{(Suresh and Kumar, 2004)} \qquad \textbf{(3.7)}$$

Where;

h=height of water lifted in a minute (m);

P_n=Number of times the power is imputed (Watt);

ρ_w = Density of water (kg/m^3)

V_d = volume of water displace in one minute (m^3)

Taking the range of heights from 1-10m

When h= 1m;

$$P_1 = \frac{1000X0.042X9.81X1}{60} = 6.9W$$

When h= 2m;

$$P_2 = \frac{1000X0.042X9.81X2}{60} = 13.7W$$

When h= 3m;

$$P_3 = \frac{1000X0.042X9.81X3}{60} = 20.6W$$

When h= 4m;

$$P_4 = \frac{1000X0.042X9.81X4}{60} = 27.5W$$

When h = 5m;

$$P_5 = \frac{1000X0.042X9.81X5}{60} = 34.3W$$

When h= 6m;

$$P_6 = \frac{1000X0.042X9.81X6}{60} = 41.2W$$

When h= 7m;

$$P_7 = \frac{1000X0.042X9.81X7}{60} = 48.1W$$

When h=8m;

$$P_8 = \frac{1000X0.042X9.81X8}{60} = 54.9W$$

When h= 9m;

$$P_9 = \frac{1000X0.042X9.81X9}{60} = 61.8W$$

When h= 10m;

$$P_{10} = \frac{1000X0.042X9.81X10}{60} = 68.7W$$

The available power generated by human muscle depends on individual physical health condition. The estimated power for long duration is eight (8) hour per day by healthy man in an exclusive environment is 75 watts (W) (0.1hp), (Murrel, 1965).

$$P = \tau\omega \qquad \textbf{(3.8)}$$

P = Power generated during whirling from human muscle,

τ = Torque,

ω = Angular velocity.

Where; P = 75W.

$$\omega = \frac{2\pi N}{60} \qquad \textbf{(3.9)}$$

$$\omega = \frac{2\pi \times 440}{60}$$

ω = 46.0767rads

From equation 3.4

$$\tau = \frac{P}{\omega}$$

$$\tau = \frac{75.00000000}{46.0767}$$

τ = 1.6277Nm

$$T_{t=}\frac{\tau}{r} \quad \textbf{(3.9.1)}$$

Where,

$T_{t=}$ Tangential tension;

r = Radius of driven spur gear.

r = 0.065m

$$T_{t=}\frac{1.6277}{0.065}$$

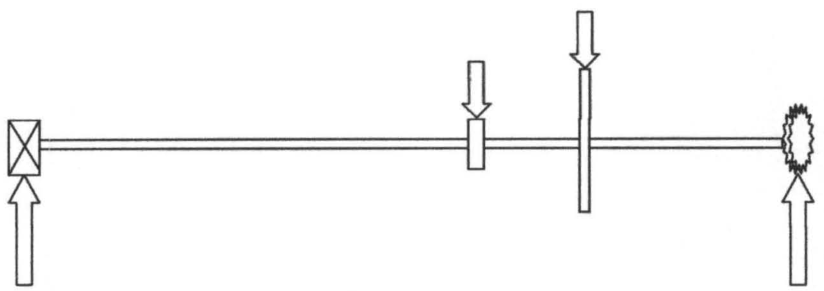
$$T_{t=25.0415N}$$

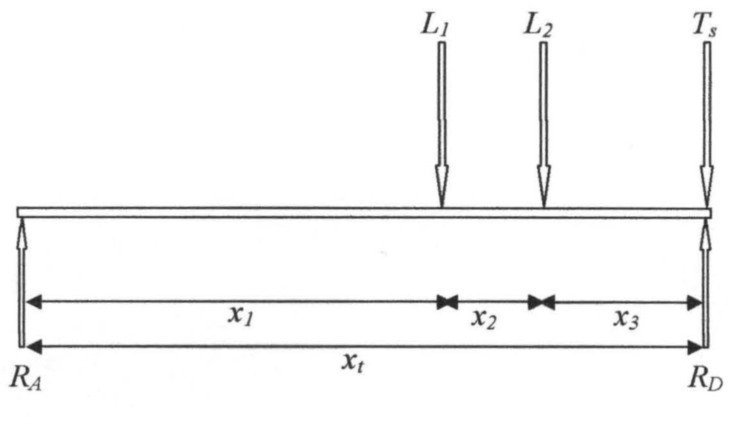
$T_{s=T_{t\ tan\theta}}$ (Khurmi and Gupta, 2004) **(3.9.2)**

$\theta = 20^\circ$ (for an involute tooth gear with full depth).

$T_s = 25.0415 \tan 20^\circ$

$T_s = 9.1144N$





Where;

$L_1 = 0.25 \times 9.81 = 2.4525N$;

$L_2 = 1.5 \times 9.81 = 14.715N$

x_1=0.24m;

x_2=0.04m;

x_3=0.21m;

x_t= 0.29m;

T_t= 9.1144N

$\sum Fy = 0$

$R_A + R_D - L_1 - L_2 - T_t$=0

R_D=$(T_t + L_1 + L_2) - R_A$ **(3.9.3)**

Moment about D.

$\sum M_D = 0.$

$R_A(x_1+x_2+x_3)$ - $L_1(x_2+x_3)$ - $L_1(x_3) = 0$

R_A=$L_1 \frac{(x_2\ x_3)+L_2(x_3)}{(x_1+x_2+x_3)}$ **(3.9.4)**

$$R_A = \frac{(2.4525(0.04+0.21)+14.715(0.21)}{(0.24+0.04+0.21)}$$

R_A = 7.5577N

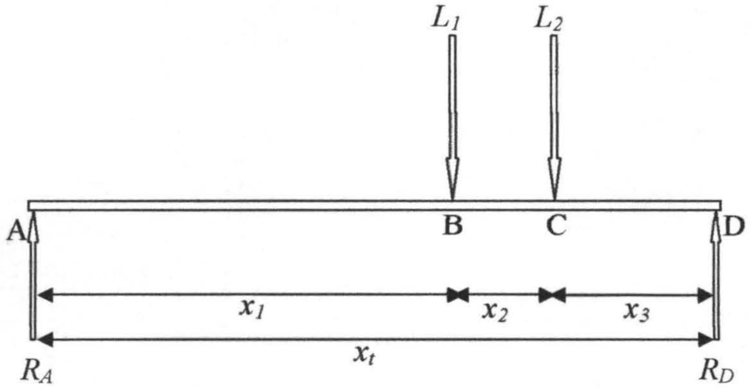
From Equation 3.9.3

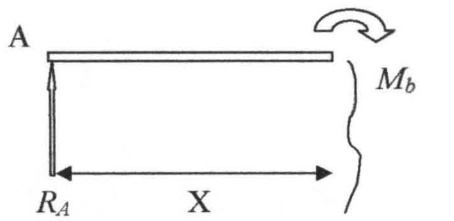
$R_D = (9.1144+2.4525+14.715) - 7.5577$

$R_D = 18.7242N$

$R_D = 18.7242 - 9.1144$

$R_D = 9.6098N$





↑+ $S.F_1 = F_x - R_A = 0$

$F_x = R_A = 7.5577N$

$M_b = F_x - R_A x = 0$

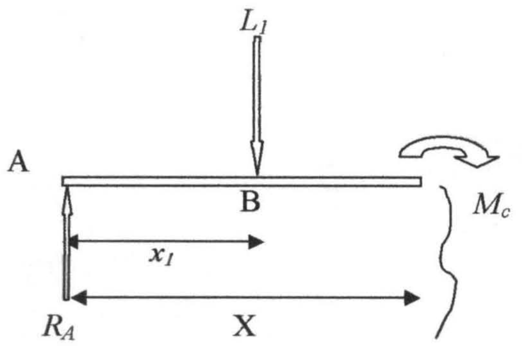
$M_b = R_A x$ **(3.9.5)**

When; x = 0, $M_b = 0$,

When; x = x_1

$M_b = 7.5577 \times 0.24$

$M_b = 1.8138Nm$



$\uparrow +$ $S.F_z = R_A - L_1 = 0$

$= L_1 - R_A$

$= 2.4525 - 7.5577$

$= -5.1052N$

$M_c = R_A X - L_1(X - x_1) = 0$ **(3.9.6)**

When; X = $(x_1 + x_2)$.

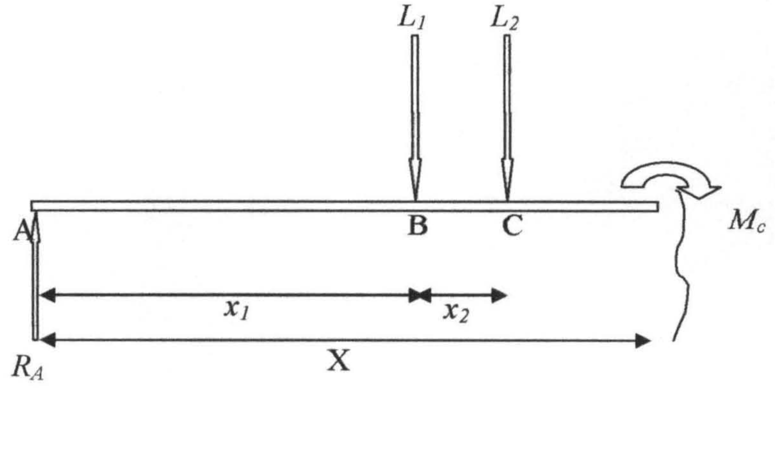
Substituting X= $(x_1 + x_2)$, in equation 3.9.6

$M_c = R_A(x_1 + x_2) - L_1(x_2) = 0$

$M_C = L_1(x_2) - R_A(x_1 + x_2)$

M_c= 2.4525(0.04) – 7.5577(0.24+0.04)

M_c= - 2.0181Nm



+S.$F_3 = R_A - L_1 - L_2 = 0$

$= (L_1 + L_2) - R_A$

= (2.4525+14.715) – 7.5577

= 9.6049N

$M_D = R_A x - L_1(X - x_1) - L_2[X - (x_1 + x_2)]$ **(3.9.7)**

When; x = $(x_1 + x_2 + x_3)$.

Substituting X = $(x_1 + x_2 + x_3)$ in equation 3.9.7

$$M_D = R_A(x_1 + x_2 + x_3) - L_1(x_2 + x_3) - L_2(x_3) = 0$$

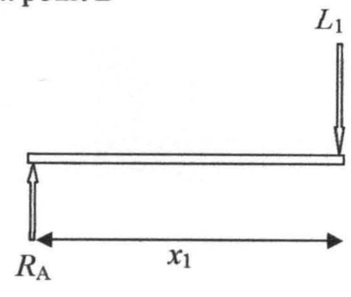
$$M_D = L_1(x + x_3) + L_2(x_3) - R_A(x_1 + x_2 + x_3)$$

M_D = 2.4525(0.04+0.21) + 14.715(0.21) – 7.5577(0.24+0.04+0.21)

M_D = 0.

Bending Moments

Bending Moment at point B

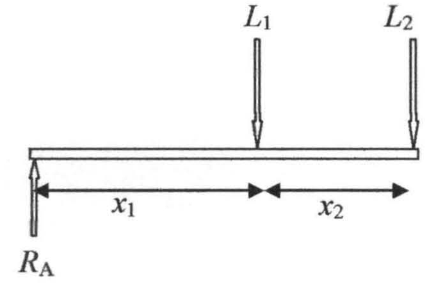


BM_b = R_A x

BM_b= 7.5577 x 0.24

BM_b= 1.8138Nm

Bending Moment at point C.



$$BM_c = R_A\,(x_1 + x_2) - L_1(x_2) \quad (3.9.8)$$

BM_c= 7.5577(0.42+0.04) – 2.4525(0.21)

BM_c= 2.9615Nm

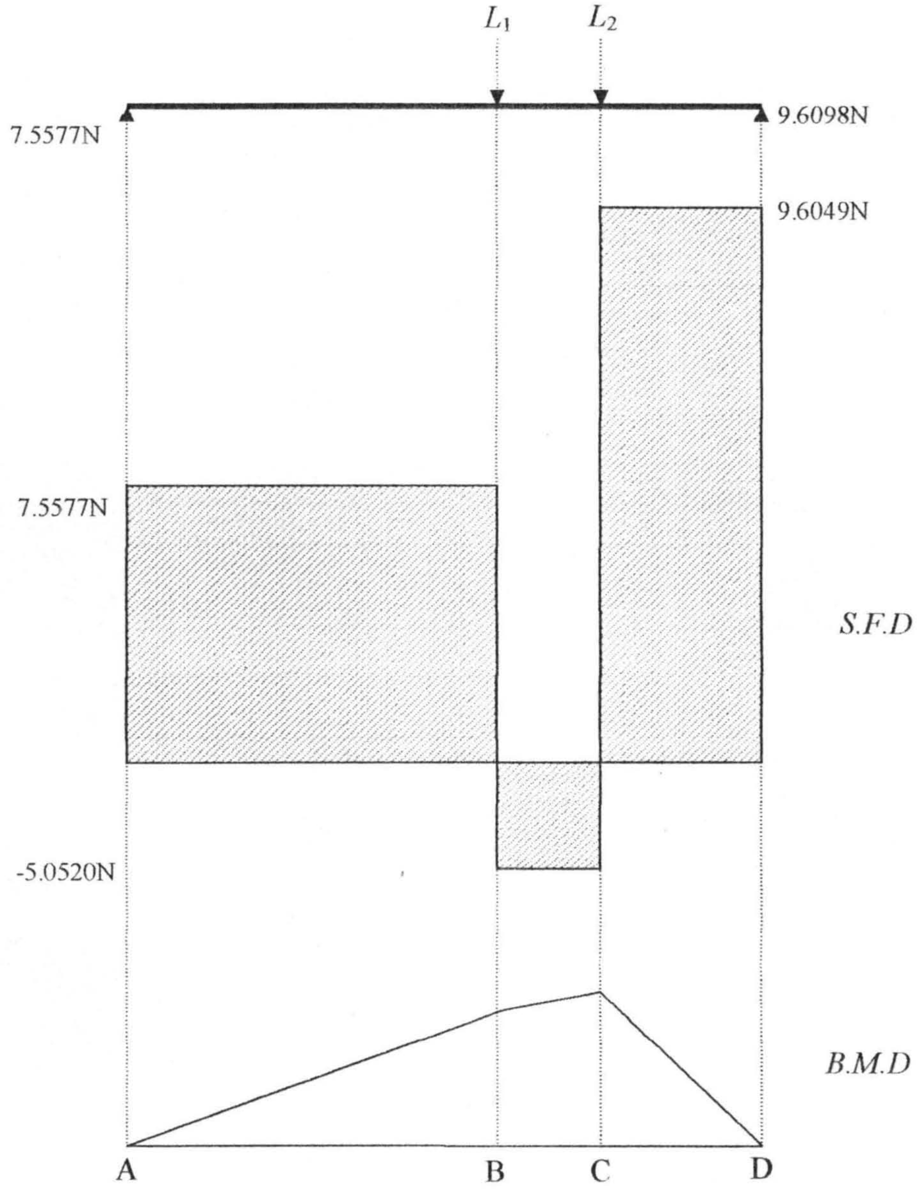


Fig 3.1 **Shows Bending Shear force and Bending Moment.**

3.7.4 **Diameter of the Shaft**

$$d^3 = \frac{16}{\pi S_a}\sqrt{(K_b M_b)^2 + (K_t M_t)^2}$$; (Khurmi and Gupta, 2004)

$$d^3 = \frac{16}{\pi S_a}\sqrt{(M_b)^2 + (M_t)^2} \qquad \textbf{(3.9.9)}$$

Where;

S_a= Shear stress, 56MN/m^2(shaft without keyed for a mild steel)

M_b= 2.9615Nm;

M_t=1.6277Nm

$K_b = K_t = 1$

$$d^3 = \frac{16}{\pi 56x10^6}\sqrt{(2.9615)^2 + (1.6277)^2}$$

d = 0.0067m

d = 6.7mm.

CHAPTER FOUR

4 RESULTS AND DISCUSSIONS

4.1 Results on Performance Evaluation

The water generated during the testing was 6.83liter per minute was recorded which is 0.00683m^3 and the water discharge through the delivery pipe to the spout level which was accurately measured as one meter (1m) from the model.

4.2 Discussion of Result

The result obtained from the test running of the working model mechanism was 86.7% and this shows that the efficiency is above average because of the use of the spur gears to ease pump efficiency but less than the required 100%. Losses incurred is due to the friction in bearing that support the pump shaft, the piping system and also losses of pressure due to the pressure pipe and the piston.

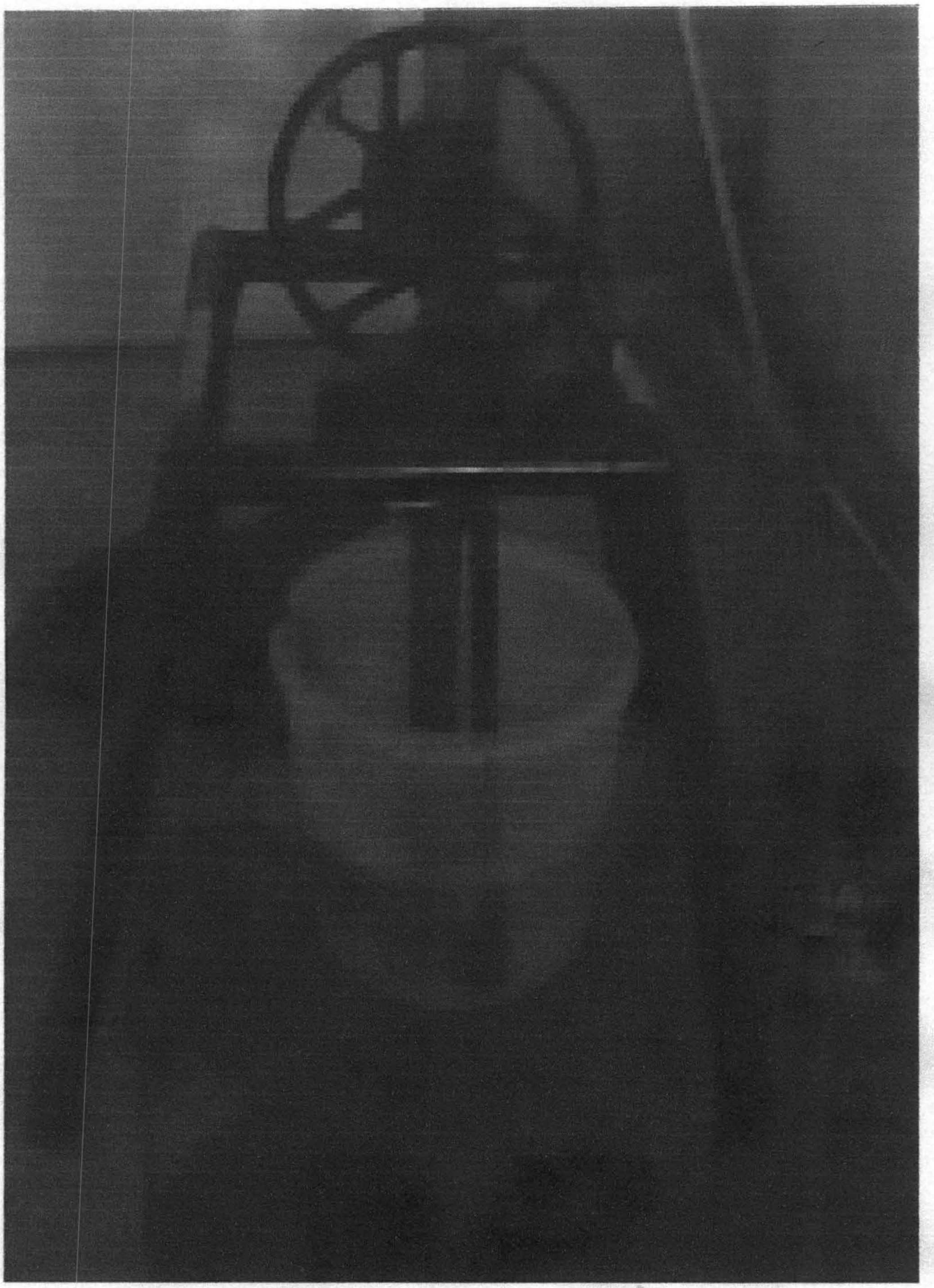


Plate 4.1 Model for Water Abstraction Pump

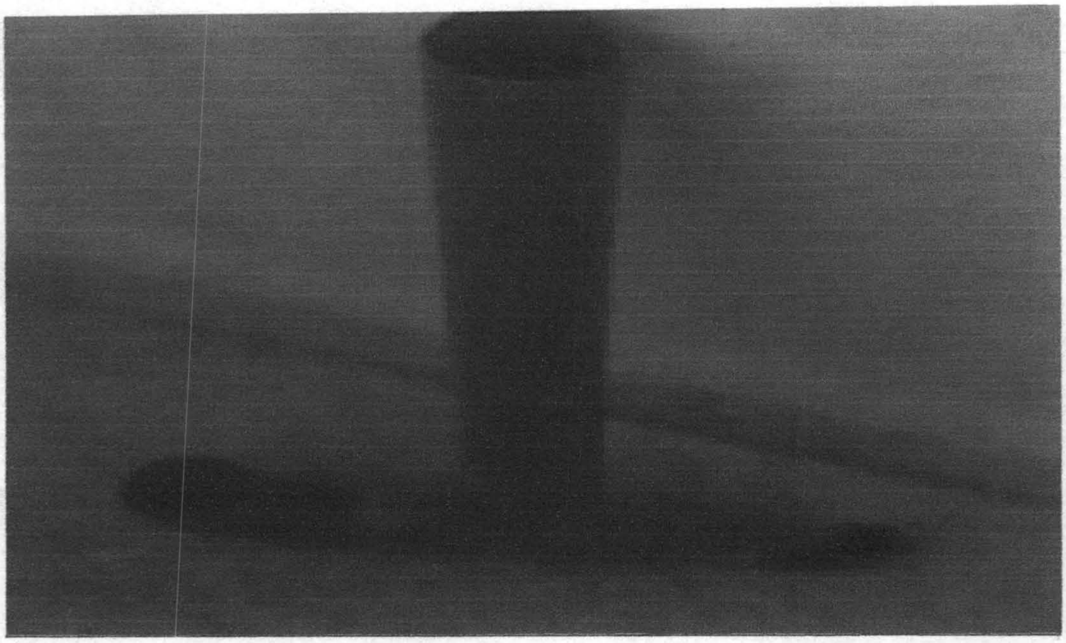


Plate 4,2 Pressure Pipe connected with Valves

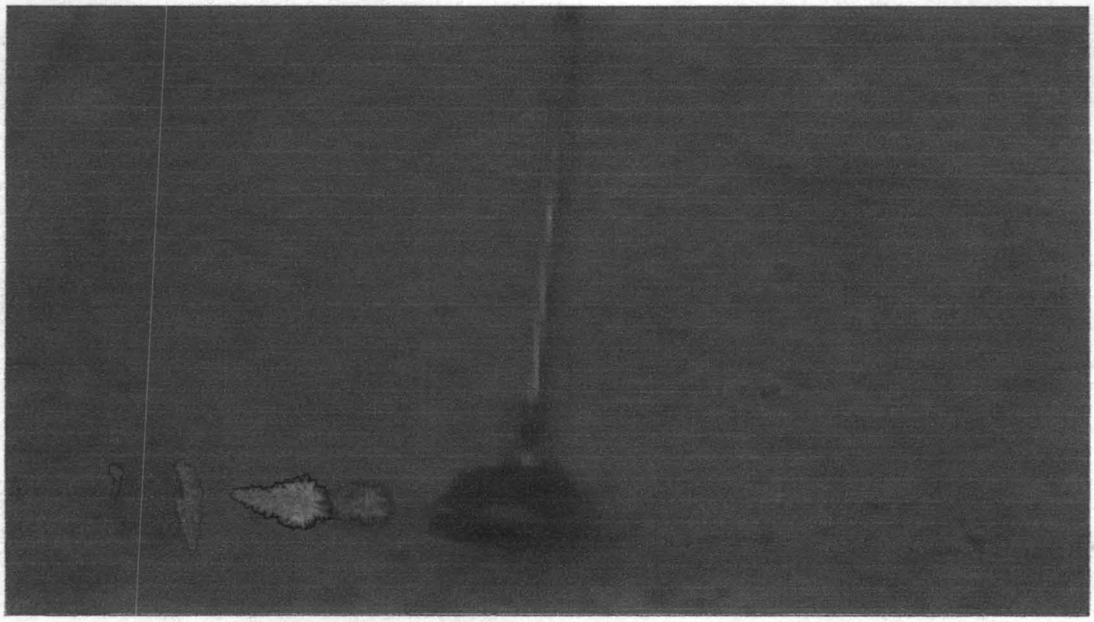


Plate 4,3 Piston with Connecting Rod

Plate 4.4 Spur Gear Mechanism

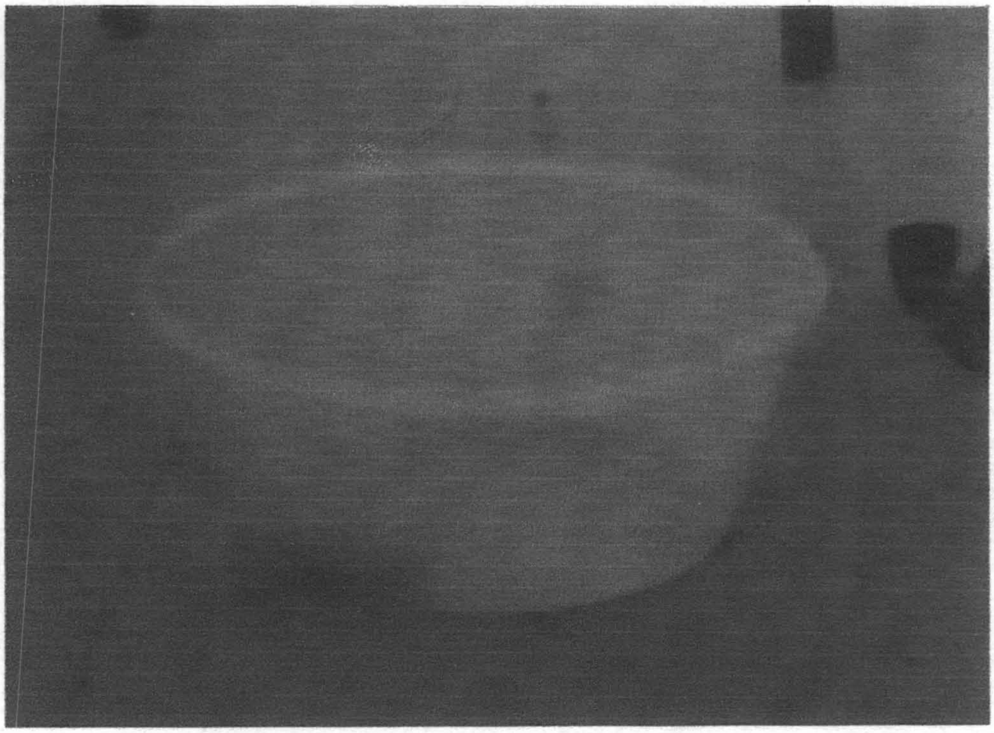


Plate 4.5 Transparent Rubber Bucket

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The model of groundwater abstraction mechanism has been designed, constructed, and tested. The model build-up showed that it is an efficient substitute for the local way of abstraction of groundwater by the use of rope and bucket in scooping water from the well. The mechanism of groundwater abstraction also showed it is suitable for both rural and urban areas because of its less stress, easy to operate and reduction in water contamination through the provision of a suitable lid and water lifting device.

The mechanism was designed in such a way that the cost of production can be affordable to the rural community. Each components of the mechanism was made from material readily available and affordable in the market.

5.2 Recommendations

Due to the lower in efficiency of the mechanism, the following recommendations that will improve the performance efficiency are as follows:

(i) An electric motor drive can be installed to facilitate the operation and increase the amount of water output.

(ii) The efficiency can be improved by providing a means to increase the pressure between the piston and the pressure pipe by installing high compression piston or compression pipe head and also some adjustment on the piping systems.

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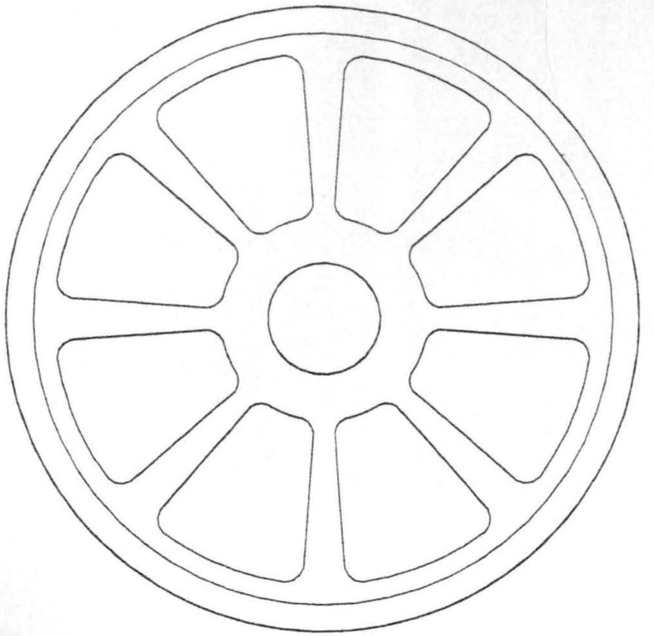
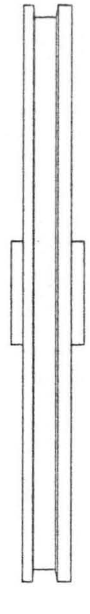
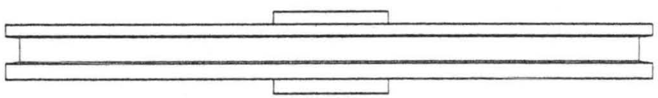
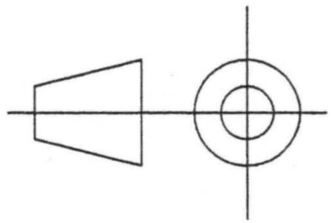
APPENDICES









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SUPERVISOR	ENGR. M. A. SADEEQ		
DRG NO:	1		
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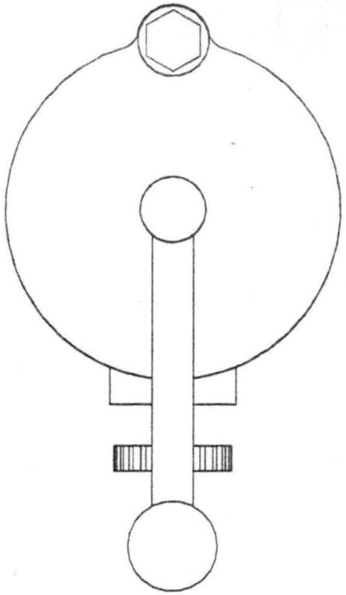

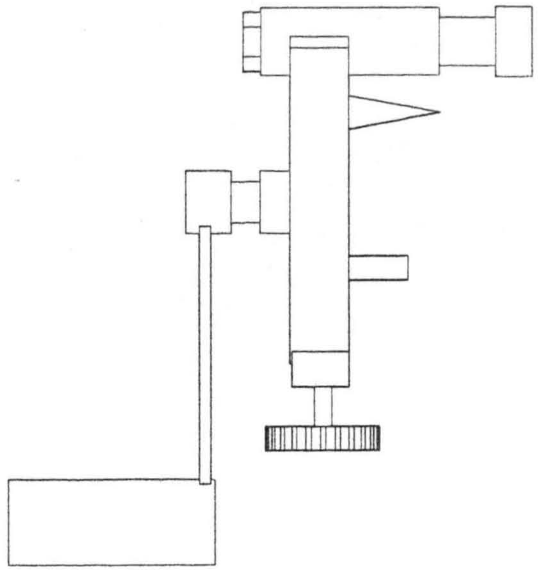

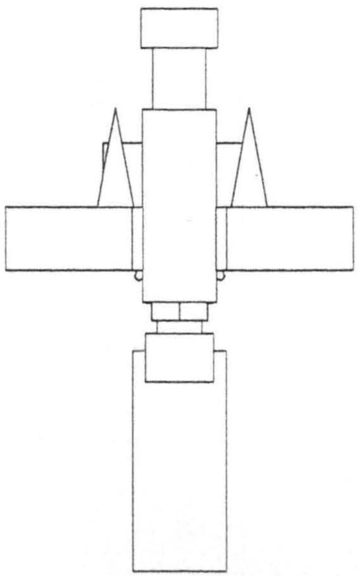

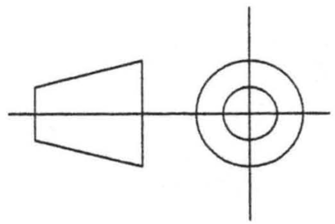

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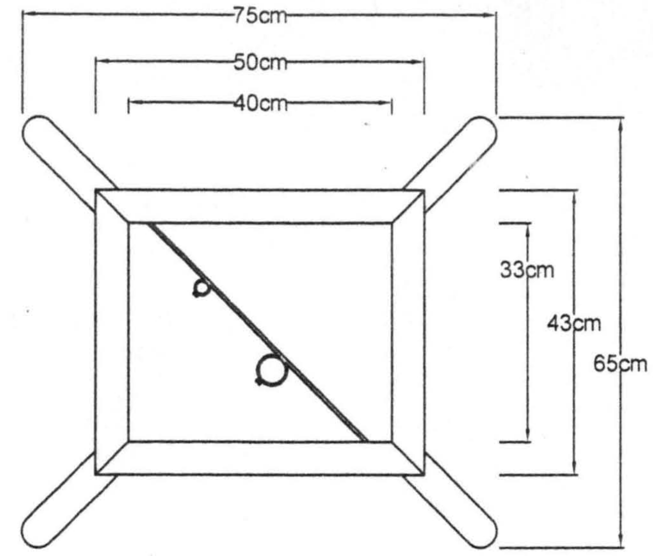

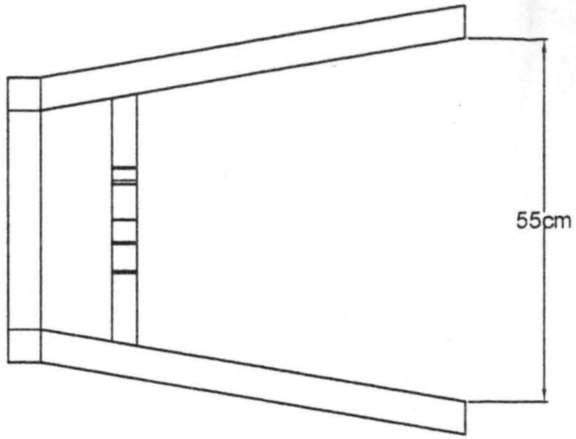

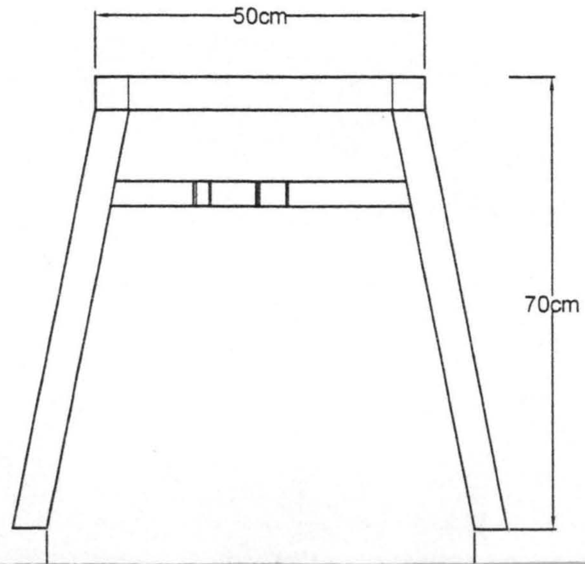

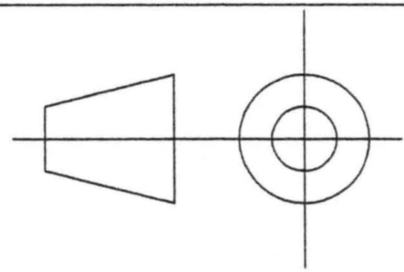

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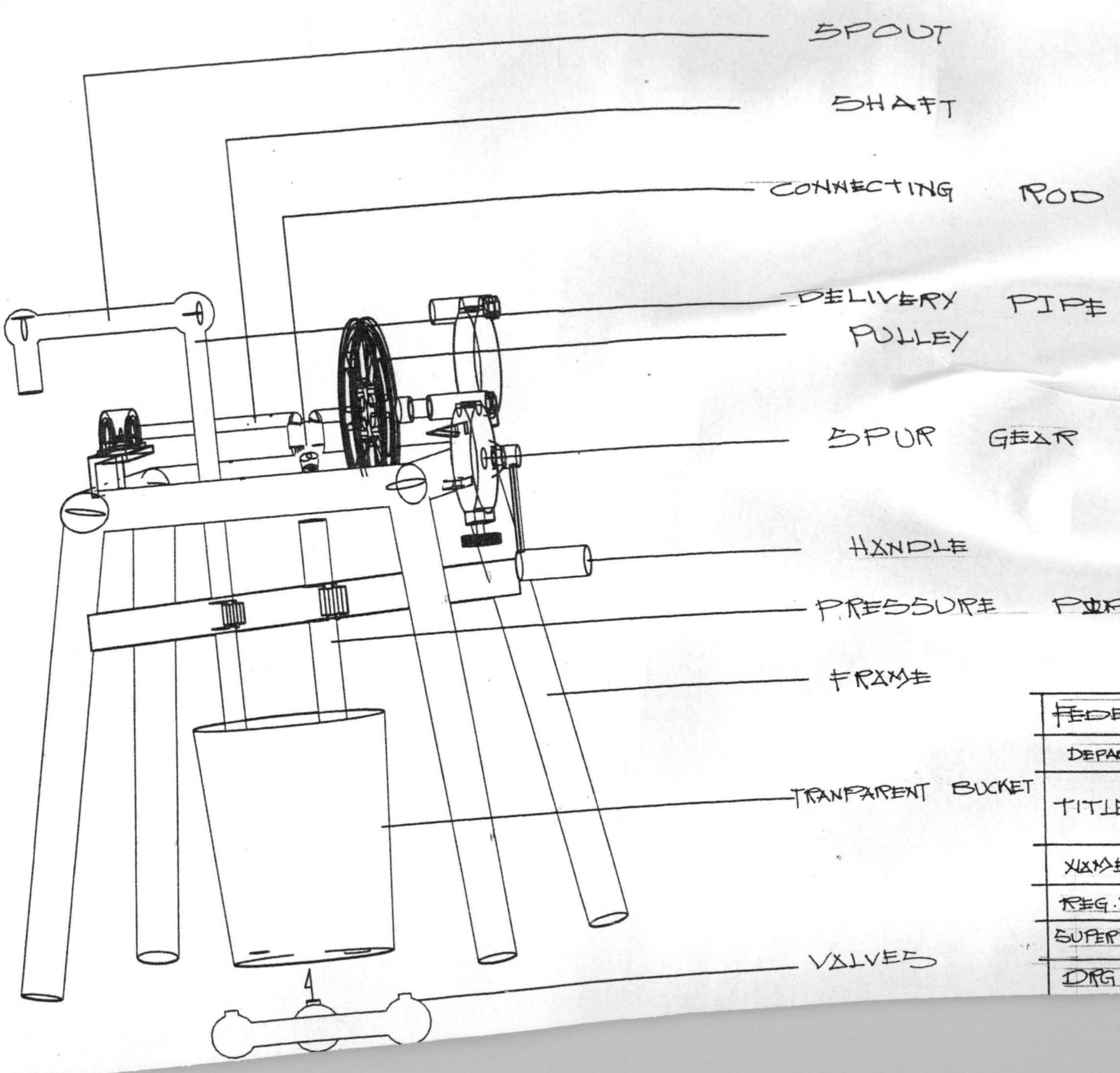

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