4-1952

Electric Chick Brooding Studies

F. D. Yung

F. E. Mussehl

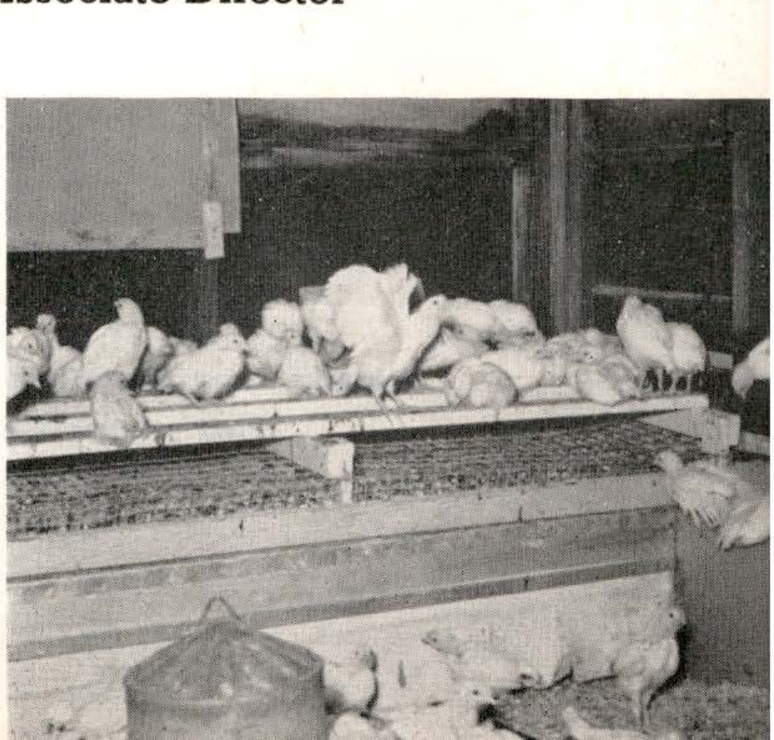
Circular 80
(Revised)

Electric Chick Brooding Studies

F. D. Yung and F. E. Mussehl

Agricultural Experiment Station
University of Nebraska College of Agriculture, Lincoln
W. V. Lambert, Director
M. L. Baker, Associate Director

April 1952



CONTENTS

Nebraska Experiment Station Circular 80 (Revised)

First printing March 1945, 5M

Revised April 1952, 3M

Electric Chick Brooding Studies

F. D. YUNG AND F. E. MUSSEHL

AS rural electric service lines are extended, the use of electric brooders is becoming more general. Electric brooders have several obvious advantages over other brooding equipment—for example, lower fire hazard, lower labor cost, and greater convenience of operation. As brooding principles receive further study, poultrymen are learning that electric brooders provide a natural "hen-like" environment which promotes rapid feathering and normal growth because of the favorable temperature and humidity conditions.

Perhaps one of the most valuable lessons to be learned from a study of chick brooding is that good results can often be obtained in more ways than one. In carrying on work with electric brooders at the Nebraska Agricultural Experiment Station, special attention has been given to such factors as insulation and to other details of design which affect economy of operation and ease of construction. Low cost rather than "cheapness" has been the ideal. The work has been cooperative between the Agricultural Engineering Department and the Poultry Husbandry Department of the University of Nebraska.

Brooding Requirements

Temperatures

For the first week brooder temperature should be maintained at 95° to 100° F., after which it may be lowered about 5° F. per week to a minimum of approximately 85° F. Experienced poultrymen do not rely entirely on the thermometer, but in regulating temperatures for chick comfort, are guided largely by the behavior of the chicks. During the day the chicks should move freely in and out of the brooder while feeding, drinking, and exercising. At night a row of heads showing at the edge of the curtain seems to be a good indication of comfort. If the brooder temperature is too high, part of the chicks may be found outside the curtain. When the brooder is not warm enough the chicks huddle together and may trample to death some of the less vigorous chicks.

Relative humidity

Observations made at the Nebraska Agricultural Experiment Station indicate that relative humidities up to approximately 80 per cent are not detrimental to the continued health of the chicks provided the soiled litter is changed often enough to maintain acceptable sanitation. Chicks brooded under conditions of high relative humidity showed excellent feathering and vigorous growth.

Spacing

For best results in rapidity of growth, economy of gain and general good health, Leghorn chicks should have not less than 8.5 square inches of brooder floor space per chick (17 chicks per square foot). Crowding tends to cause increased mortality, uneven growth, cannibalism, lower economy of gain, poor feathering, and lower quality in general. The following space allowances under the brooder are recommended:

Leghorns	10	square inches per chick
Heavier breeds	12	" " " "
Turkeys	20	" " " "

Size of brooding unit

Although the data obtained at this station cannot be considered conclusive, indications are that units not larger than 200 to 300 chicks have lower mortality, more even growth, and better general health and vigor than do large broods. It is definitely known that 200 chicks per brooder under favorable conditions do exceptionally well; but it seems reasonable to expect that this number could be somewhat larger, provided the previously suggested recommendations for brooder capacity are followed.

Additional evidence of the advantage of small units is furnished by H. L. Richardson,[1] University of Delaware, who reports flock-size studies of chicks in which lowest mortality, highest average weight, and greatest economy of gain resulted with broods of 300 to 400 as compared with those of 401 to 500 and over. His survey included 122 stove brooders.

Electric Brooder and Flock Management

Electric brooders should be started several days before the chicks are put in the house. During this period the temperature adjustments can be made and the brooder thoroughly warmed up. Chicks can be placed under the brooder at any time, but it will be somewhat easier for them to become accustomed to the new environment if they are moved toward evening, and are watched carefully for the first few hours. Placing feeders partly under the brooder and partly outside will help to develop the right feeding habits from the start. Providing plenty of feeders is important. A desirable standard for the first two weeks is one inch of feeder space per chick, and two inches per chick from the second to the eighth weeks.

Growing good pullets for laying flock replacement is one of the chief objects of farm chick raising. For best results in growing pullets, it will be well to separate the cockerels from the pullets at four to six weeks. If crowding is necessary, it is much more excusable to concentrate the cockerels which are to be sold later, than to crowd the pullets. The most favorable conditions

[1] See "Crowding is Costly," by H. L. Richardson, Animal Industry Department, University of Delaware, in *Everybody's Poultry Magazine,* March 1941, p-4.

should be provided for growing pullets because they must develop strong vitality in order to maintain nearly continuous egg production for periods of one to three years.

Chicks should be encouraged to roost as early as possible. With Leghorn chicks started after April 1, it is the usual thing to have chicks roosting at the time they are four weeks old. Low roosting frames with wire underneath the roosts to keep the birds away from the accumulated droppings will be helpful in encouraging early roosting. The top of a flat-topped brooder provides a desirable location for roosts. With this arrangement heat leakage from the brooder tempers the area above, where the roosts are placed, so that earlier roosting is encouraged.

Value of insulation

One of the most important factors in economical brooder operation is insulation. The saving in cost of electricity effected by the use of insulation was plainly shown during the 1937 brooding season [2] when a 200-chick insulated brooder made a saving of 97.5 kilowatt-hours in 6 weeks over a similar uninsulated brooder operated at the same time under similar conditions. This saving should pay for the insulation in one or two seasons. The material used in this case was half-inch insulation board.

Floor insulation is also very desirable for successful electric brooding during January, February and March. If more permanent insulating material cannot be secured, corrugated cardboard obtained from discarded packing cases can be used. Shavings, peat moss or similar litter materials have additional value as floor insulation.

Interruptions of power line service to farms are becoming less frequent as improvements are made in line construction and power transmission equipment. If a long interruption should occur during severely cold weather while the chicks are only a few days old, they must be removed to a warm room or heat must be supplied temporarily to the brooding space. Fruit jars filled with hot water have proved an effective means of providing auxiliary heat. Older chicks give off more body heat and are not so adversely affected by changes in brooder temperatures as very young chicks. A well insulated brooder has a decided advantage over one that is poorly insulated in retaining both the heat from the chicks and the supplemental heat provided during emergencies.

The Nebraska "Standard" Brooder

Members of the Agricultural Experiment Station staff have developed a standard type electric brooder. This piece of equipment occupies a rectangular floor space 27½ inches by 76 inches,

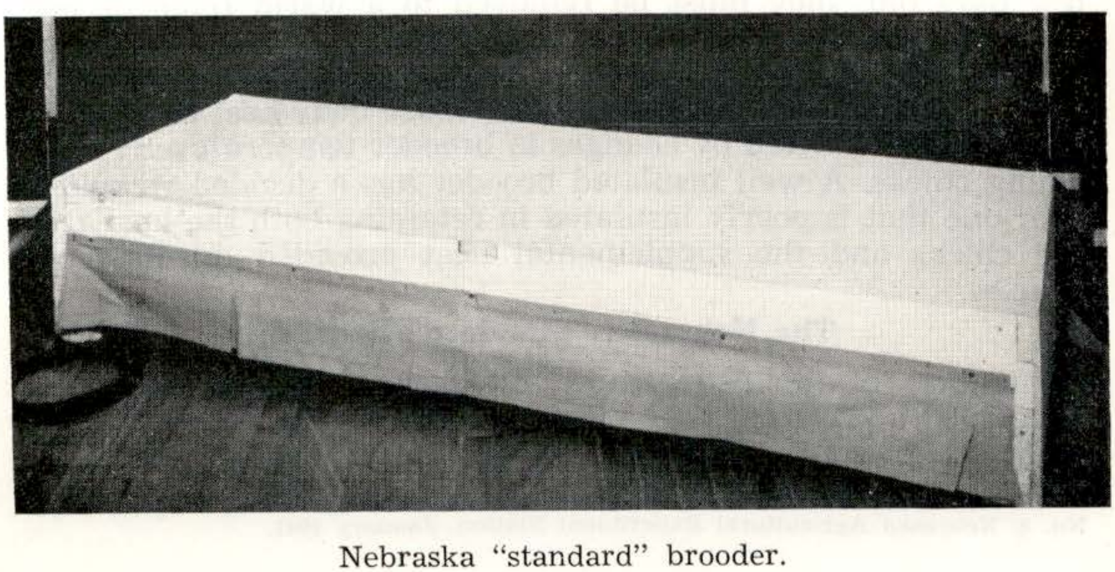
[2] *Studies of Insulated Electric Brooders*, Agricultural Engineering Progress Report No. 8, Nebraska Agricultural Experiment Station. January 1941.

and is 11½ inches high. The inside floor area measures 2 feet by 6 feet, which allows 8.64 square inches per chick. This allowance has proved ample when cockerels are removed at the end of 4 weeks. The top, rear wall and ends consist of a wood frame covered inside and outside with half-inch insulation board. The wood framing thus provides a ¾-inch air space between the two thicknesses of insulating material.

The heating unit consists of 60 feet of lead-covered soil-heating cable. The methods of mounting this cable have progressed through stages of wood slats, loops of insulated wire, and various arrangements of screw hooks to one which consists of a wood frame covered with hardware cloth. The frame, with the soil-heating cable carefully fastened to the upper side of the hardware cloth, is attached to the brooder ceiling by means of long wood screws and wood blocks so that the cable is approximately 9 inches above the floor.

Temperature control of the heating unit was originally by means of a bulb-and-bellows type thermostat which required a temperature range of 6 to 7 degrees to operate. The present thermostat is of the wafer and snap-switch type. These inexpensive thermostats respond to small changes of temperature and have been found very satisfactory. There is ample current-carrying capacity in either thermostat for the 400-watt heating element, and both types are readily adjusted.

The thermostat is located where temperature conditions are close to the average within the brooder. It is high enough from the floor to prevent the accumulation of litter around it and is shielded from the direct radiation of the heating element. A cover built of quarter-inch hardware cloth protects the wafer and switch assembly from damage by the chicks and keeps out litter that might interfere with proper operation.



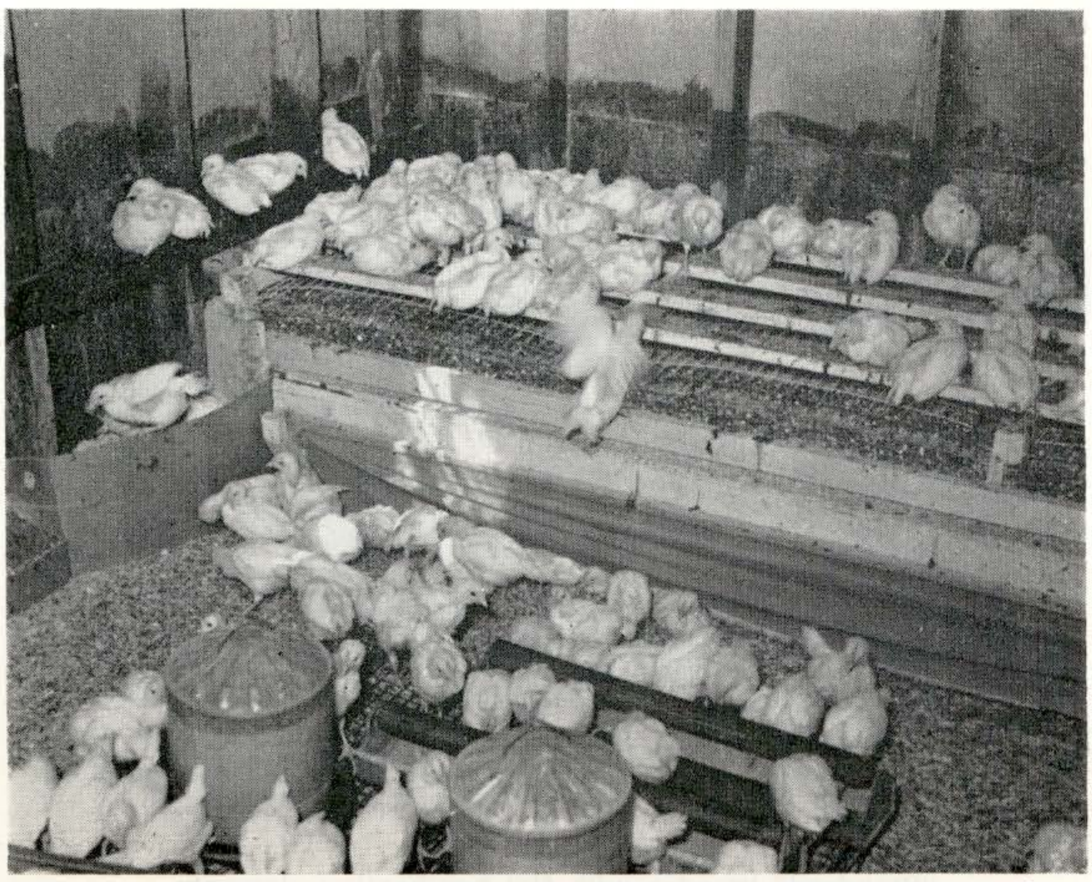
Nebraska "standard" brooder.

The top of the brooder is covered with galvanized iron which protects the top and makes cleaning easier when roosts are placed on it, as is done when the chicks are about 2 weeks old.

Aluminum paint is used on both inside and outside of the brooder. In addition to improving the appearance it seals the surface of the insulating board and prevents damage due to picking by the chicks. It also seems reasonable to assume that aluminum paint improves the insulation in some degree.

Some of the advantageous features of the "standard" brooder may be summarized as follows. This brooder:

1. Can be made on the farm with ordinary tools.
2. Fits readily into various types of brooder houses.
3. Requires no auxiliary heat in a well built brooder house, except in unusually severe weather.
4. Requires a minimum of attention.
5. Reduces fire and shock hazard.
6. Provides uniform distribution of heat throughout the brooding space.
7. Operates economically and yet provides ample heat.
8. Is easily regulated.
9. Is sturdy and dependable.



Nebraska "standard" brooder in operation. Chicks 4 weeks old.

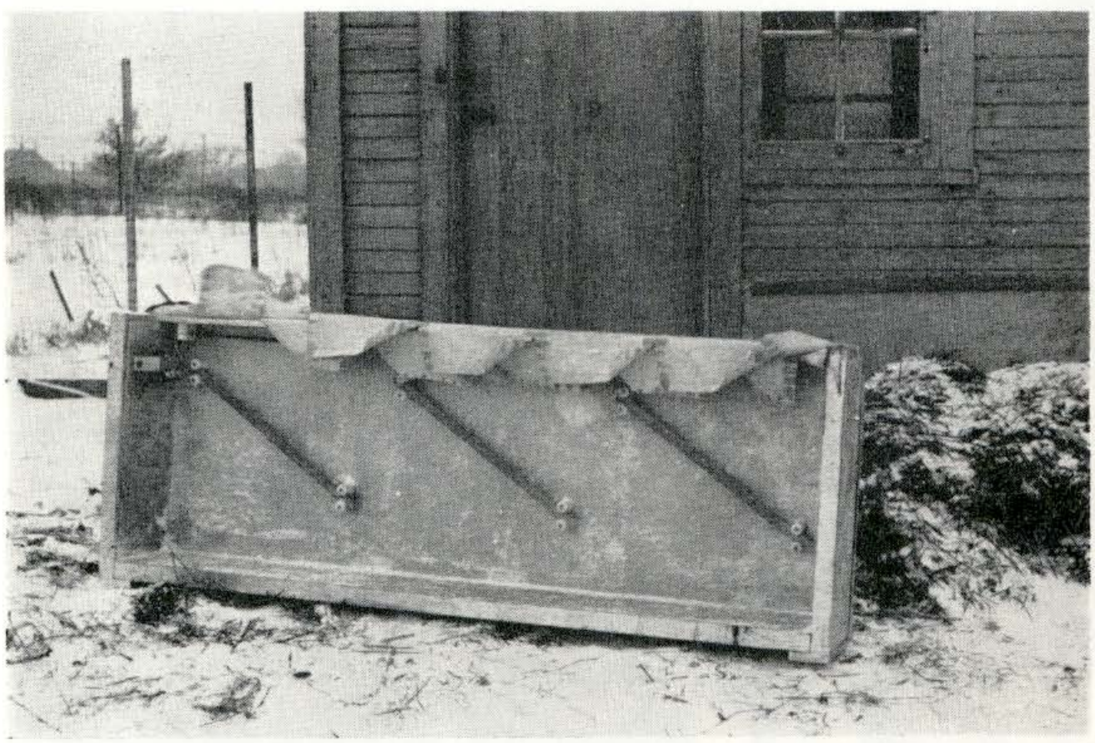
Modifications of "Standard" Brooder

Different types of heating elements have been tried in the "standard" brooder; and features such as ventilating equipment, removable top, brooder vestibule, and increased length have been added for trial. Some of the modifications proved valuable and increased flexibility of use. In other instances the changes were of little or no value.

Heating Elements

Nichrome wire

Various types of heating elements have been tried in experimental brooders. One of the least expensive—but most hazardous—of the elements commonly used is bare nichrome wire. This wire is usually coiled like a small diameter spring for convenience of installation and in some instances operates at "red" heat. The danger of fire from red hot metal is obvious. Coiled resistance wire may be so made and installed as to operate at "black" heat. Fire hazard at "black" heat is undoubtedly less than at "red" heat, but is definitely present. A simple test, using dry paper in contact with the heating element, may be made. If smoke and charring of the paper occur, no further proof of fire hazard should be necessary. There is also danger of electric shock from an exposed current-carrying resistance wire, or any bare wire, when connected to the usual 115-volt service outlet. Because of fire and shock hazards the bare wire heating elements cannot be recommended for safety.



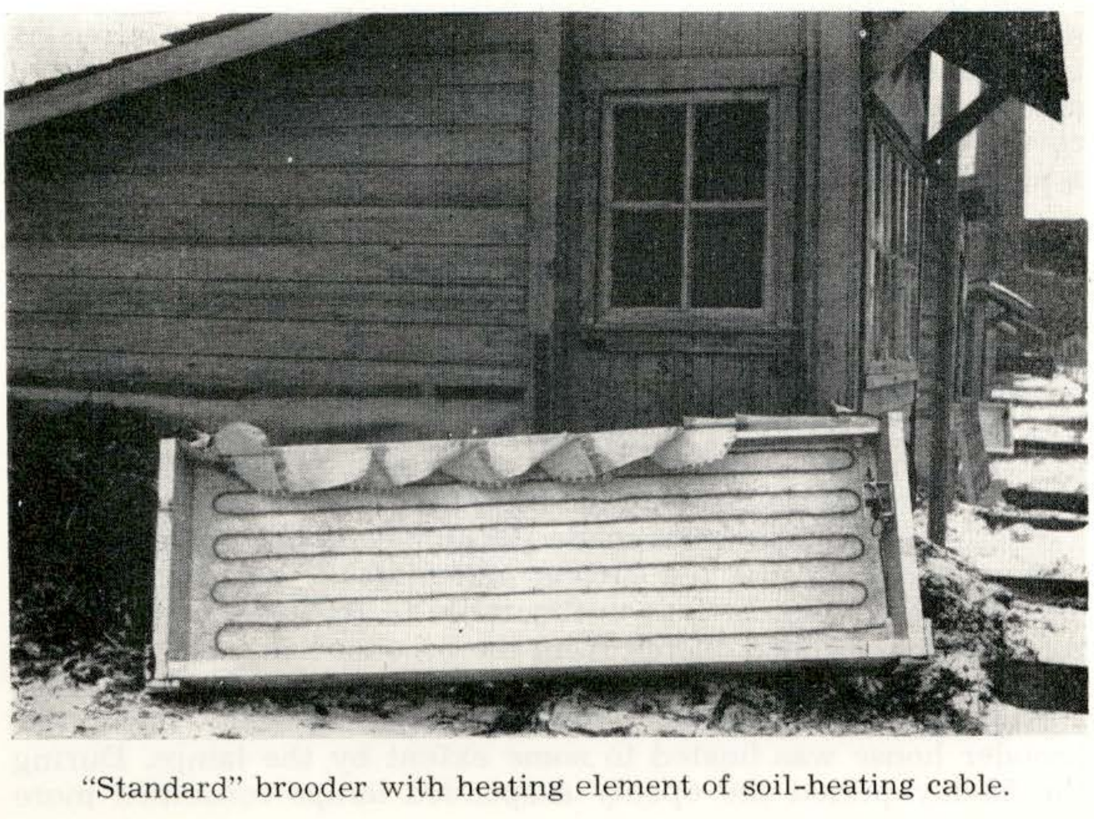
"Standard" brooder with flat bar heating elements.

Flat bar heating elements

Commonly called "strip heaters," these elements are designed for safer operation than bare resistance wire. The current-carrying wire is usually wound on a core and covered with an insulating material which in turn is encased in sheet metal for mechanical protection of the element and to facilitate mounting. Under normal brooding conditions the surface temperature of strip heaters was found to be as high as 500° F. Laboratory tests have shown that paper will char when left in contact with a metal surface having a temperature of 500° F. or even lower. That a fire hazard does exist unless such strip heaters are adequately guarded is evident. Ample protection is necessary to prevent burning of chicks and the hands of the operator.

Soil-heating cable

The heating element used in many of the experimental electric brooders at the Nebraska Agricultural Experiment Station has been lead-sheathed soil-heating cable. In the center of the cable is a single current-carrying resistance wire covered with a layer of long fiber asbestos over which a lead sheath is drawn, making the outside diameter of the cable approximately ¼ inch. The cable is flexible and can be mounted readily in various shapes of brooders. A 60-foot length has the correct resistance for use in a 115-volt circuit and makes a heating unit of approximately 400 watts. It operates at a low surface temperature and does not become hot



"Standard" brooder with heating element of soil-heating cable.

enough to ignite wood shavings, straw, or other inflammable materials used for litter. It is necessary to support the cable uniformly throughout its entire length to prevent checking and cracking of the lead sheath as expansion and contraction occur during the heating and cooling cycle. Heavy, ½-inch hardware cloth (hail screen) is a satisfactory support. The cable is fastened to the top side of a frame covered with hardware cloth. Short lengths of insulated wire hold the cable securely in place, but not tightly enough to prevent slight movement to accommodate the normal expansion and contraction. The heating element thus formed of cable and frame is then mounted by hanging it from the ceiling of the brooder at the desired height. When making the electrical connections, both ends of the lead sheath should be grounded as a safeguard against electric shock should the cable be accidently damaged so as to cause the current-carrying resistance wire to come into physical contact with the lead sheath.

An experimental 60-foot length of heating cable, having a tough asbestos braid covering instead of the lead sheath, has been used one season in a comparison test with lead-sheathed cable. Performance of the new cable was fully satisfactory and its use is being continued to determine its durability. Its potential advantages are lower first cost, longer life, and possibly greater availability if lead is needed for other more important uses.

A rubber-covered soil-heating cable, consisting of a single strand of resistance wire covered with rubber to a total diameter of ⅛ inch, was found to be unsatisfactory for use in brooders because of a tendency of the rubber covering to dry out and crack. The bare conductor, exposed wherever the protective covering cracks and falls off, increases shock hazard and becomes a possible fire hazard.

Infrared lamps

Infrared lamps in gold-plated reflectors were given a preliminary trial in the fall of 1940 as sources of heat for brooding. These 250-watt lamps were suspended from the ceiling in insulated brooder houses so that the heat and light rays were reflected to the floor. A "standard" brooder, heated with lead-covered soil-heating cable, was operated as a check and the study was continued over a period of 58 days beginning early in November.

These preliminary trials made possible some interesting observations and yielded a few strong indications if not definite conclusions. The chief factors unfavorable to the use of lamps and reflectors, suspended openly from the brooder house ceiling, were high cost of operation and spotted zones of comfort for the chicks.

High cost of operation was not surprising since the entire brooder house was heated to some extent by the lamps. During the 58-day period the openly suspended lamps consumed more

Infrared lamps suspended from ceiling resulted in high operating cost without significant advantage.

than double the number of kilowatt-hours used by the "standard" brooder for equal number of chicks.

Comfort zones for the chicks under the lamps were limited in area and there was more or less competition for occupancy of these zones. It seems possible that this factor was responsible in some degree for the higher mortality in chicks under the lamps. Mortality under the "standard" brooder was 1 per cent and under the lights 20 per cent.

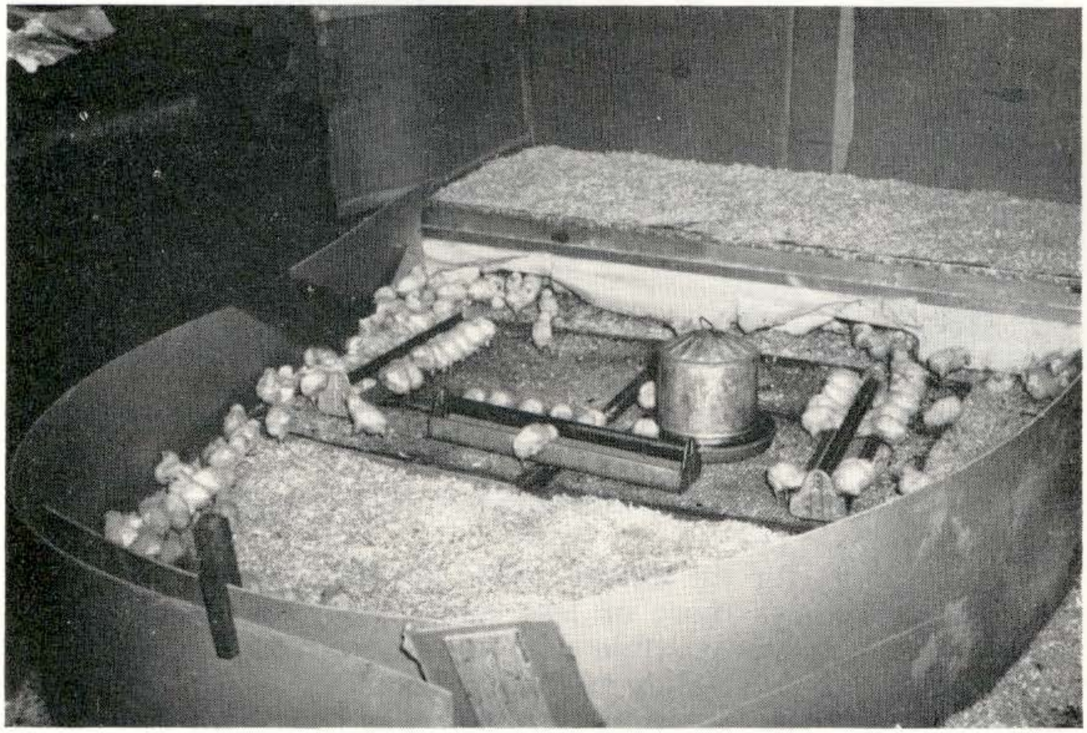
Another experiment was conducted in 1951 in which growth rate, mortality and feathering quality of chicks brooded with an infrared lamp were compared with a similar lot under a conventional black-heat brooder. This experiment was started October 17 and terminated December 12.

Table 1.—Chick brooding data for 1951.

	Infrared lamp 30" above floor	Conv. brooder
No. chicks per lot	150	150
Wt. at start (gms.) Oct. 17	36	36
28-day wts. (gms.) Nov. 14	286	354
56-day wts. (gms.)	895	908
Mortality (per cent)	4.7	2.7
Feed conversion factor	2.72	2.57
Feathering quality	Fair	Good
Approx. cost per chick at 2c per kwh (cents)	4.0	1.5

Table 1 summarizes the growth data, mortality and feathering of chicks in this comparison.

These results are in general agreement with those of Tomhave, Seeger and Lucas[3] who report that the use of infrared bulbs in brooding broilers resulted in an increase in the number of poorly feathered birds and an increase in the fuel costs, as compared with individual coal burning brooder stoves. They reported little difference in mortality, average final weight, and feed required per unit of weight gain.



Lamp-heated brooder provides excellent brooding conditions.

Tungsten-filament lamps

The tungsten-filament lamps commonly used for illumination in the home are also suitable for brooder heating. They are readily available, inexpensive and easily replaced if burned out or broken. Two lamp-heated brooders similar to the "standard" were built and operated for observation during January and February 1942 at the Nebraska Agricultural Experiment Station. One of these was heated by eight 50-watt Mazda lamps and the other by four 100-watt lamps of the same type.

Observations of the behavior, growth and health of the chicks under the lights indicated excellent brooding results and no serious detrimental effects from illumination. These observations

[3] *Types of Brooding for the Production of Broilers,* Technical Bulletin No. 292, Delaware Agricultural Experiment Station, May 1951.

on the effect of illumination were in agreement with those made during the 1940-41 season when infrared drying lamps, producing considerable light, were used as heating elements in an insulated brooder similar to the "standard."

No significant difference in effectiveness was found between the eight 50-watt lamps and the four 100-watt lamps as heating elements. A slightly larger investment in lamps, porcelain receptacles and wire is necessary when eight lamps are used rather than four. In either case the lamps may be considered as a reserve for lighting farm buildings and for household use.

Although the 100-watt lamps mounted on the brooder ceiling extended to within a few inches of the litter, no ill effects on the chicks were apparent. Since the 50-watt lamps are shorter and operate at lower temperatures they are preferred by some operators.

Fire hazard due to the use of lamps mounted on the brooder ceiling was considered negligible. Normal accumulations of litter, caused by the scratching of the chicks, were found in the corners, ends and rear of the brooder but did not reach the lamps. Shock hazard was reduced to a minimum by careful wiring and the use of two-piece combination-base porcelain receptacles.

Caution. A lamp, or any electric heating unit, gives off heat continuously while in operation. This heat must be allowed to escape or surface temperatures of the heating unit may rise to dangerous levels. Laboratory trials in which dry wood shavings were packed around the bulbs of common Mazda lamps so as to cover approximately one third of the glass area have shown that sizes as small as 50 watts will char the shavings and thereby create a fire hazard. In one instance during the 1943 season an experimental lamp-heated electric brooder gave definite evidence of such a fire hazard. The brooder was generously supplied with litter of wood shavings which were soon piled high in the rear of the brooding space by the activity of the chicks. The shavings were crowded against several 100-watt lamps mounted on the rear wall of the brooder and a fire resulted that damaged the brooder and destroyed a number of chicks.

Surface temperatures of 50-watt and 100-watt lamps and of the commonly used soil-heating cable are not normally high enough to create a fire hazard when freely exposed to the air. An occasional piece of litter coming in contact with such a surface would not be so likely to ignite as it might if lodged against the surface of a high temperature heating element such as bare nichrome wire. As a precautionary measure it is advisable not to mount any heating element on the rear wall of a hover or in any location where litter can accumulate around it. The ceiling of the brooder is perhaps the safest place for the heating unit. Noninflammable litter material such as sand is an additional safeguard.

Reflector lamps and projector lamps

These lamps have built-in reflectors to concentrate and direct the light and heat rays from the filament. They were used during the 1942 season in a rectangular brooder built of plywood and similar in construction to the brooder reported in January 1942 by the Ohio Agricultural Experiment Station.[4] The lamps were mounted in a horizontal position so as to project the light and heat rays across the brooding space rather than downward to the floor. The purpose of this lamp arrangement was to warm the chicks by direct radiation and to some extent by conduction as the air under the brooder became warm during the periods when the lamps were operating. Brooding results as compared with the "standard" were satisfactory except for higher power cost and poorer feathering.

The size of heating element

In a brooder the proper size of the heating element depends on the insulation and the conditions under which it is operated. A well insulated brooder carefully installed in a tight, well insulated brooder house with double floor operates satisfactorily on a surprisingly small heating unit even in cold weather. No other heat is needed in the brooder house except possibly in extremely cold and windy weather. The "standard" brooder, shown on page 6, has a 400-watt heating unit which has proved ample for 200 chicks under average conditions. Probably this average of 2 watts per chick should be treated as a minimum applicable only to the best of housing and should be increased generously for unfavorable brooder house conditions such as are caused by poor floors, unbanked sides and uninsulated walls and ceilings. With good thermostatic control a heating unit with ample reserve capacity will use very little if any more electricity than a unit just large enough to suffice by operating continuously in severe weather. The first cost of extra capacity is small for the added protection it affords. Operating cost of the larger unit is very little more in mild weather, because it operates a smaller proportion of the time as compared with a smaller unit.

Ventilation

In 1938 fan ventilation was compared with no ventilation in two essentially "standard" brooders, under similar operating conditions. During the first 6 weeks of the season, beginning February 16, the ventilated brooder used 155 kilowatt-hours while the unventilated brooder used 116.1 kilowatt-hours. Relative humidity in the two brooders was approximately the same during the

[4] *New Electric Lamp Brooder,* by D. C. Kennard and V. C. Chamberlin, Special Circular No. 63, Ohio Agricultural Experiment Station, January 1942.

first 3 weeks, ranging from below 10 per cent when the chicks were small to 35 to 40 per cent as they became larger. Relative humidity in the ventilated brooder averaged 39 per cent for the entire 6 weeks while that of the unventilated brooder averaged 67 per cent. The litter under both brooders was changed whenever its condition became objectionable. The number of changes made were the same in each. There was no distinguishable difference in general health and rate of growth of the chicks in the two brooders.

Briefly summarized, the results of the 1938 season seemed to indicate that with the small ventilating fan the relative humidity can be kept definitely lower than in an unventilated brooder, but at an added cost and without apparent benefit to the chicks.

In 1940 the use of vertical tubular ventilators for natural draft ventilation resulted in indications similar to those obtained with fan ventilation during the 1938 season. The brooder having natural draft ventilation used more electricity than the "standard" under similar conditions and apparently produced no better results.

These indications were not interpreted as applying necessarily to all brooders in general since the brooders under comparison were only 2 feet wide from curtain to rear wall. Undoubtedly the movement of chicks in and out under the curtain provided some degree of ventilation for these comparatively narrow brooders.

The effect of width from curtain to rear wall was studied in the spring of 1941. For comparison with the "standard" brooder, 2 feet in width, similar brooders 3 and 4 feet wide were built and operated with proportionate numbers of chicks under similar conditions. From the time the chicks were put under the brooders differences in behavior were observed. The 200 chicks in the 2-foot wide "standard" brooder were normal in behavior, but the 300 chicks. Changing the temperatures within the brooders did not portion of the brooding space. This action became so pronounced that part of the chicks were crowded out of the brooder and tended to pile up for warmth just outside the curtain. This tendency was even more marked in the 4-foot brooder with its 400 chicks. Changing the temperatures within the brooders did not decrease this objectionable tendency and the introduction of attraction lights had no apparent effect. Observation of the movement of the chicks while feeding and exercising suggested the answer. As observed, the chicks on reentering the brooder after feeding did not find it necessary to go all the way to the rear of the brooding space to find comfort but settled down only part way back. Chicks entering the brooder a little later stopped near the others, usually between them and the curtain. As a result these chicks filled the front half to two-thirds of the brooding space, making it difficult or impossible for the rest of the brood to get in. Piling up outside the curtain was the result. The number of chicks actually inside the curtain in both 3-foot and 4-foot brooders was approximately the same, thus leaving a greater number huddled together outside the 4-foot brooder than outside the 3-foot brooder. No such crowding was observed in front of the 2-foot brooder.

Carbon dioxide tests

After removing the surplus chicks from the 3-foot and 4-foot brooders it was observed that the rear portions of both brooders continued to be unused, the unsoiled condition of the litter bearing out this observation. Since the brooders were unventilated it was deemed advisable to learn something of the carbon dioxide content of the stagnant air. Samples of the air were taken in daytime and also at night when the chicks were nearly all under the brooder and moving about very little. Analysis revealed that the carbon dioxide content of all samples taken was well under 1 per cent. In subsequent tests with chicks in an air tight enclosure it was found that chicks did not show drowsiness or other evidences of discomfort until the carbon dioxide content of the air reached 5 or 6 per cent. These observations seem to indicate that even under rather poor conditions of ventilation there may not be serious danger to the chicks.

Removable top

The purpose of the removable top was to make easier the periodic inspection and cleaning of the brooder. The 60-foot length of soil-heating cable was mounted around the sides and ends of the interior leaving the top free to be lifted off. The energy consumption of this brooder was approximately the same as for the "standard." It is possible that as the brooder becomes older, warping or careless handling of the top may cause it to fit improperly, resulting in increased cost of operation. The mounting of the soil-heating cable around the sides and ends had no detrimental effect on the quality of brooding. The use of roosts on top of the brooder after the first two weeks nullified the advantages for inspection and cleaning for the rest of the season.

Vestibule

During the 1939 and 1940 season an 8-inch extension or vestibule with curtain, was attached to the front of one of the "standard" brooders by means of hinges. When lowered in place it provided an additional 8″ x 72″ enclosed unheated space between the brooder curtain and the vestibule curtain. The added space served to relieve crowded conditions as the chicks became larger and also offered a wider selection of temperatures for the comfort of the chicks. The vestibule contributed toward economy of operation by conserving some of the heat normally lost at the brooder curtain. The hinged addition was readily folded back for easy access to the brooder.

Seven foot "standard"

Increasing the length of the standard brooder by 1 foot added 16.7 per cent to the brooding space, making its capacity about 235 chicks. When operated under the same conditions as the 6-foot "standard" with 200-chick capacity the energy consumption was only slightly higher and no significant difference was noted in the quality of the chicks. When weather conditions are not too severe there seems to be no reason why the brooder length can not be increased to 7 feet and possibly more in a well insulated brooder house. It seems preferable to increase length rather than width so as to minimize ventilation problems but it should be remembered that increasing either length or width decreases the desirable reserve wattage per chick.

Attraction lights

Such lights are considered important by many poultrymen. It is also true that many fine broods of chicks have been raised without them. Most of the experimental brooders used at Nebraska have had no attraction lights and their absence has not been observed as detrimental. Nevertheless, under average conditions, the advantages of attraction lights are so many and the disadvantages so few that it seems advisable to recommend their use. Except for the trouble and slight expense of wiring and the small cost of replacing burned-out bulbs there seems to be little reason for not using them. One small lamp, red or white in color, is ample.

A pilot light

A pilot light is a convenient visual indication that the brooder is in operation. It is so connected that it glows when the heating element is "on." A number of "power off" alarms are available which close a battery circuit to a bell, buzzer or light when a power failure has occurred. When warning is given promptly the necessary emergency measures can be taken for the welfare of the chicks, such as placing fruit jars of warm water under the brooder or removing the chicks to a warm room.

Building the Brooder

Experimental and field observations have indicated that a satisfactory brooder may be of varied design and can be built of a wide range of materials. The generous use of insulation is desirable for economy of operation, and ample room for the chicks is essential for best results. Good brooder design and construction must be combined with experience and diligence on the part of the operator and the selection of well bred disease-free chicks to assure greatest success.

Electric Brooder Studies—1937 to 1940

The studies were carried on in brooder houses alike in essential details. The houses were of the same size (8 x 12 feet) and were similarly located, being in an east-west row facing south. All houses had double wood floors and were not provided with auxiliary heat or special ventilation.

The brooders used during the four seasons are briefly described as follows:

Brooder A—("Standard"). 200 chicks. Inside floor area 6 x 2 feet or 1728 square inches. Double walls of 7/16-inch insulation board with ¾-inch air space (except for wood framing) in top, ends, and rear. The front was closed with a 6-inch double canvas curtain. The heating element, 400 watts, consisted of 60 feet of soil-heating cable hung from the brooder ceiling. Temperature control was by means of a bulb-and-bellows type thermostat.

Brooder B—(Curtains on two sides). 200 chicks. Same as brooder A except that only the top and ends were of double-wall construction. Both sides were provided with 6-inch double canvas curtains.

Brooder C—(Round, uninsulated). 200 chicks. Had a conical top 48 inches in diameter made of galvanized iron. Floor area 1810 square inches. Six-inch double canvas curtain around entire circumference. No insulation. Heated with 60 feet of soil-heating cable (400 watts), bulb-and-bellows type thermostat.

Brooder D—(Round, insulated). 200 chicks. Same as brooder C except that it was insulated with 7/16-inch insulation board fitted to the inner surface of the top.

Brooder E—(Fan ventilation). 200 chicks. Same as brooder A except method of heating. The heating unit consisted of 660-watt element of coiled nichrome resistance wire centrally located at the top of the brooding space with a small fan to aid in ventilation and to circulate the warmed air. A small adjustable opening just above the vertically mounted fan supplied fresh air to be mixed with the air in the brooder. Temperature control was by means of a wafer-type thermostat.

Brooder F—(Round, asphalt paint). 200 chicks. Same as brooder C except insulated like brooder D and the inside painted with asphalt paint.

Brooder G—(Round, aluminum paint). 200 chicks. Same as brooder F except inside sprayed with aluminum paint.

Brooder H—(8-inch vestibule). 200 chicks. Same as brooder A except that a "vestibule" was hinged to the front of the brooder and when lowered in place provided an additional 8-inch enclosed space between the brooder curtain and the "vestibule" curtain.

Table 2.—Chick brooder data for four seasons—1937 to 1940 (inc.).

Brooder	Description	Brooder house insulated	No. chicks started	Mortality (%)	Six-Weeks Period: Temperatures: Brooder av. (°F.)	Six-Weeks Period: Temperatures: Outdoor mean (°F.)	Six-Weeks Period: Av. wt. cockerels end 4 wks. (lb.)	Six-Weeks Period: Electricity used: Total (6 wks.) (kwh)	Six-Weeks Period: Electricity used: Per day (kwh)	Six-Weeks Period: Electricity used: Per chick reared (kwh)
			1937 Season—Beginning February 17							
A	"Standard"	Yes	200	4.5	87.6	34.0	0.49	129.5	3.08	0.678
B	Curtains on 2 sides	Yes	200	4.0	86.5	34.0	0.49	180.7	4.30	0.941
C	Round, uninsulated	Yes	200	4.0	93.5	34.0	0.46	225.2	5.36	1.172
D	Round, uninsulated	Yes	200	2.5	94.8	34.0	0.48	127.7	3.04	0.655
			1938 Season—Beginning February 16							
A	"Standard"	Yes	200	7.5	91.6	39.0	0.54	116.1	2.76	0.627
E	Fan ventilation	Yes	200	8.0	92.8	39.0	*0.46–0.54	155.0	3.69	0.842
F	Round, asphalt paint	Yes	200	2.5	93.0	39.0	0.46	147.4	3.51	0.755
H	8-inch vestibule	Yes	200	6.5	92.1	39.0	0.47	92.7	2.20	0.495
			1939 Season—Beginning February 12							
A	"Standard"	Yes	200	16.7	96.38	39.4	0.392	110.0	2.62	0.628
H	8-inch vestibule	Yes	200	9.5	94.64	39.4	0.599	111.9	2.66	0.589
I	Removable top	Yes	200	8.1	95.78	39.4	0.510	115.7	2.74	0.597
J	Nichrome wire	Yes	200	7.6	97.04	39.4	0.559	134.4	3.19	0.690
			1940 Season—Beginning February 21							
A	"Standard"	Yes	200	1.5	99.5	34.5	0.582	141.4	3.36	0.72
G	Round, aluminum paint	Yes	200	4.0	97.6	34.5	0.569	120.2	2.86	0.63
K	"Standard"	No	200	2.0	98.4	34.5	0.585	171.0	4.07	0.87
L	Tube ventilators	Yes	200	2.5	101.7	34.5	0.582	194.6	4.63	1.00
M	7-foot "standard"	No	200	5.0	99.7	34.5	0.563	179.9	4.28	0.95
N	Strip heaters	Yes	200	4.0	98.8	34.5	0.565	138.9	3.31	0.72

* Not all removed at same time.

Brooder I—(Removable top). 200 chicks. Same insulation as brooder A. Entire top removable for convenient access to the inside. Heated with 60 feet of soil-heating cable mounted around the sides and ends, leaving the top free for removal. Temperature control was by means of snap-switch and wafer thermostat.

Brooder J—(Nichrome wire). 200 chicks. Same as brooder A with the following exceptions:

(a) Heating was by means of coiled nichrome resistance wire (400 watts at 115 volts) supported on the ceiling with porcelain knobs.

(b) The heating unit was shielded from the brooding space by ⅛-inch asbestos board, slotted to permit air circulation.

(c) Temperature control was by means of a snap-switch and wafer thermostat.

Brooder K—("Standard"). 200 chicks. Same as brooder A in all essential details. Temperature control by means of a snap-switch and wafer thermostat.

Brooder L—(Tube ventilators). 200 chicks. Same as brooders A and K except for two 2-inch adjustable tubular ventilators, one in each rear corner.

Brooder M—(7-foot "standard"). 235 chicks. Same as brooders A and K except:

(a)One foot longer (inside floor area 7 x 2 feet).

(b) Panel or slab-type construction. Top, ends and rear built as separate panels and nailed together to assemble the brooder. Temperature control by means of a snap-swtich and wafer thermostat.

Brooder N—(Strip heaters). 200 chicks. Same insulation and construction as brooders A and K but heated with three 150-watt strip heaters. Temperature control by means of a snap-switch and wafer thermostat.