DESIGN AND FABRICATION OF AN ELECTRICALLY OPERATED EGG INCUBATOR

BY

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 Information derived from personal communications, published and unpublished work were duly referenced in the text.

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Date

CERTIFICATION

This project entitled "Design and Fabrication of an Electrically Operated Egg Incubator" by Danjuma Dauda, 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 dedicated to the Almighty God, for His blessing and guidance throughout the period of my studies; I have every course to thank him. And to my beloved mother Late Mrs. Lucy Danjuma.

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ABSTRACT

A still-air incubator with a capacity of hatching 24 eggs per incubating period was fabricated from locally available materials, as an artificial method of incubating eggs in order to produce an efficient but cheap means of poultry production. The incubator was equipped with the necessary functional parts which electrically controlled the heating elements, thermostat and others. Important factors like ventilation, relative humidity and temperature necessary for incubation was established within the incubator, by providing a vent and free water surface other important factor like turning of the eggs was done manually. The functionality of the incubator was tested, temperature range of 37-39°C was observed and a relative humidity of 45-70% was observed as read from the psychrometric chart using the average dry bulb and wet bulb thermometer readings. At the end of the test, it was discovered that none of the egg hatched. The possible causes of this may include; constant power outage or probably due to fertile eggs stored for long before been installed into the incubator. Incubator for large scale production can be fabricated using the same procedure and to supplement the power failure an inverter should be built for the incubator so that the efficiency and performance of the incubator can be evaluated and tested.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

An incubator can be described as a box-like insulated fabrication in which environmental conditions, for example, temperature, relative humidity, ventilation are controlled for the purpose of keeping the eggs at constant temperature range of 37 to 39.5°C for a period of 21 days before hatching. The aim is to produce meat and eggs for human consumption. Incubation of eggs is described by Iwena (2008) as a process of providing fertilized eggs with optimum conditions of temperature, ventilation and relative humidity necessary for the development of chicks and their successful hatching.

There are two methods of incubation. These are: The natural method and the artificial method. In the natural method, the incubation is done by the hen itself, after having a number of eggs. The hen gets broody that is, it stops laying in order to incubate the eggs already laid. The artificial incubation is designed to provide the ideal conditions naturally provided by the hen. It uses man-made devices called incubator to provide optimum condition necessary for the development of the embryo into chick. However, over the years the incubation process has become a very sophisticated one, the devices are of different types and the various sources of energy through which it can be operated are electricity, paraffin, gas and so on (Iwena, 2008).

1.1.1 Advantages of Artificial Incubation

1. Large number of eggs are incubated and hatched at a time.
2. Hens do not have to stop egg production.
3. There is no danger of pest and disease causing organism.

1.1.2 Disadvantages of Artificial Incubation

1. Too expensive to purchase
2. Required skilled man-power for their maintenance.

1.2 Statement of the Problem

The incubator is the most important equipment in hatchery and is employed when a large number of eggs are to be hatched. But in the early methods, the attendants are often confronted with an unpleasant working condition such as poisonous fumes, heat and the chicks hatching are contaminated with pests, disease causing organism which may lead to high mortality rate before and after hatching.

Therefore, there is the need for improved modern mechanical incubator but these are too expensive to purchase, manage and required skilled man power for their maintenance. A few have back-up servicing facility but most do not.

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 farmers who intend into the business of chick's production.
3. To reduce the cost of importing such apparatus from abroad.

1.4 Justification of the Study

Over the years different types of incubators have been imported or produced in Nigeria, but the major problems have been its limitation, exorbitant cost and were out of reach of small scale farmers. Though, modern mechanical incubation machines have been imported and are presently in use in this country, there is still the need for modification from local raw materials to eliminate the problem of maintenance personal and minimize our exclusive dependence on indiscriminate importation of agricultural machinery.

However, there is the need to really intensify effort in the areas of studying and fabrication of a less costly incubator which will reduce or eliminate the unpleasant working condition associated with the early methods and also has a reasonable capacity for a peasant livestock farmer to boost chicken production.

1.5 Scope of the Study

Agricultural technology development is increasing day-in day-out and the need to feed the nation well is calling for improvement in food production section. Isyaku (1998) stated that poultry protein is one of the best sources of animal protein for human consumption because it contains most of the essential amino-acid in the right proportion. The consumption of which in the developing countries like Nigeria in form of meat, egg is grossly below the average required for good health. This is because animal protein in general are still too expensive to the great majority, hence the need for artificial methods of improving this source of protein. Beside its nutritive values, its products and by products serve as sources of raw materials to some industrial products such as paints, soaps, varnishes and so on.

CHAPTER TWO

2.0 LITERATURE REVIEW

Artificial incubation: This is designed to provide the ideal conditions naturally provided by hen. It uses man-made devices called incubator to provide optimum conditions necessary for the development of the embryo into chick. The incubator is the most important equipment in hatchery. Many types of incubators, ranging in size from small to room type are made. Eggs are set in trolleys (Iwena, 2008).

2.1 Types of Incubator

2.1.1 Still-Air Incubator

These incubators are not commonly used anymore for egg incubation. Still-air incubators, also known as thermal incubators, heat eggs using no air movement methods. These incubators have been replaced over the last 15-20 years by forced-air circulating incubators. When incubating quail eggs in a still-air incubators, maintain a temperature of 39.5°C. The temperature should be decreased to 37.8°C during the last 1-2 days of incubation. Humidity is also necessary for a successful hatch. However, humidity is difficult to measure in a still-air incubator. It is recommended that a flat water pan covering the incubator floor be used to provide humidity. During the last couple of days of incubation sprinkle eggs with water to increase humidity slightly (Quail place, 2005). Anderson (2008) stated that still-air incubators are small and have no fan, hatch a smaller number of chicken eggs and required more attention.

2.1.2 Forced-Air Incubator

This type of incubator is commonly used to incubator quail eggs. Forced-air incubators maintain a constant temperature throughout the incubator by means of a circulation fan. This method of incubation provides the most consistent air temperature and humidity of any incubation methods available. Most of the forced-air incubators available for sale also can be adapted with equipment which allow turning of the eggs. Turning of eggs is essential to the incubation process. If eggs are not turned a minimum of 4-5 times a days, the embryo inside the egg will settle and they will not hatch. It is advised to stop turning the eggs two days prior to hatching. This will allow the chicks to position themselves to hatch easily. Temperature inside the incubator should be maintained at 37.5°C and a relative humidity of 60%. During the final 2 days of incubation the temperature can be decreased one degree and the humidity increased to 70% (Quail place, 2005).

2.2 The Development of Artificial Incubation of Eggs

Artificial incubation of poultry eggs is an ancient practice. Aristotle writing in the year 400 B.C. told of Egyptians incubating eggs spontaneously in dung heaps. The Chinese developed artificial incubation at least as early as 246 B.C. These early incubation methods were often practiced on a large scale, a single location perhaps having capacity of 36,000 eggs (Berry, 2007).

According to Martin (2002), the early Egyptian incubators of some 3,000 years ago were a series of mud-brick-egg-ovens type rooms built each side of a passage way all within a large mud brick building or hatchery. Thousands of eggs were placed in heaps on the floor of each incubator room. In the upper chamber of the room there were shelves for low burning fires of straw, camel dung or charcoal to provide radiant heat to the eggs below. The entrance to the passage way was through a small manhole. Temperature control was achieved via the strength of the fires, jute covers over the manholes and regular openings of vents in the roof of the ovens and passage way. Humidity was controlled by spreading damp jute over the eggs as necessary. The roof vents also allowed smoke and fumes from the fires to escape and provide some light. The piles of eggs were rearranged and the eggs turned twice a day. The middle passage way also served as a warm brooding area for the chicks when they were hatched. The amazing thing about all this was that the temperature, humidity and ventilation were checked and controlled without using measuring devices or Gauges, nor were there any thermometers. They achieved all this by having the hatchery manager and the hatchery workers actually living inside the hatchery building.

2.3 The Development of Western Incubator

After the failure of Egyptian incubators in Europe, the pressure was on to develop a more sophisticated mechanical incubator. More experimental incubators were produced, some using hot water, some heated by charcoal others by steam. Self-regulating oil or kerosene lamps with a damper were also widely used to heat water and hot air incubators in the second half of 19^{th} century. Very few of these were successful because they were unable to regulate the range of temperature within the narrow range which was required. A famous hot air incubator was the American incubator the 'cypher incubator' it used a thermostat and an improved method of heating. It was the advent of thermostat to regulate temperature accurately which allowed the development of modern incubators (Martin, 2002).

Isyaku (1998) stated that modern incubators can either be a flat-type or cabinet type and both have insulated chambers in which temperature and relative humidity are controlled. Others are variation of the cabinet type.

2.3.1 The Flat-Type Incubators

This type of incubator depends solemnly upon natural ventilation and has a small capacity, between 50 to 150 eggs. The eggs are tray horizontally on a single tray and rolled through 180 when turning. It is heated from outside and the heating of the eggs inside is done from above. This is of small capacity; time consuming, laborious and it is easily affected by small change in environmental conditions.

2.3.2 The Cabinet Type Incubator

This type of incubator has two separate component namely-setting and hatching compartments. The setting compartment contains a double set of pivoted metal rack which are closely connected in such a way that they all tilted at the same time, each half tilting the opposite way to the other. The heating medium inside the machine is the electricity which will also take care of the ventilation, fans and the automatic turning device at regular interval. Moisture is provided by water spray injections arranged in conjunctions with ventilation circuit. The compartment is kept under the required environmental condition needed for hatching out of chicks.

He also stated that although it has a high capacity with high efficiency, it is vulnerable to power failure, it need skilled staff and high level of professionalism to run the machine. It is too expensive to purchase, manage and not suitable for small scale poultry man.

2.4 Factors Affecting the Hatchability of Egg

2.4.1 Physical Defects

Selects eggs for hatching that are normal in size, shape, color, and shell texture. Excessively, large or small eggs are often infertile, do not set these eggs. Remove eggs with obvious defects, dirt and cracks (Lyons, 2003).

2.4.2 Age of Egg

For best hatching results, never store fertile eggs more than two weeks. Egg hatch best if set within three to four days after laying. Older fertile eggs will hatch satisfactory if properly stored (Lyons, 2003).

2.4.3 Cleanliness of Eggs

Dirty eggs as a result of droppings should be discarded as unsuitable for incubation. It might harbour disease and pests which will later feed on its nutrients (Uguru, 1981).

2.4.4 Feeding

The nutrient needed by the hen to produce hatchable eggs must be adequately supplied in the ration. Under nourishment and lack of appropriate vitamins and minerals in feed may lead to death of the embryo during development and failure of the egg to hatch (Isyaku, 1998).

2.4.5 Hereditary Defects

The eggs should come from healthy adult chickens that have a high fertility percentage, were not disturbed during mating season (Anderson, 2009).

2.4.6 Egg Handling and Storage

All hatching eggs should be handled with care when in storage, it should be place with large end up at cool room temperature about 15.5°C to 20°C (Uguru, 1981).

Lyons (2003) stated that the embryo of a fertile egg starts the cell-division process as the egg passes through the warm oviduct of the hen that lays it. The embryo is alive see table 2.1 for sequence for the development of the chick embryo. The development is suspended when the egg cools.

Table 2.1: Events in Embryonic Development of the Chicken Egg.

Before Egg Laying	**Fertilization.** Division and growth of living cells. Segregation of cells into groups of special function (Tissues).
Between Laying and Incubation	No-growth stage of inactive Embryonic life (50, 000 to 80, 000 cells).
During Incubation	
Day1	
16 hours	First sign of resemblance to a chick embryo
18 hours	Appearance of alimentary tract
20 hours	Appearance of vertebral column.
21 hours	Beginning of formation of nervous system.
22 hours	Beginning of formation of head.
24 hours	Beginning of formation of the eye.
Day2	
5 hours	Beginning of formation of heart.
5 hours	Beginning of formation ear

42 hours	Heart begins to beat
Day 3	
60 hours	Beginning of formation of nose.
62 hours	Beginning of formation of legs.
64 hours	Beginning of formation wings.
Day 4	Beginning of formation of tongue.
Day 5	Beginning of formation of permanent organs and differentiation of sex, aortic structure begins forming and thickening.
Day 6	Beginning of formation of beak.
Day 8	Beginning of formation of feathers.
Day 10	Beginning of hardening of beak.
Day 13	Appearance of scales and claws.
Day 14	Embryo gets into position to beak the shell.
Day 16	Scales, claws, and beak become firm.
Day17	Beak turns toward air cell.
Day 19	York begins to enter body cavity
Day 20	Yolk sac completely drawn into body cavity. Embryo occupies practically all space within the egg except the air cell.
)ay 21	Hatching of chick.

;ource:(Lyons, 2003)

.5 Physical Requisites for Successful Incubation

The requirements for successful incubation and hatching are temperature, relative ımidity, ventilation, position and turning of eggs.

2.5.1 Temperature

Temperature is probably the most important single factor influencing the development of the embryo. Near the optimum incubation temperature ranges, a higher temperature will advance the hatch and a lower temperature will delay hatch. A one- half-degree change in average incubation temperature will move the average hatch time by about 5.4 hours. To monitor the temperature, place a calibrated and accurate thermometer one inch above the wire mesh screen on which the egg sits. This location corresponds approximately to the top of the eggs, where the temperature should be measured (Lyons, 2003).

According to Hermans (2000), proper temperature is critical for ensuring the maximum hatchability as well as the best physical condition of the chicks that hatch. Variation from the optimum temperature affects growth rate and incidence of embryonic mortality and deformity. Use of suboptimal conditions is evidenced of poor growth rate and successor by chicks hatching with un-retracted yolk sacs, poor vigor, and developmental problems.

2.5.2 Relative Humidity

Proper humidity is important because it keeps the egg from losing too much or too little moisture during the incubation process. Eggs should lose between 11 and 14 percent of their weight from day 1 to day 18 of incubation. This weight loss is a direct indicator of humidity control. Humidity should be balanced with temperature; different temperatures required different relative humidity. Relative humidity should be 60 to 65 percent for the first 18 days of incubation, and 70 percent for the last three days. The water pan in the incubator should be kept full at all times. Use warm water to fill the pan (Lyons, 2003).

Berry (2007) stated that egg loose water during incubation period, and the rate of loss depends on the relative humidity maintained within the hatching chamber. Metabolic balance must be maintained throughout the incubation period. Thus, humidity outside a relatively narrow range will affect the number of successfully hatched eggs. He also stated that optimum growth for most species requires a relative humidity of 60 percent until the eggs begins to pip, after which the relative humidity should be raised to 70 percent.

2.5.3 Position and Turning of Eggs

Eggs should be placed in the incubation compartment with large ends up for best results. However, a fairly good hatch can be obtained if the egg are placed on their sides. An extremely poor hatch will occur if the eggs are placed in the incubator with small end up. The eggs must be turned several times a day for best hatchability. This will ensure that the embryo will not stick to the shell. The turning should be repeated throughout the entire 24-hour day. However, the night turning may be eliminated as long as there is a late evening and an early morning turning. Eggs should be turned at least four times during each 24-hour period. In large commercial machines, turning is mechanically done, controlled by a time clock. The eggs should be turned through a 90-degree plane as gently as possible. Turning should continue until one to three days prior to hatching and or until the eggs has "pipped", position or turning will then have no effect on hatching (Berry, 2007).

2.5.4 Ventilation

Ventilation is very important during the incubation process. While the embryo is developing, oxygen enters the egg through the shell and carbon dioxide escapes in the same manner. As the chick hatch, they require an increased supply of fresh oxygen. As embryos grow, the air vent opening are gradually opened to satisfy increased embryonic oxygen demand. Care must be taken to maintain humidity during the hatching period. Unobstructed ventilation holes, both above and below the eggs, are essential for proper air exchange (Smith, 2004).

2.6 When Eggs Fail to Hatch

Approximately two out of every 10 eggs normally do not hatch. The majority of this expected embryo mortality occurs during the first and last weeks of incubation. Mortality during the last three days of incubation may be the result of an accumulation of factors that weaken chicks to the point that they cannot survive the normal rigors of the hatching process. Other causes of mortality can be related to inappropriate management or function of the incubation process. Common causes of abnormal mortality level during the first and second weeks of incubation include improper temperature or ventilation. Incubator over heating, for example, can quickly kill the developing embryo. Early in the incubation period, overheating can also contribute to the incidence of expose viscera (yolk sac and internal organs protruding from body cavity) in the nearly fully developed chick. Overheating, together with rough handling of eggs, can contribute to malformed ead part such as a protruding brain, deformed beak or lack of eyes (Lyons, 2003).

He also stated that improper temperature or ventilation can also cause death during the pipping stage as chicks peck through their shells. Other possible causes of death at this late stage of development include improper humidity control, disease and even thin egg shells.

.7 Diagnosis of Failure to Hatch

.7.1 Clears

Absence of a blood ring or embryo development indicates that either the embryo ied early in incubation or the eggs were infertile (Lyons, 2004).

.7.2 Blood Rings

Indicates very early embryonic death. Possible causes are incubator temperature o high or too low (Spencer, 2008).

7.3 Dead Early or Midterm Embryos

Many factors can cause embryos to die early or in midterm. Possible causes clude improper temperature, unknown power failure, eggs from inbred stocks, poor ntilation of hatchery or incubator, disease or infected egg (Ernst et al.,1999).

7.4 Fully Formed and not Pipped

When chicks die fully formed without pipping, the usual causes include low erage incubation temperature, weak viability of setting eggs, improper humidity, netic defects, contamination or temperature malfunction, infected eggs, poor nutrition breeder flock (Lyons, 2003 and Ernst et al., 1999).

.5 Malformed Chicks

Genetic and chance deformities may occur. The possible causes include incubator perature too high, incubator temperature too low, eggs set incorrectly or not properly ned after setting (Spencer, 2008).

2.7.6 Cull Chicks

Dry chicks with egg shells sticking to their down may indicate low humidity after pipping starts. Chicks hatching earlier than usual with bloody navels or navels not healed properly might indicate too high temperature or too wide temperature swing during incubation. Chicks hatching later than 24 hour after the start of hatch are commonly cull chicks that will not grow well and will be more susceptible to stress and disease challenges. Prolonged hatches typically result from poor egg vigor or an unbalanced environment through out the incubation period, not just at the time of hatch (Lyons, 2003).

He also stated that weak chicks may be placed in special isolation housing for their protection. However, chicks will be more settled if they are placed with other chicks. Some methods to terminate incubating eggs include placing the eggs in a container filled with carbon dioxide or in a low temperature environment.

.8 Managing the Incubation process

During incubation, eggs found to be leaking, cracked, or moldy should be removed nd disposed of such eggs may explode because of high microbial populations. The eleased odour is very offensive and would required expedient removal of all the eggs Anderson, 2009 and Lyons, 2003).

According to Lyons (2003), the normal incubation time of most chickens is 21 ys to 21 days, 6 hours. Table 2.2 shows normal incubation times for other birds. cubation time may vary according to temperature of weather and incubator, size of egg, tility of egg and vigor of the embryo, and a host of other factors.

Table 2.2: Incubation Periods for Various Birds

Bird	Incubation Period
Pigeon	18 days
Pea fowl	29 days
Chicken	21 days
Grouse	23 days
Turkey	28 days
Quail	23 days
Pheasant	23 days
araket	19 days
oose	32 days
uinea	27 days
uct (Muscovy)	36 days
uck	28 days
uail (coturnix)	16 days
strich	42 days
arnary	13 days

urce : (Berry, 2007)

2.9 Hatching Operation

Chicks begin hatching on day 21. If all the eggs do not hatch by day 25 or 26, remove the remaining eggs and discard them (Anderson, 2009).

Infertile eggs and dead embryo can be detected about six days after incubation by the process called candling. The machine used to detect living or dead and developing embryo is called the egg Candler. Candling consists of the passage of concentrated source of light through the egg in a dark room in order to see through the egg. It is usually not done in commercial basis because of the number of eggs involved. However, it is routinely done in research stations. At least two candling are done usually in six to seven days of incubation. With candling, fertile eggs can be determined. Here, live embryo shows a spider-like appearance in the egg. Infertile eggs are clear with no spider-like appearance (Iwena, 2008).

2.9.1 Effort to Ensure Uniformity of Hatching

Iwena (2008) stated that the step to be taken to ensure that the egg hatch at about the same time include the following.

1. Setting eggs uniformly on the tray.
2. Timely and regular turning of eggs.
3. Ensure suitable environmental conditions, that is, temperature, relative humidity and ventilation
4. Proper candling of the eggs.
5. Setting eggs at the same time.
6. Selecting eggs of the same size.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Design Considerations

In the design of any product, economy and serviceability factors are the major consideration. In the design of this incubator which is electrically powered contain factors which will affect the performance of the machine. These factors were taken into consideration after careful analysis of information obtained from the literature.

3.2 Serviceability

This is the ability of a designed machine or its components to be easily serviced. It is also the fitness of a machine to perform its function within the specifications. This means that a machine should be designed in such a way that fault and damage could be easily detected and rectified by means of maintenance and repairing. The sizes and nature of the material chosen had been standardized in such a way that the cost of maintenance would be easily affordable.

3.3 Cost of Materials and Fabrication

This factor can't be left out in the design consideration as cost of Fabrication and materials determined the final cost of product. This surely would determine its status in the market. For this good product to have good stand in the market and as well be affordable to people, special considerations are been taken in what the cost of production and materials would look like.

3.4 Materials for Fabrication

Engineering properties of a constructional material refer to those qualities possessed and characteristics exhibited by the materials either in its natural state or when used in the fabrication. These properties are important because they both directly and indirectly influence the strength, durability, stability and aesthetic value of the incubator. The materials used in the fabrication of the incubator include the following.

3.4.1 Timber

Timber is one of the most common constructional materials but at the same time, it is probably the most difficult to classify, select and use correctly. This difficulty is due to the great variation in the properties of the different species and to the influence of defects in growth and seasoning. This is chosen for the construction because of its very low thermal conductivity and as insulator it is superior to most of the common structural materials.

3.4.2 Hygrometer

Hygrometers are instruments used for measuring relative humidity. A simple form of a hygrometer is specifically known as psychrometer and it consist 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.

3.4.3 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.

3.4.4 Thermometers

A wet and dry bulb thermometer was installed in the incubator to obtain the maximum temperature, placing one of the thermometers in water with wool to obtain the required humidity.

3.4.5 Heating Device

The heating devices of this system is a light bulbs rated at 240 watts. This device is such that can provide the required quantity of heat energy to the system. It obtains the energy through a fuse (13A) from a 240V A-C line which is available everywhere.

3.4.6 Water Basin

It provides a wide surface from which the moisture content of the enclosed air could be maintained at required level.

3.4.7 Barometer

This is an instrument for measuring air pressure to show when the weather will change in the system.

The following are others materials used in the fabrication:

1. Avometer
2. Switch
3. Glass
4. Lamp holders
5. Water delivery system(small rubber pipe)
6. Clips
7. Dimmer
8. Heater

9. Net

10. Thread

3.5 Fabrication Procedures

1. Construct a rectangular box of length 38cm, breadth 35cm and height 44cm
2. Make a hole of diameter 15cm at the top
3. Cover the hole with glass
4. Construct ventilation holes at both sides. The diameter of the holes are about 1.5cm, the holes should be in three phases at each side. More so, construct two holes of 1.5cm, at both sides of the base through which oxygen enters the incubator.
5. Construct an exhaust hole at the side facing the door where carbon dioxide passes through. The diameter of which is 1cm.
6. Nail a point slightly above the tray where wet and dry bulb thermometer will be hanging. The thermometer must be visible through the glass of the door.
7. Nail another point beside thermometer where hygrometer must be visible through the door when hanged.
8. To the upper glass, gum the barometer with the inner part facing the glass.
9. The box should be above the ground at any convenient distance.

3.6 Fabricating the Egg Tray

This tray serves two purposes: A setter and Hatcher. It is of length 33cm, breadth 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 breadth.

3.7 Fabricating the Egg Candler

The procedures for construction are as follows:

1. Construct a rectangular box of length 19cm, breadth 8cm, and height 8cm.
2. Drill a hole of about 2cm in diameter at one of the breadth side of the box.
3. Drill a small hole at the other side of the breadth, where the extension cord can be attached to the socket.
4. Mount the proclaim socket at the breadth of a small hole.
5. With the aid of a nail join the length(s), breadth, the upper and lower part together.
6. Screw – in the light bulb
7. Hold the egg in front of the hole for observation.

3.8 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 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

$$= \frac{3.0 + 4.0}{2} = 3.5\text{cm}$$

Average radius of an egg = 3.5/2

= 1.75cm

Clearance to the edges = 0.8cm

Radius of an egg hole = average radius + clearance (1.75 + 0.80) cm = 2.55cm

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

Diameter of an egg hole = 5.1cm

Area occupied by an egg hole = $(5.1)^2 = 26.01cm^2$

Clearance area = Area occupied by an egg - effective area = $26.01cm^2 - [3.14^2 \times (1.75)^{2}]$

$= \underline{16.3876cm^2}$

3.8.1 Tray Dimension

Total area of eggs = Area occupied by an egg x number of eggs

= 26.01 x 24

= $624.24cm^2$

Area of the tray $= \frac{\text{Total area of egg}}{\text{Number of trays}}$

$= \frac{624.24}{1}cm^2$

= $624.24cm^2$

Length of the tray = 33cm

Breadth of the tray = 19cm

3.8.2 Incubator Dimension

Length of the incubator = 38cm

Breadth of the incubator = 35cm

Height of the incubator = 44cm

Volume of the incubator = 38 x 35 x 44

$= 58.5 \times 10^3 cm^3$

$= \underline{0.0585m^3}$

3.8.3 Determination of Air Properties

Analysis of data shows that the average ambient air temperature of Minna is 28.1^0 C and average relative humidity is 75%. The following ambient air properties were obtained using psychrometric chart.

Specific volume of air, $V_1 = 0.877m^3/kg$ of dry air

Humidity ratio of air, $W_1 = 0.0184$ kg/kg of dry air

Specific enthalpy of air, hi = 75kg/kg of dry air

The recommended temperature and relative humidity for successful incubation is 38.4^0 C and 60% respectively. Hence, the following air properties are obtained from psychometric chart.

Specific volume 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 $W_2 = 0.027kg/kg$ of dry air

3.8.3.1 Mass of Air

$$\text{Mass of Air} = \frac{\text{Volume of air within the incubator}}{\text{Specific Volume of air within the incubator}}$$

$$M = V/V_2 = \frac{0.0585}{0.9209m^2/kg \text{ of dry air}}$$

$$= 0.0635 \text{ kg of dry air}$$

Where M = Mass of air within the incubator.

3.8.3.2 Quantity of Heat

According to Oria (2004), the quantity of heat, Q needed in a confined space is given by Q = (MaCa + MwCw) θ___________(1)

Where Q = Quantity of heat

Ma = Mass of air in the space

Ca = Specific heat capacity of air

Mw = Mass of wood

Cw = Specific heat capacity of wood

θ = Temperature change.

To calculate the mass of air in the Incubator

$$\text{Density of air in the incubator} = \frac{\text{Mass of air in the incubator}}{\text{Volume of the incubator}}$$

Therefore,

Mass of air in the incubator = Density of air in the incubator x Volume of the incubator

The volume of the incubator = $0.0585m^3$

Density of air at room temperature (35°C) and normal atmospheric pressure (760mmHg)

= $1.2kg/m^3$

Thus, mass of air in the incubator = 1.2 x 0.058 = 0.0696kg

To calculate the mass of wood

Mass of wood = Density of wood x Volume of wood

= 0.6 x 103 x 0.058

= 34.8 kg

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.

Now, substituting all the above data into equation (1)

$Q = (MaCa + MwCw)\ \theta$

$= (0.0696 \times 0.24 + 34.8 \times 2.54) \times 4$

$= (0.016704 + 88.392) \times 4$

$= (88.408704) \times 4$

= 353.635 KJ

= 353635 J

3.8.3.3 Electrical Power Required

Energy (Joules) = Power (Watts) x Time (Seconds)

$$\text{Power} = \frac{353635}{536}$$

= 659.77 W

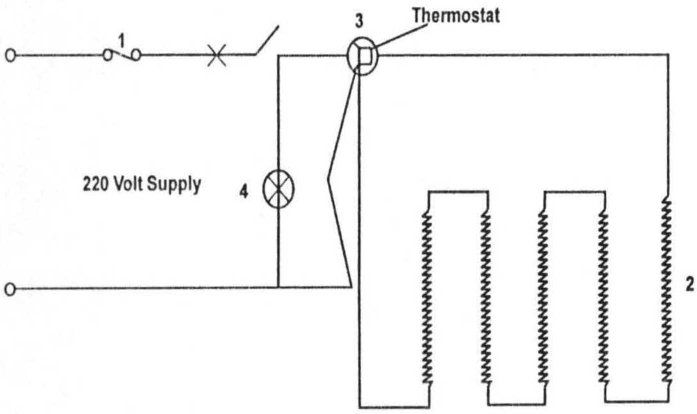

Fig 3.1 Electrial Circuit of the incubator

1. The main switch
2. Tungsten resistance wire
3. Thermostat
4. Indication switch

3.9 Cost Analysis

Table 3.1: Below Shows the Materials, Quantity and their Respective Prices

S/No	Material	Quantity	Unit price (₦)	Total price (₦)
1	Plywood	3	1500	4500
2	Thermostat	1	2800	2800
3	Bulb (40 watt)	4	40	160
4	Bulb (60 watt)	1	40	40
5	Lampholder	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	Clips	1 packet	40	40
15	Top bond glue	1 tin	250	250
16	Small screw	½ packet	100	100
17	Avometer	1	200	200
18	Thermometer	1	2500	2500
19	Hygrometer	1	2500	2500
20	Electric boiling ring	1	100	100
21	Switches	2	50	100
22	Dimmer	1	250	250
23	Pilot bulbs	3	20	60
24	Piece of glass	1	250	250
25	Fertile egg	10	40	400
	Total Cost of Material			₦16, 500

3.9.1 Labour Cost

Assuming a direct labour cost of materials, then

$$\text{Labour Cost} = \frac{15 \times 16,500}{100}$$

$$= ₦\,2,475.00\text{ K}$$

3.9.2 Overhead Cost

Overhead cost Include other expenses incurred apart from material and labour cost. Taking the overhead cost to be 10 % of the material cost. Therefore,

$$\text{Overhead Cost} = \frac{10 \times 16,500}{100}$$

$$= ₦\ 1,650.00\ K$$

Therefore, the cost of construction is the sum of material cost, labour cost and overhead cost.

Total Cost = 16, 500.00 K

2, 475.00 K

1, 650.00 K

N 20, 625.00 K

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

The results of the Relative humidity and Temperature observed during the test are presented in Table 4.1

Table 4.1: Incubation Temperature and Relative Humidity

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

Though the environmental conditions necessary for incubation of eggs was established within the incubator, it failed to hatch.

The tests were carried out with 10 eggs. The incubator was allowed to warm up to a temperature of 37°C before installing the eggs. The eggs were placed in the trays with their broad end up and turning of eggs was done by tilting the tray for at least three times daily throughout the incubation period. The turning of the eggs started from 3rd to 19th day of incubation period to prevent the developing embryos adhering to the shell membrane and equally to allow the temperature to be evenly distributed.

Dry and wet bulb thermometers were placed in the incubating chamber to determine the hotness and humidity of the chamber. Table 4.1 provides information about the thermometers readings for incubation temperature and humidity respectively. It was observed that a temperature of 37.2°C, a relative humidity of 45.0% was measured. Though for the subsequent days the values varied, the ambient temperature greatly affects the stability of the reading obtained but they are still within the acceptable range for hatchability. Candling of the eggs was done and it was noticed that in each testing most of the eggs appeared clear without embryonic development (indicating infertility or death at the early stage of incubation) only few with traces of blood that confirms fertilized eggs were present. The most likely fault that could be associated with death at early stage of the incubation may be as a result of too high incubator's temperature at second and third day of the incubation. Candling was carried out by holding the egg in front of an intense light source.

At the end of the test, none of the eggs hatched. The possible causes of this may include; constant power failure or possibly due to fertile eggs stored for long.

Table 4.2: Temperature and Relative Humidity of the Incubator for 24-Hours

Time, hr	Temperature, °C	Relative Humidity, %
1	37.2	45.0
2	37.2	45.0
3	37.8	50.0
4	37.2	45.0
5	37.8	50.0
6	37.8	50.0
7	38.3	55.0
8	38.9	70.0
9	38.9	70.0
10	38.6	65.0
11	38.3	55.0
12	38.3	55.0
13	37.8	50.0
14	37.8	50.0
15	37.8	50.0
16	37.8	50.0
17	37.8	50.0
18	37.8	50.0
19	37.2	45.0
20	37.8	50.0
21	37.8	50.0
22	37.8	50.0
23	37.2	45.0
24	37.2	45.0

The readings were taken every hour of the test, which started from 6am to 5am. Observations made showed that, the readings taken in the morning and in the night were almost the same while the readings increased slightly in the afternoon. This might be as a result of increase in the ambient temperature which affects the stability of the readings obtained.

Plate 4.1: Electrically Operated Incubator

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A poultry incubator was constructed mainly from the locally available material and has the capacity of hatching 24 eggs per incubating period.

Even though the work does not yield a positive result due to constant power outage, it provides the student with practical experience.

Conclusively, the incubator powered by electricity can still be used for its primary purpose provided there will be constant power supply.

5.2 Recommendations

The following points must be put into consideration before undertaking incubation of eggs.

1. Fertile eggs obtained must be as fresh as possible.
2. The incubator must be kept in a well ventilated room.
3. A performance evaluation should be conducted between kerosene and electrically powered incubator.
4. A standby source of power should be available since it is vulnerable to power failure at any stage.

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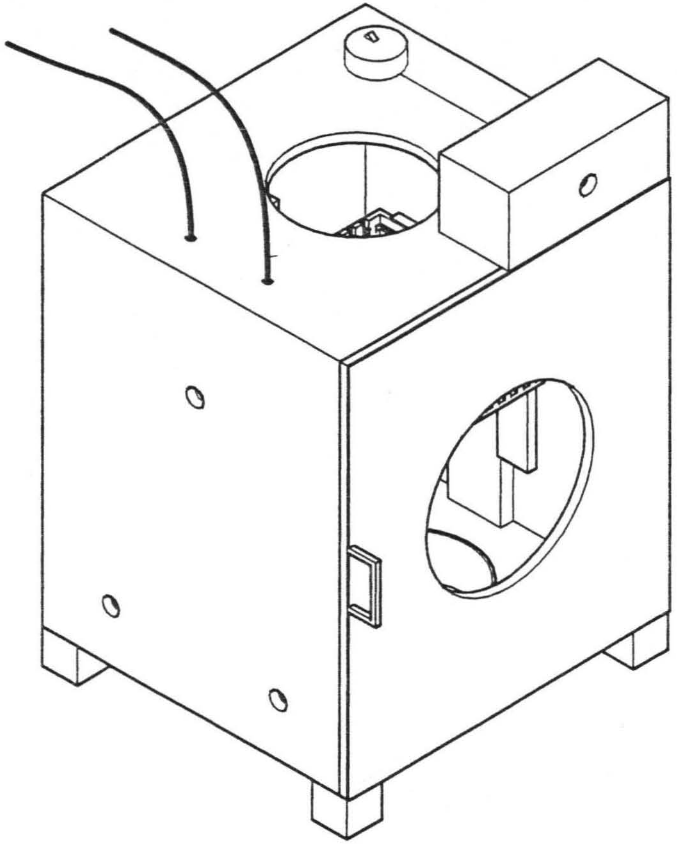

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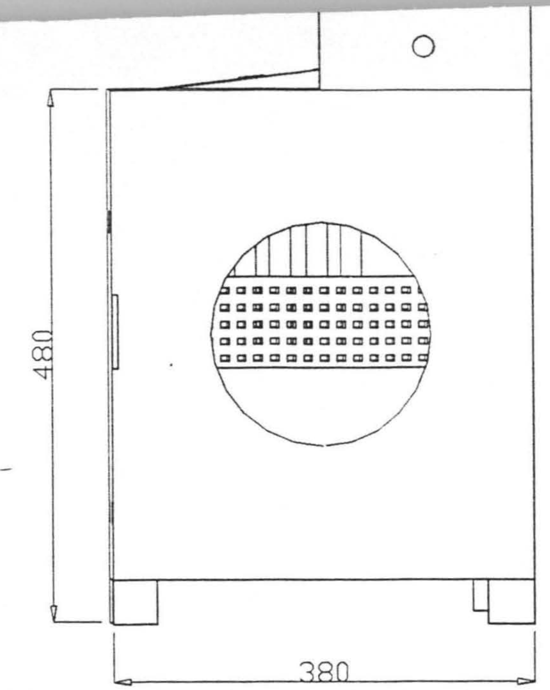
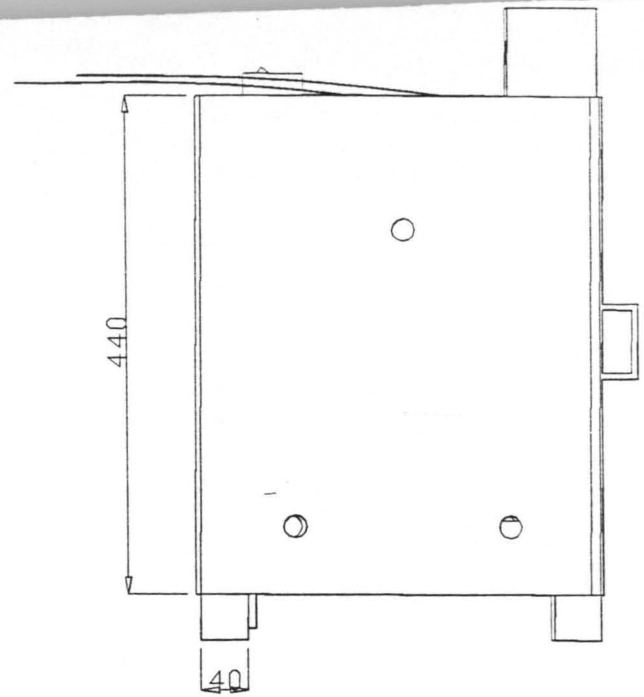
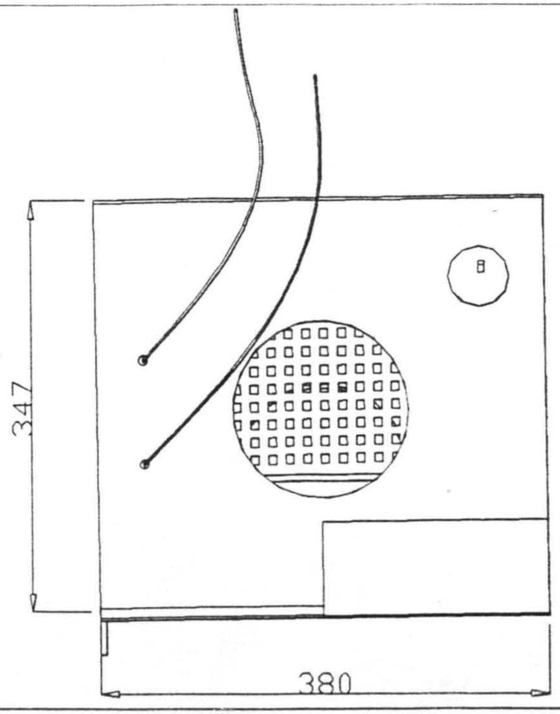
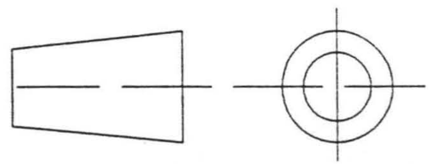
APPROVED BY	ENGR. IDAH				LEVEL 500









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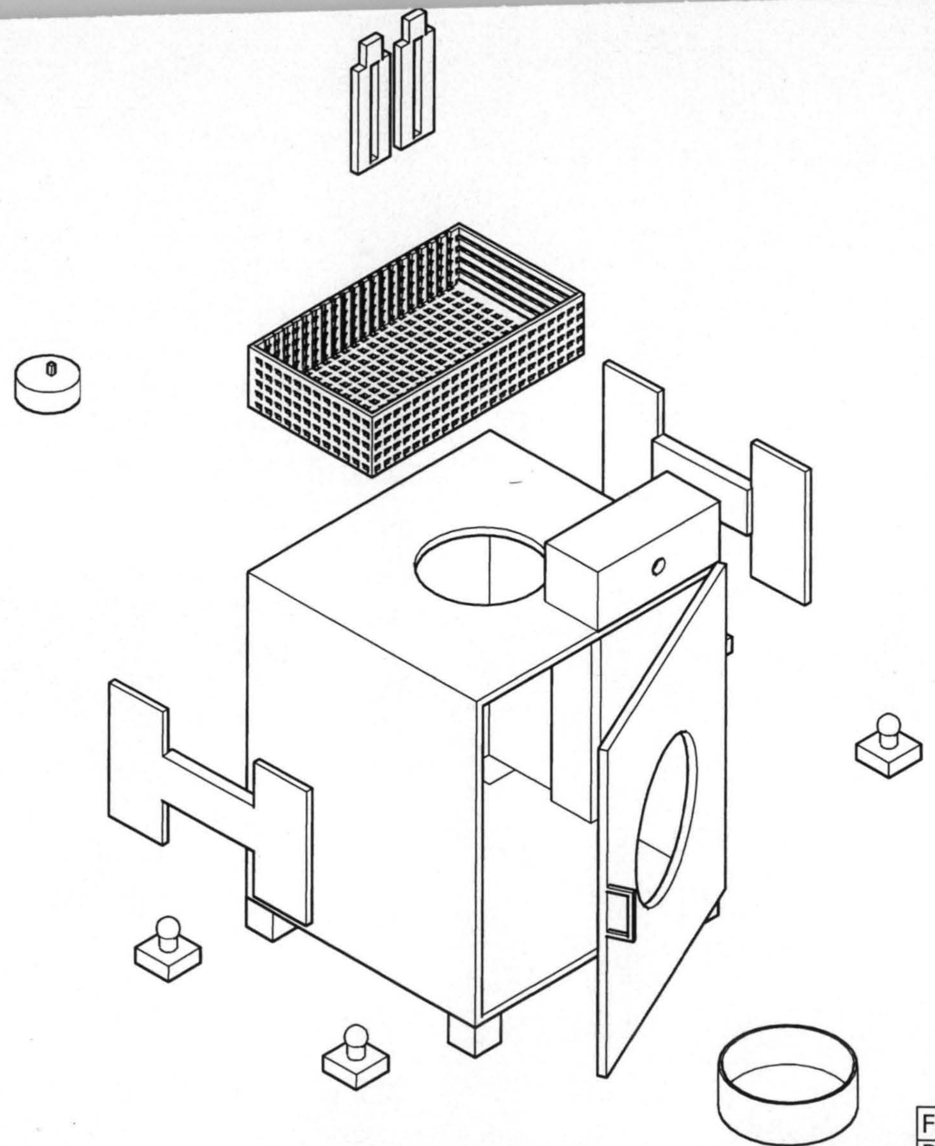

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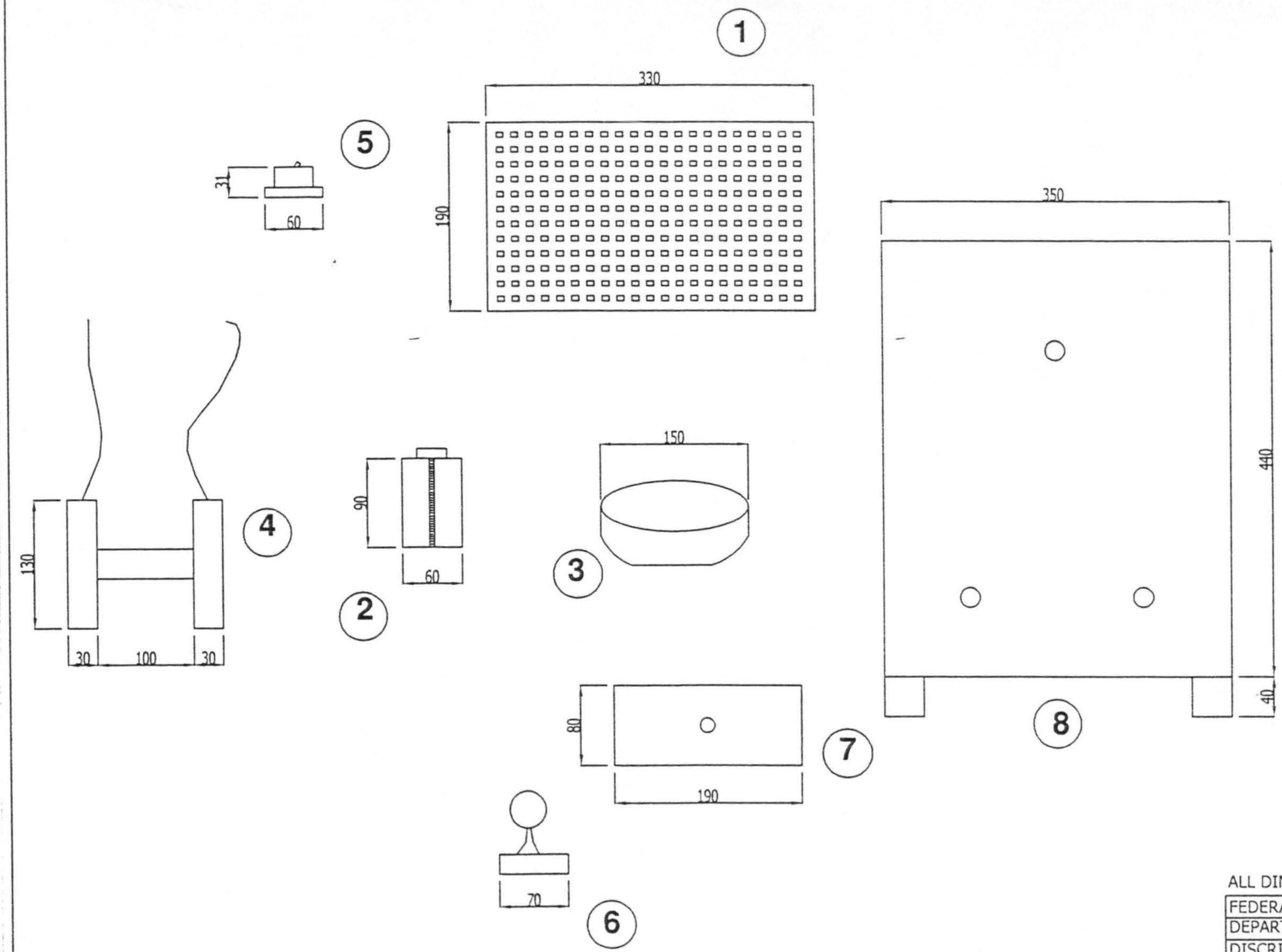

S/N	DESCRIPTION	MATERIAL
1	EGG TRAY	WOOD
2	THERMOMETER	PLASTIC
3	WATER BASIN	STAINLESS STEEL
4	TURNER	WOOD
5	SWITCH	PLASTIC
6	40 WATTS BULB	GLASS
7	CANDLER	WOOD
8	FRAME	WOOD

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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.					
DEPARTMENT OF AGRIC. AND BIORESOURCES ENGINEERING					
DISCRIPTION: PART DRAWING					
ELECTRICALLY OPERATED INCUBATOR					SCALE
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APPROVED BY	ENGR. IDAH				LEVEL: 500