

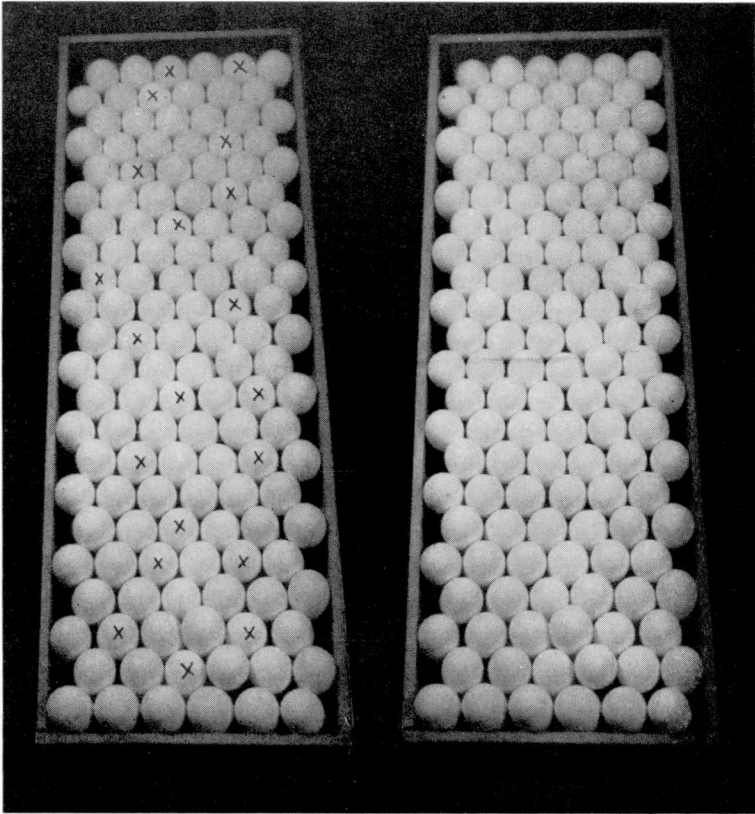
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The Detection Of Infertile Eggs And Its Application To Hatchery Management

By
D. F. KING



Possibly 112 Chicks Possibly 132 Chicks
REPLACE INFERTILE EGGS WITH FERTILE ONES.

**AGRICULTURAL EXPERIMENT STATION
OF THE
ALABAMA POLYTECHNIC INSTITUTE**

M. J. FUNCHESS, DIRECTOR
AUBURN

Contents

	Page
INTRODUCTION	3
Losses Due to Infertile Eggs	3
Development of Methods for Detecting Infertile Eggs	3
PRINCIPLES UNDERLYING FERTILITY DETERMINATION	5
Egg and Early Embryo Development	5
Preheating Eggs	5
Cooling and Handling Preheated Eggs	7
ADJUSTMENTS IN HATCHERY MANAGEMENT FOR	
FERTILITY DETERMINATIONS	8
Egg Supply	8
Turning the Eggs	8
DETECTING INFERTILE AND FERTILE EGGS	9
Candling Machine and Booth	9
Candling the Eggs	10
SALE OF INCUBATED EGGS AS FOOD	12
Quality of Infertile Preheated Eggs	12
Laws Regarding the Sale of Incubated Eggs	12
FUTURE POSSIBILITIES	12
PRECAUTIONS	14
REFERENCES	14

The Detection Of Infertile Eggs And Its Application To Hatchery Management

By

D. F. KING, Associate Poultry Husbandman

INTRODUCTION

DURING the past few years there has been a great deal of interest in the practice of candling eggs shortly after they have been put in an incubator in order to replace the infertile eggs with fertile ones. This practice enables hatcheryman to avoid serious losses from infertile eggs, and to increase the hatchability of the eggs set thus enlarging the capacity of the hatchery. If the practice is to be followed at the present time information must be obtained largely from magazine articles, advertising, and other incomplete and often unreliable sources as a guide to the correct procedure. The purpose of this circular is to present a complete discussion of the development and use of methods for detecting infertile eggs after short periods of preheating.

Losses Due to Infertile Eggs.—In hatching 1,100,000,000 chicks annually in the United States it is estimated by the U. S. Department of Agriculture that more than 1,800,000,000 eggs are incubated. Records obtained on hatcheries of more than 10,000 egg capacity show that for a season an average of 35 per cent of all eggs set fail to hatch. No definite information is available as to the percentage of infertile eggs set; however, it is reasonable to assume that at least 15 per cent of all eggs set are infertile. During a normal hatching season in the United States this would amount to a loss of approximately 270,000,000 eggs. Thus it may be seen that in the incubation industry infertile eggs cause a tremendous waste.

Development of Methods for Detecting Infertile Eggs.—Since the domestication of chickens workers have been endeavoring to foretell which eggs would not hatch. Various means have been suggested from time to time but until recently none have gained sufficient importance to be used commercially. Pioneer work which led to the development of satisfactory candling equipment at the Alabama Agricultural Experiment Station is of interest. The first candling machine was a simple home-made lamp, consisting of a stove pipe and a 300 watt mazda light bulb. This was inefficient and the glare produced was very hard on the operators eyes; from it the machine shown in Plate I A was developed which was sufficiently accurate to have a commercial value and was reported by King (1936). With this machine it was possible to remove both

brown and white shelled infertile eggs with an accuracy of 95 per cent after the eggs had been heated at 100 degrees F. for 15 hours. This was the first published report describing a filtered lamp for use in detecting infertile eggs. After patent applications had been made this machine, with improvements, was manufactured and the one shown in Plate I B offered for sale to the public in December 1937. It was exhibited at several colleges and poultry shows during January 1938. On January 17, 1938, Olsen and Knox issued a statement to the press describing a method of determining fertile and infertile eggs after the eggs had been incubated from 14 to 20 hours.

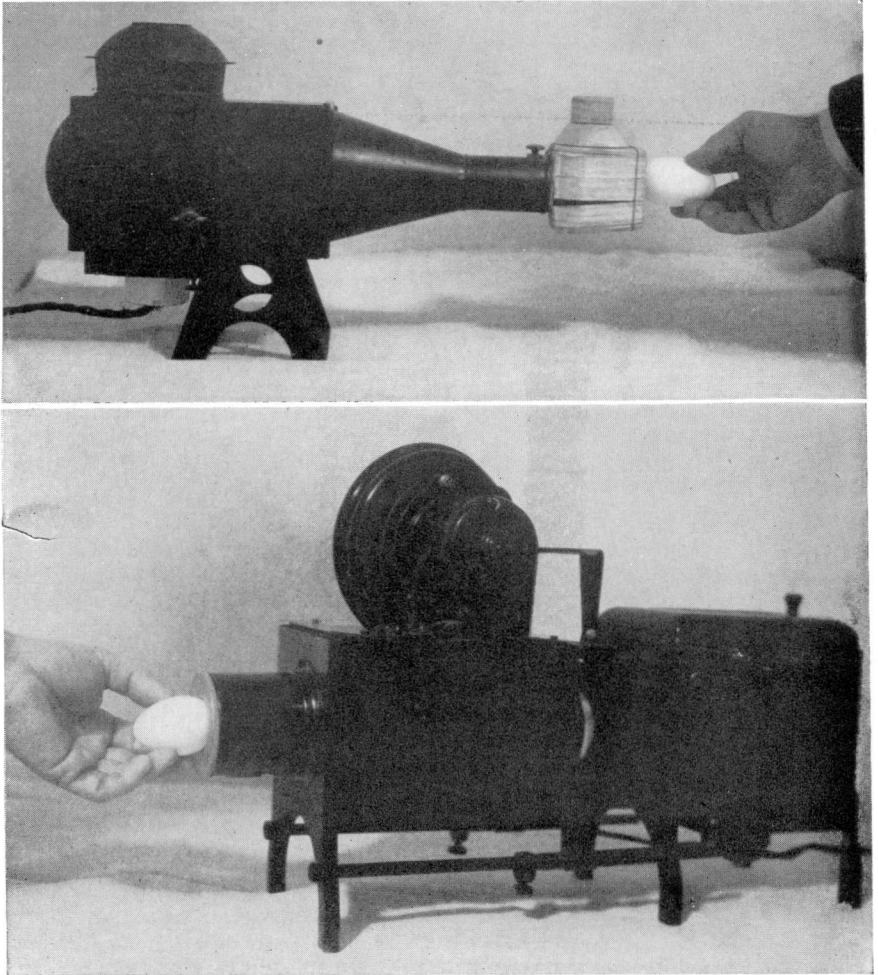


PLATE I-A (top).—The first filtered-light candling machine for detecting infertile eggs (1937). B (bottom).—First candling machine offered for sale to the public for detecting infertile eggs (December 1937).

The apparatus described utilized the same type of filters and lighting described by King in 1936. During the last few years fertility determining machines have been used by many hatcheries and like other new developments are gradually finding their place in the hatchery industry.

PRINCIPLES UNDERLYING FERTILITY DETERMINATION

Egg and Early Embryo Development.—In order to understand the principles involved in detecting infertile eggs it is necessary to know the process by which a hen forms an egg and how the early embryo develops. In the formation of an egg, the yolk is released by the ovary and is quickly picked up by a tube known as the oviduct. In the upper end of this tube the female germ cell is fertilized by the male sperm. The yolk then passes on through the oviduct gathering white, shell membranes, and shell. According to Scott and Warren (1935) this requires a period of 24 or more hours.

Since the egg in the body of the hen during this formation period is at a temperature of 100°F. or more, incubation begins soon after fertilization. The fertilized cell divides into two cells, each of these then divide forming four, then eight, sixteen, thirty-two, etc. All of this development takes place in the form of a disc only one cell layer in thickness. The number of cells soon increases to such an extent that the embryo begins to bulge in the center and the edges begin to curl under. Continued development of the edges forms a second layer of cells and thus the embryo changes from disc to ball shape. Often this ball stage is reached by the time the egg is laid. It is difficult, however, to distinguish between fertile and infertile eggs at the time of laying and additional embryo development is therefore obtained by preheating the eggs. Eggs that fail to become fertilized cannot divide or develop even though they remain in the oviduct the same length of time as fertile ones. Plate II shows the difference in appearance between freshly laid fertile and infertile eggs.

Preheating Eggs.—Although the optimum temperature for the development of fertile eggs is approximately 100°F., they will develop to some extent at any temperature above 68°F. At low temperatures the rate of development is very slow, but at a temperature of 100 degrees the development is quite rapid. In other words the higher the temperature the more rapid the development. Hatcherymen might assume from this that eggs could be preheated at room temperature. It should be pointed out that the development of an egg at any temperature other than 99° to 100°F. is abnormal and tends to weaken the embryo. For this reason as soon as an egg is laid it should be cooled to below developing temperature for the storage period. Eggs gathered from the nests two or three times a day and stored at a temperature of 67°F. or lower require approximately 15 hours of preheating to obtain sufficient

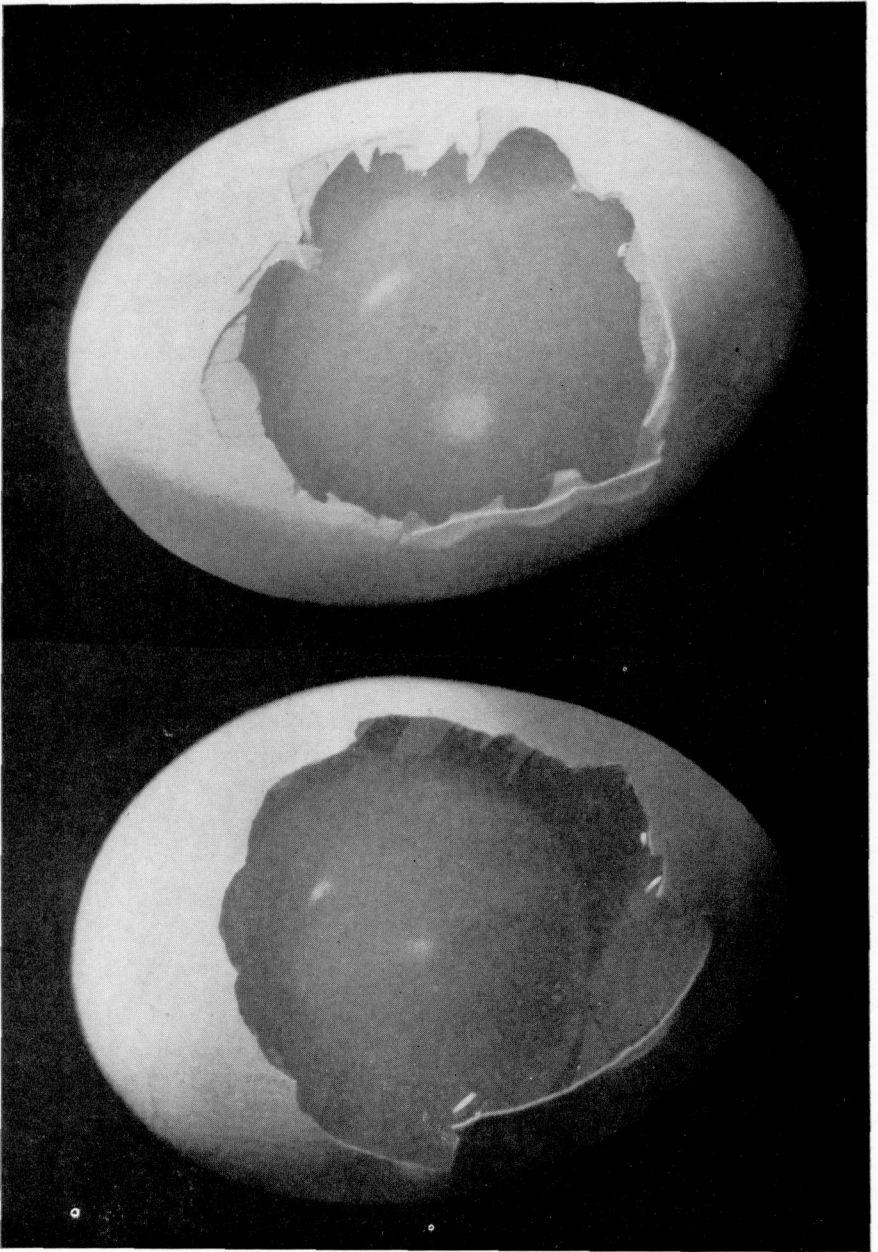


PLATE II.—Freshly laid fertile (A-top) and infertile (B-bottom) eggs.

development for the removal of infertile eggs with an accuracy of 95 per cent or better. If the eggs have not been cared for properly the embryo may be more fully developed previous to preheating and therefore a shorter preheating period can be used. From a hatcheryman's standpoint it is best to use eggs that have been stored below 68°F. This is of utmost importance in obtaining accuracy in removing the infertiles. If the eggs are not uniform as to development before they are preheated, the operator cannot be accurate in removing the infertile eggs.

In order to assure accuracy in removing infertile eggs they should be preheated in a horizontal position and care should be taken to see that the eggs are not rolled or disturbed after they have been preheated until after they have been candled. When treated in this manner the embryo always floats to a position in the top of the egg where it may be easily found, if present, when the egg is placed before the candle. On the other hand if the egg has been preheated while on end or disturbed to any extent immediately before being candled the operator may have to turn the egg and look for the embryo and if one is not readily found the operator is not certain whether the egg is infertile or whether the embryo has not yet been located. Preheating horizontally saves time in traying the eggs when they are being set, increases the accuracy of candling, and speeds up the detection of infertile eggs.

Cooling and Handling Preheated Eggs.—It is obvious that preheated eggs should not be allowed to remain out of the incubator any longer than is necessary in order to determine their fertility. If the eggs are not unduly exposed the hatchability will not be affected. Funk (1937) has shown that eggs held at 101°F. for 6 to 14 hours before cooling hatched just as well as those that had not been heated. If the eggs were heated for 18 hours or longer there was a marked falling off in the percentage of eggs which hatched. Hatcherymen should never preheat eggs for as long as 18 hours before candling them. If eggs received at the hatchery have been exposed to high temperatures for any length of time, the preheating period can be reduced to 13 or possibly 10 hours without affecting the accuracy with which infertile eggs may be detected. This should be done, however, only when absolutely necessary for as stated before eggs should show very little germ development when received by the hatchery and the preheating should take place under optimum conditions of temperature and moisture.

Olsen and Byerly (1938) have shown that embryos are least affected by handling during the first four and last six days of incubation. Their work indicates that no detrimental results to the embryos would occur due to candling the eggs after 15 hours of incubation.

ADJUSTMENTS IN HATCHERY MANAGEMENT FOR FERTILITY DETERMINATION

A great deal of confusion is sometimes caused by hatcherymen endeavoring to use a candling machine and not understanding just how to manage the hatchery under this new set of conditions. Although each hatchery has its own individual problems the following plan has been found to work satisfactorily and can usually be modified to suit the local conditions.

Egg Supply.—At the beginning of each hatching season the candling machine should be used to advantage in classifying the flocks supplying the hatchery with eggs as those having high, medium, and low percentages of fertile eggs. This of course can be determined within 15 hours after the eggs have been set and the hatcheryman can then notify the owner of good flocks to continue supplying eggs and the owners of poor flocks to check on the items listed on page 15 in an attempt to improve the fertility. After the first setting hatcherymen are not advised to candle and remove infertile eggs from flocks classed as high or those that are known to have less than 10 per cent of the eggs infertile. The small increase in hatchability obtained from candling such highly fertile eggs does not justify the labor involved. Hatcherymen should therefore set eggs from such good flocks in the usual manner. Eggs from medium or low fertility flocks should be preheated, candled and the infertiles removed. An estimate should be made as to the number of infertile eggs which will be removed and enough extra eggs set to refill the trays with fertile eggs. For example, if 360 eggs are set from a flock that previously has had approximately 20 per cent infertiles, 75 to 85 extra eggs should be set to take the place of the infertiles removed after 15 hours. Hatcherymen should determine in this way the number of extra eggs needed for their incubators. The eggs must be preheated while lying flat in the bottom of the tray. They must not be placed on end. By laying the eggs flat the usual number of eggs cannot be placed in a tray and since all of the regular hatching trays will be full, the hatcheryman will have to use a specially built tray to hold those left over and the extra eggs set for the first 15 hours. This tray can usually be placed on the floor of the incubator for this short period.

Turning the Eggs.—Care should be taken in turning the eggs during the 15-hour period so as not to spill the eggs that are lying flat in the trays. During the preheating period the trays should not be turned the regular distance, but should be turned enough to prevent the embryo from sticking. The incubator should be operated at the regular temperature during the preheating period.

DETECTING INFERTILE AND FERTILE EGGS

Candling Machine and Booth.—For best results the candling should be done in a dark booth or room. The less daylight entering the booth the more accurate the operator will be. A set-up such as is shown in Plate III is considered satisfactory.

The candling machine should be kept clean and free of dust. At least once each day the two condensing lenses should be removed and wiped clean with a soft cloth. Cleansing these lenses with a hard material or a cloth containing dirt particles will ruin them by scratching. The colored filter, the light bulb, and re-



PLATE III.—A satisfactory set-up showing booth, candling machine, trays, racks, etc., for use in detecting infertile eggs.

flector should be cleaned daily. The fan should be oiled after every ten hours of operation with a light-grade oil. Since the light bulb will burn only a limited number of hours a great deal may be added to its usefulness if the machine is turned off each time trays or eggs are being changed.

Candling the Eggs.—If both white and brown eggs are being incubated the white shelled eggs should be candled first. After the eggs have been in the incubator for 15 hours a tray of eggs should be taken to the candling booth **without allowing them to roll**. Then each egg is carefully picked up, care being taken not to turn it over, and placed in front of the candling machine. If the egg is brought into the beam of light from the top by passing it downward into the hole, no glare will be produced as is the case when the egg is brought up from the bottom. This glare should be prevented to promote speed and accuracy. When the egg is in position a distinct dark spot will be seen in the center of the egg if it is fertile and if infertile, no spot will be visible. The egg may be turned back and forth slightly to cause the embryo to move and thereby be more easily seen. The size of the spot seen in fertile eggs depends upon how much the embryo has developed. If the egg was handled properly before it was placed in the incubator it should be similar to that shown in Plate IV A. If it was held at too high a temperature before being preheated it will resemble the eggs shown in Plate IV B. If it was preheated for too short a time or at too low a temperature it will appear as a white spot with little or no dark areas showing (Plate IV C). In order to obtain accuracy in removing the infertile eggs, they must have uniform embryo development. That is, some eggs must not have been held at a relatively high temperature during the storage period and candled along with eggs that have been stored in a cool place. The candler must through experience determine how large and dark the spot must be in order for the egg to be fertile. There will be some slowly developing embryos that resemble infertiles and occasionally a rather small dark spot that might be considered fertile which is actually infertile.

The fertile eggs should be racked in the trays as they are candled and put back in the incubator as soon as possible. The infertile eggs should be cooled as quickly as possible and marketed promptly.

The eggs should be candled in this manner until all of the extra eggs set have been used. When there are no more extra eggs available for replacements there is nothing to be gained in candling those remaining. Since it is to the advantage of hatcherymen to leave the best eggs in the incubator those should be candled first which are believed to contain the most infertiles.

All eggs that are cracked or that contain double yolks, loose air cells, and large blood or meat spots also should be removed during the candling operation. The eggs of this group that are unfit for human food should be discarded.

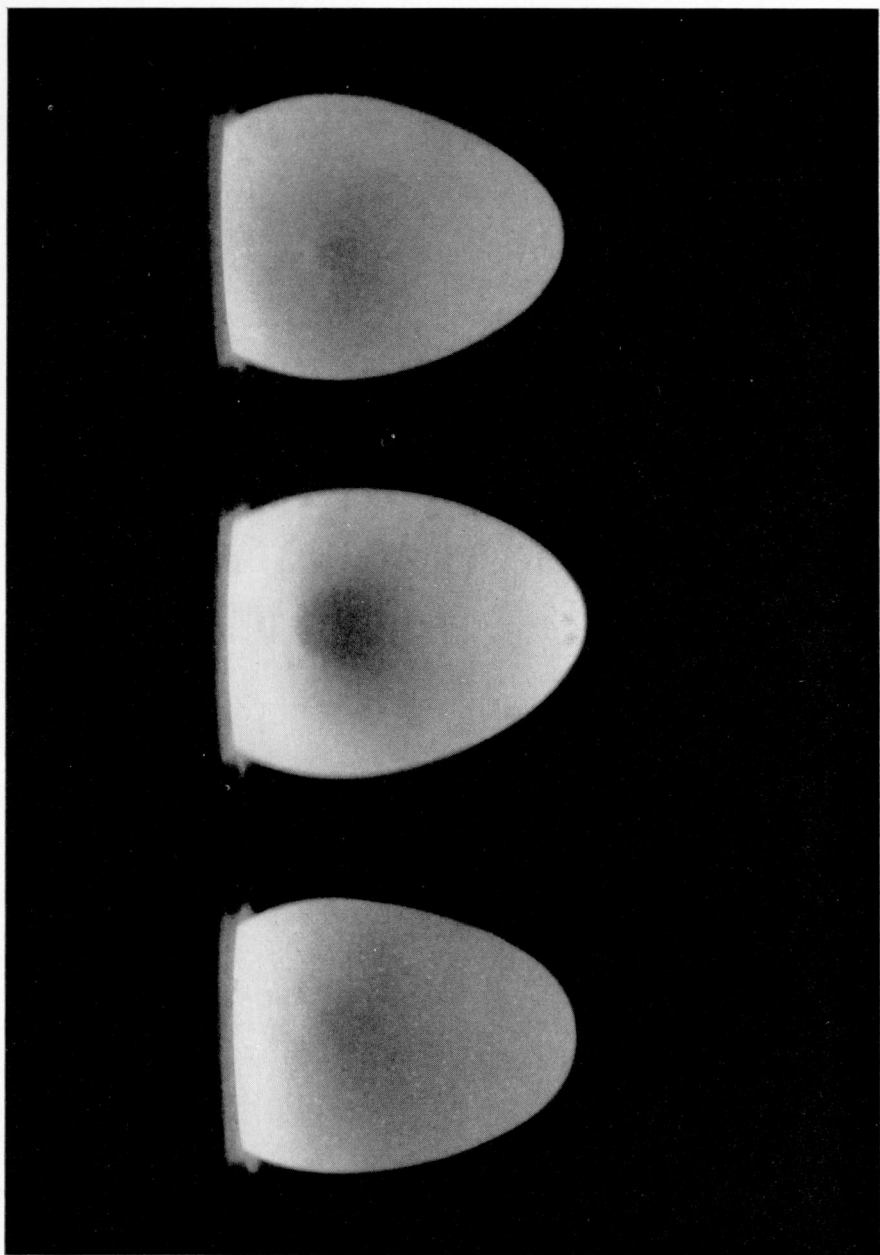


PLATE IV-A (top).—A fertile egg properly preheated showing average development of the embryos to enable one to detect fertile and infertile eggs with accuracy. B (middle).—A fertile egg improperly preheated showing too much development for satisfactory results. C (bottom).—A fertile egg insufficiently preheated. When the majority of fertile eggs resemble this, many fertile eggs will be classed as infertiles.

SALE OF INCUBATED EGGS FOR FOOD

Quality of Infertile Preheated Eggs.—Exposing even infertile eggs to a temperature of 100°F. for 15 hours lowers their market grade. The California Agricultural Experiment Station has shown that eggs which graded as U.S. Specials before preheating were no better than U.S. Standards after 15 hours of incubation. They found that 15 hours of preheating increased the size of the air cell 14 per cent, reduced the height of the albumen 21 per cent, and reduced the height of the yolk 22 per cent. Regardless of this loss in egg quality the preheated infertile eggs are still edible and are of higher quality than many of the farm eggs that reach the market in the summer.

Laws Regarding the Sale of Incubated Eggs.—The federal laws are such that interstate shipments of filthy, decomposed or putrid eggs are subject to seizure by federal authorities. Eggs, in common with other articles of food, are adulterated if they consist wholly or in part of a filthy, decomposed or putrid substance. Those which contain yolks stuck to the shell, moldy eggs, black spots, mixed or white rots, addled eggs, black rots, and eggs containing heavy blood rings have in their progressive decomposition developed to the stage where they are classed under the law as “filthy, decomposed or putrid.” Eggs taken from an incubator are subject to the same requirements of the act as apply to eggs in general. Infertile eggs that are relatively fresh when placed in the incubator for the 15-hour-preheating period, cooled soon after being candled and marketed promptly will not come under the classification of filthy, decomposed or putrid eggs and are therefore not subject to seizure by federal authorities. They may be sold on the market according to their grade and every effort should be made to preserve their quality and in this way obtain a better price for them.

Copies of state laws regarding the sale of eggs may be obtained from the Pure Food and Drug Administration of the various State Departments of Agriculture. In no case is the author aware of a state law forbidding the sale of infertile eggs which have only been preheated 15 hours. Laws regarding the sale of eggs candled out on the 18th day of incubation, which are often called incubator rejects, should not be confused with the laws pertaining to eggs that have been in the incubator only 15 hours.

FUTURE POSSIBILITIES

Removing infertile eggs before incubation or even preheating may be possible and some day may become a common practice in up-to-date hatcheries. Romanoff and Cottrell (1939) described a method of determining the fertility of fresh eggs by means of radio frequency conductivity. The differences in fertile and infertile eggs were detectable but the method was not applicable for practical use at that time. King (1938) reported on a new candling machine shown in Plate V. The machine consists of two lamps placed

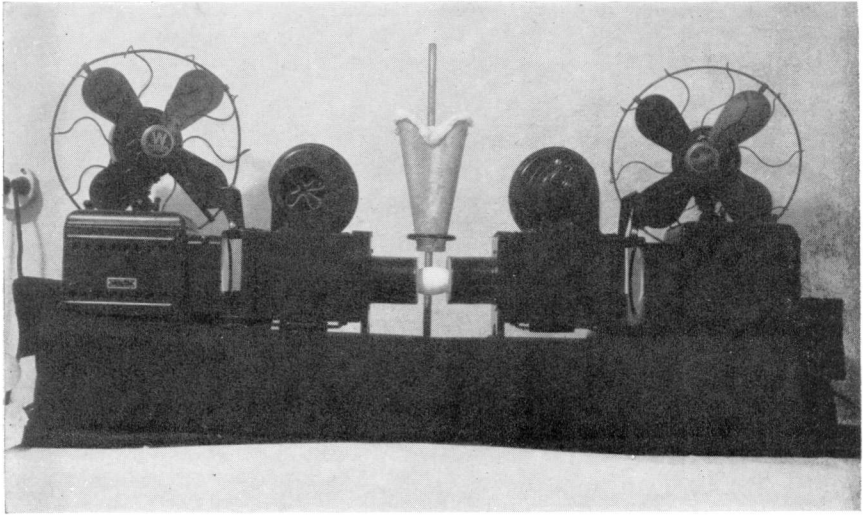


PLATE V.—Candling machine used in research work for detecting infertile eggs before incubation or without preheating.

in such a manner that the light reaches both sides of the embryo. Each lamp is equipped with a 1,000-watt bulb and an extremely dark filter. In 17 different tests approximately 70 per cent of the infertile eggs were removed when 1,462 fresh eggs, not preheated, were candled with this machine. In removing these infertile eggs 12 per cent of the fertile eggs were removed through error. The new machine illuminates the egg to such an extent that all eggs show a white spot and the candler must differentiate between fertile and infertile spots. Candling fresh eggs is much slower than candling preheated eggs.

Hatcherymen who look to the future will take advantage of what is known about detecting infertile eggs and will change the management of their hatcheries to make use of the candling machine. By doing this they will not only realize an immediate saving but will be in a position to take advantage of any future improvements in candling technic.

PRECAUTIONS

1. Eggs must be stored below 68°F. until they are ready to be placed in the incubator.
2. Eggs must be preheated for 15 hours at 100° F. while lying on their sides.
3. Eggs should not be disturbed after preheating until they have been candled.
4. Only one egg should be picked up and placed before the candling machine at a time.
5. Infertile eggs should be cooled and marketed promptly after they have been detected.
6. Cracked fertile eggs or other inedible eggs removed from the incubator while candling should be discarded.
7. One should not attempt to remove infertile eggs from flocks known to have less than 10 per cent infertility.

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Causes And Remedies Of Low Fertility *

1. **Extremely Cold Weather.**—Keep house comfortable when the temperature drops.
2. **Not Enough Males.**—Flock matings should consist of one male to every 15 to 18 females, depending upon the breed and age of males.
3. **Too Many Males.**—If flock is closely confined fewer males will fight less. Provide a good-sized range if possible or males may be alternated.
4. **Old Males.**—Cockerels produce a higher percentage of fertile eggs than cocks. It is rarely advisable to use males over 2 years old.
5. **Frozen Combs.**—Keep house dry and at a comfortable temperature.
6. **Sterile Males.**—Remove males unable to ejaculate viable sperm.
7. **Barren Females.**—Some females do not produce viable ova. Suspected females should be tested with another male and if found barren should be removed from the breeding pen.
8. **Favoritism.**—Males often mate with some hens of a flock but never mate with others. The females not laying fertile eggs should be moved to another breeding pen.
9. **Obstructions Around Vent.**—In certain breeds feathers often interfere with mating. They may be removed by plucking.
10. **Lice and Mites.**—Take proper steps to control them.**
11. **Nutritional Deficiency.**—Feed breeders a balanced diet including green feed or substitutes for it.
12. **Diseased or Sick Birds.**—Lowered fertility and hatchability will result from a number of poultry diseases some of which may be controlled.**

* Partially taken from Marsden and Martin (1939).

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