DESIGN AND FABRICATION OF AN ELECTRICALLY OPERATED EGG INCUBATOR

BY

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MATRIC NO. 2004/18432EA

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BEING A FINAL YEAR PROJECT REPORT SUBMMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) DEGREE IN AGRICULTURAL AND BIO-RESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE

FEBRUARY, 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 Information derived from personal communications, published and unpublished work were duly referenced in the text.

Anibude, Emmanuel Chinweike	8/3/2010 Date

CERTIFICATION

This project entitled "Design and Fabrication of an Electrically operated Egg incubator" by Anibude Emmanuel Chinweike, meets the regulation governing the award 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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24/02/10
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External Examiner

10/2/2010
Date

DEDICATION

This work is dedicated to the glory of Almighty God for his mercy and guidance over me. And also to my late father, Mr. Joseph Muoka (Bro. Joe).

ACKNOWLEDGEMENTS

I must acknowledge first my indebtedness to Engr. P. A. Idah whose interest, considerable tolerance, professional guidance and above all thorough supervision saw me through this work. Our academic interaction has blossomed to that of father-son relationship. I consider myself really privileged to have drunk from the knowledge fountain of this rare gem.

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I owe immeasurable gratitude to my mother, Mrs Victoria Muoka, My brothers and sisters – Mrs. Dominica Moka, Engr. Barnabas, Sir Micheal, Mrs Catherine Jerome and Arch. Eucharia Anibude for their understanding, support (morally and financially) and encouragement.

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Finally, my greatest thanks and appreciation is to the Almighty God, the God of infinite wisdom and knowledge for his very many mercies, guidance, provisions and protections of my life.

ABSTRACT

The modern hatchery is an example of an engineering solution used to solve a biological problem. An incubator is an apparatus, which simulates the broody bird by means of temperature, humidity and ventilation regulation, as well as turning of egg for embryo development into chick. An electrically operated incubator with the capacity of 24 eggs was designed and a prototype fabricated and tested in the department. It was constructed using local available materials and it is a still air incubator. Also when tested the temperature was between the range of $37^{o}c$ –$39^{o}c$, the relative humidity was also 50% - 70% and turning of egg was done 3 – times daily; however the egg did not hatch due to unavailability of a stable power supply, thus, the power supply to the incubator was improved using an alternative means of power supply.

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CHAPTER ONE

1.0 INTRODUCTION

An incubator is an apparatus, which simulates the poultry bird by means of temperature, humidity and ventilation regulation as well as turning of egg for embryo development into chick.

Four factors are of major importance in incubating eggs artificially: temperature, humidity, ventilation and turning of the egg but temperature is the most crucial. However humidity tends to be over looked and causes many hatching problems. Extensive research has shown that the optimum incubator temperature is 100°F (37°C) when the relative humidity is 60 percent, concentration of oxygen should be above 20 percent, carbon-dioxide should be below 0.5 percent.

There are two types of incubators commonly used:

1. Forced – air incubators which have fans, to circulate the air
2. Still – air incubators which have no fans so the air is allowed to stratify.

The forced air incubator should be set 99°F – 99.5°F and 60% – 65% relative humidity [83°F – 88°F]. The advantage of this type of incubator is that it is easier to maintain humidity at a constant level because of air circulation

Still air incubator is the type of incubator we are working on it's efficiency by setting eggs for embryo development into chick. Still air incubator are smaller and air flow in through the vents, humidity should be 60% – 65% (80°F – 90°F wet bulb) during incubation and 60% – 70% (92°F – 97°F wet bulb) at hatching time.

The incubator given to us is powered electrically; this is one of the major obstacle experienced due to unavailability of electricity during testing.

In the absence of electricity, a kerosene lamp is used as another source of heat, the aim is to keep the eggs as warm as possible until the power return, for this reason the lamp has been re-design in such a way that the optimum level of carbon-dioxide in the incubator atmosphere is 0.5 percent with range of 0.4 – 0.6 percent. High levels of carbon-dioxide are toxic and hence could kill the embryos.

Because of this a stand by generator is preferable as a source of power for immediate take over in case the main power is interrupted.

An incubator should be operated in a location free from drought and direct sunlight. An incubator should also be operated for several hours with water placed in the pan to stabilize its internal atmosphere before eggs are set. The incubation must be ventilated that each unit receives freely air from the outside and discharge its state vitiated air to the outside. In the same way the movement of people and equipment has to be carefully designed and managed to give the same clean flow principle.

The conditions under which the eggs are stored before incubation need good control. The optimum range is 13 – 16°C (55 – 60°F) with a high relative humidity of 75 – 80 percent, in order to maintain such conditions all farm egg stores should be well insulated and preferably equipped with an appropriate air conditioners if the eggs are to be stored for long. Pre-incubation storage should not go for more than seven days buts limits of four days is preferable, since up to this limit there is almost no loss in hatchability if storage conditions are good

We have been discussing artificial incubator, in which it out class the natural method of hatching eggs using hen. Below are the advantages and disadvantages of the two methods;

1. The advantage of the natural method is, they use for small number of eggs.
2. It has a higher percentage of hatching eggs.
3. There are no maintenance costs.

Its disadvantages are as follow:

1. Broody hen sitters are not always available.

2. There is a danger of pests when hen may get tired

3. It can not hatch large number of eggs for commercial basis.

On the other hand the artificial method is more advantageous over the natural method of hatching, these are:-

1. It is used for large number of eggs.

2. The machine can be used any time.

3. It has no danger of pest.

4. It does not get tired.

All the same there are some disadvantages of such, these are:

1. There is a lower percentage hatch.

2. It has a metal cost or wooden cost

3. It has a maintenance cost.

When the two methods are compared, there is more advantages of the artificial method. By so doing, we decide to construct a simple type of hatching incubator for the peasant farmers which is electrically operated. It is less in complexity and small enough to transport.

1.1 Statement of The Problem

The major obstacles is the unavailability of electricity but during the testing, in the absent of electricity a kerosene lamp is used as the key to keep the eggs as warm as possible. A stand by generator is more essential for immediate take over of power when the main power is interrupted before it is restored back.

Another problem is that the months of November and December is not the best time to raise chickens this is because of

1. No suitable room temperature.

2. Cold season

Both conditions are unfavourable for chickens and this may result to many of newly hatched chicks to death.

1.2 Significance of The Project

The importance of this project is to produce and test hatching machine that will give maximum hatchability efficiency at a very low and affordable cost.

1.3 Objectives of The Study

1. To test the hatchability efficiency of 24 capacity egg incubator.
2. To develop a sample low cost device aimed at easing the prevailing financial difficulties face by poultry farmers who intend into the business of chick's production.
3. To reduce the cost of importing such apparatus from abroad.
4. To stimulate the interest of upcoming students to take up research topic on the relevant field of study [Agricultural and Bio – Resources Engineering] but also extending to other field research like agriculture, the poultry farm in particular field there by demonstrating the versatility of Agricultural and Bio – Resources Engineering as a discipline or profession of great generality.

1.4 Methodology

The method of achieving the aims and objective of this project is based on the existing facts and findings about incubators. Based on the research, temperature, humidity, ventilation and (movement) turning of eggs are crucial factors which influence hatching gravity of the incubator.

1.5 Scope of The Project

The design of the project concentrates mostly on chicken eggs, as chicken are the most common poultry birds. However the incubator will be suitable for incubating the eggs of all other poultry since their basic requirement are similar, and for this reason, the egg tray size have been adjusted to accommodate any poultry eggs.

CHAPTER TWO

2.0 LITERATURE REVIEW

It appears that people probably domesticated chickens over 4000 years ago, after centuries of hunting the wild jungle fowl. The early domesticated fowls were also used in religious ceremonies dedicated to the sun. In ancient India these chickens were sacrificed to the sun God.

Cocks were pitted together in fights originally as a kind of fertility ritual as an attempt by primitive peoples to ensure many children, bountiful crops and adequate livestock.

However, the history of incubation may be traced back right from the existence of man. Normally, under normal conditions all birds incubate their eggs and hatch the fertilised ones when due. But due to certain factor that cause a decline in the population of birds, such as, killer diseases, unwillingness of some birds to incubate their eggs, increased rates of predation, reduction of suitable habitat and competition for nesting sites, the early man realised the need to find new ways of increasing the rate at which both egg and chicks were produced.

However he managed to come up with a number of skills to mention but the most popular ones include;

a. Replacing an egg laid by a particular bird with that of another bird. This idea may have been gotten from a small majority of birds that do not hatch their eggs with the heat of their own bodies. They drop their eggs into the nest of birds of other species and then give little or no further attention to their progeny. The brood parasites include a number of cuckoos widespread over the world and more sparingly represented in the new world, the cow birds of America, the parasitic wearer bird and honey guides of America, and the black headed duck of southern America.

b. Digging an invested T – like hole under ground about 2 feet deep at their usual fire wood cooking stand, after which they placed the eggs inside cotton sack and inserted through one end of the two opposite horizontal opening and then poured in ash until top hole is filled.

Basically, they cooked three times a day, so if they were to cook, the sack would be pulled to the opposite opening and back to its initial position during the next cooking.

It is therefore evident that the problem of killer diseases, and unwillingness of some birds to sit on their eggs were solve in (a) above. However another problem is created as the replaced eggs have to be thrown away or eating as food when the embryo has not began early development which rendered the egg uneatable.

In cognisance to the above problem the early man improvised amongst others, solution (b) above. Here the advantage was both ventilation and turning requirements were achieved through the two opposite horizontal openings and pulling of sack respectively. The set back of this method was the heat supplied was based on estimation as such that temperature which the eggs were been subjected to, might be greater or less than the required. For this reason the efficiency of this method was small.

A series of improvements on the methods of incubation lead to the establishment of a standard apparatus called an incubator which simulates the broody bird with the entire incubation requirement.

Eggs may be naturally or artificially incubated. The incubation period for fowls is 21 days according to (Thear and Fraser, 1986). The method used does not affect the quality of the chicken hatched. There are also two main methods used;

a) The natural method of incubating.

b) The artificial methods of incubating

a. Natural Incubation

Incubation means that the eggs are kept warm at a constant temperature of 39.5°C for a period of 21 days, after which it hatches. Natural incubating as mentioned is provided by the hen. The hen provides heat by laying on the eggs that is "brooding". While cold is provided when a hot brood spot develops on the breast of the hen. The method provided by the hen has been so much studied and so humidity and temperature are provided. The hen turns the eggs to give them equal amount of heat and ventilation. (Joy and Wibberley., 1969).

Another study of such method is from an "Introduction to animal husbandry in the tropic" by Williamson and Payne (1959). It states that most of the indigenous breeds chicks produced in our villages are by this method. The village hen sits on the usual cluck of some 8 to 10 eggs of which need little food or no attention. This contributes to poor results of hatching of eggs.

The requirements for such hen needs water, food and protection against pest, which is not much taken into consideration with in the villages.

During such time the hen should be provided with food, water and should not be disturbed. It should also be allowed to move off her nest to her breeding quarters at will. The nest should also be free from pest and should be damped daily.

b. Artificial Incubation

This method has been found useful and of good quality, large scale commercial hatcheries are equipped with various types of automated artificial incubators, which are now operating in almost all tropical countries. In Southeast Asia, the old artificial hatching method are still been practiced.

The old artificial hatching system used by the Chinese in Malaysia is well desired by Thunaisinghan and Wah (1971). The results obtain is compared and is found to be quite good with the records from modern incubators, hatching rate of 75 to 85 being normal. Williamson and Payne (1959).

Similar information is from Joy and Wibberley (1969) in their book "Tropical agricultural handbook" in which its states that artificial incubating is provided by the incubator. As studied in natural method eggs get most at a temperature of 39.5°C. Incubator been provided with all the necessary condition such as box, thermometer to tell the temperature, tray containing water for humidity.

Artificial incubator are operated 48hrs, and temperature adjusted 39.5°C before the eggs are placed in. The eggs are placed in a tray (that is egg tray) before finally into the incubator.

2.1 Selection of Hatching Egg

Hatching eggs should be gathered three to five times daily to prevent the eggs from broken by the hens and the hens from becoming broody. Hatching eggs are selected and sorted commercially as they are gathered on the breeder farm. Eggs laid on the floor are obviously dirty eggs as wells as cracked and miss happen eggs are eliminated for use as hatching eggs.

2.1.1 Egg Size

Uniformity of size is also important criteria in selecting of hatching eggs. Neither small sized egg nor very big sized should be selected. It is always desirable to select eggs before incubation in order to achieve maximum hatching of viable and strong chicks.

Table 2.0 Optimum size of hatching eggs

Species	Weight (g)
Chicken	55 – 58
Duck	75 – 80
Turkey	80 – 85
Quail	10 – 17

Source: Poultry eggs; Winton/R.L Lakhotia

In conducting this project the eggs of chicken and quails were weighted by using beam balance in order to achieve maximum hatchability.

Very small eggs oversized eggs are sold for human food. Generally the larger the egg the longer the incubation periods. Large eggs, compare to other eggs produced in the same flock will take 12 hours longer to hatch than smaller ones. Hence eggs with abnormal size do not hatch well.

2.2 Composition of Egg

The percentage of several parts of the egg of chicken, duck, turkey and quail are in the following table. It is evident from the following table below that percentage composition of egg contacts varies among different species of birds. Yolk size and amount of albumen in the shell.

Table 2.1 Composition of egg

Species	Proportional parts		
	Albumen %	Yolk %	Shell %
Chicken	55.8	31.9	12.3
Duck	52.5	35.4	12.0
Turkey	55.9	32.3	11.8
Quail	55.8	29.4	14.7

Source: Poultry eggs; Winton/R.L Lakhotia

2.2.1 Nutritive Value of Egg

The egg of the birds is composed of substances that form the basis of all animal life. Eggs are composed of proteins, fats, carbohydrates, minerals and vitamins.

All these chemicals constituents are distributed among the egg component structures in a very specific manner.

2.2.1.1 Proteins

The proteins are present in every part of the egg. The chief source of protein is albumen and yolk and only small amount is present in the shell membranes. The various parts of the average chicken egg contain the following amount of protein.

Table 2.2 Amount of protein of the various parts of egg

Egg parts	Amount of protein weight (g)	Percent content
Yolk	3.1	44.30
Albumen	3.5	50.00
Shell	0.15	2.10
Shell membranes	0.25	3.60

Source: Poultry eggs; Winton/R.L Lakhotia

2.2.1.2 Fats

In the egg a variety of fats are present which are of high energy value. Fats of egg are of four main types:

a. True fat (Glycerides) 3.8g (62.3%)

b. Phospholipids 2.0g (32.8%)

c. Sterols (cholesterol) 0.3g (4.9%) and

d. Cerebro sides (traces)

2.2.1.3 Carbohydrates

The egg contains only 1% of carbohydrates of the total egg content. The energy value of egg varies because of the species of egg size.

2.2.1.4 Minerals

Mineral are essential to life and only small quantities are needed. Eggs offer an excellent source of many major and trace minerals.

i. Major minerals: Calcium, phosphorus, magnesium, potassium, chlorine, sodium, sulphur and iron.

ii. Trace minerals: Zinc, Copper, bromine, manganese and iodine.

2.2.1.5 Vitamins

Eggs are especially valuable for many vitamins which are grouped as:

a. Fat soluble vitamins: These are vitamins A, D, E and K.

b. Water soluble vitamins: The nine water soluble vitamins namely;

Thiamin, riboflavin, niacin, pantothenia, inositol, pyridioxide, biotin, folic acid and chlorine.

2.3 Storage of Hatching Eggs

Hatching eggs are stored with the large end-up. Storage times of over one week cause a decline in hatchability. Generally, an egg room temperature of 60°F (16°C) is ideal for hatching eggs stored for one week. Eggs stored for 10 – 14 days at 50°F – 55°F (10°C – 13°C) hatch better than those stored at high temperatures. In any case hatching eggs should not be stored at temperature under 50°F (10°C), the relative humidity should be kept at 80 – 85 percent during storage.

2.4 Transportation of Hatching Eggs

Excessive jerking or shaking of hatching egg should be avoided during collection and transportation, which sometimes results in a condition known as "tremulous air cells" a condition that tends to lower hatchability.

2.5 Cleanliness of Egg

Clean eggs hatch better than soiled eggs. The effect of shell, contamination of floor egg is significantly reflected in hatchability which may be reduced by 20% as compared to the nest egg. Soiled eggs are washed with water warmed at least 5°C warmer than normal egg, containing compatible odourless, germicidal colourless and non toxic detergent sanitizer.

2.6 Incubation Periods Of Hatching Eggs

The incubation periods of a number of species of poultry vary considerably as tabulated below:

Table 2.3 Incubation periods of hatching eggs

S/N	SPECIES	INCUBATION PERIODS (DAY)
1	Coturrnix Quail	16 – 17
2	Pigeon	17 – 19
3	Bobwhite quail	22 – 24
4	Chicken	20 – 21
5	Guinea fowl	26 – 28
6	Pleasant	23 – 28
7	Turkey	26 – 28
8	Duck	26 – 28
9	Geese	28 – 34
10	Ostrich	40 – 42

Source: poultry production in warm wet climates

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials For Construction

Some of the vital materials used for the construction are define below;

- Mahogany timber (Plywood): The incubator is made up of plywood of dimension ¾ inches. Different standards of wood are available in the market, but we choose this particular size of the wood for our project. The advantage of this dimension plywood over the others is that if is in size and so heat escape is minimized. It is of high quality compared to others, it does not twist due to compressional force acting across the grain.
- Thermostat: A thermostat is a device for regulating the temperature of a system so that the system's temperature is maintained near a desired set point temperature. The thermostat does this by controlling the flow of heat energy into or out of the system. That is, the thermostat switches heating or cooling devices on or off as needed to maintain the correct temperature.
- Hygrometer: An instrument used for measuring relative humidity. A simple form of a hygrometer is specifically known as psychrometer and consists of two thermometers, one of which includes a dry bulb and the other of which includes a bulb that is kept wet to measure wet bulb temperature.
- Hydrometer: A hydrometer is an instrument used to measure the specific gravity (relative density) of liquids. That is, the ratio of the density of the liquid to the density of H_2O. A hydrometer is usually made of glass consists of a cylindrical stem and bulb weighted with mercury or lead to make it float upright. The liquid to be tested is poured into a tall jar, and the hydrometer is gently lowered into the liquid until it floats freely. The point of which the surface of the liquid touches the stem of the

hydrometer is noted. Hydrometers usually contain a paper scale inside the stem, so that the specific gravity can be read directly.

- Thermometer: An instrument used for measuring the temperature of air, a person's body etc.
- Barometer: An instrument used for measuring air pressure to show when the weather will change.
- Avometer: An instrument used for measuring alternating current in a circuit up to 10_A as well as the standard A.C.
- Humidifier: A machine used for making the air in a room less dry.

3.2 Management of Incubator During Incubation

3.2.1 Sanitation and Fumigation

Fumigation is an operation which is aimed at destroying organism that may kill the embryos or infect the hatch chick. It is therefore means of preventing egg or hatchery transmissible disease. Apart from fumigation eggs may be dipped in chemical solution for example eggs can be dipped in tylosin to minimize the incidence of chronic respiratory disease.

The practical steps for fumigation of the incubator are as follows.

1. The internal fittings are taken out and washed with hot solution of disinfectant and allowed to dry thoroughly.
2. Sweep the compartment and brush out all fluff and debris. Also cleanout the incubator room when all cleaning up has been completed, spray the floor with disinfectant.
3. Scrub the egg trays carrier-rack and the water trays with disinfectant. Re-assemble them and leave them outside for a short time for air to dry them up.
4. Replace the rack and trays in the component.

3.2.2 Regulating Incubator

A trial run (warming) of the incubator at the beginning of each hatching, regardless of the incubator new or old is a must. The thermometer should be checked. The thermometer should be regulated accordingly and the machine operated at temperature of 39°C – 40°C first cateress 24 hours to make sure that the machine is alright.

3.2.3 Placing Egg

Egg should be trayed (set on trays) before the tray is fixed in the incubator, the eggs placed with long axis horizontal or vertical to the tray. When placed vertically the broad end should be up. There are more pores in the shell at this end which probably permits greater loss of moisture and gasses that form other part of the shell. The loss of these substances causes a contraction of the internal content of the egg and creates an air space at the broad end. This air reservoir provides air readily for the embryo during the last few days of incubation when it respires with its lungs.

Positioning egg with the broad end down would minimize the size of this space or prevent its formation as the eggs contain weights down on it. It is also suggested that when eggs are positioned with the small end up, the extra-embryonic membrane may be ruptured and this is found to be accompanied by lower hatchability of eggs and it has been reported that malformed chicks may be produced.

3.2.4 Regulating Temperature

The most satisfactory results are sourced when the temperature ranges from 37.2°C to 39.4°C. The exact temperature depends on the incubator type the age of the eggs in the incubator. The optimum temperature is 37.3°C – 38.3°C (98.6°F – 100.4°F) in forced air incubators and approximately 38.4°C – 39.4°C (100.6°F – 102.4°F) in still air incubators. Within a moderate range, incubator temperature directly influences the rate of embryonic development. If relatively low, it leads to delayed hatchability and if high, it hastens hatching.

High incubator temperature may cause unhealed navels, there by assisting the entry of bacteria infection. Excessive high or low temperature causes death of embryos at any stayed of incubation. To avoid excessive overall heat for the embryo temperature during last few days of incubating to the level of (36.7°C).

3.2.5 Relative Humidity Regulator (Water Pan)

It is important to keep a pan of water inside the incubator at all times. The pan should be more than half the size of the egg tray and always under the eggs. This helps to regulate the relative humidity in the incubator.

An adequate level of moisture in the air around the eggs maintain the water balance between the eggs and the air and prevents the internal membranes from drying up. At the same time ensures the required rate of diffusion of oxygen and carbondioxide out. If however the relative humidity is too high, which is rarely the case in properly ventilated still air incubators, the diffusion of oxygen is impeded and the embryo dies, a common condition known as dead in the shell.

The ideal moisture level is about 50 – 55 percent relative humidity (83 to 87°F) on a wet bulb thermometer for the first 18 days of incubation. For the last three days it should be about 65 percent (89 to 90°F wet bulb). Some variations above or below the ideal level will not drastically affect hatchability. To increase the humidity the last three days an extra pan should be set in the incubator or a wet sponge should be put in the incubator.

An excellent method to determine correct humidity is to candle the eggs at various stages of the incubation. The normal size of the air cell after 7, 14 and 18 days of incubation for a chicken egg is shown in figure 3.6.1 below, an air cell that is too small is as a result of insufficient humidity, while one that is too large is caused by excessive humidity. Necessary humidity adjustment can be made as a result of the candling inspection.

Measuring weight loss during incubator is another way of checking relative humidity. Hen's eggs should be 11 – 13 percent of their initial weight up to point of hatching. Eggs are weighted at regular intervals and the projected weight loss calculated. If it is below 11 percent, the air cell is too small and action should be taken to decrease humidity and if it is above 13 percent, humidity increment is necessary.

The relative humidity can also be measured using a wet and dry bulb psychrometer.

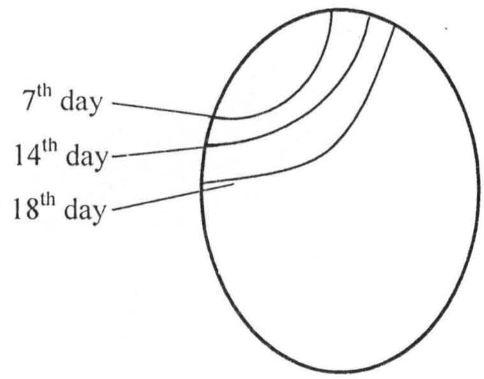

Fig 1: shows the Size of Air cell on 7th, 14th and 18th day of Incubation

3.2.6 Sufficient Ventilation (Vent Holes)

Ventilation is needed to rid the incubator of ammonia or other noxious substances arisen perhaps from the spoilage of some eggs or remaining after fumigation of incubator.

The average size egg consumes 5.11m^3 of oxygen and emits 2.81m^3 of carbon – dioxide throughout incubation period. To meet these respiratory needs there should be 21 percent oxygen inside the incubators, as in normal air. Towards the end of the incubation, carbon-dioxide is also needed to active sufficient muscle tone for the embryo to peck its way out of the shell in preparation for emergence. However, too much carbon-dioxide is toxic. The optimum level of carbon-dioxide in the incubator atmosphere is 0.5 percent with range of 0.4 – 0.6 percent. This emphasizes needed for good ventilation and particularly the necessity of keeping the ventilation outlet well open during incubation.

3.2.7 Turning of Eggs

Turning is done to prevent the embryo and the yolk from sticking to the shell membrane which will cause the death of the embryo from dehydration. Best hatching results are obtained when the large end of egg is kept uppermost. The eggs should be turned not less than three times a day during the early stages of incubation. After about a week the number of turnings may be regulated at 8 hours equal interval. Lease turning when it is 3 days for an egg to hatch and transfer it to hatchers for the remaining days to hatch.

It is required to turn an egg for an odd number of times if turning is confirmed to a day time. If turned for an even number of times the eggs will continue to rest on one particular side every night which will tend to defeat the purpose of turning them. The eggs should not be roughly shaken; it is required to be turned as gently as possible.

Egg turning is automatic in the electric type of incubator but it is operated manually in this electric type of incubator not automatic and egg turning should start within twenty-four hours of setting the eggs. Turning should be in opposite direction at an angle of 45°.

3.2.8 Egg Testing "Candling"

Candler is an apparatus used for detection of infertile eggs and dead embryo. Candling is method of examining egg against a bright light in a darkened room, so that interval development can be monitored. The prime reason for candling is to identify infertile eggs but it can also be used to monitor the external development of the embryo.

White eggs should be tested for fertility on the third day. Brown shelled eggs on the fifth or sixth day because it is difficult to see the embryo clearly before this time.

A small reddish area with blood vessels extending away from it will be visible infertile eggs. This is the embryo floating around inside the egg, looking like a huge red spider. If the embryo dies, the blood draws away from the embryo and forms what is called a blood ring.

All clear eggs showing blood rings or streaks should be removed from the incubator. If eggs are not candled during the early stages of incubation, it will be difficult to determine whether the egg was fertile; embryo that die early soon decompose and are not easily distinguished from rotten eggs.

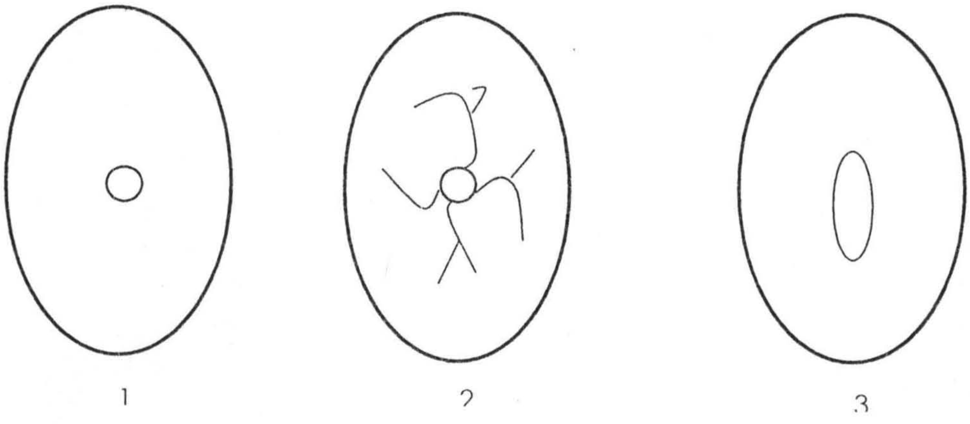

Fig 2: Eggs after 7 Days of Incubation

1. Clear Egg (infertile)
2. Fertile Egg (embryo alive)
3. Dead Embryo

3.2.9 Care During Hatching

A good hatch is that when the chicks are out of their shell before the end of 21^{st} day. It is of no use to assist a chick to come out of its shell as usually in such cases the chick becomes weak or crippled. The chicks which have hatched should remain in the incubator without any feed for at least 18 – 24 hours after dry of and fluffed out, the temperature should be gradually reduced to 93 – 95°F for "hardening off" the chicks before transferring them to the brooder. There is no need to worry about food and drink at this stage, because they still retain the remnants of the yolk in their abdomens.

3.2.10 Electronic Temperature Control Device

The temperature is controlled electronically using the latest proportional microprocessor regulation, once the operating temperature has been reached. A separate safety over teat cut-out is fitted which are integrated into the main system. The temperature is monitored by digital readout calibrated and reading in °C mounted in the control panel for easy reference.

3.3 Procedure For The Construction

i. Construct a rectangular box of length 38cm, breadth 35cm and height 44cm
ii. Make a hole of diameter 15cm at the top.
iii. Cover the hole with glass.
iv. Construct a ventilation holes at both sides, the diameter of the hole is about 1.5cm, the holes should be in three phases at each side. More also, construct two holes of 1.5cm at both side of the base through which oxygen enters the incubator.
v. Construct an exhaust hole at the side facing the door where carbon dioxide passes through with diameter of 1cm.
vi. Nail a point slightly above the tray where wet and dry bulb thermometer will be handing. The thermometer must be visible through the glass of the door.
vii. Nail another point beside the thermometer where hygrometer must be visible through the door when hanged.
viii. To the upper glass, gun the barometer with the inner part facing the glass.
ix. The box should be above the ground at any convenient distance.

3.3.1 Construction of The Egg Candler

Though, there are three types of candlers, wooden, coffee can and improved Vu-graph candler (Obadu 2004). The one used in this project is the wooden type. Materials used include, one proclaim socket, one 60 watt bulb, 4 to 5 foot extension cord.

The procedures for construction are as follow:

i. Construct a rectangular box of length 9cm, breath 8cm, and height 8cm.

ii. Drill a hole of about 2cm in diameter at one of breadth side of the box.

iii. Drill a small hole at the other side of the breath where the extension cord can be attached to the socket.

iv. Mount the proclaim socket at the breath of a small hole.

v. With the aid of a nail join the length(s), breath the upper and the lower part together.

vi. Screw in the light bulb.

vii. Hold the egg in front of the hole for observation.

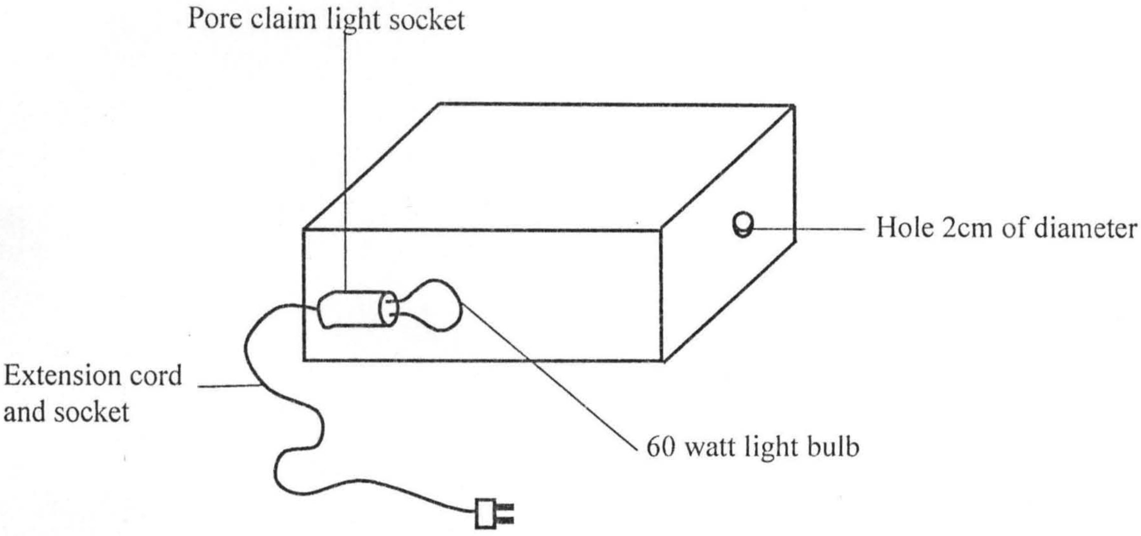

Fig 3: Egg Candler

3.3.2 Construction of the Egg Tray

This tray serves two purposes; a setter and hatchers. It is of length 33cm, breath 19cm and a height of 7cm. It is surrounded at the bottom and sides by net. It has tray support at the bottom; the distance between each support is 15cm along the breath.

3.4 The Design Calculation

Capacity of the incubator = 24 eggs

Number of tray = 1

Maximum major diameter of sampled eggs = 4.6 - 5.7cm

Maximum minor diameter of the sampled eggs = 3.0 – 4.0cm

Arranging the eggs along the minor axis (vertically) with the broad end up, then average

diameter of an egg $= \frac{3.0 + 4.0}{2}$

= 3.5cm

Average radius of an egg $= {}^{3.5}/_{2} = 1.75$

Clearance to the edges = 1cm

Radius of an egg hole = Average radius + Clearance

= (1.75 + 1.00) cm = 2.75cm

Diameter of an egg hole = 2r (where = radius)

$= 2 \times 2.75 = 5.15$cm

Area occupied by an egg = (major diameter of an egg) ^{2}

$= (4.8)^2 = 23cm^2$

Clearance area = Area occupied - effective area

But effective area = Πr^2

$= 23 - (3.142 \times 1.75^2)$

= (23 – 9.62) cm

3.4.1 Dimension of the Tray

Total area of eggs = Area occupied by an egg × No of eggs

= $23\ cm^2 \times 24$

$= 552\ cm^2$

$$\text{Area of the tray} = \frac{\text{Total area of eggs}}{\text{No of tray}} = \frac{552\ cm^2}{1}$$

$= 552\ cm^2$

Length of the tray = 33 cm

Breath of the tray = 19cm

3.4.2 Dimension of the Incubator

Length of the incubator = 38 cm

Breath of the incubator = 35 cm

Height of the incubator = 44cm

Volume of the incubator $= (38 \times 35 \times 44)\ cm^3$

$= 58{,}520\ cm^3$

$= 0.058 m^3$

3.4.3 Determination of Air Properties

According to Ande (2008), the average ambient air of temperature of Niger State Capital (Minna) is 28.1°C and the average relative humidity is 75%: Using Psychrometric chart, other properties is as follows;

Specific volume of air, V_1 = 0.8776m3/kg of dry air.

Humidity ratio of air, W_1 = 0.018kg/kg of dry air

Specific enthalpy of air, h_1 = 75kg/kg of dry air.

The recommended temperature and relative humidity for successful incubation is 38.4°C and 60% respectively (M_CNiH), 1983. Hence, the following air properties are obtained from psychrometric chart.

Specific vol. of air within the incubator, V_2 = 0,9209m^3/kg of dry air

Specific enthalpy of air within the incubator, h_2 = 108kg/kg of dry air.

Humidity ratio of air within the incubator, $W_2 = 0.027$kg/kg of dry air.

$$\text{mass of air} = \frac{\text{volume of air within the incubator}}{\text{Specific volume of air within the incubator}}$$

$$m = \frac{V}{V_2} = \frac{0.058\text{m}^3}{0.9209\ \text{m}^3/\text{kg of dry air}} = 0.06298\text{kg of dry air}$$

Where m = mass of air within the incubator

3.4.4 Quantity of Heat

According to the law of thermodynamics, the quantity heat, Q needed in a confined space is given by;

$Q = [M_aC_a + M_wC_w] \times \theta$ ....(i) (Oria, 2004)

Where Q = Quantity of heat (J)

M_a = Mass of air in the space (kg)

C_a = Specific heat capacity of air (J/kgK)

M_w = Mass of wood (kg)

C_w = Specific heat capacity of wood (J/kgK)

θ= Temperature required (K)

To calculate for mass of air in the incubator

$$\text{Density} = \frac{\text{mass of air}}{\text{volume of air}}$$, So Therefore

Vol. of air = Vol of cabinet

Mass of air in the incubator = Density of air in the incubator × Vol. of incubator

The volume of the cabinet or incubator = 0.058m^3

Density of air at room temperature (35°C) and normal atmospheric pressure

(760mmHg) = $1.2\ \text{kg/m}^3$

Thus, mass of air in the incubator = 1.2×0.058

$= 0.0696kg$

Where K = temperature change in degree Kelvin

K = The difference between the temperature of the incubator and the normal room temperature.

$= (39 + 273)K - (35 + 273)K$

$= 4K$

Where 39°C is the temperature of the incubator

35°C is the room temperature.

Thus, To calculate the mass of wood used for the fabrication

$$\text{Density of the wood} = \frac{\text{Mass of the wood}}{\text{volume of the wood}}$$

Density of the wood $= 0.6 \times 10^3 kg/m^3$

Vol. of the wood $= 0.058m^3$

Mass of the wood = ?

$$0.6 \times 10^3 \; kg/m^3 = \frac{M_w}{0.058 \; m^3}$$

$M_w = 0.6 \times 10^3 \times 0.058$

$M_w = 34.8kg$

Mass of the wood = 34.8kg

Specific heat capacity of wood $= 0.6 \times 10^3 kg/J$

Now, substituting all the above data's into equation (i)

$Q = [\, M_aC_a + M_wC_w \,] \times \theta$

$Q = [(0.0692 \text{ X } 0.24) + (34.8 \text{ X } 2.54)] \text{ X } 4$

$Q = 353.632 \text{ kJ}$

But, also quantity of heat is the same as energy
Therefore,

Energy = power × time

353632 = P X 536secs

$Power(watt)$ = 353632 / 536

=659.7$watts$

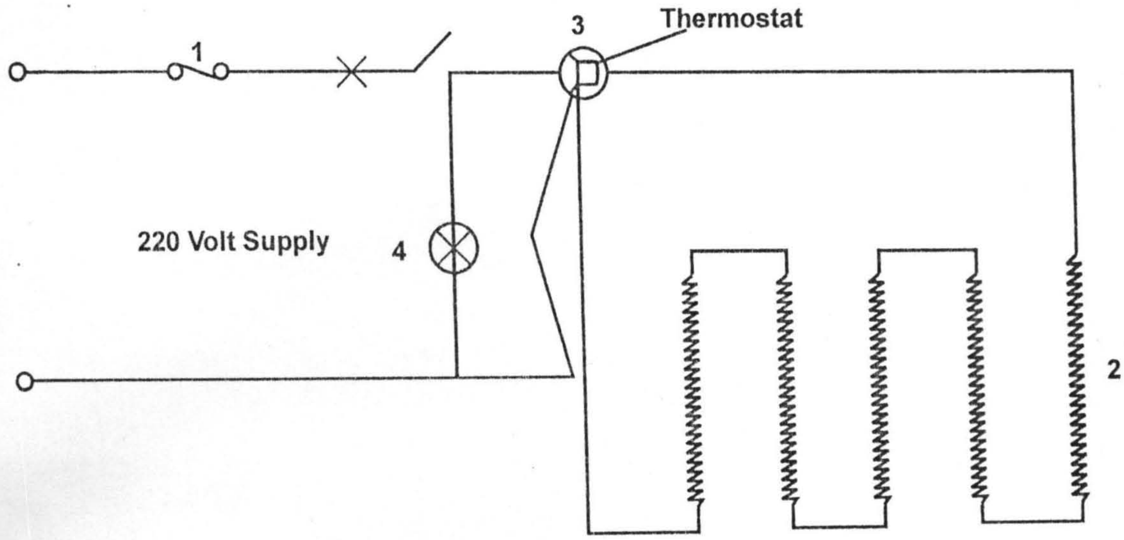

Fig 3.2 Electrical circuit (Worithington, 1984)

1. Main switch/ miniature circuit breaker (MCB)
2. Tungsten resistance wire
3. Thermostat
4. Indication switch
5. Heating element base insulator

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Presentation of Results

The detail of the embryo development of the eggs for the three weeks during incubation is shown table 4.1

Table 4.1: Observation of the eggs during incubation

Stage or period	What takes place
First day	Appearance of primitive streak –longitudinal axis of embryo.
Second day	Appearance of alimentary track.
Third day	Appearance of blood islands; vitelline circulation.
Fourth day	Appearance of Amino (protection)
Fifth day	Growth of amnion completely around embryo
Sixth day	Appearance of allantoises: functions as aids in absorption of albumen by embryo
Seventh day to Tenth day	Accumulation of carbon dioxide ammonia and lactic acid in the blood
Eleventh day to Sixteenth day	The embryo turns its head toward the broad end and near the air space.
Seventeenth day to Twentieth day	Small intensive formed and yolk sac begins to enter body cavity
Twenty first day	The embryo turns dark when candled and the egg did not hatch

At the first week of incubation, the appearance of alimentary track, primitive streak, blood islands, amino and allantoises shows that the eggs are fertile and that the incubator is in good shape. Some observations were noted during the remaining two weeks of incubation and in the sixteenth day of incubation when the egg was candled. The embryo turns its head toward the broad end and near the air space. But the problem of inadequate power supply made it impossible for the fertile eggs to hatch.

Monitoring of the incubators temperature and relative humidity was done during the first-five days and observations of the readings were noted during those days. Temperature was within the range of 37°c – 39°c and relative humidity was within the range of 50% -70%. Table 4.2 below shows readings of temperature of relative humidity during those days of observation of the incubator.

Table 4.2: Relative Humidity and Temperature of the Incubator

Days	**Relative Humidity %**	**Temperature °C**
1	**45.0**	37.2
2	**50.0**	37.8
3	**55.0**	38.3
4	**65.0**	38.9
5	**70.0**	38.9

Table 4.2 provides information about the thermometer and hygrometer reading for the incubation temperature and relative humidity respectively. It was observed that at a temperature of 37.2°c, a relative humidity of 45% was measured. Though, for the subsequent days, the value varies but the values are still within the acceptable range for hatchability.

The fertile eggs did not hatch due to problem of inadequate power supply. The turning of eggs was done 3 times daily at the early stages of the incubation period. Temperature was also monitored as well as the pressure and ventilation in the incubator. Humidity in the incubator was maintained by adding more water in the water pan, thermostat controlled the temperature when it reaches the exact degree of celcius. But the problem of inadequate power supply has been an obstacle or constraints hindering the hatchability of the incubator.

Table 4.3 The Relative Humidity and Temperature Readings of the Incubator for 24 hrs

TIME (hrs)	RELATIVE HUMIDITY (%)	TEMPERATURE(°C)
1	45	37.2
2	45	37.2
3	50	37.8
4	45	37.2
5	50	37.8
6	50	37.8
7	55	38.3
8	70	38.9
9	70	38.9
10	65	38.6
11	55	38.3
12	55	38.3
13	50	37.8
14	50	37.8
15	50	37.8
16	50	37.8
17	50	37.8
18	50	37.8
19	45	37.2
20	50	37.8
21	50	37.8
22	50	37.8
23	45	37.2
24	45	37.2

The readings were taken every hour of the test. Observations were made during the test and the readings taken in the morning and at night were almost the same while the reading increased slightly in the afternoon, which might be as a result of the increase in the ambient temperature.

4.1.1 Causes of Low Fertility

Percentage fertility largely depends on the frequency of matching but there may be other factors;

1. Wrong mating ratio: the correct mating ratio of male to female is 1:8 for heavy strains and 1:10 for light strains.
2. Wrong time of egg collection: fertile egg can be collected for seven days after males are removed from the flock. After this the percentage hatchability will decrease, if eggs are collected beyond 7 days to the extend of 10% for each subsequent day.
3. Age of breeders: the old males may be too heavy for the females or may have large spurs that injure the back of the females.
4. Poor nutrition of breeders: prolonged deficiencies of vitamins A and E adversely affect spermatogenesis and storage of the follide – stimulation hormone in the pituitary.
5. Bad management and social stress: all bad management factors like inadequate floor, feeding and drinking space excess ammonia which undermines stamina can also be implicated.

4.1.2 Causes of Infertile Eggs

The causes of infertile eggs are as follow

1. Insufficient or two many hens per male bird
2. Over fat hens.
3. Cross mating of a light and heavy bread

4. Cold condition in early of the season

5. Egg held too long

6. Under fed males

4.1.3 Causes of Embryonic Death "Dead in the Shell"

There are three major peaks of likely embryonic mortality during incubation.

- The first peak occurs at about the fourth to fifth day, which coincides with stress arising from the transition from carbohydrate to protein as the source of energy. The accumulation of carbon dioxide ammonia and lactic acid in the blood, which may arise from poor ventilation and in adequate turning, is believed to be the cause of embryonic mortality at this stage.
- The second peak a low one occurs at about 14^{th} - 15^{th} day of incubation. Nutritional deficiency is suggested as the cause
- The third peak a high one, occurs at eighteenth day this peak is attributed to wrong handling during testing, such as long exposure to low temperature and violent shaking mortality is increased by poor ventilation and inadequate turning.

4.1.4 Incubation Trouble Shooting

The incubating trouble shooting and their possible causes during incubation is given in the table

Table 4.4 Incubation Trouble Shooting

Symptoms	Possible causes
Chicks hatching too early, which bloody navels	Incubation temperature too high
Draggy hatch: some chick hatch early but slow in finishing	Temperature in incubator too cold
Delayed hatch: eggs not pipping until maximum day or later	Temperature in incubator too cold
Mushy chicks: dead on flat form bad odour	Navel infection, caused by bacteria in incubators high humidity
Chicks too small	Low humidity or high temperature
Shell sticking to chicks	Low humidity at hatching time
Straddled legs	Slippery hatching surface trays
Cripped chicks: missing eye cross beak, extra legs, etc	Mostly chance poor nutrition of stock; heredity
Rough navels	High temperature or low humidity

Source: poultry meat and egg production

4.2 Economic Analysis

Economic analysis deals with the measures in details of the amount resources (that is money, time, labour etc) expended during course of carrying out this project.

a. Material cost

b. Labour cost

c. Over head cost

4.2.1 Material Cost

The table below shows a comprehensive list of the cost of materials used in the constructing of the incubator.

Table 4.5 Cost of materials in the construction of incubator

S/No	Material	Quality	Unit price (N)	Total
1	Plywood	3	1500	4500
2	Thermostat	1	2800	2800
3	Bulbs (40 watts)	4	40	160
4	Bulbs (60 watts)	1	40	40
5	Hamp holder	5	30	150
6	Paint	2	250	500
7	Brush	2	60	120
8	"2" by "2" wood	2	150	300
9	1/2`` Nail	2kg	50	100
10	1`` Nail	1kg	60	60
11	Net	1 yard	300	300
12	Humidifier	1	600	600
13	Wire	3 yard	40	120
14	Clipps	1 packet	40	40
15	Top bond blue	1 tin	250	250
16	Small screw	½ packet	100	100
17	Arometer	1	200	200
18	Dry and wet bulb thermometer Hygrometer	1	2500	2500
19	Electric boiling ring	1	2500	2500
20	Switches	1	100	100
21	Dimmer	2	50	100
22	Plot bulb	1	250	250
23	Piece of glass	3	20	60
24	Fertile eggs	1	250	250
25		10	40	400
			Total = 16,500	

4.2.2 Labour Cost

Labour Cost is the most important cost during hatching is concerned. Priority would be given to the time rather than man hours spend during hatching since the man hours spend cannot be estimated we assumed the labour to be 15% for the period of one month "minimum wage".

Assuming a direct labour cost of material,

$$\text{labour cost} = \frac{15}{100} \times \frac{16500}{1}$$

= N 2,475

4.2.3 Overhead Cost

Overhead cost are the expenses which cannot be identified with any specific components. These include transportation, photocopies of relevant materials of the of an egg, internet browsing for information about hatching procedures, feedings and other indirect labour.

Overhead cost is assumed to be 10% for three members assigned to complete the project.

$$\text{Overhead cost} = \frac{10}{100} \times \frac{16500}{1}$$

= N 1,650

Thus, the total cost is stated:

Material cost = N16,500

Labour cost = N 2,475

Overhead cost = N 1,650

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

An electricity powered incubator with a capacity of 24 eggs was designed, fabricated and tested. The limitation of this project hatchability efficiency is due to the unavailability of a stable form of electric power supply. This was and is the major obstacles restraining people from affording modern incubators due to inconsistency in the supply of power from the Federal Government and high cost of energy. In order to attain maximum hatchability efficiency this will result to considerable profit a constant form of power supply was use to achieve the objective of this study.

Temperature, humidity, sufficient ventilation and turning of eggs are the most crucial factors which influence hatching quality hence careful eyes have to be kept on these four factors.

It is clear that an egg presented here was produced and tested at a low affordable rate.

5.2 Recommendations

1. The main reason of getting a low hatchability in unavailability of electricity. For this reason solar energy panel can be used to get a high hatchability but it might be expensive for farmers who want to involve in poultry farming.
2. The Federal Government should intensify effort to bringing the problem of electricity to an end. This will enable organizations and individual to operate their business to reduce high cost of energy used.
3. The project was designed, fabricated and tested thus, the prospective investor should put in place a stable source of power supply in order to achieve optimal use.
4. Government and private organization should offer maximum support to technology students in order to contribute to the development of Nigerian technology.

5. The design of the project concentrates mostly on chicken eggs. This is proved from the result obtained that the chicken eggs hatched better compared to other poultry birds eggs set.

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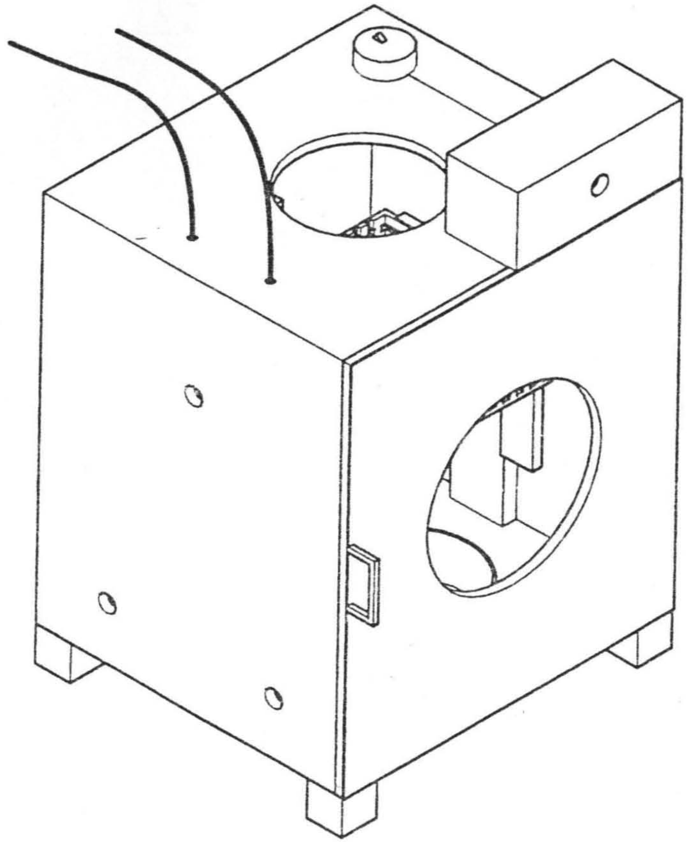

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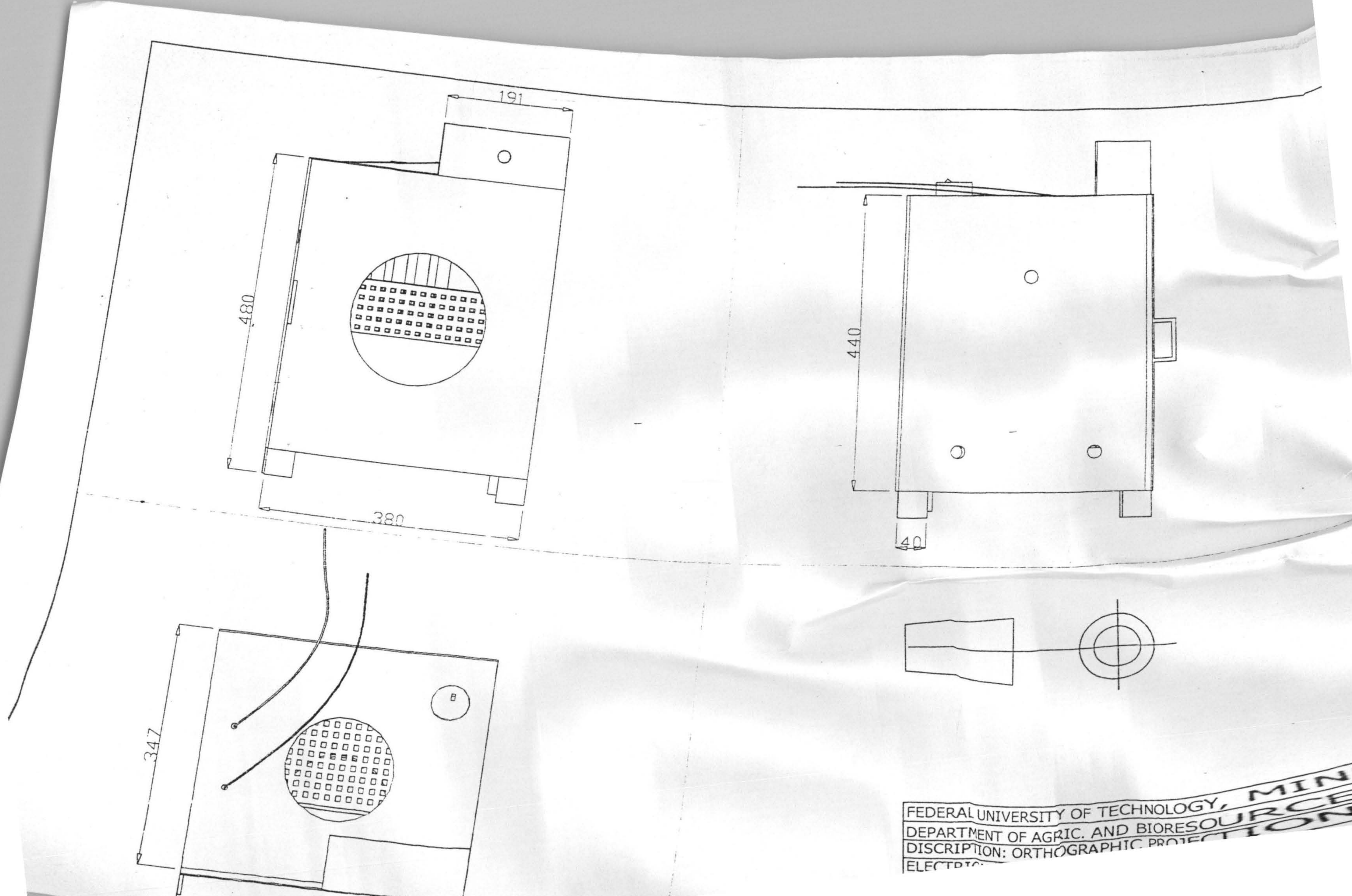

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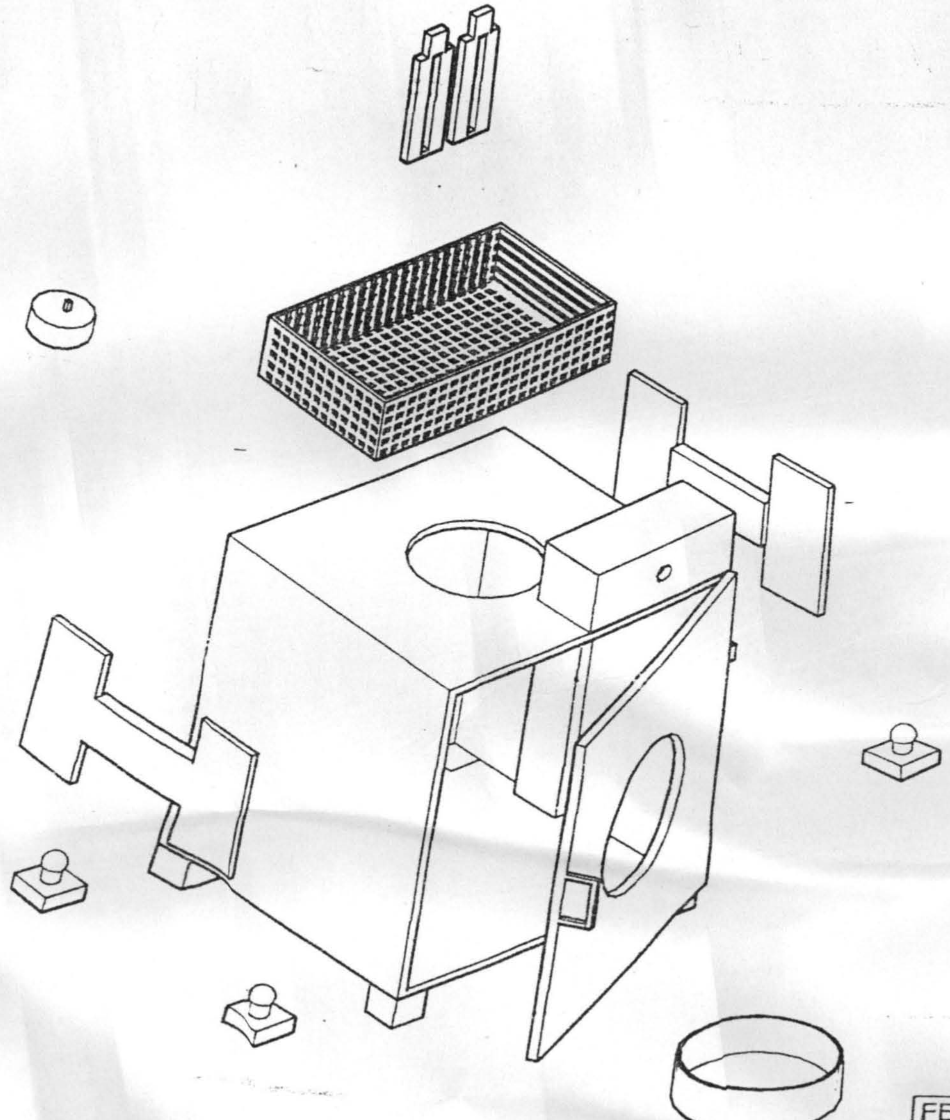

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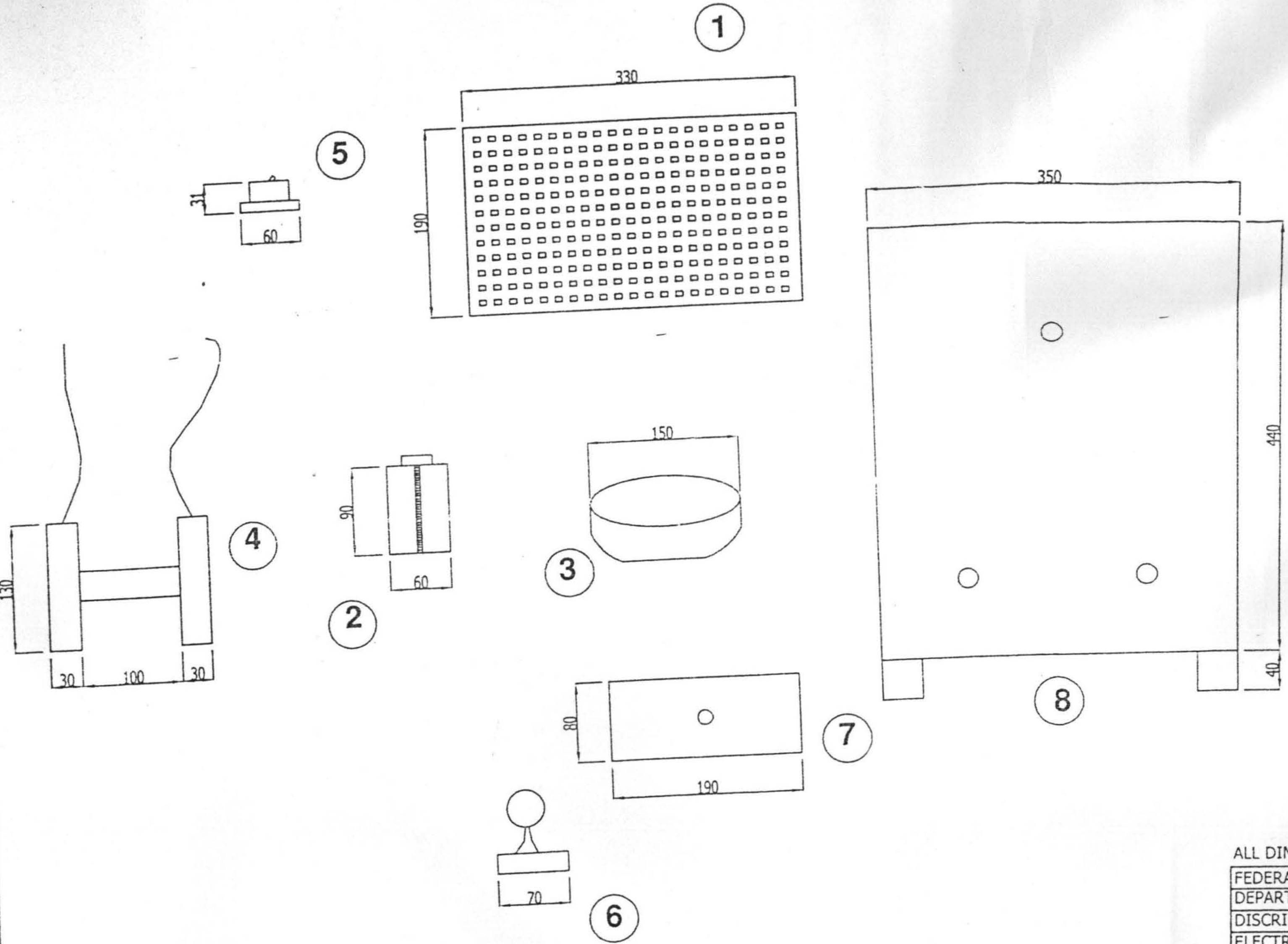

S/N	DESCRIPTION	MATERIAL
1	EGG TRAY	WOOD
2	THERMOMETER	PLASTIC
3	WATER BASIN	STAINLESS STEEL
4	TURNER	WOOD
5	SWITCH	PLASTIC
6	40 WATTS BULB	GLASS
7	CANDLER	WOOD
8	FRAME	WOOD

ALL DIMENSIONS IN MILLIMETERS

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DEPARTMENT OF AGRIC. AND BIORESOURCES ENGINEERING					
DISCRIPTION: PART DRAWING					
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APPROVED BY	ENGR. IDAH				LEVEL: 500