A STUDY OF THE FACTORS INVOLVED IN THE SELECTION OF CHICK BROODERS

by

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A STUDY OF THE FACTORS INVOLVED IN THE SELECTION OF CHICK BROODERS

INTRODUCTION

The method of brooding chicks on the farm is rapidly changing from the old "setting hen" method to that of artificial brooding. This trend is due largely to the development of dependable and efficient brooders, thereby lowering production costs, and to the increasing practice of average farmers producing more poultry as a minor farm enterprise for increasing farm income. Many types of brooders have been developed, the type usually being identified by the fuel used for producing heat.

The rapid extension of electric distribution lines into rural areas is making electric service available to thousands of Virginia farms for the first time each year. Electric rate schedules are being designed to promote the extensive use of electricity for operating farm equipment. The availability of electricity to the farmer at a price competitive with other fuels will, in many cases, mean a change in types of equipment.

Although the electric brooder has been in the process of development and use for over twenty years, there is still a doubt in the minds of many as to its practicability, both from the standpoint of brooding results that it will produce and economy of operation. Many types of electric brooders involving a number of operating principles have been

developed. It has been found that climatic conditions have greatly influenced the development of different type electric brooders in various geographical areas. In the east central area, the hover type brooder equipped with low temperature black heat units has proven to be the best general type of electric brooder. Although there are several differences in the design and operation of this type brooder, the newest and most questionable one is the use of a fan for forced air circulation through the hover.

The main desire of the farmer in selecting a brooder is to secure the one that will do the best job of brooding at the lowest unit cost. The labor requirement factor is also given much consideration and is increasing in importance as a point to keep in mind in selecting a brooder. Then the questions that must be answered in deciding on which general type brooder would fit a given situation best will relate to fuel consumption, fuel costs, brooding results to be expected, and labor requirements.

OBJECTIVES

This study was planned and conducted to secure the information necessary to determine the following objectives:

1. The operating costs of each type brooder under identical operating conditions.
2. The brooding results obtained with each brooder tested.
3. The most satisfactory and practical type of electric brooder for use on Virginia farms.

SCOPE AND PLAN OF STUDY

In order to make the study as complete as possible, it was planned to cover each of the common types of brooders used in Virginia. These included coal, kerosene, wood and electricity. The tests were planned to secure data during each of the brooding seasons generally referred to as fall, winter and spring. Therefore, it was necessary to conduct three series of tests, the duration of each being eight or ten weeks, which is the normal period necessary for producing light broilers. The test was set up so that the brooders would be operated under conditions as near normal or typical farm as possible.

Figure 1.- The six colony brooder houses in the foreground were used in conducting the brooder studies.

EQUIPMENT SET-UP FOR THE INVESTIGATION

Selection of Brooders

The brooders used in making the tests consisted of typical units available on the market and two homemade electric brooders. The following is a brief description of each of the brooder units used in the three series of tests:

1. Standard commercial electric brooder with natural ventilation: Diameter of the hover 56 inches, black heat low temperature heating coils of 440 watts, thermostatically controlled. Approximate retail price - $29.00.
2. Standard commercial electric brooder with forced ventilation: This unit was identical to the No. 1 brooder except in method of ventilation. A small fan was located in the center of the brooder to force fresh air downward through the center and from under the curtain. Approximate price - $34.00.
3. Homemade electric brooder: This unit was constructed in the laboratory by using a 56 inch tin hover from an old discarded kerosene brooder. The hover was insulated with aluminum foil and wood. Low temperature 440 watt heating coils were installed and thermostatically controlled. The ventilation flue was located vertically through the center of the brooder and was adjustable. Approximate cost - $10.00.
4. Homemade flat top electric brooder: This brooder was rectangular shaped with a flat top. Over-all dimensions were 72 inches long

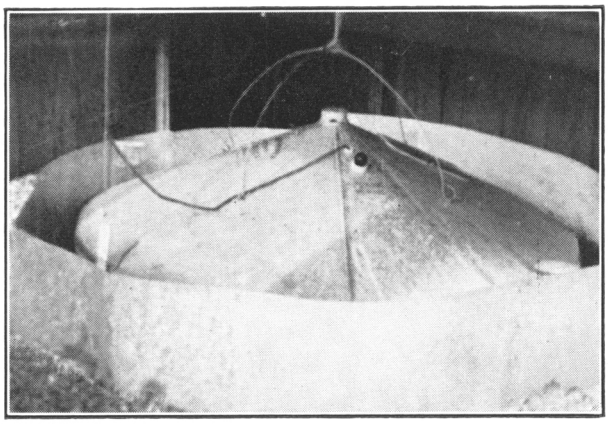

Figure 2.- Commercial electric hover with natural ventilation. Note the metal screen around the brooder to prevent baby chicks from getting too far from the brooder during the first few days of brooding.

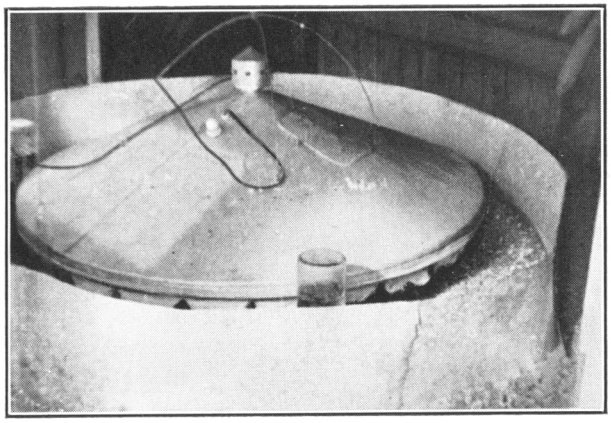

Figure 3.- Commercial electric hover with forced ventilation. The fan unit can be seen at the top of the brooder.

by 30 inches wide and 9½ inches high. It was constructed of wood. Low temperature, 440 watt heating coils were used and controlled thermostatically. Approximate cost - $12.00.

5. Commercial coal brooder: A popular make of brooder with thermostatically controlled draft and designed for the type brooder house used for the tests. Approximate retail price- $20.00.

6. Commercial kerosene brooder: A popular make of kerosene brooder with a thermostatically controlled fuel valve. Approximate retail price - $20.00.

7. Commercial wood stove brooder: Cast iron wood stove with thermostatically controlled damper and tin hover. Approximate retail price - $2.50.

Brooder Houses

Colony type brooder houses approximately 12 feet long and 9 feet wide were used. The houses were all uninsulated, had single thickness tongue and grooved floors and were of similar design. Ventilators were arranged to have the same principle of ventilation in all houses. The brooder houses were all located on the southeastern slope of a hill, as shown in Fig. 1, so that a uniform exposure was assured.

Litter: Peanut hulls and wood shavings were used for brooder house litter.

Brooding stock: Several breeds of chicks were used in the tests; however, an equal number of each breed was placed in each house. All stock

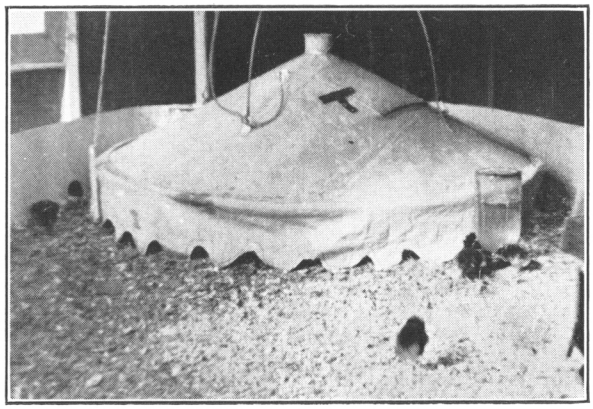

Figure 4.- This electric brooder was made by insulating and electrifying the hover from an old kerosene brooder. Natural ventilation is provided through the ventilator in the top.

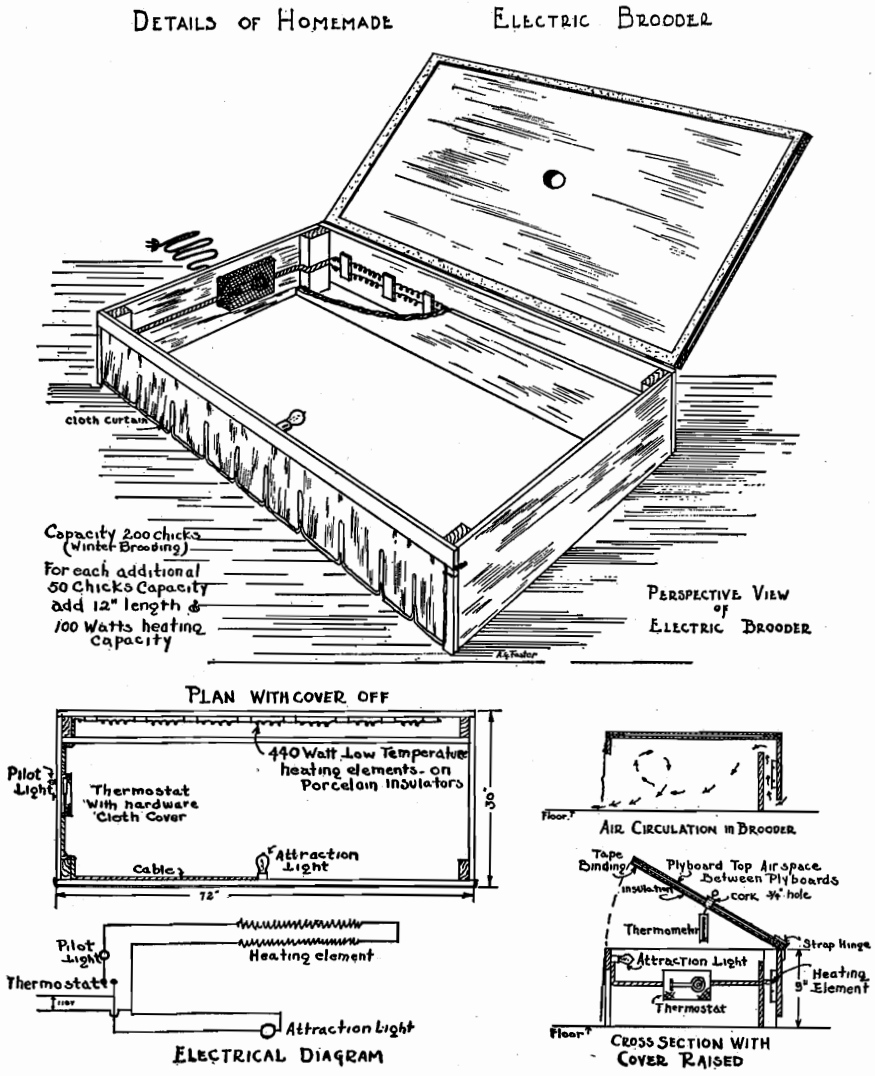

Figure 5. The homemade flat top electric brooder used in the tests in detail.

was state certified and pullorum tested, and the stock for each test was obtained from one hatchery.

Feed: A standard brand of commercially ground and mixed starter and growing mash was used for all the tests. Proper sized feed hoppers were kept filled in each house at all times. Water fountains of the same capacity and design were used in all brooder houses.

Thermometers: Fahrenheit thermometers were used in securing temperature readings at various points in the brooder houses and under the brooders. A continuous record of outside temperature and humidity was secured by a recording hygrothermograph.

Data Sheets: A uniform data sheet was provided for each brooder house and all thermometer readings, fuel consumption, chick mortalities and other pertinent data were recorded on these sheets.

First Series of Tests

The following brooders were used in these tests: commercial electric hover with natural ventilation (Fig. 2); commercial electric hover with forced ventilation (Fig. 3); homemade electric made from old kerosene hover (Fig. 4); flat top homemade electric brooder (Fig. 5); commercial coal brooder (Fig. 6); and commercial kerosene brooder (Fig. 7).

Thermometers were placed at the following points in each brooder house for recording temperatures: (1) at the apparent coldest point, (2) average temperature point, (3) at the edge of the brooder hover, (4) under the brooder hover, and (5) twenty-four inches above the highest po' on the hover. The thermometers were read at approximately 9:00 A.M.

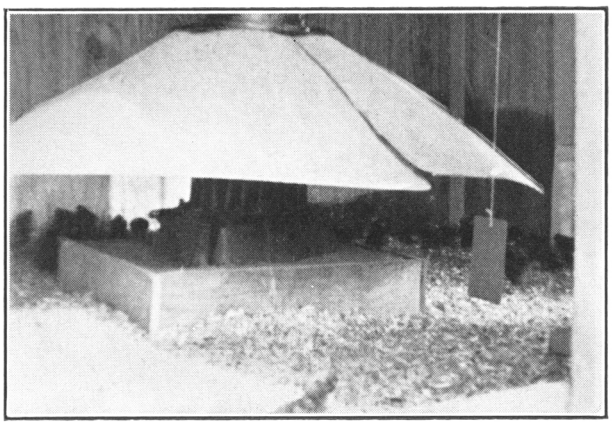

Figure 6.- Commercial coal burning brooder.

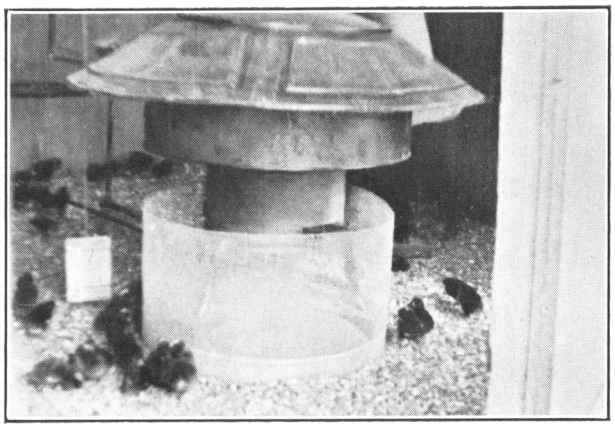

Figure 7.- Commercial kerosene brooder.

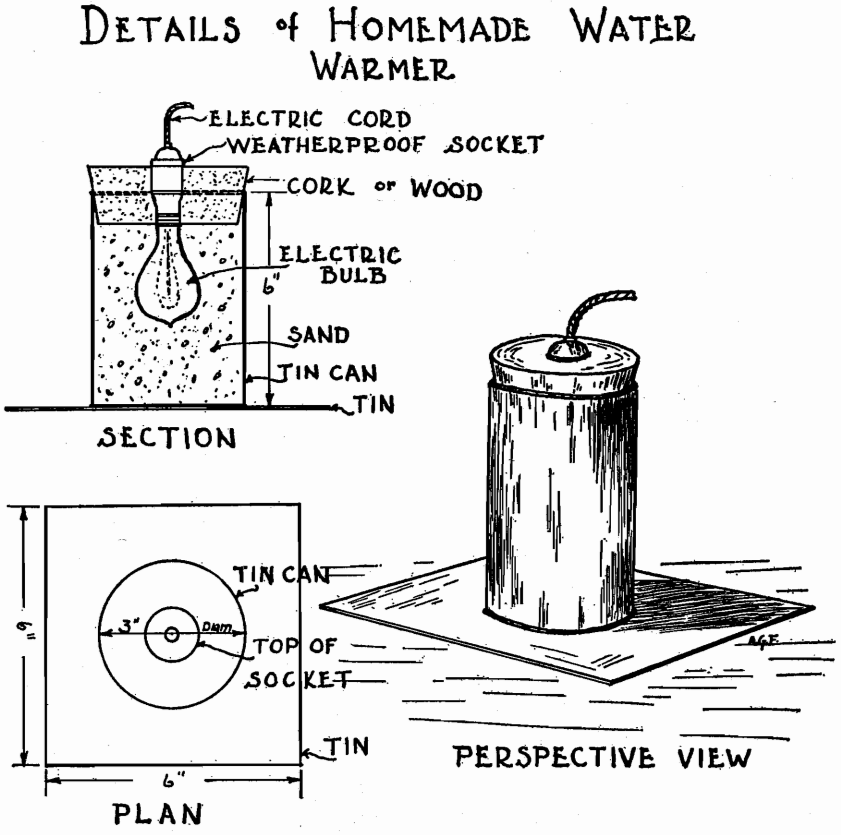

Figure 8.- Details of homemade electric water warmer.

DAILY BROODER RECORD

Brooder Number 2 | Test Number 1 | Month - December 1935

Date	Time	Brooder Temp.	Temp. at Brooder Edge	Temp. at Coldest Corner	Temp. 2' Above Brooder	Average Room Temp.	Dead Chicks	Meter Reading or Fuel		Remarks
								Reading	KWH	
1	10 A.M.	99°F.	57°F.	47°F.	51°F.	50°F.	-	0066	2	
	10 P.M.	100	37	31	33	31	-	0068	2	
2	10 A.M.	98	41	33	38	36	-	0071	3	
	10 P.M.	102	31	19	23	20	-	0076	5	
3	9 A.M.	103	34	25	32	28	-	0079	3	Water frozen in founts.
	10 P.M.	104	40	30	34	30	-	0083	4	
4	10 A.M.	103	54	32	40	38	-	0086	3	
	10 P.M.	101	31	20	28	23	-	0089	3	
5	9 A.M.	97	43	33	38	37	-	0092	3	Ice in water founts.
	9 P.M.	100	43	32	39	33	-	0094	2	
6	9 A.M.	102	53	40	45	44	-	0097	3	Brooder temp. reduced
	10 P.M.	96	40	32	40	34	-	0098	1	to 95°.
7	8 A.M.	98	44	38	40	40	-	0100	2	Drizzling rain.
	10 P.M.	97	47	40	45	40	-	0102	2	
8	9 A.M.	90	54	49	51	50	-	0103	1	Raining.
	10 P.M.	95	58	49	52	50	-	0104	1	
9	9 A.M.	95	60	52	56	56	-	0104	0	Sunny and warm.
	9 P.M.	96	50	40	46	43	-	0106	2	Room light left on.
10	9 A.M.	95	48	41	47	45	-	0107	1	Cloudy and damp.
	10 P.M.	98	45	33	35	35	-	0108	1	
11	9 A.M.	95	49	39	43	40	1	0110	2	
	10 P.M.	99	39	28	35	30	-	0112	2	
12	9 A.M.	95	42	33	40	37	1	0114	2	
	9 P.M.	96	42	33	37	34	-	0117	3	Changed litter.
13	10 A.M.	97	49	42	42	41	1	0119	2	
	10 P.M.	95	50	44	46	43	-	0120	1	
14	9 A.M.	95	68	46	50	46	-	0121	1	
	10 P.M.	100	60	43	50	46	-	0122	1	
15	10 A.M.	96	63	50	52	50	-	0124	2	Stirred litter.
	10 P.M.	96	47	40	45	42	-	0125	1	
16	9 A.M.	97	42	37	40	37	-	0127	2	
	10 P.M.	100	50	32	37	32	-	0128	1	
17	9 A.M.	97	45	34	40	34	-	0130	2	
	9 P.M.	98	47	36	42	38	-	0133	3	
18	9 A.M.	97	44	37	39	36	1	0135	2	
	9 P.M.	98	48	40	41	41	-	0136	1	
19	9 A.M.	100	61	38	42	40	-	0138	2	Changed litter.
	10 P.M.	98	32	27	29	28	-	0139	1	
20	9 A.M.	100	35	23	31	27	-	0140	1	Water founts frozen.
	10 P.M.	100	27	9	13	10	-	0141	1	
21	9 A.M.	97	28	10	14	12	2	0142	1	Water founts frozen.
	10 P.M.	95	37	13	17	15	-	0145	3	Water heaters installed.
22	10 A.M.	94	29	20	24	22	1	0147	2	
	10 P.M.	105	39	23	39	24	-	0150	3	
23	9 A.M.	105	45	26	37	31	-	0155	5	Reduced brooder temp to
	9 P.M.	95	63	32	36	34	-	0156	1	95°.
24	10 A.M.	97	61	31	33	34	-	0157	1	
	9 P.M.	98	40	30	34	28	-	0159	2	Changed litter.
25	9 A.M.	96	42	28	30	30	-	0160	1	
	9 P.M.	92	22	10	18	12	-	0162	2	
26	9 A.M.	90	22	10	12	10	-	0163	1	
	9 P.M.	90	25	14	19	16	-	0165	2	
27	9 A.M.	100	30	16	19	19	1	0167	2	Litter added.
	10 P.M.	98	34	16	21	18	-	0170	3	
28	9 A.M.	103	40	27	32	28	-	0172	2	Attraction light burnt
	10 P.M.	102	37	27	31	28	-	0175	3	out. Inner curtain replac.
29	10 A.M.	102	34	24	26	25	-	0176	1	Stirred litter.
	10 P.M.	102	35	26	31	27	-	0178	2	
30	9 A.M.	103	32	23	28	23	-	0179	1	
	10 P.M.	102	36	21	26	21	-	0181	2	
31	9 A.M.	103	47	37	43	40	-	0183	2	Added litter.
	9 P.M.	100	47	30	35	33	-	0184	1	

TABLE IA. TYPICAL DATA SHEET SHOWING RECORD OF BROODER OPERATION FOR ONE MONTH.

8:00 P.M. each day and the readings recorded on the data sheet. Table 1A shows a typical data sheet from one of the brooder houses during this series of tests.

Twelve hundred Virginia state certified Barred Plymouth Rock chicks were received from the hatchery at 5:00 P.M., November 19, and were placed under the four electric brooders for the night. The kerosene and coal brooders were ready for use the following morning and the chicks were subdivided and 200 were placed under each of the six brooders. Small lights were burned in the coal and kerosene brooder houses at night. After December 9, lights were burned at night in all the electric houses but were not used for the first few weeks because of the danger of attracting the baby chicks from under the hover at night. A tin screen was placed around the electric hovers as shown in Figures 2, 3 and 4 for the first week to prevent the baby chicks from wandering too far from the hover.

During the ten-week period of this brood the weather was severe. The average outside temperature for the entire period was 29.8° F. The lowest temperature during the period was -7° F. and the highest was 56° F. The only difficulty encountered in the electric brooder houses was that of the water freezing in the drinking fountains on extremely cold nights. A homemade electric warmer was devised using a 25-watt light bulb as illustrated in Figure 6. One of these warmers placed in each water pan prevented the water from freezing. A summary of the operation of the brooders and the brooding results of the first tests is shown in Table 1.

TABLE I

THE FIRST SERIES OF TESTS OF CHICK BROODERS BEGINNING NOVEMBER 21, 1935 AND ENDING JANUARY 30, 1936.

Brooder	Times Litter Changed	Chicks reared	Mortality	Total Weight	Average Weight Per Chick	Average Brooder Temperature	Average Outside Temperature	Fuel Consumed
	Number	Number	Percent	Pounds	Pounds	Degrees F.	Degrees F.	
Commercial electric with fan	9	191	4.5	334	1.75	98	29.8	543 kwh.
Commercial electric with natural ventilation	7	181	9.5	325	1.74	99	29.8	288 kwh.
Converted electric	7	170	15.0	300	1.77	95.4	29.8	533 kwh.
Homemade electric	9	177	11.5	329	1.86	98.8	29.8	405 kwh.
Coal	5	185	7.5	366	1.98	79.3	29.8	1895 lbs.
Kerosene	5	182	9.0	346	1.90	92.8	29.8	251 gals.

Second Series of Tests

The homemade electric brooder constructed with the old kerosene hover was omitted from this series of tests because of its high current consumption and generally unsatisfactory performance during the first test. In its place, a new type commercially built wood burning brooder was installed.

The stock for this test consisted of 1,000 Barred Plymouth Rock and 200 Rhode Island Red chicks, all Virginia state certified and purchased from the same hatchery. The chicks were divided so that an equal number of each breed was placed in each house, making a total of 200 chicks per house. The brooding was started on February 11, and records were kept for a period of eight weeks in the same manner as in the first series of tests. The average outside temperature during this brooding period was 44° F. The maximum temperature was 74° F. and the minimum was 7° F. There was precipitation on 45 percent of the days, and 61 percent of the days were cloudy.

TABLE II

THE SECOND SERIES OF TESTS OF CHICK BROODERS BEGINNING FEBRUARY 11, 1936 AND ENDING APRIL 7, 1936.

Brooder	Times Litter Changed	Chicks Reared	Mortality	Total Weight	Average Weight Per Chick	Average Brooder Temperature	Average Outside Temperature	Fuel Consumed
	Number	Number	Percent	Pounds	Pounds	Degrees F.	Degrees F.	
Commercial electric with natural ventilation	5	162	19.0	229	1.42	96.4	44	251 kwh
Commercial electric with fan	5	175	12.5	270	1.54	92.0	44	359 kwh.
Homemade electric	5	186	7.0	273	1.42	95.6	44	387 kwh.
Wood	4	191	4.5	269	1.40	72.9	44	124 cu.ft.
Coal	4	195	3.5	300	1.55	78.0	44	1326 lbs.
Kerosene	4	184	8.0	262	1.42	84.3	44	132 gals.

Third Series of Tests

The following four types of brooders were used in this series of tests: (1) natural ventilation commercial electric, (2) coal, (3) wood stove, and (4) kerosene. The electric brooder used in this test was selected from the four electric brooders that had been used in the other tests because it held the best all-round record of operation.

Conditions under which these tests were carried on were such that it was necessary to keep the chicks confined in the brooder houses during the entire brooding period. In view of these conditions, the number of chicks allotted to each house was reduced to 150. The stock used for this test came from the same hatchery and consisted of an equal number of Virginia state certified Jersey Black Giant, Barred Plymouth Rock and Rhode Island Red chicks. The breeds were all divided equally among the houses in order to assure uniform stock for each house. The maximum outside temperature during this period was 92° F. and the minimum was 37° F. The brooding was started on April 28, and records were kept for a period of eight weeks. All records were kept and data were obtained in the same manner as in the other two tests.

TABLE III

THE THIRD SERIES OF TESTS OF CHICK BROODERS BEGINNING APRIL 28, 1936 AND ENDING JUNE 23, 1936.

Brooder	Times Litter Changed	Chicks Reared	Mortality	Total Weight	Average Weight Per Chick	Average Brooder Temperature	Average Outside Temperature	Fuel Consumed
	Number	Number	Percent	Pounds	Pounds	Degrees F.	Degrees F.	
Commercial electric with natural ventilation	4	140	6.6	226	1.61	96.1	68.7	132 kwh.
Wood	4	143	4.6	228½	1.59	84.6	68.7	44 cu.ft.
Coal	4	139	7.3	220	1.58	83.8	68.7	408 lbs.
Kerosene	4	144	5.2	247½	1.72	85.7	68.7	66 gals.

DISCUSSION OF RESULTS

A study of Tables I, II and III clearly indicates that good brooding results can be obtained with each of the brooders tested, provided they are properly operated. Although the mortality was higher in some brooders than others, in each case this could usually be traced to an accident by the attendant rather than to the brooder.

Close observation of the tests definitely showed some of the faults or weak points that are characteristic of, and may be expected in, each type of brooder. On two occasions the fire died in the coal stove due to burned and clogged grates. It happened that the condition was discovered before the chicks were visibly damaged; however, the difficulty in rebuilding the fire under adverse conditions, and the possibility of the situation not being discovered in time, clearly shows how disasterous this fault might be. On several occasions during the removal of ashes from the coal and wood brooders, ashes were spilled on the dry litter. Although no damage was done because of the carefulness of the attendant, a fire could easily originate from this necessary operation of either of these brooders.

On several occasions the kerosene brooder went out due to clogging of the fuel line and burner. The brooder caught fire once but was discovered and extinguished before doing much damage. The electric brooders failed to heat up properly at first and this was found to be due to low voltage. The effect of low voltage on the performance of the electric brooders

TABLE IV

THE NUMBER OF HOURS OF LABOR REQUIRED TO OPERATE THE CHICK BROODERS DURING THE THREE SERIES OF TESTS

Brooder	Changing Litter			Adjusting Temperature Regulator			Supplying Fuel, Cleaning & Removing Ashes			Total Number of Hours of Labor		
	First Test	Second Test	Third Test	First Test	Second Test	Third Test	First Test	Second Test	Third Test	First Test	Second Test	Third Test
Commercial electric with fan	9	5	-	1½	1½	-	0	0	-	10½	6½	-
Commercial electric with natural ventilation	7	5	4	1	1½	1	0	0	0	8	6½	5
Converted electric	7	-	-	2	-	-	0	-	-	9	-	-
Homemade electric	9	5	-	1½	1½	-	0	0	-	10½	6½	-
Coal	5	4	4	1	2	1	47½	28	19	53½	34	24
Kerosene	5	4	4	2	2	1½	25½	18	9½	32½	24	15
Wood	-	4	4	-	1	1	-	18	9½	-	23	14½

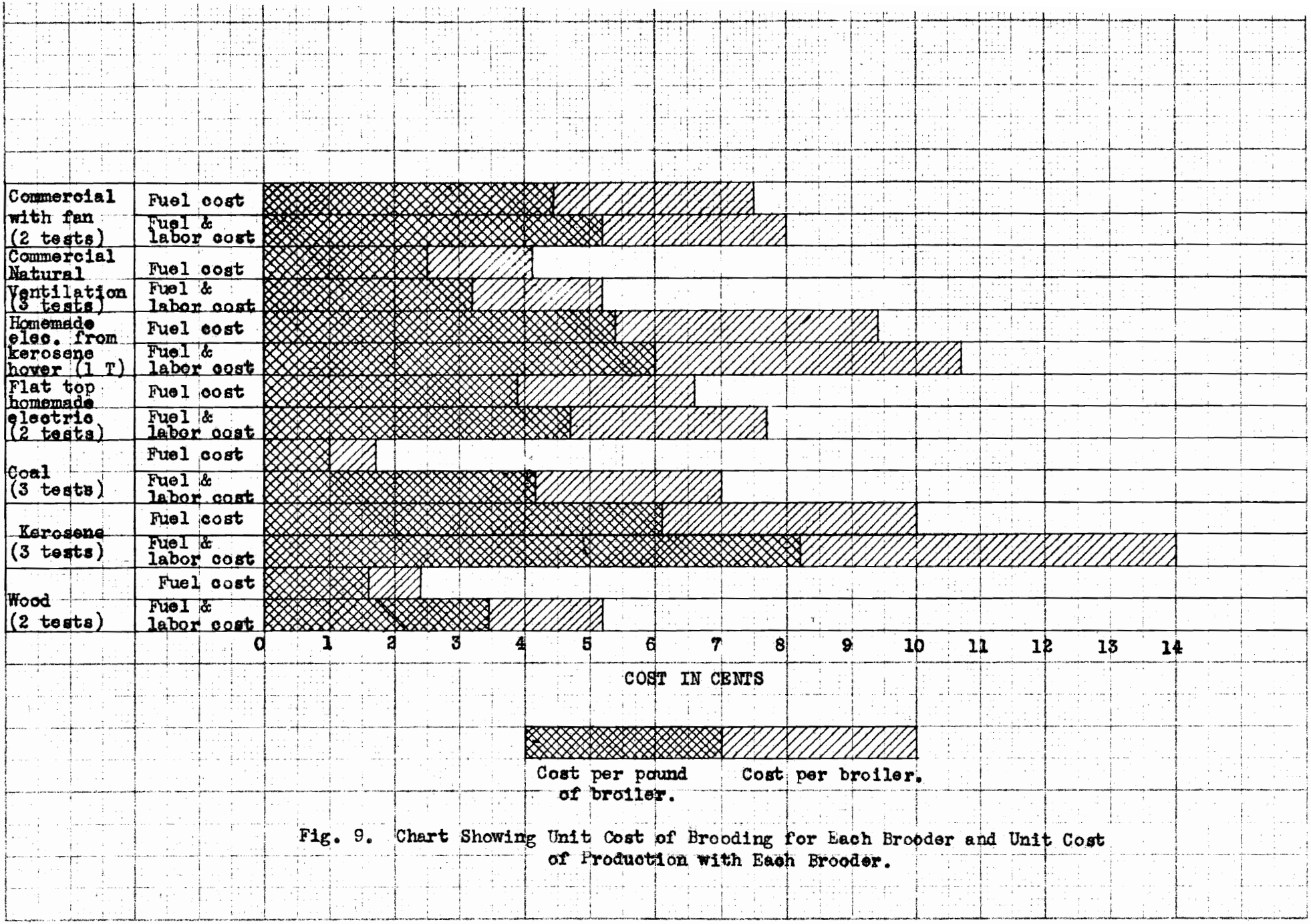

Fig. 9. Chart Showing Unit Cost of Brooding for Each Brooder and Unit Cost of Production with Each Brooder.

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was so significant that this condition could prove disasterous under farm conditions. It clearly showed that the voltage should always be checked before putting electric brooders into actual operation.

Characteristics of the Broilers

There was no consistent variation in the quality of the broilers reared under the different brooders during the tests. The broilers were fairly uniform and the rate of feathering seemed to be about the same in all houses in all tests. The average weight per chick under the converted electric hover was highest; but mortality was also highest under this brooding period. A number of dead chicks were examined and no trace of disease could be found. Some chicks were mashed by attendants while changing litter and these are included in the mortality percentages.

Table V shows an interesting comparison of the labor required for each of the brooders tested. Table VI and Figure 9 compare the operating costs and unit cost of brooding with each type brooder tests. This date is based on prevailing costs of the various fuels at Blacksburg: Coal - $5.00 per ton; kerosene - 12 cents per gallon; wood - $6.00 per cord; and electricity - 3 cents per kilowatt-hour. Since the cost of fuel and labor varies so much in different parts of the county, it is evident that this would probably be the most important factor to consider in deciding which type brooder should be selected.

Advantages and Disadvantages of the Brooders

The following points listed for each brooder give comparative operating characteristics of the brooders tested.

TABLE V

THE COSTS OF OPERATING BROODERS FOR TEN WEEKS IN THE FIRST SERIES OF TESTS AND EIGHT WEEKS EACH IN THE SECOND AND THIRD SERIES OF TESTS.

Brooder	Fuel Cost			Labor Cost at 25¢ Per Hour			Total Operating Cost		
	First Test	Second Test	Third Test	First Test	Second Test	Third Test	First Test	Second Test	Third Test
Commercial electric with fan	$16.29	$10.77	-	$2.63	$1.63	-	$18.92	$12.40	-
Commercial electric with natural ventilation	8.49	7.53	$3.96	2.00	1.63	$1.25	10.49	9.16	$5.21
Converted electric	15.99	-	-	2.25	-	-	18.24	-	-
Homemade electric	12.15	11.61	-	2.63	1.63	-	14.78	13.24	-
Coal	4.73	3.81	1.02	13.38	8.25	6.00	18.11	11.56	7.02
Kerosene	30.12	15.84	7.92	8.13	6.00	3.75	38.25	21.84	11.67
Wood	-	5.83	2.07	-	5.75	3.63	-	11.58	5.70

1. Commercial electric with forced ventilating fan:

No attention required other than occasional adjustment of temperature regulator.
No fire hazard.
Slightly better litter conditions under the hover than in other electric brooders.
Easy to maintain uniform brooding temperature.
Most uniform temperature under hover of all brooders.
High current consumption compared with other electric brooders.
Means of heating drinking water in extremely cold weather necessary.
More litter required in damp weather than for fuel type brooders.
High first cost.

2. Commercial electric with natural ventilation:

No attention required other than adjustment of temperature regulator.
Easy to maintain uniform brooding temperature.
No fire hazard.
Lowest current consumption of electric brooders tested.
First cost lower than the fan type electric brooder.
Considerable dampness in evidence on floor under hover but no noticeable effect on chicks.
Required more litter in damp weather than for fuel type brooders.
Means of heating drinking water in extremely cold weather necessary.

3. Kerosene hover converted to electric operation:

No attention required other than adjustment of temperature regulator.
No fire hazard.
Temperature more difficult to regulate than under other electric hovers.
High current consumption because of inefficiency of insulation.
More temperature regulation required than for other electric brooders.
First cost low but increased current consumption offsets original saving.
Means of heating drinking water in extremely cold weather necessary.
High mortality, probably due to low temperature under outer edges of brooder, allowing chicks to become chilled.

4. Homemade wooden electric brooders:

No attention required other than adjustment of temperature regulator.
Easy to maintain uniform temperature.
Lowest in first cost of electric brooders.
More difficult to clean around than hover type electric brooders.
Screen or other structure required to keep chicks off top of brooder.
More litter required than for fuel type brooder.
Current consumption about the average of all electric brooders tested.
Means of heating drinking water in extremely cold weather necessary.

5. Coal brooder:

Provides heat for entire room making water warmers for drinking fountains unnecessary.
Requires most labor of any type brooder tested.
Presents some fire hazard and must be handled with care.
Requires less litter than with electric brooders.
Difficult to maintain uniform brooding temperatures.

6. Kerosene brooder:

Provides heat for entire room making water warmers for drinking water unnecessary.
Requires considerable labor for supplying fuel and cleaning burner.
Presents greatest fire hazard of all brooders tested and must be operated with extreme case.
Requires less litter than electric brooders.
Easier to maintain uniform brooding temperature than coal brooder.

7. Wood brooder:

Provides heat for entire room making provisions for warming the drinking water unnecessary.
Requires less labor than coal brooder and about the same as kerosene brooder.
Requires same litter as coal or kerosene but less than electric brooders.
Presents less fire hazard than either coal or kerosene brooder.
Occupies considerable space in brooder house, requiring larger building for same number of chicks than any other type brooder.
First cost about same as for good commercial electric.

SUMMARY OF TESTS

The steps taken and work done in conducting the series of brooder tests may be briefly summarized as follows:

1. Typical popular type brooders of standard make and design were selected. Two types of homemade electric brooders were constructed for information on their practicability as compared with commercially built units.
2. The set-up for the tests was planned to have all operating conditions uniform and identical so that the type brooder would be the only varying factor.
3. Three series of tests of normal duration were made to secure information that would be typical for fall, winter or spring brooding seasons.
4. The data secured was summarized to give an actual comparison of the performance of the brooders and operating costs of each.

CONCLUSIONS

1. Although it is certainly desirable to maintain as uniform brooding temperatures as possible under the hover or canopy, the results of these tests show that probably too much stress has been placed on this point.

2. Good brooding results may be had from either electric, kerosene, coal or wood brooders when properly operated.

3. Where the labor item will not be considered in the cost of operating brooders, the most economical brooder to use will depend on the comparative cost of fuels at the place where the brooder is to be operated.

4. The ventilation of the brooder and brooder house is just as important as the maintenance of a uniform brooding temperature. This is true in the fuel heated house because the open fire removed large quantities of oxygen from the air and this must be replenished. In the electric brooder house no effort is made to heat the room and, therefore, good ventilation is necessary to assist in keeping the litter in good condition.

5. The operating results of the converted electric brooder indicate that there is nothing to be gained by trying to convert old hovers into electric brooders. The increased current consumption soon makes up the difference between the cost of rebuilding the brooder and the price of a proved electric brooder.

6. The homemade electric brooder, a plan of which is included in this report, gave good brooding results with an average current consumption.

The tests indicate that the principle on which this brooder operates is a good one. The design is such that good ventilation is assured and the distribution of heat under the brooder is uniform. The total cost of a brooder of this type is approximately $10.00, exclusive of labor. Anyone handy with carpenter's tools can construct the brooder with good success.

7. No particular advantage could be noted in the operation of the commercial fan-type brooder over the standard commercial brooder. Although the mortality rate was slightly lower and the average weight per broiler produced was higher, these factors do not offset the increased investment and cost of operation.

8. During the coldest weather the floors under the litter, and especially under the hovers of the electric brooders, had a tendency to become damp. This was probably due to the prolonged damp weather and to insufficient ventilation during these periods. No ill effects on the chicks were noted as a result of this condition.

9. The firing of the wood and coal brooders, together with the handling of fuel and ashes, required considerable more time and labor than that for other brooders. The kerosene brooder was second in labor requirements. It was necessary to dismantle the kerosene brooder twice during each of the three trials to remove soot.

10. The lowest temperature during the tests was seven degrees below zero. As indicated in Table 1, the average outside temperature for the 10-week period was 29.7 degrees F. This test indicates that a well insulated electric brooder will give good brooding results in an unheated brooder house in the coldest weather that is likely to occur in Virginia.

11. A study of the results of this series of tests shows that over-crowding of chicks in a brooder house tends to lower the average weight of broilers produced.

RECOMMENDATIONS

The results secured from the series of tests appear to be conclusive enough to be used as a basis for certain recommendations.

The flat top homemade electric brooder shown in detail in Fig. 6 operated very satisfactorily. This brooder is easy to construct and will give excellent operating results. It is 72" long and 30" wide and will care for 200 chicks to broiler age in any weather. The brooder can be varied in length to conform with the capacity recommendations at the end of this bulletin. For each additional 50 chicks, 12" should be added to the length of the brooder and the electric heating element capacity should be increased 100 watts. In constructing this brooder, the dimensions shown on the drawing should be followed closely. Only black heat or low temperature heating elements should be used and care should be taken in installing the heating coil on porcelain insulators. The wiring diagram shows all electrical connections and these should be carefully checked.

Bill of Materials

The wood used in constructing the homemade brooder should be thoroughly dry and of good quality. The top can be constructed of two pieces of 3/8" ply wood with a 1/2" dead air space between them, or of insulating board such as Insulite, Celotex, etc., mounted on a supporting frame. The brooder will be more substantial if it is assembled with screws instead of nails. The following materials of given dimensions will be needed:

2 end boards 9" wide, 29-1/8" long, 7/8" thick.
1 back board 8-7/8" wide, 72" long, 7/8" thick.
1 baffle board 6-5/8" wide, 70½" long, 7/8" thick.
1 bottom board 5-3/4" wide, 70½" long, 7/8" thick.
1 front board 2½" wide, 70½" long, 7/8" thick.
2 front battens 2½" wide, 9" long, 7/8" thick.
2 back battens 2" wide, 8-1/8" long, 7/8" thick.
1 insulated top 30" wide, 72" long.
1 front curtain 9" wide, 72" long.
18 ft. binding tape.
6 dozen 1½" wood screws.
1 low temperature electric heating coil, 110 volts A.C., 450 watts.
1 adjustable wafer thermostat, 5 ampere capacity.
10 porcelain 2 wire cleat insulators.
1 porcelain attraction light receptacle.
1 pilot light receptacle.
1 attraction light bulb, 15 watts.
1 pilot light bulb, red, 7½ watts.
1 rubber covered 2 wire extension cord 8 ft. long.
15 feet #16 rubber covered wire.
10 feet loom for two #16 wires.
1 piece 1/4" hardware cloth 15" square.
1 Fahrenheit thermometer not over 3/4" wide.
1 cork stopper 1" diameter.
3 strap hinges, 6".

Installation and Operation

The homemade brooder should be located in the back center of the brooder house with a space of at least six inches between the brooder and the wall. Since fresh air enters the ventilator opening in the back of the brooder, this spacing is necessary to allow a free circulation of air. Because the brooder is flat on top, provision must be made to keep the chicks from flying upon the brooder. This can be done by attaching poultry wire to the back of the brooder houses at a point about four feet above the brooder and letting it extend out over the brooder at an angle of about 45 degrees. An iron rod can be run through the lower edge of the wire to keep it stretched over the front edge of the brooder. If poultry wire is not

available, several layers of paper can be placed on top of the brooder and then be removed a layer at a time as it becomes soiled.

The brooder should be plugged in and started before the chicks are placed under it. The thermostat should be adjusted to maintain a temperature of 98 degrees F. for the first two weeks and then gradually reduced to about 92 degrees as the chicks grow older. A tin screen or wide boards should be placed around the front of the brooder for the first few days so that the chicks will not get too far away from the heat until they become accustomed to the brooder. The feed and water containers should be placed under the brooder for the first few days. Front windows should be kept at least partly open all the time to allow good ventilation, since the litter must be kept dry by ventilation of the house.

The brooder will operate more economically if the floor of the house under the brooder is either insulated or double with paper between. If the entire floor is not double, the extra floor or insulation should be placed under the floor to keep the surface smooth and make cleaning easier.

Space Requirements

(Winter Brooding)

Electric Brooders: 10 square inches per chick under the hover; 115 square inches floor space per chick in the brooder house.

Fuel Type Brooders: 110 square inches floor per chick in the brooder house.

(Spring Brooding)

Electric Brooders: 7 square inches per chick under the hover; 115 square inches floor space per chick in the brooder house, if no outside runway is provided; 75 square inches per chick with runway.

Fuel Type Brooders: 115 square inches floor space per chick, if no outside runway is provided; 75 square inches per chick with runway.

BIBLIOGRAPHY

1. Electric Brooders on Indiana Farms, Truman E. Hienton, Purdue University, Lafayette, Ind. December 1934.
2. Electric Brooding, W. E. Lyon, Lyon Electric Company, San Diego, Cal.
3. Electricity on The Poultry Farm, L. J. Smith and Harry L. Garver, State College of Washington, Pullman, Wash. 1932.
4. Construction and Operation of Electric Brooders, J. E. Dorgherty and B. D. Moses, Univ. of California, Berkley, Cal. 1932.
5. The Electric Brooder, B. D. Moses and T. A. Wood, Univ. of California, Berkley, Cal. 1927.
6. Electricity for Raising Poultry, H. E. Lacy, Georgia State College of Agriculture, Athens, Ga. 1930.
7. Electric Brooding of Chicks, Cir. 46, Univ. of New Hampshire, Durham, N. H. 1934.