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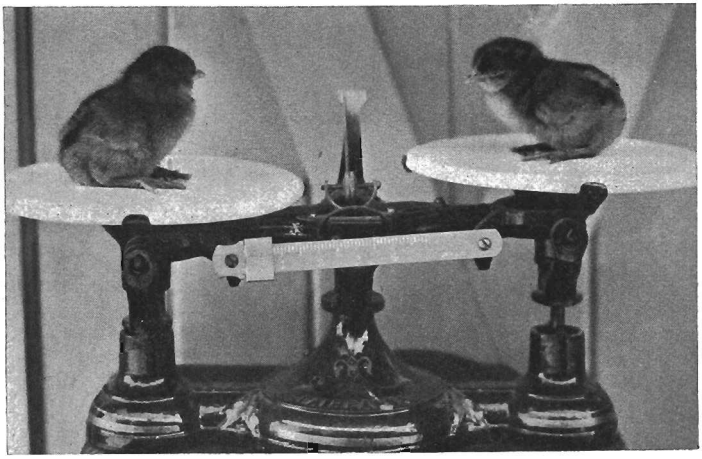

AN INCUBATION PROBLEM

Incubation Experiments

CORVALLIS, OREGON

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Incubation Experiments

By JAMES DRYDEN

INTRODUCTORY

The frequent renewal of the flock is one of the first essentials of profitable poultry-keeping. It has been proven that to get a good egg yield the stock of laying hens should be renewed at least once every two years. To keep the flock longer than that will usually mean that the egg yield at average prices of eggs and poultry food will not be profitable. In renewing the flock, however, the object will be defeated unless the health and vigor of the old flock be transmitted to the new. Failure in this respect will very soon manifest itself because of the rapidity with which one generation of fowls follows another. Susceptibility to diseases, decrease in egg yield, decrease in size of fowl, lessened fertility and hatchibility of the eggs, are the usual symptoms of deterioration in the flock. The failure of many poultry enterprises can be traced to a loss of constitutional vigor in the stock.

Artificial incubation in recent years has assumed large proportions. Large numbers of incubators and brooders are purchased in every community, entailing in the aggregate a large investment of capital. It is admitted that there are great losses in the artificial incubation of eggs and brooding of chicks, and many explanations are given as to the cause. The complaint is that the chicks either fail to hatch, or, hatching, they fail to live. Why the embryo should live through the incubation period and die before hatching, is a problem that bothers the incubator operator more probably than any other. It is a keen disappointment to the incubator user to find after the eggs apparently have progressed satisfactorily up to the time of hatching that twenty-five per cent of them, more or less, have failed to hatch. This means a large loss to the poultryman, and if there were no other problem involved in incubation than that of the chicks dying in the shell it would warrant extended investigation.

The testimony is very conflicting as to the efficiency of incubators. Hatches as high as 90 to 95 per cent of "fertile" eggs are frequently made and as low as 25 per cent or less. Some claim

that the fault is in the stock that laid the eggs. This is doubtless true in many cases, for unless the parent stock be healthy and of good vigor the eggs they lay will not hatch well. Others claim that the man who operates the incubator is usually to blame in failing to closely follow instructions, and this very often is true.

But this is not the only problem; a more serious problem is to hatch the chicks well. Some claim that it is easy to hatch the chicks but hard to raise them. Reports are frequently made where inside of four weeks after being hatched every chick has died. At certain seasons of the year probably fifty per cent of the incubator chicks die. In winter and early spring the mortality is small compared with late spring and summer. The cause of the mortality is usually ascribed to faulty methods of brooding or feeding. The fact that the chick may be hatched with impaired vitality has not been fully recognized, and the evidence of vitality should not be merely that the chick survives the brooding period, but that it comes to maturity with vitality equal to that of the parent stock and capable of transmitting the same vigor and health to the second generation.

Purpose of the Experiments

The importance of the problems of incubation has led this Station to begin a series of investigations along the following lines:

(*a*) The relative efficiency of natural and artificial incubation;

(*b*) Improvements in incubation and brooding.

In planning the work the importance was recognized of determining accurately the relative merits of natural and artificial incubation and of discovering the fundamental differences in the two methods in order that the problem of improvement might be more intelligently attacked. The ultimate object of the work is to determine, if possible, how the losses in artificial methods may be prevented.

The experiments were started in April, 1908, and this bulletin reports the results of investigations that have progressed far enough to warrant conclusions being safely drawn.

Plan of the Experiments

The plan involved the running of one set of incubators strictly in accordance with directions of the makers and other sets of ma-

chines of the same make under different conditions of moisture, the idea being that possibly under the conditions of humidity of the atmosphere here some modifications of the directions would produce better results.

The incubators were run in sets of four, one set being started on April 4, others on April 6, April 9, April 30, May 22, June 6, July 14. The last three tests were made a basis of a comparison between hens and incubators. The plan also involved a sufficient number of hens to get average results.

The eggs for hatching were purchased from farmers near Corvallis, and in starting up a set of incubators and hens the eggs were divided between them in such a way that one machine would not have an advantage over another, and that the incubators would not have an advantage over the hens, nor the reverse. In comparative tests the same kind of eggs, or eggs from the same flock, were put in the incubators and under the hens. In dividing the eggs, a basket was carried on the arm and two eggs at a time were dropped into each lot to be set.

The incubator house was built during the past winter. It is shown in Fig. 1. In dimensions it is 20x30 feet, without cellar

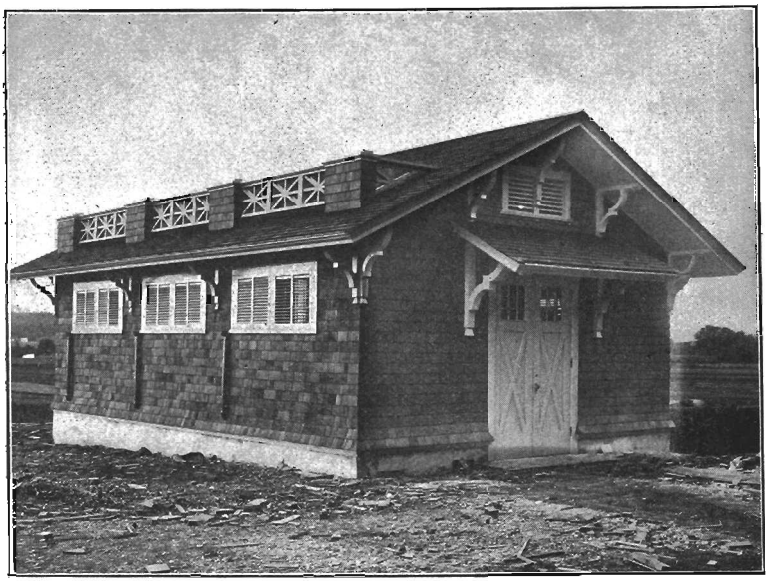

Fig. 1. INCUBATOR HOUSE

or basement. The foundation and floors are of cement. It is ventilated by means of three 3-inch flues on each side of the house and by the windows which open inside on hinges, as shown in Fig. 2. When the windows and doors are closed, which, however, is

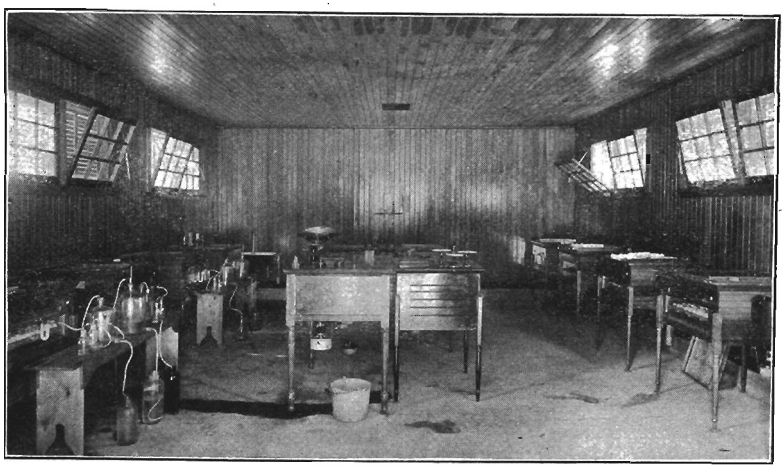

Fig. 2. INTERIOR INCUBATOR HOUSE

not very often necessary, the ventilation is in through the flues and out through ventilators in the ceiling and ventilating dormers in the gables. Tests of carbonic acid gas made by the station chemists showed that the ventilation was efficient. Each window is provided with a shutter on the outside to minimize the effect of the sun on the temperature of the room. The house is substantially built, having double wall with a dead-air space in the center.

The equipment in incubators consisted of fourteen machines of one standard make, and one each of two other makes, the three representing the moisture, semi-moisture and non-moisture types.

A special wet and dry bulb hygrometer was used in determining the moisture conditions in each machine, and a Weather Bureau type of instrument was used for the room.

A house 7x14 feet was used for the sitting hens. It contains a row of ten nests along each side of the interior of the house, 2½ feet from the floor. (Fig. 3.) The purpose in raising the nests above the floor was to make it more convenient for the chemists to take air samples from under the hens. The photograph was

taken when samples of air were being drawn, and it shows part of the apparatus used for that purpose. The nests are 14 inches

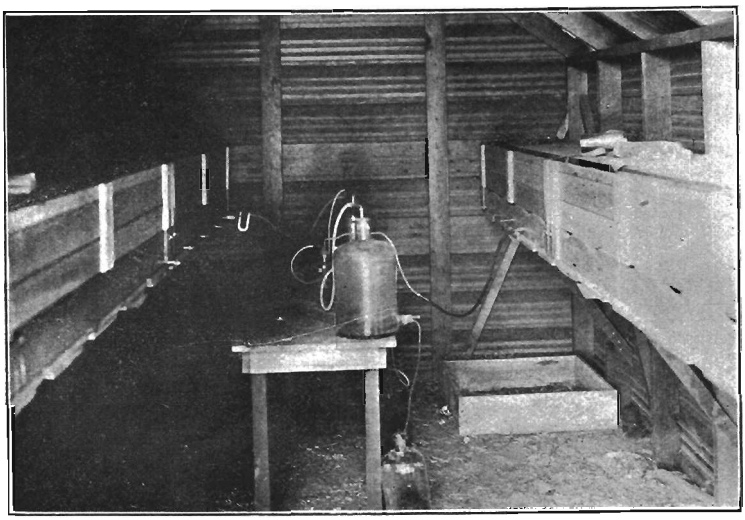

Fig. 3. HEN-HATCHING HOUSE

deep, 11 inches high and 11½ inches wide, inside dimensions, with ventilation at the top and a little in the front of the nest. The front is on hinges. This door was kept closed all the time except when the hens were let off once a day for feed and water. An inch of earth was put in the bottom of the nests and on top of this straw. The nest is therefore a dry one, but this method gave very satisfactory results.

Another method of hen-hatching was to set four hens in a small colony coop. (Fig. 4.) This coop is floored and the conditions as to humidity are practically the same as in the other house. It is 6x4 feet in size, divided by movable partitions into four divisions for four sitting hens, and the hens are set in a low box in the corner, feed and water being kept before them all the time. They leave the nest at will. There is also provided a small enclosed run 3 feet long and 20 inches wide for each hen, to which she has free access. We found this to be a very practicable and easy method of caring for sitters. Only one test has been made with this coop, when four hens hatched 49 chicks. After the hatch was off one of the partitions was removed and the chicks given to two hens.

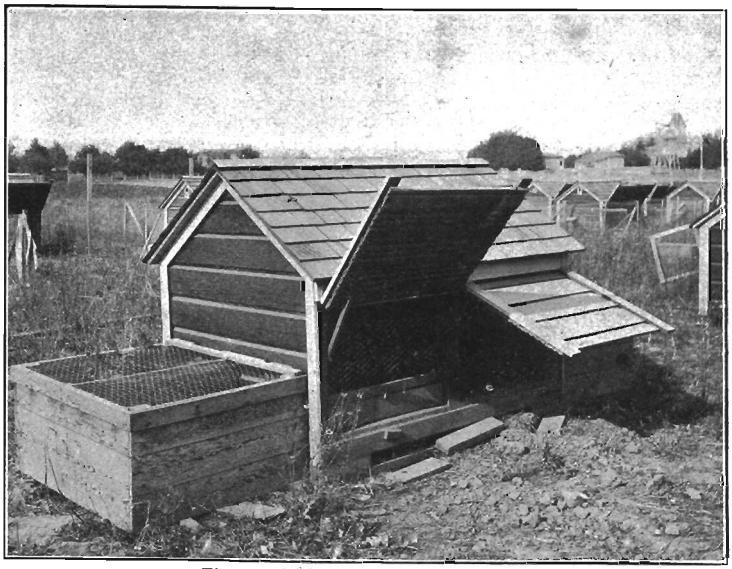

Fig. 4. COOP FOR SITTING HENS

For brooding the chicks artificially, a brooder coop, similar to the one described above, was used, in which is a movable partition in the center. One side is kept warm by means of a hover heated from a lamp outside the coop. The other side of the coop

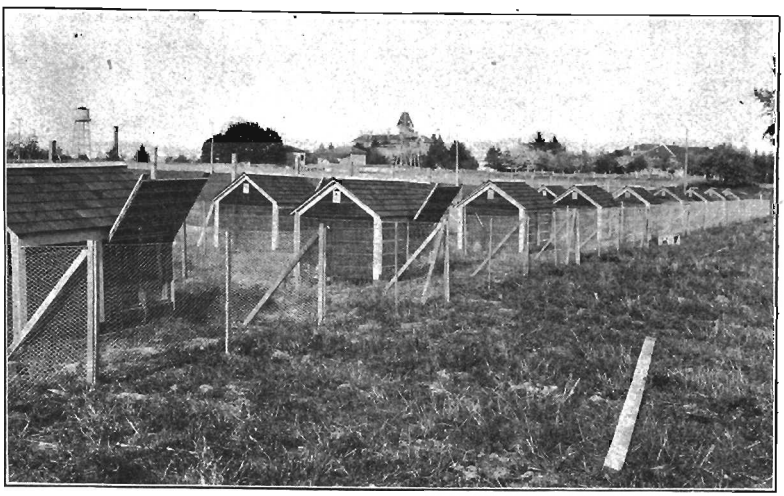

Fig. 5. BROODING COOPS FOR CHICKS

is a cool scratching room. This was bedded with cut straw several inches deep in which the feed was scattered every two or three days. This "scratching" room furnished the chicks cool, fresh air and necessary exercise when confined to the coop. The coops are built on runners so that they can be moved to fresh ground when necessary. A fence of one-inch mesh poultry netting encloses a yard 10x25 feet for each coop. These fences can be moved in separate sections. The separate enclosure for each house is necessary to make it possible to keep a record for each separate lot of incubator chicks.

Fig. 6. COLONY LAYING HOUSE

The coop was used for hen brooding as well as hen-hatching with satisfactory results, and when comparisons were made between hen and brooder brooding the same conditions were obtained. When the chicks were old enough to do without artificial heat the hover and lamp were removed and they were allowed to remain in the house during the summer or growing period. The coop therefore served the purpose of an artificial brooding house, a hen-hatching house and a colony house for growing chicks.

The Records

In these experiments the following records were kept: An "Incubation Record," which included a history of the eggs set, number set, number tested out as infertile, number of chicks hatched and dead in the shell, weight of chicks when hatched; a record of the temperature and humidity of incubator, taken three times a day, and amount of moisture put in; a record of temperature and humidity of the incubator room; for the sitting hens the "Incubation Record" was also used. A "Mortality Record" was kept which shows which incubator the chicks are from, date they were put in brooder, and number and date of chicks dead. To distinguish hen-hatched chicks from incubator chicks a toe-mark was put on one of the lots.

In addition to the above a record was kept every six days of the evaporation or loss of weight of eggs in each incubator or under the sitting hens. This was kept on a specially ruled sheet.

Hen-hatching vs. Incubator-hatching

The results of comparative tests of hens and incubators are summarized in Table 1. This summary shows tests on three separate dates, namely May 22, June 6 and July 14. On the first date five incubators were set and three hens, all on the same kind of eggs. The incubators were of 150-egg capacity and they were filled, but only 101 or 102 eggs, as the case may be, are considered in the test. The balance of the eggs were of different kinds and are eliminated. Comparative tests of course must be made with eggs of the same kind.

Fertility of Eggs.—It is the custom among incubator users in giving the results of a hatch to say that the incubator hatched a certain percentage of the fertile eggs. Frequently large numbers are tested out as infertile, entailing a great loss in eggs, and the hens that laid the eggs get the blame for laying infertile eggs. It is true that feeding, management and other things affect the fertility of the eggs, as well as the strength of the embryo, but not to such an extent as is commonly supposed; at any rate, this table would indicate that a large per cent of the eggs tested out of incubators are not infertile and if placed under hens would have hatched. The incubator eggs set on May 22 tested out 27 per cent,

TABLE 1—Summary of Hen and Incubator Hatching.

Date Set	INCUBATORS								HENS							
	Eggs Set	Tested Out	Number Fertile	Hatched	Dead in Shell	% Fertile Eggs Hatched	% Eggs Set Hatched	Average Wgt. of Chicks	Eggs Set	Tested Out	Number Fertile	Hatched	Dead in Shell	% Fertile Eggs Hatched	% Eggs Set Hatched	Average Wgt. of Chicks
								Oz.								
May 22, '08..	102	30	72	51	22	70 8	50 0	1.177	15	1*	14	13	1	92 9	86.7	.....
"	102	21	81	64	17	79.0	62 7	1.167	15	2*	13	13	0	100	86 7	....
"	102	23	79	49	31	62.0	48.0	1.067	15	2	13	13	0	100	86.7	.....
"	101	27	74	51	21	68.9	50 5	1 180	..	...	...	...	...	....	....	....
"	101	37	64	45	19	70.3	44 5	1.204	...	..	...	...	...	....	....	....
Totals& Av'rgs	508	138	370	260	110	70 .3	51 2	1.159	45	5	40	39	1	97 5	86.7	.....
June 6, '08.	36	8	28	23	5	82.2	63 9	1.252	30	6*	24	24	0	100	80.0	1 340
"	36	14	22	16	6	72.7	44 4	1.308	13	4	9	8	1	88 8	61 5	.....
"	. .	.			..	....	....	.....	11	1	10	10	0	100	90.8	.....
"		..	..	.	...	....	....	....	13	3	10	9	1	90	70.0	....
Totals& Av'rgs	72	22	50	39	11	78.0	55 7	1 280	67	14	53	51	2	96 2	76 1	1 340
June 6, '08.	72	10	62	52	10	83 9	72 2	1 184	30	4	26	25	1	96.2	83.3	1 256
"	77	7	70	63	7	90.0	81 8	1 175	...	.	..	..		..	....	.....
Totals & Av'rgs	149	17	132	115	17	87 0	77 1	1.180	30	4	26	25	1	96 2	88.3	1.256
July 14, '08	..	.	...	..	.	....	....	.....	137	*29	108	104	4	96.3	75 9	1 199
" 20 "	150	23	127	119	8	93 7	79.3	1 185	...	...	...	..	...	....	....	....

*19 Eggs broken.

while the same kind of eggs under hens tested out only 11 per cent. Of the 72 eggs set in incubators on June 6, 30 per cent tested out, and 67 of the same kind of eggs set under hens tested out about 21 per cent. In the case of the hens, a number of eggs were broken and these are counted among the infertiles. In the

last two tests the number of eggs broken in the nests was so large that the comparison of fertility cannot be made. The table shows, however, that the percentage of fertile eggs hatched, or of eggs not tested out as infertile is not a true measure of the relative efficiency of hen and incubator hatching. A surer test is the percentage of eggs hatched of total eggs put in incubator.

Number of Chicks Hatched.—The fourth column gives the number of chicks hatched by each incubator and the hens. The variation in the number hatched by the incubators is due to differences in methods of running the incubators. Different amounts of moisture were used in each machine, and this affected the results, as will be seen later under the discussion of moisture tests. The five incubators set on May 22 hatched from 508 eggs set 260 chicks. In the case of the hens set on same date, 45 eggs produced 39 chicks. The two incubators set on June 6 produced 39 chicks from 72 eggs. Five hens set on the same date hatched from 67 eggs 51 chicks. Another set of two incubators set on June 5 hatched from 149 eggs 115 chicks. Thirty eggs of the same kind under two hens gave 25 chicks. One incubator set on July 14 hatched from 150 eggs 119 chicks. Hens set on the same date on same kind of eggs hatched from 137 eggs 104 chicks, fourteen of the eggs being broken in the nests.

"Dead in Shell."—The column headed "Dead in Shell" represents the number of eggs that failed to hatch in each case. The eggs were tested on the 6th and 12th days of incubation and none but fertile eggs were left in the machines. Most of the chicks dead in the shell were apparently fully developed; many of them had pipped the shell and died. The total of all these hatches in incubators shows 146 dead in shell from 879 eggs set, or 16.6 per cent. Of 279 eggs set under hens, 8 were dead in the shell, or 2.8 per cent. This shows that the problem of chicks dying in the shell is confined largely to artificial methods of incubation.

Per Cent of Fertile Eggs Hatched.—The sixth column of Table 1 gives the percentage of "fertile" eggs that hatched. As already explained, the eggs that were left in the machine after being tested on the sixth and twelfth days of incubation, were called "fertile," though many of those tested out were doubtless fertile, the embryo for some reason failing to develop and show signs of life

when the tests were made. But as this is the usual method of figuring the percentage, this column is included. It is very possible that careful tests made later, say on the 18th day, would eliminate nearly every egg that would fail to hatch, or at any rate careful tests would eliminate many of them, which would show a higher percentage hatch. This explanation is necessary in arriving at the relative merits of the natural and artificial methods. However, on the basis of fertile eggs hatched, each test shows better results from the hens than the incubators. The first set of five machines hatched 70.3 per cent of the fertile eggs; the hens 97.5 per cent. The second set showed 78 per cent for the incubators and 96.2 for the hens. The third set gave 87 per cent for the incubators and 96.2 per cent for the hens. In the last test the results were 93.7 per cent for the incubators and 96.2 for the hens.

Per Cent Hatched of Total Eggs Set.—This information is given in the seventh column of the table. This is probably a more accurate test of efficiency than per cent of fertile eggs hatched, but it has the objection that hens break eggs in the nest which otherwise would hatch, and this reduces the percentage of the hatch. Had no eggs been broken in the nests the results would be more in favor of the hens. As it is, the results are in favor of the hens. The average of all the tests shows that the incubators hatched 60.6 per cent of the eggs set and the hens 78.8 per cent.

Weight of Chicks.—The last column of Table 1 gives the average weight of the chicks when hatched. Only such weighings are included as offer fair comparisons between the two methods of hatching. The chicks vary in weight naturally as the size of egg varies. A large egg will produce a large chick and a small egg a smaller chick. This was shown in all weighings. The chick inherits the characteristic of weight from the female, as was shown in weighings where eggs from small hens mated to a large male produced chicks of same weight as eggs from small hens mated to a small male. When the chick begins to grow, however, the influence of the male becomes apparent. It is important, therefore, that comparisons of weight of chicks just hatched be made on the basis of eggs of like size. The first lot of eggs, those set on May 22, were small eggs from Brown Leghorn fowls; the second lot were from Rhode Island Red fowls, and the third and fourth lots were

from the same flock as the first lot. Through an oversight the weights of the chicks of the first lot hatched by hens was not made.

It will be noticed that there are variations in the weights of chicks from different incubators. This is due to differences in methods of incubation.

The variations in weights in hen and incubator hatched chicks are very marked. The chicks from the first set of five incubators averaged 1.159 ounces each. The second lot were Rhode Island Red chicks and averaged from the incubators 1.28 ounces, and from the hens 1.34. The third lot, Brown Leghorns, averaged from the incubators 1.18 and from the hens 1.256 ounces. The fourth lot, also Brown Leghorns, averaged from the incubators 1.185 ounces and from the hens 1.199.

What makes the differences in the weights of hen and incubator chicks is a matter yet of speculation, but the difference is undoubtedly an unfavorable condition. It will be shown that the adding of moisture to the incubators increased the weight of the chick, and it is a question whether by setting the hens on moist nests on the ground the hen-hatched chicks would not show a greater weight. This will be tested in our later work, for there are doubtless problems affecting the vitality of the chicks in natural methods of incubation. It is not, however, a question of moisture alone. It will be shown later that by increasing the moisture in incubators to such an extent that the eggs lost less weight than eggs under hens normally, the incubator chicks weighed less than the hen chicks, though the moisture increased the weight of the incubator chicks.

A recent bulletin from the Ontario Station contained analyses of hen and incubator chicks, showing a larger percentage of lime in the former than in the latter. The analyses showed further that the lime in the chick was several times greater than was found in the contents of the fresh egg, the theory being advanced that the embryo in some way draws upon the shell for its lime requirements.

Hen Chicks vs. Incubator Chicks

Table 2 gives the mortality record of hen-hatched chicks and of incubator-hatched chicks. One of the conditions of this test was that the chicks be hatched from the same kind of eggs, or laid by the same flock where comparisons are drawn between hen and incubator chicks.

TABLE 2--Chicks Brooded in Brooder.

Date Put in Brooder	Hen-Hatched Chicks			Incubator-Hatched Chicks		
	Number Brooded	Dead in 4 Weeks	Per Cent Dead	Number Brooded	Dead in 4 Weeks	Per Cent Dead
May 10, 1908	27	2	7.4	40	16	40
June 13, 1908.....	10	1	10.	52	14	26 9
" " "	9	2	22.	63	22	34.9

Brooded with Hens.

Date Set in Brooder.	Hen-Hatched Chicks			Incubator-Hatched Chicks		
	Number Brooded	Dead in 4 Weeks	Per Cent Dead	Number Brooded	Dead in 4 Weeks	Per Cent Dead
May 10, 1908.....	5	0	0	15	7	46 6
" "	5	0	0	15	5	33 3
" "	5	0	0	15	8	53.3
June 13, "	10	1	10	10	7	70
" "	10	0	0	10	5	33.3
April 28, 1908.....				12	2	16 7
				12	8	66.7
				16	5	31.2
				16	5	31.2
				16	2	12 7
				20	16	80 0
				20	11	55 0

On May 10, 27 hen-hatched chicks and 40 incubator chicks were put in a brooder, the former being toe-marked. On the same date three hens were each given 5 hen-hatched chicks and 15 incubator chicks to brood. These were from the same lot of chicks as were put in the brooder. The hens were kept in a brooder coop, without the lamp and hover, so that the hen lots had the same kind of housing as the incubator lots. The feeding was also the same in

each case. No unfavorable conditions existed in the brooder during the period of the test.

On June 10 another comparative test was begun. In one brooder 10 hen-hatched chicks were put with 52 incubator chicks, hatched from the same kind of eggs. On the same date another lot of 9 hen-hatched chicks and 63 incubator chicks were put in another brooder. At the same time two hens were given each 10 hen-hatched chicks and 10 incubator chicks from the same lot of chicks.

The mortality record was kept for four weeks, by which time the mortality in brooder chicks usually has ceased.

It should be stated here that the mortality of brooder chicks varies at different seasons of the year, and these tests covered the period in which the mortality is usually the greatest. It is the common experience that chicks hatched during the winter or early spring show greater vigor and lower death rate than during the months of May or June when these experiments were made. During the winter and early spring the results no doubt would have been more favorable to the artificial method of hatching.

That the incubator is the cause of the mortality in the chicks, was demonstrated in two ways: First, when hen-hatched chicks and incubator-hatched chicks were put together in the same brooder the former lived well and the latter showed a large death rate; and, second, it was demonstrated when hen-hatched chicks and incubator-hatched chicks were put together with the same hen or hens, the former lived well and the latter showed the usual mortality, or practically so.

Hen-hatched chicks showed a mortality of 10.8 per cent in brooders and 2.2 per cent with hens. On the other hand incubator-hatched chicks in the tests here reported showed a mortality of 33.5 per cent in brooders and 49.2 per cent with hens.

Other tests were made in brooding incubator chicks with hens against which no check test was made with hen chicks, in which the mortality was as follows:

This shows a death rate of 43 per cent as against 49.2 in the former lot. Taking all the incubator chicks brooded by hens during these experiments, the death rate averaged 46.5 per cent.

The percentage mortality of all the hatches made in incubators and brooded in brooders was 58.4 per cent. The mortality was

greatest in the early hatches when there were no check tests with hen brooding. The latter percentage, for this reason, should not be used as a basis for a comparison with hen-brooding of incubator chicks. In the check tests, in which the comparisons may be made fairly, the chicks died just as fast with the hens as with the brooder. This proves that it is not a question of brooding.

If not in the brooding, is the parent stock to blame? It is very frequently asserted that the mortality is due to the condition of the "parent stock." A writer in *Farm Poultry,* page 311, 1908, cites the following as proof that the mortality is caused by "some trouble in the parent stock." In the spring of 1905 he hatched at different times 400 chicks in all and raised only 4 to maturity. In 1906 he hatched 300 and only 46 lived. In 1907 hatched 150 in two hatches and inside of ten days only 12 were living. He next tried eggs that he bought which were laid by what he calls "good stock." From 200 eggs he hatched 124 chicks; put them in the brooder in which the others died, and raised all but two or three. In the spring of 1908 he hatched 74 chicks from 200 eggs that he bought, and lost only one in four weeks. Then he tried eggs from his own stock again; hatched 99 and in one week lost half of them. In the spring of 1906 hatched 150 chicks, half of them from his own stock and half from eggs that he bought. Ninety-five per cent of his own died the first week; the others all lived and did well. He cites a case of another man who hatched 2,000 chicks and could raise only 5 to 10 per cent of them, while he could raise 95 per cent of the chicks from other eggs which he bought. The writer concludes by saying that he can come to no other conclusion than that it "is caused by some trouble in the parent stock." The facts as presented are conclusive as far as the brooding is concerned, namely, that the trouble was not in the brooding. The trouble could then only be in the incubator or the parent stock and the hen was condemned without a hearing. To test the theory that the parent stock was to blame, he used the incubator which was itself on trial. Then the tests extended over several seasons with but one or two machines, without any checks, and it is quite possible that the conditions were not all alike when the tests were made from which conclusions are drawn.

Our experiments show that the parent stock is not to blame. This was demonstrated in two ways: First, chicks hatched by hens lived

well, whether brooded by the hen or brooder; and, second, chicks hatched in incubators from the same kind of eggs showed high death rate whether brooded in brooders or with hens.

The vitality of hen and incubator chicks was also tested by weighings showing their relative rate of growth. The chicks were weighed when hatched and at different periods later. The following shows the rate of growth of hen-hatched and incubator-hatched chicks brooded by hens. The weights given are the averages in ounces per chick. The chicks were Brown Leghorns and the first weight is the weight when hatched:

Weight of Chicks with Hens.

	Hen-Hatched	Incubator-Hatched
May 10	1.277 ounces	1.151 ounces
May 28	2.75 "	2.31 "
June 18	6.26 "	5.48 "

On the same date a number of the same kind of chicks were put in a brooder, with the following results in growth:

	Hen-Hatched	Incubator-Hatched
May 10	1.277 ounces	1.151 ounces
May 28	1.981 "	1 895 "
June 18	3.894 "	3.708 "

One lot of Rhode Island Red chicks hatched in incubator on May 22 were divided between brooder and hens. On June 24 a weighing was made showing an average of 3.833 ounces per chick of those brooded in brooder, and 3.96 of those brooded by hens.

Another lot of chicks hatched June 12 by hens and incubator were put in brooders and with hens with following results:

	Brooded with Hens		Brooded with Brooders	
	Hen-Hatched	Incubator-Hatched	Hen-Hatched	Incubator-Hatched
June 12	Not weighed	1.172	Not weighed	1.172
July 18	2 656	2.014	.....	.....
July 22	.....	.....	3 212	2 737

The results of the different weighings show from rate of growth that the hen-hatched chicks have greater vitality than incubator chicks. The result is the same whether the chicks are brooded by hens or brooders.

No brooding experiments were involved in these tests and no conclusions should be drawn from the data secured as to the relative merits of natural and artificial brooding.

Conclusions.—The results of these experiments warrant a few conclusions as to the relative efficiency of hen and incubator hatching. They show that the hens are more efficient hatchers than the incubators, though the incubators hatched a fairly satisfactory number of the eggs. It may be true in practice that the incubator will hatch as many chicks, on the average, as the sitting hen, because the hen sometimes breaks eggs in the nest and sometimes quits her job, two things that the incubator is not guilty of; though occasionally the lamp will go out, the temperature will go wrong and all the eggs will be spoiled. But this is a matter of care with the operator and with fair care the loss from accidents will be less in the incubators than under hens. It may therefore be that an incubator properly attended will, on the average, hatch as many chicks from a certain number of eggs as a certain number of hens will hatch from the same number of eggs of the same kind.

Successful incubation, however, does not mean merely the hatching of a large percentage or a certain percentage of the eggs; the serious problem is not how to hatch the greatest percentage of the eggs, but it is rather how to hatch the largest number of chicks of greatest vitality. The test of the incubator is not that it hatch, on the average, as large a percentage of the eggs as the sitting hen, but that it hatch as many and as good chicks as a good sitting hen. Until this can be done poultry enterprises will continue to lag where artificial methods of incubation are used.

On the whole the results show that artificial incubation is responsible for the large percentage of chicks "dead in the shell" as well as for the large mortality of chicks in the brooder. There are doubtless brooder problems affecting the vitality of the chick, but this fact should not obscure the plain demerits of artificial incubation.

Moisture and Incubation

Investigations are now under way at this station along lines of improvement in incubation. These will be reported upon from time to time as the results warrant publication. A series of moist-

ure tests designed to show what degree of humidity in incubators gives best results in hatching was started on April 4, 1908, and a report of these experiments is given herewith.

Twelve incubators of the same make and of 150-egg capacity were used in these tests. They were operated according to the directions of the makers with the exception that moisture was used in different amounts. In the machines with "no moisture" a tray of dry sand, corresponding to the tray in the "maximum moisture" machines, was kept under the egg tray. The sand in the maximum moisture machines was kept wet all the time, or as wet as it could be kept without the water standing on top of the sand. The "medium moisture" machines had a tray of sand half the size of the other trays. In machines Nos. 3, 8 and 9 this half tray was kept as wet as the full trays in the maximum machines, while in Nos. 1 and 6 of this set only as much of the sand was dampened as would take up half the water that was put into the maximum machines. The first set of three machines was started on April 4 and the last set on May 22.

A fourth machine was used in the first three hatches in which the sand tray was raised as close up under the eggs as the egg tray would permit. This was to determine if more moisture would not be evaporated by raising the sand nearer the source of the heat. The results showed no increase in the percentage humidity or decrease in evaporation from the eggs, compared with tray lower down.

Table 3 gives a summary of the results of the hatching.

Most of the incubators on the market are non-moisture machines and the results of these tests become of great importance. It will be seen that in no one of the five tests did the no-moisture machines equal the moisture machines in percentage of fertile eggs hatched. In the test started on April 4 the no-moisture machine slightly exceeded the medium moisture machine in per cent of eggs set hatched. This is explained by the fact that an unusually large number of eggs were tested out of the medium machine in this test, the number not tested out being 95 while the dry machine had 110. In all the other tests the number tested out ran very even.

TABLE 3--Summary of Moisture Tests.

Date Set	No Moisture					Medium Moisture					Maximum Moisture				
	Incubator No.	Number of Eggs Set	Number Hatched	Per Cent Eggs Set Hatched	Per Cent Fertile Eggs Hatched	Incubator No.	Number of Eggs Set	Number Hatched	Per Cent Eggs Set Hatched	Per Cent Fertile Eggs Hatched	Incubator No.	Number of Eggs Set	Number Hatched	Per Cent Eggs Set Hatched	Per Cent Fertile Eggs Hatched
April 4, 1908 ..	4	150	83	55.3	75.5	3	150	81	54 0	85.2	2	150	99	66	85.3
" 6, "	5	156	54	28 2	44.2	8	156	90	57.7	77 6	7	157	81	51.6	71.6
" 9, "	12	154	60	39 0	54 0	9	154	87	56.4	83 7	10	154	88	57.1	79.3
" 30, " ...	2	138	84	60 9	75.7	1	139	102	73.2	85 0	4	150	101	67.3	78.2
May 22, "	7	102	49	48.0	62.0	6	102	64	62 7	79 0	8	101	51	50.5	68 9
Totals & Av'rgs		700	330	47 1	61.9		701	424	60.5	82.1		712	420	59	77.3

The average results show strongly in favor of moisture against no-moisture, and slightly in favor of medium moisture as against maximum moisture.

In each test the machines were filled to their capacity. Where the table shows less than the full number of eggs it is because a few eggs of a different kind were eliminated in the calculations.

Figuring on percentage of fertile eggs, the medium moisture gave an average of 32.6 per cent more chicks than no moisture, and the maximum moisture 24.9 per cent more. On the basis of total eggs set medium moisture averaged 28.4 per cent and maximum 25.3 per cent better hatches than no moisture.

It will be noticed from the incubator number that no one machine was used twice in the same test. This was done to eliminate any possible differences in efficiency of the different machines. Though the machines were all of the same make, it was recognized that there might be individual differences in construction not discernible which would impair the value of the tests. Whatever differences in machines there may have been, it will be seen that the results in each case point to one conclusion that a relatively high amount of moisture is necessary to successful hatching.

Temperature of Machines.—The temperature of each machine was recorded three times daily, namely at morning, noon and even-

ing. The thermometer used was furnished by the makers of the incubators. As a check another standard thermometer was used in each machine. The two thermometers agreed very well.

It is not thought necessary to publish at this time the complete daily record of temperature. The directions of the manufacturers were followed in each case in regard to temperature, and in all the tests the temperatures were fairly constant. The variations in temperature were so small that it is doubtful if they had any influence on the results of the hatches.

TABLE 4--Temperature of Machines.

Date Set	No Moisture				Medium Moisture				Maximum Moisture			
	Incubator No.	Highest Temperature	Lowest Temperature	Average Temperature	Incubator No.	Highest Temperature	Lowest Temperature	Average Temperature	Incubator No.	Highest Temperature	Lowest Temperature	Average Temperature
April 4, 1908	4	105	100	102.6	3	105	100 5	102.5	2	105	100 .5	102.5
" 6, "	5	104.5	100	102.5	8	104 5	100	102 3	7	105	100	102.2
" 9, "	12	105	100.7	102.5	9	107.0	100	102 6	10	106	100	102.4
" 30, "	2	104.5	98	101 8	1	104.5	97	102 0	4	105	98	102.0
May 22, "	7	104.5	100	102.4	6	106	100	102 0	8	105	90	102.1

Table 4 gives the average temperatures for each set of incubators, together with the highest and lowest temperatures during the hatch.

TABLE 5--Temperature of Incubator Room.

Date Set	Morning			Noon			Evening		
April 4, 1908	64	48	55 3	70	54	60.9	75	53	63.7
" 6, " ..	64	48	55.5	70	55	61.3	75	53	64.4
" 9, " ..	64	50	56 1	72	56	62.5	79	53	65.5
" 30, " ..	59	49	53 5	76	53	60.8	68	53	60 1
May 22, " ..	65	51	57.6	78	58	66 7	84	59	67 0

Temperature of Incubator Room.—Table 5 gives the highest and lowest and average temperature of the incubator room three times

a day. It will be noticed that the temperature varied little during the two months or more of the experiments. This shows a difference between the highest and lowest temperature during the three weeks of incubation of 15 to 20 degrees; in one case the difference was 25 degrees. The daily variation was relatively small.

TABLE 6--Per Cent. Humidity of Room.

Date Set	Humidity of Room				Rainfall Inches	Days Rain
	Morning	Noon	Evening	Average		
April 4, 1908.....	82 1	70.7	70.1	74 5	4 07	7
" 6, "	81.1	70 0	68.3	73 4	3.97	7
" 9, "	80 2	72.1	70.4	74.3	3.97	7
" 30, "	83.1	69.8	69 3	73 9	4.63	14
May 22, "	79.6	66.0	66 6	70.9	2.05	7

Humidity of Room.—The percentage humidity of the room taken by means of a wet and dry bulb hygrometer is shown in Table 6 for each set of machines. These are the averages of the readings taken three times daily, without fanning the wet bulb.

The rainfall in inches is also given in this table, with the number of days on which rain fell during each period. The precipi-

TABLE 7--Humidity of Incubators.

(Wet Bulb Not Fanned.)

Date Set	No Moisture					Medium Moisture					Maximum Moisture				
	Incubator No.	Morning	Noon	Evening	Average	Incubator No.	Morning	Noon	Evening	Average	Incubator No.	Morning	Noon	Evening	Average
April 4, 1908.	4	45.4	46.5	45.5	45.8	3	50.7	51.6	51.4	51.2	2	66.0	66 3	65.6	66 0
" 6, " .	5	45.3	46.2	46.6	46.0	8	58.2	58.5	58.3	58.3	7	63.9	63.9	65.2	64.3
" 9, " .	12	51.4	53.6	52.3	52.5	9	53.8	54.1	53.2	53.7	10	....	....	....	...
" 30, " .	2	44.3	47.6	47.3	46.4	1	57.4	59.0	56.8	57.8	4	61.2	62.3	62.1	62.1
May 22, " .	7	51.9	52.5	53.7	52.7	6	57.8	55.4	53.8	55.8	8	66.1	64.2	62.9	64.5
Averages...		....	.	...	48.7		...	...	....	55.3		....	....	....	64.7

tation was about 12 inches during the two months of the experiments and as a consequence the humidity was high.

Humidity of the Incubators.—The percentage humidity of the incubators is given in Table 7. The readings were made at the same time as those for the room. It should be stated that the readings of the wet bulb were taken without fanning and therefore the percentages are not mathematically correct. It is difficult to fan the thermometer in the incubator, and in practice this would not be feasible, but the readings are given here for purposes of comparisons and may be a guide to incubator users.

The proper degree of humidity in incubators has not yet been determined, but it would seem that these experiments have brought us close to an actual demonstration. Investigations will be continued along this line. The tests show unmistakably that moisture or humidity conditions of the egg chamber of the incubator have a remarkable influence on number of chicks hatched. The results apparently show the limits of extreme dryness and dampness. A percentage of 48.7, average of the no-moisture machines, gave poor results; 55.3 per cent gave relatively good results and 64.7 was not as good as 55.3, as determined by the unfanned wet bulb thermometer.

It is a question of some importance as to what effect climatic conditions have upon hatching. Will the eggs hatch better in a dry climate than in a moist one? Does the incubator require moisture in a dry climate and none in a humid one? A study of records of experiments at the Utah Station in connection with the records at this Station will throw some light upon this subject.

In May, 1907, the writer conducted a similar moisture test at the Utah Station where the atmosphere is very dry. The records show that the humidity of the room during that month averaged 43 to 47 per cent, against 70.9 to 73.9 here during the same month. The no-moisture incubators there showed an average humidity of 50 per cent; here the same kind of incubators operated in the same way had a humidity of 48.7 per cent. Though there was a great difference in the humidity of the rooms there was practically no difference in the incubators. In the case of moist machines, however, there was a difference. They show higher humidity when run in a moist atmosphere than they do in a dry atmosphere. At

Utah the medium moisture machines averaged 52 per cent and the maximum machines 55.5 per cent. The explanation is probably that the no-moisture machines are never so moist, no matter whether they be run in a dry or a moist climate, that the moisture will pass from the machine to the room. This would indicate that, except at the time of hatching when the eggs are giving off more moisture, the ventilators in the dry machines may be opened without any fear of the moisture escaping from the machine to the room, because unless there were more moisture in the incubator than in the room it would not pass from the machine to the room. Even in the dry climate the moisture in the atmosphere outside was greater than in the dry machine, the same condition that obtained in the humid climate, as indicated by the percentage humidity at both places. In either case moisture is required for best results.

Another point to consider is, should as much moisture be supplied in a moist climate as in a dry one? The records show that the "maximum" moisture produced in Utah 55.5 per cent humidity and in Oregon 64.7 per cent, and the medium moisture showed the same percentage in Oregon as the maximum in Utah. This indicates that a medium amount of moisture produces the same results in a humid atmosphere that a maximum amount produces in a dry atmosphere. The indications are that the vapor pressure in any climate is from the outside to the inside of the incubator when no-moisture is used, but it is reversed when sufficient moisture is supplied. The moisture then passes from the machine to the outside through ventilators and cracks, the rate at which it passes from the machine to the room depending upon the amount of ventilation which the machine has.

An explanation may be necessary in regard to the term "percentage humidity." Air varies in moisture-holding capacity as the temperature of the air varies. The fact that the moist incubators showed a lower relative humidity than the room does not mean that the actual amount of moisture was less in the incubators than in the room. The air in the incubator by reason of its higher temperature was capable of holding more moisture than the room air and the percentage humidity of 64.7 in the moist machines means only that the air in those machines contained just 64.7 per cent of

the moisture it was capable of holding. The actual humidity, or the weight of vapor, in the machines may be greater than in the room, though the percentage humidity may be lower.

The Wet Bulb Temperature.—It is the opinion of the writer that considerable use may be made of the wet bulb thermometer by incubator users. Having demonstrated that the humidity conditions of the air is a vital factor in hatching, the question arises as to how the incubator user is to determine when he has the proper degree of humidity in the machine. It is difficult to get the percentage humidity, while the wet bulb thermometer gives at a glance

TABLE 8--Wet Bulb Temperatures.

Date Set	No Moisture					Medium Moisture					Maximum Moisture				
	Incubator No.	Morning	Noon	Evening	Average	Incubator No.	Morning	Noon	Evening	Average	Incubator No.	Morning	Noon	Evening	Average
April 4, 1908	4	82.4	83.9	83.3	83.2	3	86.2	86.1	86.5	86.3	2	91.6	91.5	91.6	91.6
" 6, "	5	83.6	83.5	84.0	83.7	8	89.1	89.1	89.3	89 2	7	91.1	90.9	91.4	91.1
" 9, "	12	86.1	86.5	86 6	86 4	9	86.8	86.6	81 0	86.8	10	....	....	....	....
" 30, "	2	82.4	83.4	83 4	83 4	1	87 8	88 5	87 7	88.0	4	....	....	....	....
May 22, "	7	85.6	85 6	85.6	85.6	6	88 7	87 2	87.2	87.7	8	91.0	90.2	90 0	90.4
Average .	..	....	....	....	84.5	..	....	....	....	87.6	..	....	....	....	91 0

the actual conditions of the machine. Table 8 gives the average wet bulb readings for each machine used in the moisture experiments. It gives the average of the morning readings and of the noon and evening readings, together with the daily average for each hatch. Taking the average of all the machines, this table shows the following temperatures for the three sets of incubators: No-moisture, 84.5; medium moisture, 87.6; maximum moisture, 91.

As shown in Table 3, the medium moisture incubators gave considerably better hatches than the no-moisture machines and slightly better than the maximum moisture; therefore the wet bulb temperature of 87.6 gave better results than the higher or lower wet bulb temperatures. It will require more and extended tests to determine exactly what is the best wet bulb temperature, but from the

tests so far made it would seem to be within the limits of 86 and 90 degrees. If the temperature should read below the lower figure more moisture should be put in the machine; if above the higher figure cut off some of the moisture supply or open the ventilators. The moisture may be controlled by the size of the evaporating surface of the moisture tray. The larger the moisture tray or the evaporating surface the greater will be the humidity of the incubator and the higher the wet bulb will read. The more ventilation given a moist machine the less the humidity will be and the lower the wet bulb temperature will be, but increasing the ventilation of the dry machines will have little or no effect on the moisture content of the incubator or on the temperature of the wet bulb.

Evaporation of Eggs.—It is known that the egg is constantly losing weight during the progress of incubation. The rapidity of evaporation is influenced by several factors. Putting moisture in the machine will check the loss of weight, and the circulation of air in the incubators affects the evaporation. The problem is to produce the same conditions in the incubator as are found under sitting hens.

TABLE 9--Per Cent Loss of Weight in Incubator Eggs.

Date Set	No Moisture					Medium Moisture					Maximum Moisture				
	Incubator No.	First 6 Days	Second 6 Days	Third 6 Days	Total	Incubator No.	First 6 Days	Second 6 Days	Third 6 Days	Total	Incubator No.	First 6 Days	Second 6 Days	Third 6 Days	Total
April 4, '08	4	4.49	5.07	5.55	15.11	3	3.78	3.68	2.95	10.41	2	2.82	3.03	3.83	9.68
" 6, "	5	5.08	4.82	6.20	16.10	8	4.16	3.80	6.25	14.21	7	3.49	3.75	5.77	13.01
" 9, "	12	4.89	5.24	9.49	19.62	9	3.68	4.04	4 67	12.39	10	2.97	3.01	3.63	9.61
" 30, "	2	4.88	4.55	7.26	16.69	1	3.98	3.49	6.00	13.47	4	3.58	3.25	4.90	11.73
May 22, "	7	5.07	4 23	6.37	15.67	6	4.31	3 81	5.21	13.33	8	3.45	2.45	4.06	9.96
Average.	..	....	.....	.....	16.64	..	.....	.....	.....	12.76	..	.....	.....	....	10.8

In these experiments weighings were made every six days during incubation. In each case three dozen eggs were weighed in each machine. The infertile eggs were tested out on the 6th and 12th days and only fertile eggs were weighed thereafter. The eggs

were weighed when set, then on the 6th, 12th and 18th days. On account of eliminating the infertile eggs the actual loss would be slightly less than is shown in the column which gives the total per-centage loss for 18 days. The difference is small, however, and does not vitiate the comparison between hens and incubators.

Table 9 gives the results of the weighings of the incubator eggs. The no-moisture machines lost an average of 16.64 per cent of their weight in eighteen days; the medium moisture 12.76, and the maximum moisture 10.8 per cent.

TABLE 10--Per Cent Loss of Weight in Eggs Under Hens

Date Set	Number of Eggs	First 6 Days	Second 6 Days	Third 6 days	Total 18 Days
April 18, 1908	5	4.25	5.05	4.35	13 65
" "	4	4.80	5.28	5.45	15.53
" "	6	4.55	4.85	4.93	14.33
" "	6	3.89	5.08	5.34	14.31
May 22, "	6	4.01	8.90		12.91
" "	5	5.57	10.09		15.66
" "	5	5.13	10.63		15.76
June 6, "	5	5.26	5 33	6.22	16.81
" "	4	5.93	3.47	5.51	14.91
Average	....	....	....	....	14.87

Table 10 gives the weighings of eggs under hens. In this case it was necessary to weigh each egg separately because the breaking of an egg in the nest would destroy the weighings if the eggs in the nest were all weighed at one time. The table gives the average results for a certain number of eggs, which was four, five or six, weighed in each nest. The average total loss in weight for 18 days was 14.87. The variation in the different nests was from 12.91 to 16.81 per cent. As explained in another part of this bulletin, the nests were two and a half feet from the floor and were dry. The weighings therefore represent probably the maximum evaporation of eggs under sitting hens. The evaporation, of course, would be less where the hen sits on the ground or on moist nesting material.

In comparing the weighings of incubator and hen eggs, the eggs in the no-moisture incubators lost 12 per cent more weight than the eggs under hens, but the moisture machine showed less loss. The results show that the dry machines "dry down" the eggs too much, while the maximum moisture machines show too little evaporation. Between the medium moisture machines and the hens there is considerable difference. It is a question, however, if less evaporation of the eggs under the hens would not be desirable. It has never been demonstrated, to the writer's knowledge, whether it is better to set the hens on the ground than on dry nests. On the whole the result of the weighings agree with the results of the hatching in showing the necessity of supplying a certain amount of moisture to the incubators.

Weight of Chicks.—The weighings of chicks hatched in incubators with different amounts of moisture are not yet complete enough to warrant extended discussion, but the weighings so far made indicate that the effect of supplying moisture is to increase the weight of the chick when hatched from five to ten per cent. There was a noticeable difference in the size of the chick whether hatched with or without moisture.

Moisture and Vitality in the Chick.—In another part of this bulletin the mortality of incubator chicks is mentioned in connection with a comparison of hen and incubator-hatched chicks showing that the mortality due to so-called white diarrhoea was confined wholly to incubator chicks. No conclusive results, however, have yet been secured as to the effect of moisture on vitality of the chick. The results will be published later when further data have been secured. It may fairly be stated, however, that so far as the data that have already been secured show, there is very little difference in the mortality of chicks whether hatched with moisture or no moisture, that difference being in favor of a medium amount of moisture. As has already been mentioned the mortality was high, whether hatched with or without moisture, and it is evident that we must look to some other cause for the great mortality of incubator chicks than the lack of moisture in the incubator, however much moisture may be demanded in the hatching.

Chemical Tests for Oil on Egg Shells

It is a matter of common notice that eggs on which a hen has been sitting for some time acquire a smooth, oily appearance. To determine whether this smoothness is due to the presence of oil or fat in the pores of the shell, Professor C. E. Bradley, Station Chemist, proposed that some chemical tests be made. Preliminary tests showed the presence of oil, and as this oil might have a function to perform in the incubation process, Professor Bradley decided to make quantitative tests for it on eggs under different conditions. Accordingly fresh eggs, eggs on which a hen had been sitting two weeks, and eggs which had been in an incubator two weeks, were tested. Likewise china nest eggs on which a hen had been sitting two weeks were tested.

Professor Bradley reports the results as follows:

"The method followed was to brush off loose material from surface of egg shell with small brush and while holding egg in tongs, wash shell with jet of ether from wash bottle, catching washings in weighed watch glass. The ether was allowed to evaporate at room temperature, residue dried in dessicator and weighed. Care was taken to use only clean eggs in the tests.

"The following weights show amount of oily material extracted from different eggs:

12 fresh hen eggs	3	milligrams oil
12 china eggs, 2 weeks under hen	3	milligrams oil
12 hen eggs, 2 weeks under hen	28	milligrams oil
12 hen eggs, 2 weeks in incubator	4.6	milligrams oil

"That the residue from ether evaporation was an oil could be readily verified by microscopical and chemical tests. The amount extracted under these conditions does not, of course, represent the total amount present, but the results are at least comparative, as treatment was uniform throughout.

"It is quite evident that the eggs on which hen has been sitting have a small oily deposit on their surface and since eggs from incubator at same stage of incubation show only a small fraction of this amount of oil it is plain that the oily matter is not deposited on the exterior surface of shell through evaporation in process of

incubation, but is a natural secretion from the hen. What the function of this secretion is, or whether it has any particular function other than to possibly check evaporation is not yet determined, but some tests are now under way in this connection which will be reported later.

"The smooth surface of the china eggs probably accounts for the fact that only a very small amount of secretion was found on them."

SUMMARY

Efficiency of Hens and Incubators

1. From 879 eggs set, incubators hatched 533 chicks, or 60.6 per cent.

2. From 279 eggs, hens hatched 219 chicks, or 78.8 per cent.

3. Eliminating eggs broken in nests, the hens hatched 88.2 per cent of eggs set.

4. The incubators hatched 78.5 per cent of "fertile" eggs, and the hens hatched 96.5 per cent.

5. Eggs incubated artificially tested out 22.7 per cent as infertile, while those incubated by hens tested out 11.8 per cent.

6. The incubators showed 16.6 per cent of chicks "dead in the shell," and the hens 2.8 per cent.

7. Chicks hatched under hens weighed heavier than chicks hatched in incubators.

8. The mortality of hen-hatched chicks brooded in brooders was 10.8 per cent in four weeks, and of incubator-hatched chicks 33.5 per cent.

9. The mortality in hen-hatched chicks brooded under hens was 2.2 per cent, and of incubator chicks 49.2 per cent.

10. In other tests the mortality was 46.5 per cent for incubator chicks brooded by hens and 58.4 brooded in brooders.

11. Hen-hatched chicks made greater gain in weight than incubator chicks, whether brooded by hens or brooders.

Moisture and Incubation

12. There was an increase in number of chicks hatched of 32.6 per cent by using moisture in incubators.

13. Both a medium and a maximum amount of moisture gave better results than no moisture.

14. Climatic conditions as to humidity have apparently no effect on hatching in the case of non-moisture incubators.

15. In the case of moisture machines less moisture will be required in a moist climate than in a dry one.

16. The wet-bulb thermometer may be used to advantage as an indicator of the proper degree of humidity in the incubator.

17. An average wet-bulb temperature of 87.6 gave 32.6 per cent better hatches than one of 84.5, and slightly better than one of 91.

18. The average loss in weight of eggs incubated under hens in a dry nest was 14.87 per cent in 18 days.

19. Eggs in non-moisture incubators lost 16.64 per cent of their weight, in medium moisture incubators 12.76 and in maximum moisture incubators 10.8 per cent.

20. The chicks from the moisture machines were heavier than from the dry machines, but it has not yet been demonstrated what relation moisture in incubation has to vitality in the chick.

21. The lack of moisture does not alone explain the great mortality in incubator chicks, but it is responsible for a large percentage of the losses in hatching.

Oil on Egg Shells

22. Chemical tests showed the presence of oil on egg shells. There was a very small quantity on fresh eggs and on incubator eggs, but a relatively large amount on hen-hatched eggs. The function of this oil or fat, whatever it may be, has not been determined.