THE CORNELL BOOK ON

# Artificial Incubation and Brooding

Including Directions for Operating

CORNELL

Incubators & Brooders

and PEEP-O'-DAY BROODERS

By E. C. HUFFAKER, C. E.

FOR

CORNELL INCUBATOR MFG. CO.

PRICE, FIFTY CENTS



Published by

Cornell Incubator Mfg. Co.

ITHACA, N. Y., U. S. A.

Union & Advertiser Press, Rochester.

# THE CORNELL BOOK

ON

# Artificial Incubation and Brooding

INCLUDING DIRECTIONS FOR OPERATING

## CORNELL INCUBATORS AND BROODERS AND PEEP-O'-DAY BROODERS

*By* E. C. HUFFAKER, C. E.

FOR

Cornell Incubator Manufacturing Co.

PRICE, FIFTY CENTS



PUBLISHED BY

CORNELL INCUBATOR MANUFACTURING CO.

ITHACA, NEW YORK, U. S. A.

# Publisher's Notice

This book, like *Cornell* incubators and brooders, is a step ahead, neither copied nor quoted. It is as plain, practically speaking, as is consistent in treating the subject "Artificial Incubation" scientifically; following nature's laws in a manner that will be instructive to those who may be interested in poultry raising, either by natural or artificial methods.

The author has been ably assisted in the preparation by a series of patient, painstaking, and costly laboratory experiments, which have been carried on during the seasons of 1900, 1901, 1902, by skilled physicists connected with the *Cornell* crew.

There is not an incubator on the market, and we feel safe in saying there likely never will be, whose projectors will have been to so much expense in perfecting as have been those of the *Cornell.* If the Cornell machines, together with this book, prove the means of helping those who have previously found artificial incubation unsatisfactory; and successfully aid the majority over the hard places in poultry raising, we will be amply repaid.

CORNELL INCUBATOR MFG. CO.

# Contents

# Directions for Operating the Cornell Incubators

## I

BY H. H. BLACKMAN

1. Carefully unpack your incubator and see that it is properly set up, screwing the legs tight to the cabinet case. It is necessary that the top of the incubator be perfectly level. Test with a spirit level both "North and South" and "East and West."

2. Fill the lamp and light it, adjusting so that it gives a large, clear and even flame, without smoking. Usually better satisfaction is obtained, and it is also considered economical, to use the best grade of kerosene oil.

3. See that the regulator works freely. Place the thermometer on a slat of the egg tray, sliding the flange of the thermometer under the metal clasp, which holds it firm and in the proper position at all times.

* 4. Heat the machine to 100° adjusting the regulator by turning thumb-nut; turning *down* opens the valve and *lowers* the temperature; turning *up* closes the valve and *raises* the temperature.

5. Never have the temperature of an *empty* machine more than 101°. Carefully adjust the regulator before the eggs are put in so that the damper or disc-valve over the lamp chimney is open about one-fourth of an inch, when the thermometer on the tray is at 101°.

6. Run the machine two or three days before putting eggs in, so that you will thoroughly understand its operation and get it nicely adjusted.

7. If you thus far have everything as directed, you are ready to place eggs in the tray, with the bulb of the thermometer between and against two eggs. Allow some hours for the eggs to become heated and do not change the regulator until the disc-valve is well opened. See

* The adjusting device will be found beneath the table top. Remove the pocket cover to reach "thumb-nut."

that the temperature never gets above 102°, except at hatching time, when it will and may rise to 104°.

8. Use only eggs which you know to be fresh, well fertilized and from healthy stock. In order to get the best results the room in which you have the incubator should be dry and well ventilated; the temperature holding as near 60° as possible night and day.

9. Eggs should be tested on the evening of the sixth day, when all eggs that do not show a strong, healthy germ should be taken out. The second test should be on the evening of the sixteenth day, when all that look unfavorable should be taken out.

10. Begin turning the eggs on the fourth day, and turn at a regular stated time, morning and evening, until the eighteenth day. Discontinue turning on the eighteenth day. Each incubator is supplied with an extra tray for turning. Turning is done by first taking the tray of eggs out of machine and putting on top of the incubator, placing the extra tray over the one containing the eggs, and turning or inverting both together. The machine should be kept closed while turning or testing the eggs.

11. Cooling eggs should begin on the fourth day at noon, and they should be cooled each day at noon until the eighteenth day. Discontinue cooling on the eighteenth day. To cool the eggs, take the tray of eggs out of machine, placing it on top. Keep the door closed while eggs are out of machine. Be sure that the thermometer bulb is resting against two live, fertile eggs; cool down to 85°, or 90°. Care should be taken not to cool below 85°. The room should be so ventilated that there will be no draft on the machine. This would be very injurious, chilling the germs instead of cooling them.

12. Eggs should not be turned or cooled, neither should the incubator door be opened after they begin to pip or hatch.

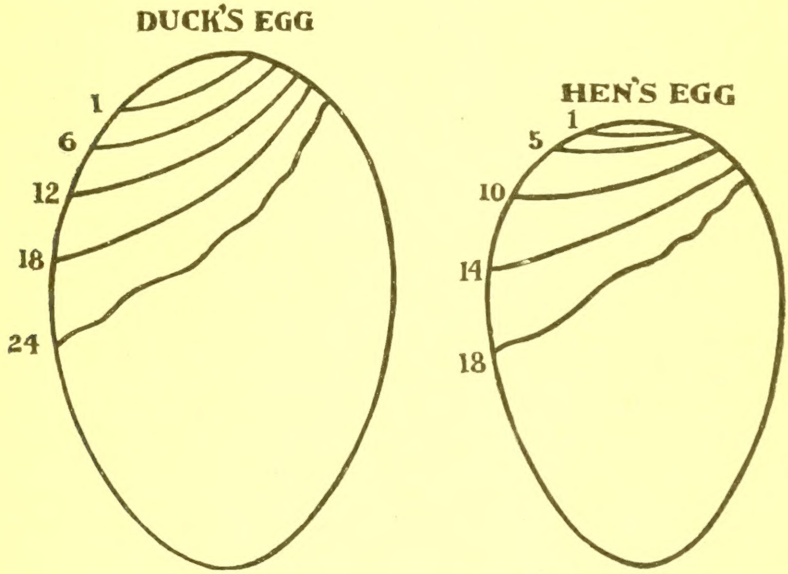
## Moisture and Ventilation

The ventilating slide of the incubator should be gradually opened until wide open when the chicks begin pipping. Instructions regarding the proper supply of moisture and ventilation, at all times, can only be given correctly with the Cornell machines, for the reason that other incubators have different systems of heating and ventilating.

Webster tells us that *diffusion* is an *extension*, *dispersion*, or *circulation* that *spreads widely*, or an *even* and *proper spreading*. Our system amounts simply to a perfect method of ventilation, and unless your incubator has this system it will never give the best results.

Our advice is: Start your machine with the outlet or ventilating slide partly open, say one-fourth. Then by using the egg tester every two or three evenings, and comparing the size of the air cell with the lines and dates on the drawings which show approximately the proper size of air cell in hen or duck eggs at various dates, during period of incubation, you can tell whether you need more or less ventilation.

Never put water in the moisture pans until you find the eggs need it. If you find the air cell is too small, in other words that the egg is not drying away fast enough as compared with the following drawings you should open the ventilator wider. On the other hand if you find




the eggs are drying away too fast, you should close the ventilator a little.

The sliding ventilator should never be completely closed, and for this reason, should you find the eggs drying away too fast or the air cell getting too large, you can retard the evaporation by putting water in the pans. Experiments have proven that lukewarm water should be put in the pans on the evening of the eighteenth day *anyway*, and the ventilating slide opened wide.

Experiments have also proven that different localities require a different management of ventilation, equivalent to the proper or natural supply of moisture; as do also the different seasons of the year. For these reasons we have been able to prove, through the results of many careful experiments which have been conducted by experts connected with the company, that an incubator with a fixed ventilation cannot give general satisfaction, and so have we also proven an incubator should not be built and sold without being fitted and supplied with moisture pans. While a person operating a Cornell incubator, favorably located, at certain seasons of the year, in New York State, may never have occasion to use supplied moisture, yet manufacturers cannot honestly claim this of localities like Colorado, and the same comparison will apply to the different seasons of the year as well as to the different localities.

## Placing the Machine

A room in which to run an incubator for satisfactory results, should be protected, to avoid the extreme changes of temperature. The temperature of the room should be kept at all times as nearly as possible to 60°. It is essential that the room should be properly ventilated, so that the air is kept pure and sweet; in fact, so that one cannot detect the odor from the lamp when entering the room from the fresh air out doors. Remember that in the egg there is life, which is very easily destroyed by poisonous gases and impure air.

The incubator should be so placed in the room that the sun cannot shine upon it. Great care should also be used in ventilating the room so as not to cause a draught. The incubator should be so placed that it is practically impossible to cause a draught across it from open doors or windows.

## Attention to the Lamp

The proper time to fill the lamp is after turning the eggs each evening, which *regular* attention is necessary. It is advisable from an economical point of view to use the best grade of kerosene oil obtainable. The wick should be trimmed every day, using a knife blade to remove the charred particles, instead of cutting the wick. A clear, true flame sufficient to keep the disc-valve slightly open should be maintained. Keep all parts of the lamp scrupulously clean, as a dirty lamp is not only more liable to smoke, but smells badly, tainting the air. One should always watch the lamp a few moments after lighting, as the flame is liable to run up when the burner gets hot. If not cared for properly in this respect, the lamp will smoke, which is to be avoided, as an accumulation of lampblack in any lamp or heater is likely to ignite and cause trouble.

## Placing the Eggs

The eggs should be placed on the tray in rows, with the small ends slightly depressed (the lowest), and all the eggs intended to be incubated in any particular hatch should be started at one time. Do not add eggs to those already in, after the machine is once started. The selection of eggs to be placed in the machine being the most important part, great care and judgment should be used. First, the eggs must be *fresh* ; the fresher the better. The fertility and vitality of the eggs will depend chiefly on the vigor of the parent stock. The principal conditions necessary to the fertilization of eggs are simply those which will insure good health to the parent stock.

## Temperature

Heat the egg chamber to 101° and no higher, before placing the eggs on the trays. When it is running at 101°, place the eggs in the machine and allow several hours to elapse without changing the regulator, as it will take time for the eggs to become heated. Watch the thermometer and see that it does not get above 102°. Between 101° and 102° is the proper temperature for hen and duck eggs for the first week of incubation. During the second and third weeks the temperature may run from 102° to 103°. It is essential that the thermometer bulb should rest *between* and *against* two live, fertile eggs. A low temperature is less dangerous than a high one, as it may not kill, but will if continued, lengthen the time of incubation and weak chickens will result.

Be sure that the thermometer, after the fifth day, is resting against two fertile eggs ; this may be ascertained by using the egg tester. As we have stated, the temperature of the fertile eggs is from two to three degrees higher than that of infertile, or dead ones. If the thermometer bulb is against infertile eggs and at 103°, the fertile eggs may, unknown to the operator, be at 105° or 106°. Apparent fluctuations of the temperature are frequently due to changing the thermometer from fertile to infertile eggs.

The thermometer should be placed three or four rows back, facing the front so it can be easily read through the glass door without opening the machine. Do not change the regulator, or bother about the temperature after the chicks begin to hatch. The temperature, as stated, may at hatching time rise to 104° or 105° without danger, as it is caused by the animal heat from the hatching chicks.

## The Regulator

The regulator is perfectly simple and easily understood. The thermostat is inside the egg chamber directly over the eggs. With the slightest change of temperature it automatically raises or lowers the rod connecting it with the carefully balanced regulator bar encased beneath the clear, smooth top of the machine, tilting the bar so as to open or close the disc valve over the chimney. This governs the amount of heat supplied to the machine.

If one is particular in the adjustment, the regulator will work easily and freely; responding quickly to a fraction of a degree's variation of the temperature in the egg chamber. The adjustment is made by turning the thumb-nut on the rod which connects the thermostat and regulator bar. This should be adjusted until the disc valve is opened about one-quarter of an inch, when the thermometer is at 101° or 102°. Turning the thumb-nut *down* opens the valve and lowers the temperature; turning it *up* closes the valve and *raises* the temperature.

## Turning Eggs

Many devices have appeared for turning eggs, but the best and only practical way is by the use of an extra tray which we furnish with each machine. Remove the tray containing eggs, from the machine, place the extra tray over it in an inverted position so that the eggs are encased between the two trays, then grasp both trays with the hands on opposite sides, raising the trays, turning them to or from you, so that the eggs are transferred from one tray to the other with the large ends slightly elevated. Remove the top tray, see that each egg is in its proper position, with small end depressed, then replace the tray in the machine. This should be done twice each day after the third day. We advise that you establish a system in this respect, and turn the eggs at a regular stated time morning and evening, beginning on the fourth day and discontinue on the eighteenth day.

## Cooling Eggs

Begin to cool the eggs on the fourth day at noon, and cool them each day at noon, until the nineteenth day. To cool the eggs, place the tray with eggs on top of machine, being sure that the thermometer bulb is resting between and against two live, fertile eggs. When cooled to 85° or 90° replace in machine, care being taken to never cool below 85°. During cooling, the door of the incubator should never be left open ; excepting perhaps during very warm weather, when it has been found more satisfactory to cool the eggs in the machine, by opening the door ; not leaving it open very long at first, gradually increasing the time as the hatch progresses, from five to twenty-five minutes, and as above stated, never allow the temperature to go below 85° when cooling.

## Testing the Eggs

This is a very important matter and one that should not be neglected. Success largely depends upon careful testing and the

operator's care and attention in following these instructions. Right here we wish to say : persons operating Cornell machines are expected to *follow these instructions* and not some one's suggested ideas, or unsubstantiated theories. If our instructions are carefully followed the results will be most gratifying.

We furnish an egg tester with each machine, which can be used on a small hand lamp in place of a chimney. The room should be darkened, and for this reason we recommend testing in the evening. The tray of eggs should be taken out and placed on top of machine and the door closed. Have the lamp with tester at hand, and hold each egg in front and tight to the opening of felt on tester, when you can readily see the developing germ on the fifth or sixth day. All eggs not showing a developing germ on the evening of the sixth day should be thrown out. The embryo should not show in sharp outline, or too near the shell and the blood vessels should not appear excessively bright red. On the seventh day the eye becomes visible as a large, dark, blurred spot. From the eighth to the twelfth day the movements of the embryo may be distinctly seen. Infertile eggs remain quite clear, resembling fresh eggs except for the increase in the size of the air cell. Where the germ or embryo starts and then dies within the first week of incubation, the blood may collect in a bright red circular vein, forming the so-called "blood ring." The fertile egg with a strong healthy germ becomes darker each day until on the eighteenth day it is very opaque, excepting the air cell.

## Preparing for the Hatch

Before the eggs begin to hatch, say on the evening of the eighteenth day, remove the galvanized strip found in each tray, leaving an opening through which the chicks will pass as they crowd forward to the light. This end of the tray should be toward the front of the machine. The bottom of the nursery underneath the egg tray should be covered with the nursery tray, or burlap frame, provided for the purpose. This tray also enables you to keep the machine perfectly clean and pure. After pipping of the shells begins, the door of the incubator should not be opened, except for refilling of the water pans, in case the air is not sufficiently moist, so the chicks come out moist, and without the membrane being dried fast. The door should not be opened until every chick is hatched, and is perfectly dry.

## Hatching Time

During the winter and early spring months you should not expect such large hatches as during the natural hatching season. The best results and largest percentages are hatched in the late spring, that being the natural season. Fowls lay the largest number of eggs at this season, and a larger percentage of the eggs are fertile, will hatch better, and the chicks will be more vigorous. Taking the whole season into consideration, seventy-five per cent of fertile eggs is a large average. A larger percentage than this is unusually good, but some of the germs are liable to be weak. Hen eggs usually begin hatching on the nineteenth day. Careless opening of the door might prove fatal by chilling the wet chicks just hatched or causing those which have pipped, to stick fast to the shell and making it impossible for them to get out. However, if you follow these instructions carefully, you will have no trouble in hatching every egg which nature intended should be hatched.

## Notes of Importance.

Never close the ventilating slide completely. Never let your lamp get empty, and always have enough flame turned on to keep a constant strain on the regulator—if the disc valve or damper does remain open five or twenty minutes at a time do not turn the lamp down.

When life begins to be generated in the eggs, it will produce animal heat which will increase with the age of the embryo. The heat will, in consequence gradually run up ; then you will have to adjust the regulator accordingly. Adjust as often as necessary to hold the temperature to 102°, rather a trifle below than above.

Use the egg tester, and dry the eggs down to one-fourth or one-fifth of the contents of the shell by the time hatching begins.

Turning and cooling should be discontinued on the eighteenth day for hen eggs and on the twenty-sixth day for duck eggs.

Great care should be taken not to let the temperature run down when hatching, as it will cause the chicks to stick to the shell and die there.

Cornell Incubators and Brooders are hot air machines. They will hatch every egg that nature intended should hatch, and the chicks will be healthier, stronger, and more vigorous than can be hatched with any other incubator on the market. Careful experimenting has proven this beyond a doubt.

If through negligence you should happen to get a poor hatch, do not blame the machine. Thousands of successful operators are speaking in the most favorable terms, with regard to the satisfactory work of the Cornell, as is proven by the testimonials in our catalogue, all from prominent and well-known poultrymen.

Anyone is liable to have a poor hatch. The result may be from one of many causes. For instance, the operator can't understand the instructions ; has not taken time to read them ; and being very busy probably would not have followed them if he had taken time to carefully read them. This is a very common cause, and then when a poor hatch is the result, the machine and the manufacturer are blamed for it all, when there could not be a greater injustice.

Do not be over-anxious; use care and judgment in selecting your eggs. Beware of old eggs, chilled eggs, (eggs do not have to freeze to chill), and eggs from ill-fed or ill-bred breeding stock.

# II

## The Brooder

The chicks should remain in the incubator twenty-four hours after hatching. During this time they should be given no food. In the meantime the brooder should be gotten ready and warmed up until there is a regular temperature of 90° at about two inches above the floor, under the hover. The chicks should be conveyed carefully and without chilling from the incubator to the brooder. With a little care and training during the first day or two, the chicks will quickly adapt themselves to the comfortable and attractive conditions of the hover of the brooder, which is heated automatically, and is practically as near Nature or mother hen as may be.

By putting the chicks into the brooder the temperature will, if there be a very large number of chicks, rise to 95°, possibly higher, at first. The temperature should be gradually regulated down until it averages about 75° in the third and fourth week after hatching. Always take the temperature from about two inches above the floor under the hover.

## Care and Feeding

Outdoor brooders are ordinarily not intended to be used out of doors in the winter. An outdoor brooder is usually intended to be used out of doors when the season and weather permit of the chicks exercising or running on the ground outside. The Northern States during January, February and March—the three most profitable months for hatching—are so liable to extremes of temperature, strong winds and severe storms, that the brooder should, if possible, be placed in a brooder house, poultry house, or a well-lighted, comfortably protected shed or shelter of some kind. Chick grit, coarse sand or fine gravel should be thrown over the floor of the brooder and exercising compartment; then a thin layer of chaff or finely cut clover, and a small quantity (not more than they would eat up in five minutes if placed where they could get it readily) of baby chick food, rolled oats or any other dry granulated grain scattered frequently—say four times a day in this litter on the brooder floor. Their food should include besides the grains and meal, scraps and bones, some green food. Lettuce is excellent, also cabbage leaves, if fresh and crisp. Green cut clover is also good ; finely cut, dry clover, steam-cooked, will answer when you cannot get anything better.

Avoid sloppy foods and guard against overheating or chilling the chicks, which conditions might produce diarrhoea. The brooder should be kept clean, and a water fountain constantly supplied with fresh water, from the first moment the chicks are placed in the brooder, should be kept before them.

Concluding, we wish to state that our interest in your success does not cease as soon as we receive your order for incubators or brooders, and obtain the pay for the machines. If you have the slightest difficulty in operating, we will be glad to help you to the full extent of our ability, and letters from customers asking advice will always be cheerfully responded to.

Since the above directions were written the Cornell Incubator Mfg. Co. has acquired the business, patents and good will of the Peep-O'-Day Brooder industry, and the directions shown herewith relating to the Cornell Brooders will apply to the Peep-O'-Day as well.

The Cornell Incubator Mfg. Co. will exercise the same care and diligence in the construction of the Peep-O'-Day Brooders and specialties as has always been shown in all of the products of the Cornell factory.

## In General

Read the following pages carefully. A few technical terms are used, but do not let these frighten you. Once thoroughly understood you will derive inestimable benefit from a careful reading and study of the text.

# Artificial Incubation

BY C. E. HUFFAKER

## III

## The Incubator

1. Artificial incubation as an industry is scarcely more than twenty years old, yet in that short space of time its growth has been enormous and is destined to be still more gigantic. The growing scarcity of game birds of all kinds, coincident with the increase in population and the accumulation of wealth, has created a demand for domestic birds, which is constantly growing.

Furthermore, the general introduction of incubators has rendered it possible to supply the tables of the well-to-do with young birds out of season, and of a quality superior to that formerly obtained in the natural way. Having made up his mind that quail and snipe and wild duck and ortolan are no longer to be had, the epicure's thoughts are now turned to broilers and roasters and Pekin ducks. He insists only that they shall be of the best quality obtainable. For such, he is willing to pay prices which will in the future doubtless appear fabulous.

2. From the first of January until the first of September, broilers may be sold in the open markets for from fifteen to forty-five cents per pound, roasters may be sold for sixteen cents, and ducks are accounted low at fourteen cents per pound. The cost of food in producing these birds has been found not to exceed five cents per pound, eggs for incubation may be had at from one to four cents each, oil for incubating and brooding will cost about half as much as the eggs. These are the chief items of expense, and it is evident that with reasonable success in hatching and rearing, the gains will be large, compared with profits obtained through raising cattle and hogs.

3. That the high prices of broilers will continue for many years to come is manifest from the fact that the great bulk of them must be produced by artificial methods, and that dependence must be placed upon individual operators rather than upon a few great broiler plants, so that the supply is not likely to equal the demand until the number of incubators is greatly multiplied.

4. The cost of an incubator of two hundred egg capacity, with brooders to accommodate the chicks, is less than that of two good cows, and the expense of running them will about equal the cost of feed for the cows. It takes less room to accommodate them and less time to look after them, while the profits which may result from intelligent management of the machines will exceed any that can possibly be made from the cows.

5. While it would not be wise to place an incubator in the hands of a ten-year-old boy, who usually has the faculty of leaving his tasks unfinished, the work is admirably suited to boys and girls a few years older, who are oftener than otherwise destitute of employment and only too glad to have an opportunity for making money for themselves. Even where they have other employment they may still successfully run an incubator, as the principal part of the work may be done at night. The incubator also offers profitable employment to those mothers, who are in straitened circumstances but whose domestic duties prevent their seeking employment away from home. Especially is it adapted to the use of the farmer's wife whose surroundings and experience with natural methods eminently fit her for the work.

6. The three problems which the inventors of incubators have sought to solve are the economical application of heat to the eggs and its regulation ; the uniform ventilation of the egg chamber ; and the regulation of the supply of moisture.

Of these the first has been more satisfactorily solved than either of the others. This is due to the fact that while the temperature of the egg chamber can be accurately determined by means of a thermometer, we have no common instruments for determining the amount of air and moisture passing through. We have also in the variations of the temperature a force of sufficient intensity to set in motion mechanical devices by means of which the degree of heat in the egg chamber may be automatically controlled. By this we mean to say that while the outside temperature may vary many degrees, or the flame of the lamp which supplies the heat may be turned high or low, the temperature in the chamber will either not vary at all, (in which case the regulation of the heat would be perfect), or the variations will be less pronounced than they would be if the regulator were not used.

On the contrary the slow passage of the air through the chamber, by which ventilation is effected, is so slight as to be wholly unavailable for operating mechanical devices, however delicate, so that we have no direct means of regulating the ventilation through its own variations. In the same way automatic regulation of the supply of moisture through variations in its amount, is impossible.

7. The source of life in an incubator is the heat, which by its rarifying force starts two currents of air, by one of which the hot fumes from the lamp are carried through the heater, while the other drives a slow current of pure air over the eggs. Upon the latter current ventilation depends. In one type of incubator the heater takes the form of a drum overlying the egg chamber and the ventilating current rises through the chamber, being introduced as cold air through apertures in the bottom and escaping as warm air near the level of the drum. In this type of incubator it is evident that the amount of ventilation will vary almost directly as the outside temperature, and can only be regulated by hand.

In another type the heated air surrounding the lamp chimney is carried to the top of the machine, thence is deflected downward through the egg chamber, and passes out at the bottom into one or more tubes by which it is again carried to the top of the machine and allowed to escape. As in the preceding type, the ventilation will vary as the outside temperature and is in no sense automatic in its regulation.

In still another type the heater lies wholly outside the machine and the ventilating current after being deflected downward through the egg chamber is withdrawn at the bottom of the chamber and returned to the heater, the ventilation being feebly automatic but in the main varying with the outside temperature.

These are the principal types of incubators made, and in none of them is the ventilation clearly automatic. The manufacturers of the Cornell Incubator have, however, recently introduced a new feature which seems to justify them in claiming that their machines are automatically ventilated. The ventilating current passes first upward through an external heater into the top of the egg chamber, is deflected downward and allowed to pass or diffuse through the false bottom of the incubator, thence into the left end wall and forced to pass out through the graduated ventilating slide on that end of the machine. The Cornell does not use the same air over and over again, nor is the air surrounding the eggs left to stagnate. The carbonic acid gas, escaping from the growing embryos through the porous shells of the eggs, is carried off and away by the current of air, and not returned through the heater to poison the atmosphere surrounding the eggs. Variations in the outside temperature will in this case have but little effect on the ventilation, since the driving force is the difference in weight of equal columns of air in the heater and in the egg chamber. The temperature in the egg chamber is practically constant and the ventilation will therefore vary as does the temperature in the heater outside the chimney, which carries the fumes from the lamp. If the outside temperature should fall, the damper above the heater will descend, through the operation of the thermostat, and the temperature of the heater will rise. The fumes are now deflected in greater volume through the pipes which traverse the space above the egg chamber. It will be seen therefore that the temperature of the chamber is maintained chiefly by the increased flow of hot air through these pipes and not through the increased temperature of the fresh air in the heater, which remains nearly constant. The ventilation is therefore automatically regulated in the strict sense of the term.

8. Very little progress has as yet been made in the way of automatically regulating the supply of moisture, though the manufacturers of the "no-moisture" class of machines claim that by properly adjusting the amount and distribution of ventilation, the addition of moisture is no longer necessary. In these machines advantage is taken of the principle that the vapor of water contained in the air constantly tends to rise on account of its relatively low specific gravity, and that it may be arrested and accumulated in any inclosed space, like the egg chamber of an incubator, through which it may be passing; provided the movement of the air be sufficiently slow and its course downward. The moisture in the ventilating current is thus in part left behind in its descent through the chamber. It is evident that any incubator may be converted into a "no-moisture" machine by simply diminishing the ventilation. The regulation of the supply in this manner cannot, however, be considered automatic.

9. Even conditions throughout the egg chamber is the great desideratum in any incubator, and such is the rivalry between the leading manufacturers that not a stone is being left unturned in the development and perfection of their several machines. In selecting an incubator one should bear in mind that it costs any manufacturer quite a sum to build a good machine, and that many of the "cheap" machines are really worthless. The beginner may purchase any good machine with a reasonable assurance of success. It is best to purchase outright rather than on trial. The best guaranty one can have is the unqualified agreement of the manufacturers to take back the machine and refund the purchase money if the purchaser is dissatisfied.

# IV

## The Hen

10. There are many persons who believe that Nature, like the king, can do no wrong, and that we can never hope to equal her accomplishments by artificial methods. A Russian once thought differently, and decided to test the matter by means of fish eggs. Nothing could be more unnatural than the impregnation of such eggs on dry land and in a tin pan having no water in it. Yet this is what the Russian attempted and with such signal success that his method has superseded Nature's in all the great fish hatcheries throughout the world.

It is not in man's power to produce an egg artificially, but given the egg he may hatch it, even with more uniform success than the hen. This follows from the fact that he may obtain better control over the conditions of incubation than the hen is able to do. At one time the hen brings off a full brood of chicks, at another a small one. At one time eggs are reported to be hatching well all over the country, at another the hatches are everywhere poor. The only rational explanation of this is that in some cases the hatches are made under more favorable conditions than in others.

11. The hen supplies the eggs with heat, ventilation and a certain amount of moisture through the insensible perspiration from her body, but while the heat of her body is very nearly constant, the temperature of the egg will also depend upon the temperature of the air, the character of her nest, and the number of eggs ; the ventilation will vary with the character and location of the nest and with the season ; while the amount of moisture which the eggs receive will depend upon the humidity of the air, the character of the nest and its proximity to the ground. Her control of the conditions is therefore but partial, and the sum total of all conditions may be either favorable or otherwise. The hen accordingly offers us no certain indication as to what the most favorable conditions are, and a study of natural incubation leaves us in doubt as to the best course to pursue in artificial incubation. Nevertheless such study is exceedingly valuable, though it may not in all cases be entirely conclusive.

12. We may learn from the hen that the temperature of the eggs during incubation should be about 103°, though somewhat less during the first one or two days, while the nest is becoming warmed up, and greater during the last week when the animal heat developed by the chicks runs the temperature up.

At irregular intervals the hen leaves her nest, even when supplied with food and water, allows the eggs to cool. Just what purpose is served in cooling the eggs is not clear, but it has become the almost universal practice in artificial incubation to follow nature and cool the eggs.

The hen not only cools her eggs but turns them as well. She does so by pressing the outer edges downward into the interior of the nest, those within being forced outward. It is possible that she does so to equalize the temperature, and that the turning is incidental. However, the general practice is to turn them when incubated artificially. This is done either by hand or by means of an extra tray. In most incubators it has likewise been found beneficial to shift them occasionally into new positions.

In the wild state the hen probably constructed her nest as the pheasant and the wild turkey do to-day, in the woods, close upon the ground, and with only a thin layer of dead leaves intervening between the eggs and the damp earth. Hence in a state of nature the eggs probably received a liberal supply of moisture from the nest and the underlying earth. This wild instinct is still observable in those hens which secrete their nests in the woods or among clumps of bushes, and it is noticeable that such hens usually come off with large broods.

The general experience of farmers' wives is that turkeys do much better when hatched and raised by their own mothers than when hens are used in raising them, and a possible explanation of the fact may be that as the turkey nests in the woods the eggs receive more moisture than when placed under hens and under shelter.

13. In order to obtain the best results, the laying stock should be in proper condition; that is, the fowls should be free from disease, neither too fat nor too lean, and have access to such food as will produce an egg suitable for hatching, and to some form of calcium carbonate so that the shell may be properly developed.

To what extent a diseased fowl may transmit her disease, or at least a predisposition to disease, to the chick, is a mooted question. Any chronic disease or constitutional infirmity may possibly be so transmitted, but it is doubtful if this is true of passing ailments. It seems more likely that when the hen is ill-fed or chilled, or otherwise out of condition, the constitution of the egg may not be altogether normal or suited to the proper development of the chick.

Some experiments made by the writer with eggs from stock known to be weakened by disease gave very poor results. On the other hand, eggs from stock known to be in excellent condition hatched no better than others from stock in ordinary condition. The results obtained by careful selection of eggs from good stock, have been but little better than those obtained from village stores. Apparently the eggs from scrubs and mongrels are as fertile and hatch as well as those from better stock.

# V

## The Egg

14. The fowl's egg belongs to the class of meroblastic ova, in which the germ is provided with a supply of nourishment in the form of a yolk, or vitellus, inclosed in a yolk sac, or vitelline membrane. The yolk constitutes the true ovum, the white and the shell being in a sense extraneous. The white is 78 per cent water, and as the yolk, or true ovum, in the fresh egg is centrally located it is in effect surrounded by water and as truly immersed in it as the egg of a fish or a frog in a running brook. It is held in place by the weight and tension of two heavy white cords, the chalazae, which may be seen on breaking a fresh egg, and which connect the yolk with the ends of the shell.

Under the combined influence of air and heat the yolk floats slowly upward until it comes in contact with the shell and subsequently takes the form of its upper surface, in which position it more readily absorbs oxygen from the air.

The significance of this arrangement becomes apparent when we consider that the early embryonic development of any animal corresponds with the more complete development of those occupying a lower place in the series of animal forms. Thus the early development of the chick is very similar to the more mature development of the fish and frog, and it seems altogether likely that in its early development the ovum of the fowl's egg requires conditions of incubation similar to those which persist through the entire incubating period of the frog and fish, i. e., a complete submersion under water, which will be secured by keeping the yolk in the middle of the egg, This is accomplished by keeping the egg cool prior to incubation and allowing the temperature to rise slowly after incubation begins, at the same time restricting the ventilation.

When the hen goes on her nest, especially if it be located in a cool spot near the ground, one or two days will elapse before the temperature reaches its full height, and an incubator will be found to do best when the temperature is allowed to rise slowly. Strange as it may seem, the development will be more rapid with a low than with a relatively high temperature, especially if accompanied with a small amount of ventilation. Just where the fish stage of development, if we may so term it, ends, we of course do not know; but the operator will make no mistake in keeping the temperature down for three days, and at the same time greatly restricting the supply of air.

15. The shell protects the contents of the egg from injury, at the same time that it limits the amount of ventilation. It is pierced by innumerable pores which admit of the slow passage of air to the interior. The effect of moisture appears to be to partially close these pores through the swelling of the substance of the shell, and the consequent restriction of the ventilation. At any rate the addition of moisture answers the same purpose as shutting off the air. The shell is lined with a double membrane whose layers separate at the larger end of the egg to form an air space which enlarges through evaporation until at the end of the period of incubation it occupies more than one fourth of the volume of the shell. The growth of the air cell may, to a certain extent, be regulated by properly adjusting the supply of air and moisture, and is commonly regarded as an index to the amount of evaporation which has taken place. If at any stage of development it appears larger (when seen through the egg tester) than experience has shown it should be, moisture is to be added. This is a crude method of determining when moisture should be supplied to the eggs, and somewhat unsatisfactory as the evil following too much ventilation is detected too late.

16. In selecting eggs for hatching, it is well to examine them with an egg tester and to reject all those which are unusually large or small, as well as those which are irregular in form or whose shells have a mottled appearance. The latter seldom hatch except when abundantly supplied with moisture. It is preferable to use eggs of one color and if possible from a single breed of fowls. The Mediterranean class, including the Leghorns and Minorcas, lay white shelled eggs; the classes of Asiatics, the Brahmas and Cochins and Langshans, lay dark brown eggs; while the American class, the Wyandottes and Plymouth Rocks, lay eggs which are either brown or white, according to the origin of the breed. The interior of the egg should in all cases be of a uniformly rich golden color when viewed through the egg tester.

# VI

## The Germ

17. Imbedded in the upper surface of the yolk of a fertile egg and immediately beneath the vitelline membrane, lies a single spherical cell, known as the germ or germ-cell. Fertilization takes place in the oviduct and a certain stage of development is often reached before the egg is deposited. It consists for the most part of a structureless mass of protoplasm, having an outer cell wall and a nucleus. So simple is it that scarcely anything more can be added in the way of describing its appearance, even when viewed through the most powerful microscope. Like other forms of protoplasm it is endowed with the mysterious principle of life, and possesses within its small compass forces of whose nature we are wholly ignorant. Almost all we know of it is that it can convert dead into living matter, that it can reproduce itself, that it forms the basis of all organized structures, and that it can be brought into existence only through the agency of pre-existing protoplasm. In its simplest form and to a limited degree, it possesses the power of performing all the functions of all the bodily organs.

It was once supposed that the germ-cell contained an extremely small chick, and that the process of development was one of enlargement only ; but it is now known that such is not the case. On the contrary the germ-cell does not possess organs of any kind and its only evident function is to reproduce other cells, like itself, each of which in turn possesses the same power of reproduction.

18. Cell reproduction takes place through division, each cell becoming divided into two, and each half enlarging to the size of the original cell and being endowed with all its functions. The process is accompanied by a mysterious coiling and uncoiling of a thread-like mass of a dark substance known as *cromatin*. Except in the arrangement of the *cromatin* threads and its manner of uncoiling there is scarcely any observable difference in the germ-cells of different animals. In chemical composition the cell is simple but in its molecular constitution it is thought to be inconceivably complex. The germ-cell loses much of its importance as soon as reproduction begins, as it then becomes but one among many similar cells, all having similar functions.

# VII

## The Blastoderm

19. The cells produced from the original germ-cell by repeated subdivisions do not develop equally in all directions, but at first cohere to form a continous membrane known as the blastoderm, or germ-skin, whose growth is for the most part peripheral over the surface of the yolk, immediately beneath the vitelline membrane. The membrane has been rightly termed the germ-skin, as it resembles nothing else so much as the skin of an animal. The crowding together of the cells over the upper surface of the yolk gives to the membrane at first a morula, or mulberry appearance, while by a further lateral compression the cells become hexagonal in cross section, and the membrane uniform in texture.

When viewed through the egg tester at the end of the first day of incubation, the blastoderm appears as a bright blush, indefinite in outline, which by the end of the second day is as large as a silver quarter and deep scarlet in color. By the end of the third day the size has increased to that of a half dollar, the interior has grown lighter and the outer portion darker, so that the blastoderm now appears ring shaped. Subsequently the upper portion of the ring passes under the air cell, and the blastoderm assumes the appearance of a horseshoe or crescent.

20. The blastoderm, which is at first a single membrane, splits in two, giving rise to an outer layer called the epiblast, or epiblastoderm, and an inner layer known as the hypoblast. There is subsequently developed between the two a middle layer called the mesoblast. Still later the mesoblast becomes divided into two layers, the outer being termed the somato-pleure, or body wall, and the inner the splanchnopleure, or visceral wall. Thus in its final development the blastoderm comprises four distinct layers. From the outer of these, the epiblast, will be formed the epidermis of the chick, the brain and spinal cord, the nerves, the eye, and parts of the ear and nose. From the inner, or hypoblast, the linings of the intestines and air passages. From the outer layer of the mesoblast the true skin, the voluntary muscles and the skeleton. From the inner layer of the mesoblast the heart, the alimentary canal and the larger blood vessels.

21. From the different layers of the blastoderm there are also developed certain appendages, or temporary organs, the Amnion, the umbilical vesicle, and the allantois, which will be treated under separate chapters. These serve to nourish and protect the chick during its embryonic existence and disappear when it emerges from the shell.

# VIII

## The Amnion

22. While the blastoderm is in process of formation, by a peripheral growth over the surface of the yolk, important changes are in progress at the original seat of the germ-cell, by which the dead materials of the egg are being vitalized and fashioned into the rudiments of a chick, or embryo.

23. The embryo first appears as a delicate furrow, called the primitive trace, in the epiblast, or upper layer of the blastoderm. The margins of this furrow are quickly raised into ridges, as shown in Fig. 1, which curve inward, and unite to form a cylinder, or tube, as shown in Fig. 2.

In these and the following figures, s is the shell, sm the shell membranes, w the white, y the yolk of the egg; bl the blastoderm, whose separated layers are not indicated. The figures represent sections through the embryo at right angles to the long diameter of the egg.

24. The tube thus formed is the primitive vertebral column of the chick, and is shown at v in the illustrations. Its formation is accompanied by depressions, along the outer walls, of the four layers of the blastoderm, which by incurvation give rise to the body walls of the embryo, as seen in Figs. 2 and 3. It will be seen that the body walls do not unite upon the under surface, but that the blastoderm, out of which they are formed, is reflected upward and outward over the surface of the yolk. As the infolding here described applies not only to the sides of the original tube, but to its ends as well, the embryo may at this stage be roughly described as consisting of two parallel (closed) tubes, of which the lower and larger has a slit upon its under surface, by means of which communication is kept open with the interior of the yolk.

25. Of the four layers comprising the body walls of the embryo, the outer is the epiblast, the inner the hypoblast, and the middle ones, the two layers of the mesoblast. The outer two are subsequently to be used in the formation of the permanent body walls of the chick, the skin, skeleton, and principal muscles; the inner two will enter into the formation of the intestinal tract and other internal organs.

26. The outer two layers of the blastoderm immediately surrounding the embryo are now drawn up over it on all sides to form a closed sac, called the Amnion. It is shown in process of formation in Fig. 4, and in its closed form in Fig. 5, where it appears as a

circle surrounding the embryo, an opening being left in its lower surface where the slit in the walls of the embryo occurs. In Fig. 6 it has lost its circular form in cross section and has been made to conform to the surrounding surfaces of the inner layers of the blastoderm, and the overlying vitelline membrane.

27. When the outer two layers of the blastoderm are folded upward around the embryo to form the amnion, as described in par. 26, a portion of their outer expanded surfaces is cut off, by the junction of the amniotic folds over the back of the embryo, and their further connection with the embryo is completely severed. The severed portion is called the chorion, or false amnion, and takes no further part in the development.

28. The severance of the chorion from the amnion leaves but two living membranes overspreading the general surface of the yolk, the hypoblast and the inner layer of the mesoblast. The amnion has a double wall, of which the inner is the epiblast, the outer the external layer of the mesoblast. The two sets of membranes are brought into contact within the body of the embryo.

The cavity of the amnion is filled with a fluid of saline reaction, called the amniotic fluid, which is clear and colorless, and by which the amniotic sac becomes greatly distended.

29. The amnion contains no blood vessels. Like its contained fluid it is clear and colorless, so that if the shell be broken and removed from above it, the embryo can be distinctly seen imbedded in a pit in the yolk.

30. The functions of the amnion are the protection of the embryo, the secretion of the amniotic fluid, by which its free movement is facilitated, and the storage of moisture during the early stages of incubation, to be used at a later period. Its rupture by jarring when the eggs are turned, or otherwise, is fatal.

31. The amount of the amniotic fluid varies, not only with the stage of incubation, but with the conditions of heat, ventilation and moisture. In general it is more abundant during the second week of incubation, and disappears rapidly during the latter part of the third week, when the eggs dry down with corresponding rapidity, giving the chick room to get out.

32. The proper development of the amnion is closely connected with the moisture problem, and too little attention has been devoted to the subject by poultry writers. Having no blood vessels and taking no part in the sustenance of the embryo, it has been passed over as a practically unimportant organ; as one which the chick could not

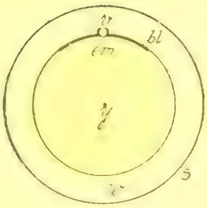



FIG. 1.

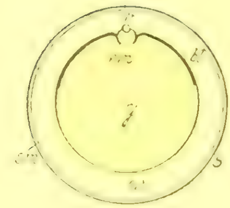



FIG. 2.

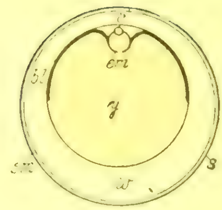



FIG. 3.

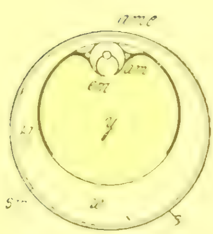



FIG. 4.


FIG. 5.

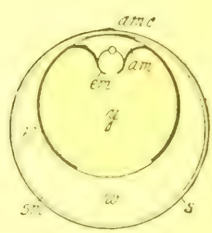



FIG. 6.

FIGURES SHOWING SUCCESSIVE STAGES IN THE DEVELOPMENT OF THE AMNION.

*s*, shell.
*sm*, shell membrane.
*w*, white.
*y*, yolk.
*bl*, blastoderm.
*am*, amnion.
*amc*, amniotic cavity.
*em*, embryo.
*v*, vertebral column.

get on without, and yet one with which nature rather than the poultryman was concerned. It will, therefore, be worth our while to devote some space to its consideration from the standpoint of utility.

33. The almost universal practice among operators of incubators, and the instruction given by all those manufacturers who advocate the use of moisture is to apply it during the latter part of the period of incubation. Some manufacturers give instructions to fill the water pans on the eleventh day and allow them to remain until the hatch is over. Others furnish water pans with instruction to add water whenever in the judgment of the operator it becomes necessary, that is, whenever the air cells seem to be growing too large. However, as the air cell seldom grows rapidly until after the tenth day, few operators, following these instructions, will be likely to add moisture before that time. Only two reasons can be given for his mode of procedure, either that experience has shown it to be best, or that it is nature's method, and therefore to be followed implicitly.

34. As regards the matter of experience it must be admitted that the results obtained by most operators have not been of a character to justify them in making any emphatic statements as to what is best. Operators generally may have found it more advantageous to add moisture after the tenth day than to leave it out; but this does not signify that it might not have been better to use it earlier, especially when we consider that perhaps not one operator in a hundred has ever tried using it earlier. The sort of experience which invariably follows one course, and that to doubtful advantage, is of little value. That this is not an exaggerated statement of the case is shown by the recent reply of an editor to a correspondent who wished to hatch 200 chicks with incubators, that in order to do so it would be necessary to set from 400 to 600 eggs. Evidently there is room for improvement on the general practice. It might be supposed that the manufacturers had worked out the problem; but owing to the somewhat sudden rise of interest in artificial incubation there was little time for prolonged experiment, and machines were rushed on the market when the principles of incubation were but imperfectly understood. In addition, it was universally assumed that the purpose of moisture was the regulation of the size of the air cell, and it was not until about 1898 that certain manufacturers ventured to disregard the air cell as an important factor in artificial incubation. We may accordingly assume that the problem has not yet been completely solved experimentally.

35. If we turn to nature we find no authority whatever for supplying moisture in the latter part of the incubating period. On the con-

trary, the indications are that it is supplied in greatest abundance during the first week of incubation. Some writers have pronounced it absurd to suppose that the hen supplies any moisture at all to the eggs; but a little reflection will show that while she may not use water pans, the heat from her body may evaporate such moisture as may be in her nest, or in the earth beneath it, and that this moisture may be brought into direct contact with the eggs. This explains why the hen which hides her nest in the woods or in a meadow usually comes off with a full brood of chicks, while the one that sits where we put her, so often comes off with a smaller number. In the first case the hen selects a spot where the earth is moist and builds her nest near the ground, where the moisture can be utilized; in the second, she is usually set in a box, on hay or straw, and under cover, under conditions which can furnish but little external moisture. Other things being equal, the evaporation will be greatest at the outset of incubation or as soon as the earth beneath has become thoroughly warmed.

36. In the absence of any definite knowledge on the subject, let us reason about the matter. It is true the self-styled practical poultryman has little sympathy with theories and theorists, preferring more definite knowledge, as for instance, why he does not get more eggs, what ails his chicks, how to make hens moult early, how to get rid of lice, how to build scratching sheds and trap nests; all important matters, but hardly such as to employ all of a thoughtful man's time. Theory has its place no less than practice and is often the surest and shortest method of arriving at the truth.

37. A man who had been unfortunate in the matter of fires might argue that when a fire gets well under way the only sure means of putting it out consists in turning on a full stream of water. In like manner it might be argued that under certain conditions a full supply of moisture in the third week of incubation is all that can prevent chicks dying in the shell. But as a little water applied at the right time will often prevent a great conflagration, so a little moisture applied to the eggs at the right time may accomplish more than a great deal applied at the wrong time. It is the beginning of a fire that escapes notice; there is no merit in discovering it after the building is half consumed. So the need of moisture in an incubator steals upon us as insidiously as a fire in a garret, and before we are aware irreparable damage may be done.

38. If a fertile egg be boiled on the sixth day of incubation for ten minutes and then opened, about four fifths of it will be found solid, like a fresh one, and would make good eating, while the re-

mainder can be poured off like water. This liquid portion consists chiefly of the amniotic fluid and shows how abundantly it has been secreted. A large portion is water, the remainder representing solids held in solution. It seems a reasonable assumption that nature has some purpose in withdrawing so large an amount of moisture from the body of the egg at this period, and that it must in a measure defeat her purpose to dissipate it by evaporation.

An examination of the figures on pages 36 and 43 will show that as incubation progresses the yolk floats upward until in time it comes in direct contact with the shell membranes. In order that this may occur it is necessary that the intervening white should be displaced, and this is accomplished in part by its liquefaction and absorption by the amnion, and in part by its settling to the bottom of the egg. Liquefaction is brought about through the agency of the amnion and it is extremely important that it should be complete. If through undue evaporation a thin hardened layer of albumen be left between the yolk and the shell the consequences are fatal. Either the germ will adhere to the shell or the expansion of the blastoderm will be arrested, though the evil effects in the latter case usually do not become manifest until a later period.

39. The upward movement of the yolk is hastened by either two much ventilation or too high a temperature. If the temperature be allowed to rise to 110° and to remain at this height for a few hours the germs will be found dead and adhering to the shell. It is in part to prevent such adherence that the eggs are turned. Surely the best temperature for the first week lies between 101° and 102°.

40. A simple rule may be given by which the operator can decide whether the eggs are receiving too much or too little air. On the seventh day or earlier, the eyes of the embryo become visible in the egg tester. If the amniotic fluid is abundant they will appear as large blurred images, and the blood vessels can be made out indistinctly. This appearance corresponds to a normal development of the embryo. If the supply of the amniotic fluid is scant, the eyes will appear as small black dots, the blood vessels will be distinct and bright, and they are receiving too much air. If on the other hand the embryo and blood vessels can with difficulty be made out at all, the eggs are receiving too little air. To be on the safe side, it is best to keep the temperature low and the ventilation greatly restricted during the first week, and more especially during the first four days.

Fig. 7.

Fig. 8.

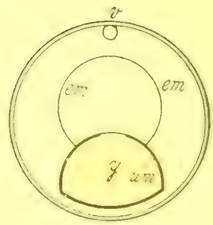



Fig. 9.

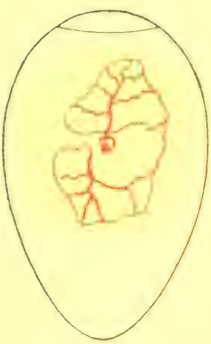


Fig. 10.

Fig 11.

Fig. 12.

Showing Successive Stages in the Development of the Umbilical Vesicle.

Figures 7, 8, 9 represent transverse sectional views. The heavy lines show the extension of the umbilical vesicle over the yolk. Fig. 9 shows the position and size of the yolk just prior to hatching, and before it is withdrawn into the body of the chick.

Fig. 10 shows the vascular area of the umbilical vesicle and sinus terminalis, with shell removed, at the end of the fourth day; Fig. 11 the same at the end of the fifth day, the sinus terminalis being no longer visible; Fig. 12 the same, seen from below at the end of the eighth day. In the figures *y* is the yolk, *w* the white of the egg, *am* the amnion, *um* the umbilical vesicle, *em* the embryo, *v* the vertebral column.

# IX

## The Umbilical Vesicle

41. That portion of the blastoderm which ramifies over the surface of the yolk (see Chapter V), is called the umbilical vesicle. It consists originally of four layers, but in the formation of the amnion (see par. 27), the outer two are completely cut off from all connection with the embryo, leaving only two layers, the inner being an expansion of the hypoblast, the outer the inner layer of the mesoblast. The hypoblast may be considered as the lining membrane of the umbilical vesicle, as it is of the intestines, of which it is a continuation.

42. Within the body of the embryo, and out of the substance of the inner layer of the mesoblast, is formed the heart; from which one set of blood vessels diverge to carry nutriment to the embryo, and another to collect it by overspreading the outer layer of the umbilical vesicle. We are at present concerned with the latter only. The blood vessels emerge from the body of the chick through the opening on the ventral surface (par. 24), and branch out over the yolk, beneath and around the amnion, as shown in Figs. 7, 8, 9. The heavy lines show the extension of the umbilical vesicle, the dotted lines that of the vascular area or that portion which is penetrated by blood vessels. In Fig. 10 is shown the appearance of a germ and the umbilical vesicle on the fourth day, as seen from above with the shell removed. In Fig. 11 the vascular area is shown greatly extended as it appears on the fifth day. While in Fig. 12, representing the eighth day of development, the under side of the egg is shown, the blood vessels approaching the median line from opposite directions.

The appearance of the egg in the egg tester is not greatly different from that shown in Figs. 10, 11, 12, with the shell removed. There is, however, one important difference. As shown in Fig. 10, the vascular area is bounded by a somewhat circular vein, called the Sinus Terminalis, by which in part the blood is returned to the heart. In the egg from which Fig. 11 was drawn, this vein was not visible to the naked eye, and under normal development it can at no time be seen in the egg tester. However, if the embryo dies within the first ten days it will often appear in the tester as a bright red ring, which is a sure sign of death. It is the result of congestion of the blood in the sinus terminalis, and where actual congestion does not take place, it often becomes so engorged with blood as to be distinctly seen in the tester, at the same time that the remaining blood vessels are remarkably bright and prominent, so much so that the inexperienced operator is disposed to think the development is excellent. This condition is, however, the indication, not of health, but of disease, and is the result of too much ventilation. It seldom or never occurs with a full supply of the amniotic fluid.

43. The extension of the vascular area over the under surface of the yolk is accompanied by numerous divisions and subdivisions of the main blood vessels until its extreme margin becomes a plexus of capillaries, connecting veins and arteries. The capillary area now expands over the surface of the yolk in a reverse direction, until it completely encompasses the yolk sac. This is under normal development, but it frequently happens that the vascular area fails to encircle the yolk, a large portion of the under surface being left bare of blood vessels. In this event the area covered by the capillaries, by which nutriment is absorbed, is greatly restricted and the subsequent growth of the embryo is retarded. The cause of this restriction is the inability of the blastoderm to expand freely. That portion of the white immediately surrounding the yolk is normally more fluid than other portions and facilitates the expansion of the blastoderm, but if it has become hardened through evaporation, the blastoderm will form creases or folds along its borders and advance but slowly and so check the expansion of the vascular area. When this occurs the folded margins will appear dark or black in the tester. The creasing is especially likely to occur along the outer borders of the yolk and upon the under surface.

44. An examination of the figures from 7 to 12 inclusive will show that the yolk gradually loses its spherical form, the amnion upon the upper surface floating up against the shell, while the lower surface may become flat or concave. When looked at from above, it appears elliptical and eventually becomes oval, touching the shell at all points. The white is meanwhile either absorbed by the amnion or pressed downward beneath the yolk, and so collects in the lower half of the egg in a condition similar to that of a fresh egg.

45. Perhaps the most essential thing in artificial incubation is that the blastoderm and the vascular area should invest the yolk in a specified time, and as this should occur early in the process of development, we can appreciate the importance of a statement made by Mr. Hodgson, to the effect that there is a missing link in artificial incubation, an unsolved problem pertaining to the first days of incubation. He states that eggs transferred to an incubator from hens, hatch much better than when the transference is made from incubators to hens. In order to

understand why this is, we must bear in mind that our instructions are to use moisture during the latter part of the incubating period. The trouble lies, not in the incubator, but in the manner in which it is operated.

The vascular system of the umbilical vesicle must get around the yolk and its capillary system must be fully developed at an early period in order that the nutriment of the yolk may be absorbed and transferred to the body of the embryo. Provision has been made by nature for withdrawing what remains of the yolk at hatching time into the abdomen of the chick. It is, however, extremely important that the bulk of the yolk should be assimilated before instead of after hatching, as one of the chief sources of mortality in incubator chicks is in the decomposition of the unabsorbed yolk. On the other hand the complete assimilation of the yolk means a larger and stronger chick. Not only is this true, but the failure of the vascular area to inclose the yolk will interfere with the proper development of the allantois, an organ to be subsequently considered.

46. Granting the importance of the early and complete development of the umbilical vesicle, let us see how it is to be brought about. The essential thing is to get rid of the white overlying the yolk as speedily as possible. This is accomplished through the agency of the amnion and we may extend or restrict the area of its operations almost at will by regulating the supply of moisture. The white of the egg is mucilaginous and may be rendered viscid through undue evaporation, and if this hardening of the white takes place between the yolk and the shell, the expansion of the umbilical vesicle may be retarded or stopped altogether. In addition, the white may adhere to the shell, especially around the air cell, preventing its normal growth and hindering the expansion of the allantois, which must slip in between the shell and the yolk.

47. The sixth day is a critical period for the reason that the vascular area of the umbilical vesicle should at this time be passing to the under surface of the yolk and crossing the air cell. If evaporation has been profuse, its further extension may be stopped for several days, so that it is not uncommon to find the development no further along on the twelfth day than it should be on the sixth. The chick may die at this stage, or it may live on and be found dead in the shell on the twenty-first day. Where the development is arrested about the sixth day, the under surface remains persistently clear and yellow for several days.

48. One of the physiological effects of too much ventilation is a serious derangement of the heart, the only organ which is functionally active during incubation. The restriction of the vascular area, the

partial congestion of the blood in the sinus terminalis, and the stimulating influence of too much oxygen, at first produce an unnatural activity and afterward an enfeebled condition of the heart, due to exhaustion. When the chick is hatched it will be listless, sleepy, with a disposition to chill and hug the fire, and liable to die suddenly and without apparent cause, especially after violent exercise.

As diarrhœa is usually traceable to a chill, such chicks are especially liable to suffer from that disease.

# X

## The Allantois

49. The chief function of the umbilical vesicle is, as we have seen, to gather nutriment from the yolk of the egg. The allantois is a somewhat similar organ whose function is the absorption of the white. The latter appears at a later date than the former and becomes the more important organ during the third week of incubation. Each in turn acts as the chief respiratory organ of the embryo, and for the full performance of its functions it is necessary that each should be fully developed and at its proper time.

50. As explained in Chapter IX., the two membranes constituting the umbilical vesicle are continuous with those originally lining the body walls of the embryo. These are subsequently wrought into the intestines and internal organs of the chick, and in the process, the neck of the umbilical vesicle is greatly contracted. There is thus left a space between it and the surrounding abdominal walls.

The allantois has its origin in a budding process on the rear intestine, which develops into an elongated tube. By its continued growth it passes out of the abdomen of the embryo between the abdominal walls and the neck of the umbilical vesicle, and forthwith expands into a flattened bag. It lies exterior to the amnion, and expands over its upper surface so as to come into immediate contact with the vitelline and shell membranes. It is highly vascular and secretes a quantity of fluid which facilitates its movements.

The appearance of the principal blood vessels of the allantois on the eighth day is shown in Fig. 15. At this stage the yolk, as seen from above is at all points in contact with the shell, except where it joins the air cell. Its upper surface is approximately a plane, above which lies about two fifths of the contents of the egg, chiefly

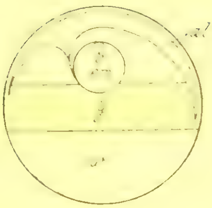


Fig. 13.

Fig 14.

Fig. 15.

Fig. 16.

Fig. 17.

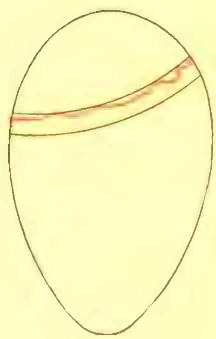


Fig 18.

Figures Showing Successive Stages in the Development of the Allantois.

In Fig. 13 the allantois is seen as a flattened bag originating in the abdomen of the embryo, and overspreading the upper surface of the yolk and the amnion. In Fig. 14 the allantois has encircled the greater part of both yolk and white Fig. 15 shows the principal blood vessels of the allantois, with shell removed on the eighth day ; Fig. 16 its appearance in the egg tester on the tenth day; Fig 17 the same seen from below on the eleventh day. Fig 18 shows the size of the air cell and the only blood vessel that should be visible on the 19th day. *y*, yolk ; *w*, white ; *al*, allantois ; *em*, embryo ; *v*, vertebral column.

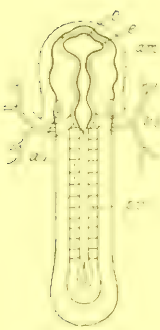


Fig. 19.

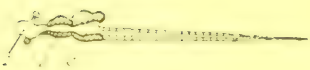


Fig. 20.

Fig. 21.

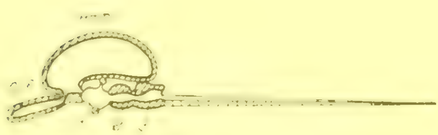


Fig. 22.

Development of the Brain and Spinal Cord.

*C*, anterior encephalic vesicle; *o*, primitive optic vesicle, *au*, primitive auditory vesicle; *am*, amnion; *vv*, vitelline veins, connecting with heart; *1*, *2*, *3*, primitive anterior, middle and posterior cerebral vesicles, *hmp*, hemispheres; *olf*, olfactory lobe.

in the form of a watery liquid. All of the unchanged white now lies below the yolk, which in cross section has the form of a band, as shown in Fig. 13.

The vitelline membrane now envelops everything above the white, and the allantois, expanding over its inner surface, eventually encircles the yolk, its folds meeting upon its under surface. Meanwhile, at the point of inflection where the allantois turns upon the under surface of the yolk, a fold creeps down the sides of the shell and encircles the white. In cross section the allantois therefore eventually takes the form of a distorted figure 8. It will therefore be seen that the allantois in its final form is in contact with the shell membranes at all points, and that in addition, a septum passes through the egg, separating the white from the yolk.

51. The blood vessels of the allantois appear in the egg tester about the tenth day upon the upper surface, and a day later upon the lower. They do not radiate from a point as do those of the umbilical vesicle, but traverse it from right to left and irregularly, so that the appearance of no two eggs is the same. They should be large and dark and not too distinct.

52. When the principal blood vessels of the allantois have come into place, the development of its capillaries begins along its terminal margins and progresses backward toward its origin. As the effect of the capillaries is to darken the interior of the egg when viewed through the tester, an egg properly developed will appear nearly or quite opaque by the end of the fourteenth day, except for the space occupied by the air cell.

53. We see now how complete are Nature's arrangements for the nourishment of the embryo. One membrane, the umbilical vesicle, similar in origin and digestive powers to the intestines, completely invests the yolk ; another, the allantois, embraces within its folds both yolk and white, and each is provided with innumerable capillaries for absorbing nutriment and with blood vessels for carrying it into the body of the embryo. At the same time abundant provision is made for the aëration of the blood. In the earlier stages, when not much air is needed, the surface exposed to the action of the air is restricted through the agency of the amnion, while a sufficient supply is secured through the umbilical vesicle. While in the later stages, when much more air is needed, aëration takes place throughout the whole interior of the shell.

54. The same causes which facilitate the expansion of the umbilical vesicle, abundance of moisture and a limited supply of air, are also favorable to the expansion of the allantois, and it will usually

be found that the proper development of the first insures that of the second. The conditions, however, should be but little changed during the second week, the ventilation being still restricted, but toward its close, when the development of the allantois is complete, the supply of air should be increased. If, however, evaporation has been too pronounced during the first week, it will be necessary to use moisture during the last week, but in this case the development will not be altogether normal.

55. The growth of the air cell, which is commonly taken as an index to the amount of evaporation that has taken place, is largely influenced by the supply of moisture. If the white of the egg overlying the yolk is not completely absorbed, that which remains will adhere to the shell and evaporation will not only be retarded, but the air cell will be deeply concave and appear much smaller than it really is, leading the operator to increase the supply of air at a time when it ought to be diminished.

In deciding whether to add moisture, one really should rely upon the appearance of the eggs rather than upon the size of the air cells. Two tests should be made, at the end of the fifth and fourteenth days. If the embryos appear deep seated at the time of the first test, the amnion large, the blood vessels not too distinct, and the opaque area of the blastoderm well advanced over the surface of the yolk, the development is normal. To insure its being so it is well enough to give the eggs very little air during the first five days, and to leave the incubator doors closed until the time for testing arrives. The eggs should be nearly or quite opaque by the time the second test is made. However, if the opacity covers half the egg, including the pointed end, the development may be considered satisfactory. If the eggs are not doing well at this time, as indicated by an incomplete development of the capillary system, clear spaces, blackened areas and bright blood vessels, not much can be done toward improving the conditions beyond adding moisture. A few of the eggs should be tested about the eighth and eleventh days, to see that they are developing properly. We have this simple rule to guide us :

The eggs should be growing dark upon the eighth day and noticeably darker on the eleventh. To render them darker add moisture or decrease the supply of air. It is possible to render the eggs prematurely dark by following this rule. In this case increase the supply of air.

56. Before the chick leaves the shell, the umbilical vesicle, with what remains of the yolk, is withdrawn into the abdomen and serves as food for a time after hatching. In rare cases the amount of the

yolk remaining is so great that it can be but partially provided for and the chick on hatching pulls out its bowels and dies. The allantois, however, must be left behind, and as the chick must cut through it in order to get out it is necessary that at the proper time it should perish, the blood which it contains being withdrawn into the body of the chick. This normally takes place with the establishment of the pulmonary circulation, but is in part due to the continued growth of the chick. At a certain time, assuming that the temperature has been kept at about 103°, the chick will begin breathing, and may continue to do so for some time, owing to the partial aëration of the blood by the allantois. If it can break through the shell by pipping, it may live for two or three days before getting out. However, if the allantois dies prematurely, the chick can live but a short time on the limited supply of air within the shell. Full grown chicks may therefore die in the shell from either of two causes; the allantois may continue to perform its functions until the chick becomes enfeebled from inhaling carbon dioxide and dies of exhaustion; or the allantois may die prematurely and the chick die quickly of suffocation. In the first case the hatching may extend over two or three or more days, the chicks not hatching until long after pipping. In the second case the hatching is soon over with, the chicks hatching quickly after pipping, or else dying. In the first case the shells are usually hard and thick and the chicks which hatch are subject to leg weakness. In the second, the shells are thin and very brittle, and the chicks are usually large. In the first case the eggs have had too much air during the last half of the incubating period, in the second, too little.

57. Not infrequently the chick dies of strangulation in attempting to break through the unabsorbed white of the egg, or it comes out covered with slime. This is due to an imperfect development of the allantois. What remains of the white is left in the shell, as well as all the membranes except the umbilical vesicle.

58. In running an incubator it is best to meddle with it as little as possible. For the first five days it should not be opened under any circumstances, the attention of the operator being confined to the regulation of the temperature, which at this stage should not be allowed to go above 102°. It may be raised to 103° by the tenth day, but should be kept under rather than over that figure until the chicks begin to pip, when it may be allowed to run up to 105°. If the temperature at any time runs to 106° or over, take out the eggs, turn them and replace them at once in the incubator.

# XI

## The Embryo

59. The development of the embryo embraces a formative or creative period covering the first eleven days of incubation, and a growing period, extending over the remaining days. A certain amount of growth takes place during the first period, but it is slight in comparison with what follows. The egg before incubation contains nothing which resembles a chick even in the most remote degree. Only the materials exist, and the mysterious power which moulds these into a living being.

60. As described in Chapter V, the first appearance of the embryo is in the form of a delicate furrow, called the primitive trace, at the original seat of the germ-cell. Lateral ridges arise along its borders and curving inward unite to form a canal or tube known as the cerebro-spinal axis. This tube is formed from the outer layer of the mesoderm, and is lined with epiblastic cells, from which are developed the brain, spinal marrow, and the nervous system.

61. The forward portion of the canal is greatly enlarged to form a receptacle for the brain, and as shown in Figs. 19, 20, 21, 22, is divided into three parts by lateral constrictions which are known as the anterior, middle and posterior cerebral vesicles, and are designated as 1, 2, 3, in the sectional figures; o is the primitive optical vesicle, am the amnion, au the auricle or ear, vv the vitelline veins, pv the pro-vertebræ.

62. In Fig. 20 we have a stage of development common to all vertebrates, including a spinal cord and three cerebral vesicles. Fig. 21 represents a higher stage of development. From a protrusion on the anterior cephalic vesicle a fourth is developed which eventually becomes much larger than the three others combined. Within it, is developed the great mass of the brain, its volume being an index to the degree of intelligence possessed by any given animal. Fig. 22 represents a co-incident stage in which the olfactory lobes and nasal passages are formed as an outgrowth from the skull. The socket of the eye is formed by outgrowths from the cranium and the eye from a protrusion from the brain itself. The ear is sunk as a pit in the base of the skull, and is connected with the primitive posterior cerebral vesicle.

63. A second and larger tube is formed by the downward incurvation of the four layers of the blastoderm, as described under the

Amnion. This is the main body cavity, which along its forward portion is greatly contracted to form the neck, while a slit is left upon its ventral surface for the free communication with the yolk. From the outer layer of the mesoblast, or somato-pleure, the body walls are formed and within it are developed the skeleton, the true skin, and the voluntary muscles. The inner layer gives rise to the intestines, and the various internal organs, of which the hypoblast becomes the lining membrane.

64. A third tube, open at either end, is the primitive heart, which is formed from a fold in the inner layer of the mesoblast and lined with hypoblastic cells. Numerous other tubes, developed within the same membranes, and by the same process of folding, unite to form veins and arteries, which become respectively connected with the rear and forward ends of the heart. From the hypoblastic cells lining the blood vessels are developed blood corpuscles and simultaneously the first circulation of the blood is established. The tubular heart now bends upon itself, bringing its two ends together. It is subsequently developed into a conical form with inter-communicating chambers.

65. A fourth tube is the alimentary canal, developed like the heart from a fold of the splanchno-pleure and hypoblast. It is at first a blind tube, but subsequently communicates with the surface through the buccal and anal orifices. By its great elongation and enlargement in different portions, the crop, stomach, gizzard, and intestines are produced.

66. A fifth tube springs from the upper portion of the alimentary canal, and follows it downward into the body cavity, giving rise to the trachea, or windpipe. It divides and subdivides to form the bronchial tubes and the finer substance of the lungs.

67. A sixth tube is developed from the rear intestine, as already described, into the allantois, the stalk of which ultimately becomes the bladder. From still other tubes are produced the liver, kidneys and gall bladder.

68. The wings and legs spring from the vertebral column, in the substance of the somato-pleure, and at first have the form of solid rods penetrating the body walls and carrying with them its covering of epiblast. The development of the joints begins at the distal extremities and proceeds inward. Bones, muscles, nerves, and skin are formed in place, and from the custis grow feathers, scales and claws.

69. False limbs give rise to the upper and lower mandibles, and the remainder of the body framework of the face is developed from processes upon the cranium. The eye is an outgrowth from the brain and therefore of epiblastic origin. The ear is sunk in a pit at the base of the

skull, and its chain of small bones developed from what are supposed to be the remains of disused organs of locomotion among its remote ancestors.

70. So the structure goes up as if by magic, like a city built by genii, with towers and palaces, spires and minarets, in the stillness and darkness of night. We know in part the law of sequence and no more. Through all the marvelous process we see the operation of an omniscient and all-powerful intelligence, working through agencies of whose nature we can form absolutely no conception.

## Directions for Operating

# "PEEP-O'-DAY" BROODER

BY E. F. HODGSON, PATENTEE.

## XII

Set the brooder level, and when out of doors place it in a sheltered spot if possible. When starting the lamp for the first time, have only a medium flame and allow it to gradually come up to the heat. If a good oil is used the lamp will give off no odor and give better satisfaction. It is well to cut down the black part of the wick every few weeks, but at other times simply scrape the crust off with a match.

The chicken-run to the No. 1, 4 and 5 Brooder is held up by a stick under the run. Keep it up for the first day, then drop it and throw a little food down it so that the chicks will run down. They will always come back. Put a small yard, not over the width of the Brooder and about three feet long, in front of the Brooder to confine the chicks in front until a week old at least, then a long yard can be made. The incline to the No. 2 and No. 3 Brooders is held up by a stick on the inside of the Sunparlor. It is best to keep it up the first day, and nights, until the chicks are a week old.

Regulating the Temperature.—By turning the hover it opens or closes the register. When opened it allows the hot air to escape and reduces the temperature under the hover. The glass slides in all brooders except the No. 5 are for ventilation, and in warm weather it is well to also ventilate and keep down the temperature by raising the cover an inch or two. It is an easy matter to run the lamp so that there is very little variation in the temperature, between 90 and 95 degrees for the first few days, then gradually lowering it until it is about 85 degrees at the end of the third week. It is then best to remove the hover from the brooder, but if the weather is cold, the lamp should be kept burning for a week or two longer, then remove chickens to some well-constructed coop. All chickens are not alike, some requiring more and some less heat, and you should be governed accordingly. For all of our brooders except the No. 3, we can supply a small burner, if desired, for warm weather, and it will burn much less oil and will not have to be turned so low.

We will furnish any part of this brooder should it be desired.

FEEDING CHICKENS.—Hard-boiled eggs chopped fine, shell and all, and mixed with about four times its bulk of soaked bread is best. By soaking the bread in cold water it makes it crumbly, which is more desirable than sloppy food. A little bran mixed with it is excellent. Feed this twice in the morning, and rolled oats or pinhead oatmeal twice in the afternoon. *Do not overfeed your chickens*, but give them what they will eat up clean in a very few minutes. More trouble is caused by overfeeding young chickens than in any other way. Keep them hungry until they are about two months old and there will be little cause for complaint. At the end of three weeks meal and beef scraps can be mixed with their soft food, and cracked corn and other fine grains may be fed. It is advisable to mix oyster shells with their soft food for they will not eat the required amount of grit if it is simply set before them in a dish. Keep plenty of fresh water before them, and milk is excellent.

CARE OF BROODER.—It should be cleaned out each day and a little loam, coal ashes or sand sprinkled on the floor. In warm weather it is a mistake to keep the chickens in the brooder too long, and at the end of three weeks they should be divided into flocks of 20 to 30 each, and placed in coops ; both coops and brooders should be placed where it is shady and on grass land if possible. It is almost impossible to raise chickens in a brooder house after warm weather sets in, and the brooder should be put outside. Not over 50 to 60 chickens should be placed in any brooder, as they will not stand crowding. Many brooders no larger than this one, are advertised to accommodate from 100 to 150 chickens, but it would be only a disappointment to the operator to put so many in any brooder.

Write to the manufacturers for any instructions you need, also, report to them your successes and failures in operation. They will be glad to aid you where they are able to do so.

## Directions

PEEP O' DAY FIVE-DOLLAR BROODER.

Set the brooder level, and when out of doors place it in a sheltered spot if possible. When starting the lamp for the first time, have only a medium flame and allow it to gradually come up to the heat. If a good oil is used, the lamp will give off no odor and give better satisfaction. It is well to cut down the black part of the wick every few weeks, but at other times simply scrape the crust off with a match. If at any time this burner does not give enough heat, it would be best to send for our No. 2 burner, which is mailed from the factory at fifty cents each.

Temperature: 90° to 95° for the first week, then drop to 80° to 85° afterward.

To remove hover, unhook the thermometer and remove it (when shipped there is a tack above it to hold it in until you receive the brooder). Keep the cotton about the thermometer to prevent the escape of hot air, especially the first week. Push the hover forward and lift it out, Also see that the hover is pushed back in place, for if not properly put back it will allow the escape of heat from the heater.

Keep fresh loam, sand, or finely sifted coal ashes on the brooder floor. A little coarse bran sprinkled on the floor for the first day or two is good. Never use sawdust. The more often the brooder is cleaned the better.

Don't feed or water your chickens until they are twenty-four hours old.

The glass slides are for ventilation and light.

## Correct Temperature

It is impossible to give the exact temperature required in a brooder. Ninety degrees is generally right. Should the chickens show signs of crowding about the dome of heater box, it is a sure sign that the temperature is not high enough, therefore increase the temperature until all crowding is stopped. It is a good sign to see the chicks lying with their heads outside the hover at night, while during the day there is seldom need of over 90° of heat. There is little or no danger of overheating your chicks in this brooder, for they will not stay under the hover if too warm.

## Caution

The Cap or Top of our burner raises off to clean the wick; and when replaced, see that it is pushed down into place; and if the No. 2 burner is used (the one that has an inch wick), special care should be taken to see that the cap is put on so that the small notch at the base fits down over the wick arbor. There is but one way to put on the large cap, but the No. 1 burner (one-half inch wick) can go on either way. If these caps are not properly set down, the flame will not fill out and it will give but little heat and quite a little odor.

To Remove Burner.—Pry open the wire loop in the connecting wire with a screwdriver, and slip it off the arbor loop and unscrew the burner. The No. 3 and $5.00 Brooders are fitted with a No. 1 burner, and should more heat be required the No. 2 burner can be used. All other brooders are fitted with a No. 2 burner and the No. 1 can be used if the No. 2 is giving more heat than required, at a saving of quite a little oil.

## Caution to Users and Makers of Brooders

Peep O'Day brooders are fully protected by patents Nos. 564,689, 622,148, and 644,599, belonging to the Cornell Incubator Manufacturing Co.; and all persons are hereby WARNED against MANUFACTURING or OPERATING brooders so made as to INFRINGE upon above mentioned ORIGINAL PATENTS.

Cornell Incubators are protected by patent No. 683,830, and other later PATENTS APPLIED FOR.

INCORPORATED 1900

C

THE CORNELL INCUBATOR MFG. CO.
ITHACA, N.Y. U.S.A.