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DEVELOPMENT OF A TWO-WAY MOTIONS EGG INCUBATOR AND HATCHERY

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Abstract: Incubation is a natural process undertaken by certain oviparous (egg-laying) animals in which the eggs laid by the mother is provided the proper conditions needed for the eggs to hatch into the young ones. For higher hatchability, the important incubating parameters (of suitable temperature, proper humid condition and adequate air circulations as well as sufficient turning of the eggs) within the incubating chamber must be established and met. This paper reports on the design and development of egg incubator and hatchery. The new technology in this incubator and hatchery is the incorporation of a mechanism that allows for both lateral and tilting movements (2-way motions) of the eggs. The 2-way motions which occur at every 3 hours interval is achieved with the aid of a power antenna, timer and conveyor which are powered by a 12V dry cell battery. In the developed incubator/hatchery the incubating chamber is made of plywood with the heat of combustion from kerosene as the heat source. The heat source is set to generate a regulated working temperature of 38°C in the incubating chamber. With the introduction of 2-motion mechanisms, the initial task is to ensure that the incubating parameters for better hatchability are achieved. These parameters were investigated and the results obtained compared favourably with the available standards for egg incubators and hatcheries (Appendix I). The incubator performance test shows that the turning mechanism incorporated resulted in 97% in egg hatchability.

Keywords: Fertility; hatchability; hatchery; incubator; motion mechanism; temperature

INTRODUCTION.

Incubation is a natural process undergone by certain oviparous (egg-laying) animals, usually birds and reptiles, in which the eggs lain are provided the proper conditions needed for the eggs to hatch into young ones. It involves getting the embryo in the eggs to develop [1]. Egg incubation is a technology that provides the opportunity for farmers to produce chicks from eggs without the consent of the mother hen; it's one of the ways of transforming eggs to chicks [2]. Eggs have been incubated by artificial means for thousands of years. The most important difference between natural and artificial

incubation is the fact that for the natural incubation, the mother hen provides warmth by contact while the artificial incubation surrounds the egg with warm air [3]. It was also revealed that heat, air and moisture on hatchability exhibit significant effects on egg incubation and hatchability [4].

Modern commercial incubators are heated by electricity, have automatic egg-turning devices and are equipped with automatic controls to maintain the required level of temperature, humidity and air exchange. Either still-air or forced-draft incubators are used in hatcheries. Nevertheless, new egg incubators are forced-draft, with the aid of a fan to circulate the air. They are able to maintain temperature, humidity and air exchange than still-air incubators [5]. For sustainability in hatchery production, the need for environmental friendly energy source is paramount. Such energy source should be attractive and readily available. Among the different types of energy sources available for incubator/hatchery are: solar, electricity, kerosene, and bio-fuel. For this work, kerosene is used as energy source with the benefits of cost efficiency, availability and adaptability to both rural and urban hatchery production.

Many researchers have worked on different types of incubators and hatcheries, some of such were manually operated egg incubators using both kerosene and electricity as their heat source [6]. Another contribution was made by Shri Milan Jyoti [7], who designed and constructed an electrically operated incubator for household use. He incorporated three 100watts electric bulbs as heat source and recorded a hatchability rate of 75.2 and percentage fertility of 64.8% when he tested the incubator with 20 eggs. Sansomboonsuk et al, [8] designed a manually operated kerosene incubator for egg hatchery with temperature range of between 37^{0}C and 39^{0}C having efficiency of 80%. Design and construction of an electric automatic egg incubator, using four 60 watt halogen lamps as heat source and turning the eggs by inclining the egg tray was carried out by Deeming [9]. The incubator was operated at a temperature of 37^{0}C and relative humidity of 60%. The incubator achieve 81.6% hatch rate. Lourens [10] characterized a photovoltaic powered poultry egg incubator using solar as energy source, with temperature and relative humidity between 36^{0}C - 39^{0}C and 67 – 77% respectively. The eggs were turned manually through an operated lever system at an angle of 45^0. Hamidu et al, [11] constructed a low-cost semi-automatic incubator using 100W bulbs as heat source and the eggs being turned at an interval of 6 hours, recording a hatchability of 91% after maintaining the temperature and humidity between 36^{0}C - 39^{0}C and 55-70% respectively.

The new technology in this egg incubator and hatchery is the incorporation of a mechanism that allows for both lateral and tilting movements (2-way motions) of the eggs. The eggs movement occurs every 3 hours with the aid of a power antenna, timer and conveyor all powered by 12V dry cell batteries. The fabricated egg incubating chamber and hatchery is made of plywood with the heat of combustion from kerosene as the heat source and the working temperature of 38^{0}C which is controlled automatically in the incubating chamber.

It can be observed from the above literatures surveyed that majority of the available incubators and incubator with hatcheries have only a single movement (motion) of eggs (i.e. tilting motion). With the new (2-ways motions) turning mechanism incorporated in this design, it is expected that 97% improvement on egg hatchability would be achieved.

DESIGN AND DEVELOPMENT.

Materials.

The materials used for this work are plywood, wooden planks, kerosene lamp, copper pipe, DC fan, power antenna and electronic temperature controller.

Developed parts

The developed parts of the incubator include the followings:

(a) Incubating Chamber

The incubating chamber comprises of the casing, egg platform, egg conveyor, hatcher, water bowl, 12V dc fan, power antenna, K- type thermocouple and a copper pipe.

(b) Heating System

(c) Control Unit

(d) Power Source

Developmental Analysis.

Incubating Chamber.

The incubating chamber (Fig. 1) is a box of length 645mm, width 550mm and height 700mm. It is made of 20mm thick plywood, assembled with nails and wood screw for easy dismantling. It houses the egg platform, egg conveyor, Hatcher, water bowl, copper pipe, k-type thermocouple, power antenna, 12V dc fan and hygrometer.

Eggs platform.

The egg platform as shown in Fig. 2 is designed based on the size of an egg. It can hold between 35 and 42 chicken eggs. It is made of 15mm by 35mm wooden strips with external dimensions of 380mm x 585mm x 170 mm. The strips are joined together with screw and nails and the top lined with 3.18mm plywood strips equidistant at 10mm for heat circulation to the hatcher and also to control the moisture from the water bowl. Support is provided on the side of the platform to allow for proper mounting of the power antenna.

Eggs conveyor.

Figure 3 is the egg conveyor which is a wooden strip of dimension 15mm by 35mm joined together by nails and screw to a base of dimension 360mm x 430mm. Six rods of 6mm diameter are placed at equal distance within the conveyor tray. Attached to the wooden construction is a metal linkage which connects the tip of the antenna to the conveyor in such way that its outward movement results in lateral movement of the conveyor, and also tilting the eggs. Fig. 4 shows the egg platform and conveyor assembly with power antenna to provide for the 2-way motions of the egg inside the incubator.

The hatcher.

The hatcher (Fig. 5) is a 15mm by 75mm packing case wood with external dimensions of 410mm x 585mm x 75mm. The bottom is covered with a spike wire to allow for the movement of humid air across the chamber.

Water bowl.

The water bowl is a shallow bowl to be placed in the lower part of the hatcher compartment. The fan blows warm air over the bowl thereby evaporating the water for maintaining the required humidity and also cooling the air within the chamber.

Heating system.

The heating system comprises of a kerosene stove with a long chimney, the heat exchanger (Fig. 6a) and a copper pipe (Fig. 6b) through which hot air is being transferred into the incubating chamber.

Control unit.

The control unit ensures proper regulation of the incubating parameters. Elements of the control unit includes; k-type thermocouple, electronic temperature controller (embedded thermostat), hygrometer, heat inlet controller, timer, and a 12V battery.

a. Thermocouple.

Figure 7a shows a K-type thermocouple employed as the temperature sensor. It is

calibrated to actuate the heat inlet control valve once a temperature of 38^0C is attained inside the chamber.

b. Temperature controller.
The temperature controller is a device with embedded thermostat that regulates the incubating chamber at a preset temperature of 38^0C (Fig. 7b).

a. Hygrometer.
The hygrometer is placed inside the incubating chamber is to regulate and maintain relative humidity of about 57-70% in the chamber.

b. Timer.
The timer is an embedded circuit that controls the lateral movement of the power antenna attached to the egg conveyor providing a delay of 3 hours interval.

c. Power Source.
Battery serves as the source of power for the electronic components of the unit and the temperature controller. The battery employed is a 12V, 7.2Ah/20HR rechargeable battery. Although the intended fabrication of the project was to use DC as the only power source, hence the need for electricity, However, a DC temperature controller would be designed as embedded unit for further improvement.

RESULT.
The design and development of a 2-way motions egg incubator and hatchery using locally available materials was carried out (Fig. 8). The egg incubator and hatchery were initially test run without eggs to verify that the proper incubating parameters of temperature, humidity, turning (egg motions) and ventilation were achieved. The incubator, for its performance evaluation (Table 1) was loaded with 40 chicken eggs for a period of twenty one days. To prevent sticking of the developing embryo to the egg shell before being moved to the Hatcher, the eggs were turned automatically at an interval of 3 hours with the aid of a power antenna and a timer for 18 days incubation period. Candling was conducted before loading the eggs into the incubating chamber to ascertain the condition of the eggs. This process was repeated on the 7^{th} and 14^{th} day of the incubation period.
The incubator temperature was monitored with the heat inlet and temperature controller, while the relative humidity was measured with the hygrometer.

The result shows that optimum incubation conditions was achieved and maintained during the incubation period.

Percentage fertility (% fertility) is the ratio of the number of fertilized eggs to the total number of eggs multiply by 100 (i.e. the percentage of fertile eggs to the total number of eggs). This is given by Eq. 1

$$\begin{aligned} &Percentage\ Fertility \\ &= \frac{No.\ of\ fertilized\ eggs}{Total\ number\ of\ eggs} \qquad (1) \\ &= \frac{39}{40} \times 100 \\ &= 97.5\% \end{aligned}$$

Percentage hatchability (% hatchability) is the ratio of the number of hatched eggs to the number of fertilized eggs (i.e. the percentage of fertile eggs that actually hatched into young chickens (chicks) at the end of the incubation period. This is given by Eq. 2

$$\begin{aligned} &Percentage\ Hatchability \\ &= \frac{No.\ of\ hatched\ eggs}{No.\ of\ fertilized\ eggs} \qquad (2) \\ &= \frac{38}{39} \times 100 \\ &= 97.4\% \end{aligned}$$

4.0 Conclusion.
The kerosene incubator and hatchery was carefully designed and developed to incubate chicken eggs of between 35 to 42

eggs. From the analysis and performance test carried out on the incubator, the following conclusions were drawn:

1. The percentage fertility (i.e. fertility efficiency) of the incubator was calculated to be 97.5%
2. The two-motion mechanism results in improved hatching efficiency (i.e. hatchability) hatchability of 97.4% of the incubator
3. Effective turning of the eggs at an interval of three (3) hours thereby reducing sticking of egg yolk contributed to high hatchability of the incubator
3. The incubator can be used in rural area where electricity supplies is not available or limited.

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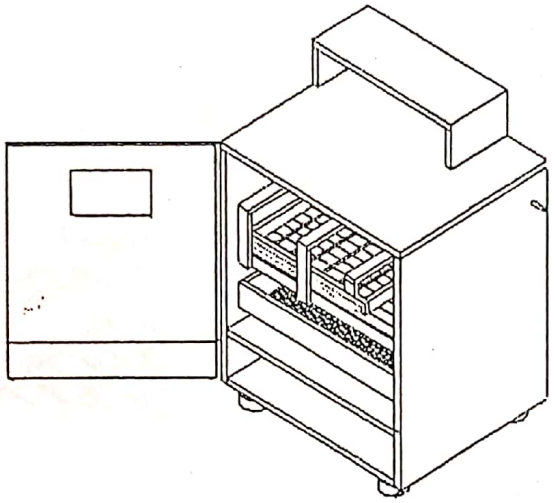

Fig. 1 Incubating chamber with egg platform and conveyor in positioned

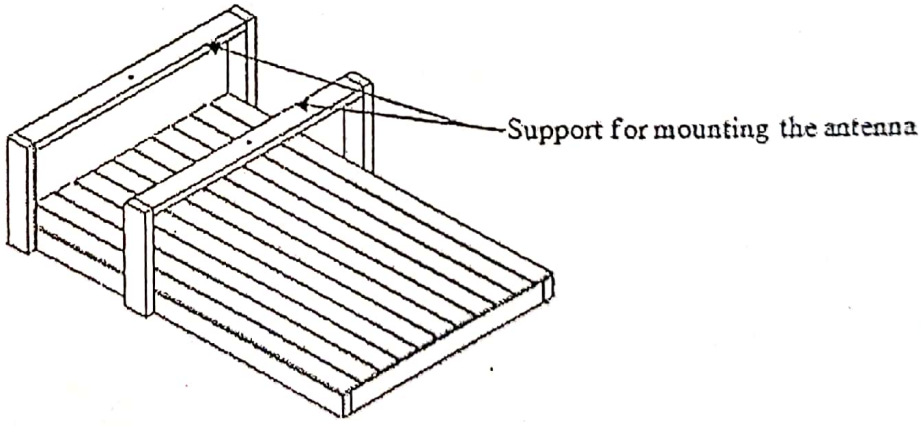

Fig. 2 Egg platform

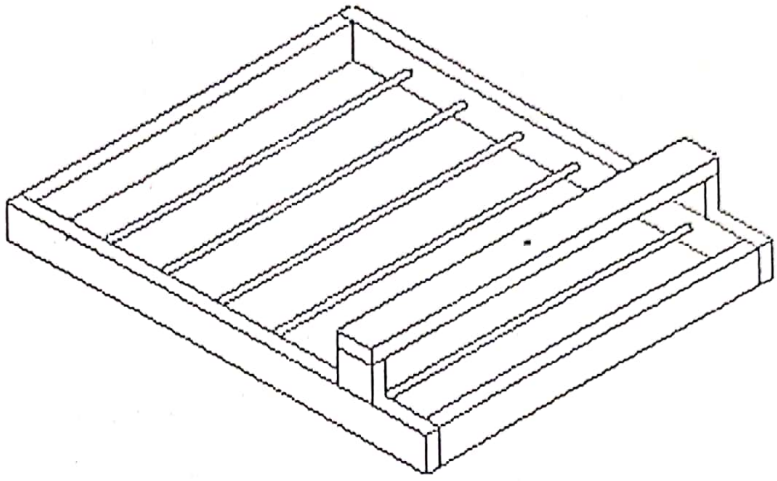

Fig. 3 Eggs conveyor

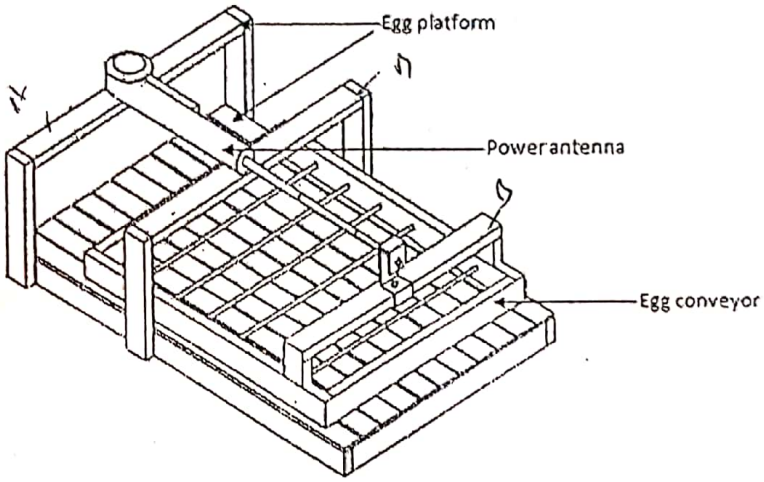

Fig. 4 Assembled eggs platform and conveyor with the power antenna (2-way motions mechanism)

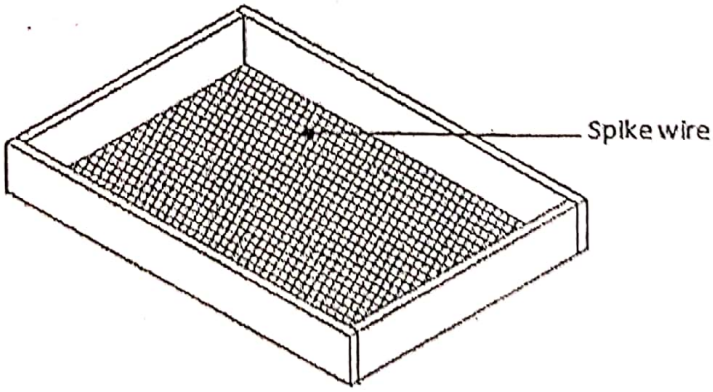

Fig. 5 Hatcher

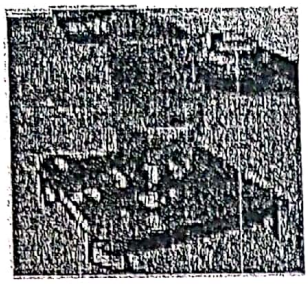

Fig.6a: Kerosene stove

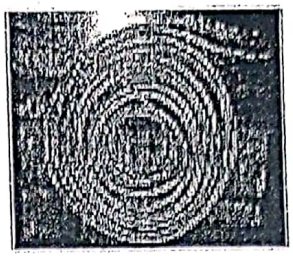

Fig. 6b: Copper pipe

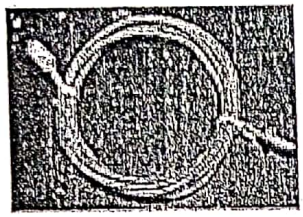

Fig. 7a

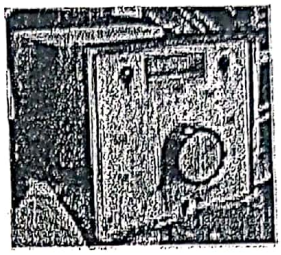

Fig. 7b

Fig. 7a: K-type thermocouple
Fig. 7b: AC Temperature controller

Table 1. Performance evaluation of the incubator

S/No.	Parameter	Number of Eggs
1	Number of fertilized Eggs	39
2	Number of hatched Eggs	38
3	Total number of Eggs	40
4	% Fertility	97.5%
5	% Hatchability	97.4%

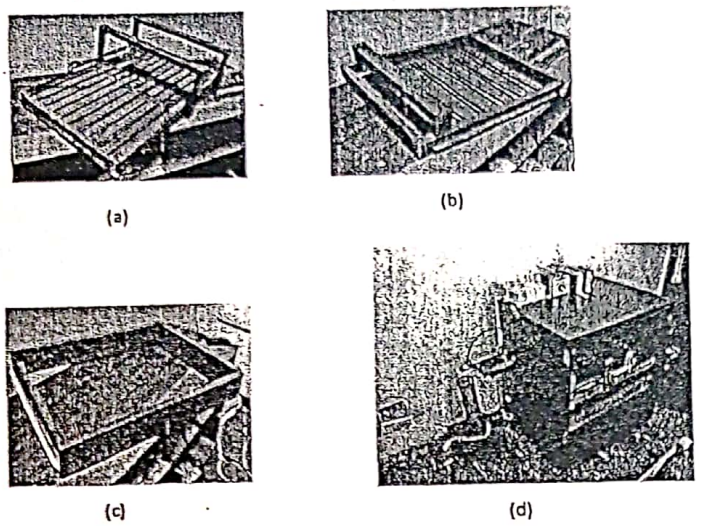

Fig. 8 Developed Incubator showing (a) Egg platform, (b) Egg conveyor, (c) Hatcher and (e) Assembled Incubator and Hatcher.

Appendix I. Manual on Incubation and Hatchery.

Fertilization rate (%)	**Hatching rate (%)**	**Latency (months)**[2/]
90-95	75-85	6
90-95	70-80	12

Source:[12].