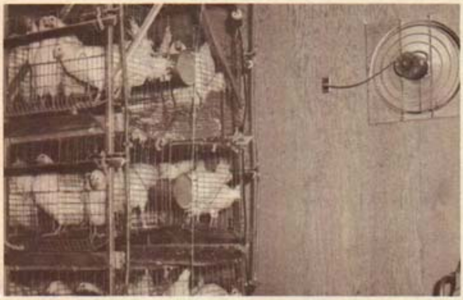

EXTENSION BULLETIN 524
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Poultry Housing for Layers

Replaces Farm Building Circular 744

COOPERATIVE EXTENSION SERVICE
MICHIGAN STATE UNIVERSITY

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POULTRY HOUSING FOR LAYERS

By M. L. Esmay, C. C. Sheppard and H. C. Zindel

Departments of Agricultural Engineering and Poultry Science

The design and construction of a poultry housing system must provide for:

1. Top performance of the layers
2. Optimum environmental control
3. Functional arrangement of equipment
4. Maximum labor efficiency
5. Satisfactory waste disposal
6. Minimum housing cost per dozen eggs produced

Under good management, layers will attain top performance with either a floor or a cage system. A house width of 36 to 40 feet, depending on the space requirements of cages or floor equipment is *optimum*. In houses of this width an automatic, mechanical, exhaust-type ventilation system operates most effectively.

The 36- to 40-feet house width is economically adaptable to clear-span roof trusses. Cages and equipment may be suspended from them. The length of the house may vary in length from 200 to 1,000 feet.

THE WINDOWLESS HOUSE

Consideration should be given to a *windowless* house. In favor of no windows are:

1. Less expensive to build.
2. More complete control of ventilation during all seasons may be attained.
3. Better overall insulation and less uncontrolled infiltration of air.
4. Easier control of light
5. No cold window glass for condensation, cold drafts, or radiant heat absorbers.

Disadvantages of windowless houses are:

1. Must have uninterrupted supply of electricity for light and ventilation.
2. Require higher electricity consumption during hot weather for continuous operation of lights and ventilation fans.
3. Must have enough fan capacity for maximum air movement through the house during hot weather.
4. Need summer and winter ventilation air inlet systems.

No supplemental heat is necessary to maintain the house temperature above 50°F. in Michigan throughout the winter if layers are housed at near one square foot of equivalent floor area or less. The house must be insulated R-value of 10 or above (R-values are explained in the last part of this bulletin).

For optimum summer and winter environmental control, the house should have an insulated ceiling 8 to 10 feet above the floor. This height minimizes house volume to provide better air movement and environmental control.

The housing and equipment investment for a 5,000-bird layer operation is shown in Table 1 (page 3) in terms of monthly or yearly payments and cost per dozen eggs produced. One can easily determine from this table the affect of the variables of housing and equipment cost from $2.00 to $5.00 per bird, interest rates from 5 to 7%, and lengths of loan from 5 to 10 years. The significance of the housing and equipment investment is readily observed.

Keep in mind that the cost per dozen is for every dozen produced in the house for the period of time covered by the loan at the assumed production rate for 5,000 birds. The housing and equipment investment per bird usually decreases for larger houses up to 20,000 to 25,000 birds. This factor may be considered in using this Table by selecting a lower cost per bird. Even though your estimated costs may not come out to be an even dollar per bird, this Table should be valuable for planning purposes. Note the difference between simple interest rates and the add-on type. Simple interest saves over ½ cent per dozen (.61 cents per dozen) at the rate of 6% for a 10-year loan on a $4.00 per bird housing and equipment cost.

ENVIRONMENTAL CONTROL

An optimum *controlled environment* with a temperature not less than 50°F. throughout the winter months is possible in Michigan and similar northern states. Heat from the birds is sufficient to:

(1) Keep the house warm.

(2) Warm incoming ventilation air.

(3) Evaporate excess moisture.

The above however, is only possible with the management systems and insulated houses as described in this circular.

Figure 1 shows the desirable temperature ranges for chickens for both summer and winter seasons. The thermal neutrality zone (61.5° to 81.0°F.) is the range of room temperatures within which the birds can maintain body temperatures with their normal metab-

Table 1.—Housing and equipment capital investment for a 5,000 bird layer operation. Production rate is assumed to be 17½ dozen eggs per year per bird housed.

House & Equip. Cost per bird	Total Cost	Interest Rate	Length of Loan	Monthly Payment	Yearly Payment	Cost per dozen
$2.00	$10,000	5% add on	5 yrs.	208.33	2500.00	2.86¢
3.00	15,000	5% add on	5 yrs.	$312.50	$3750.00	4.29¢
4.00	20,000	5% add on	5 yrs.	416.66	4999.92	5.71¢
5.00	25,000	5% add on	5 yrs.	520.83	6249.96	7.14¢
2.00	10,000	6% add on	5 yrs.	216.67	2600.00	2.97¢
3.00	15,000	6% add on	5 yrs.	325.00	3900.00	4.46¢
4.00	20,000	6% add on	5 yrs.	433.33	5199.96	5.94¢
5.00	25,000	6% add on	5 yrs.	541.66	6499.92	7.43¢
2.00	10,000	7% add on	5 yrs.	225.00	2700.00	3.08¢
3.00	15,000	7% add on	5 yrs.	337.50	4050.00	4.63¢
4.00	20,000	7% add on	5 yrs.	450.00	5400.00	6.17¢
5.00	25,000	7% add on	5 yrs.	562.50	6750.00	7.71¢
2.00	10,000	5% add on	10 yrs.	125.00	1500.00	1.71¢
3.00	15,000	5% add on	10 yrs.	187.50	2250.00	2.57¢
4.00	20,000	5% add on	10 yrs.	250.00	3000.00	3.42¢
5.00	25,000	5% add on	10 yrs.	312.50	3750.00	4.29¢
2.00	10,000	6% add on	10 yrs.	133.33	1600.00	1.83¢
3.00	15,000	6% add on	10 yrs.	200.00	2400.00	2.74¢
4.00	20,000	6% add on	10 yrs.	266.66	3199.92	3.65¢
5.00	25,000	6% add on	10 yrs.	333.33	3999.96	4.57¢
2.00	10,000	7% add on	10 yrs.	141.67	1700.00	1.94
3.00	15,000	7% add on	10 yrs.	212.50	2550.00	2.91¢
4.00	20,000	7% add on	10 yrs.	283.33	3399.96	3.89¢
5.00	25,000	7% add on	10 yrs.	354.16	4249.92	4.86¢
2.00	10,000	6% simple	5 yrs.	193.33	2319.96	2.65
3.00	15,000	6% simple	5 yrs.	290.00	3480.00	3.97¢
4.00	20,000	6% simple	5 yrs.	386.66	4639.92	5.30¢
5.00	25,000	6% simple	5 yrs.	483.33	5799.96	6.63¢
2.00	10,000	6% simple	10 yrs.	112.14	1345.68	1.54¢
3.00	15,000	6% simple	10 yrs.	166.54	1998.48	2.28¢
4.00	20,000	6% simple	10 yrs.	222.05	2664.60	3.04¢
5.00	25,000	6% simple	10 yrs.	277.56	3330.72	3.80¢

Add-on interest is figured by computing the interest for the total length of time on the original amount borrowed. For example:

10,000 × 5% = $500 interest for 1 year

$500 × 5 years = $2,500 interest for 5 years

$10,000 + $2,500 = $12,500 total amount to be repaid in 5 years

$12,500 ÷ 60 = $208.33 monthly payments

$12,500 ÷ 5 = $2500 yearly payment

$2500 ÷ 87,500 doz. = 2.86c per dozen for each dozen produced for 5 years at 17½ doz. per hen housed for each 365 days.

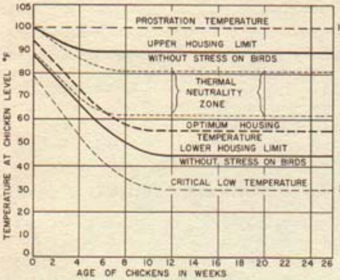


Fig. 1.—Optimum temperature for chickens

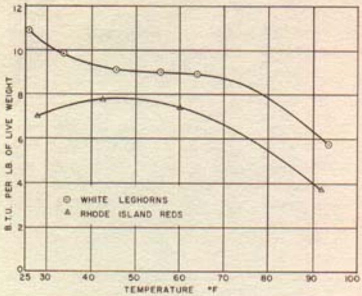


Fig. 2.—Total heat produced by caged layers per pound body weight at different temperatures, OTA.

olism rate and feed consumption. The 55°F. *optimum housing temperature* for cold weather is a practical and economical compromise between the theoretical lower temperature (61.5°F.) of the thermal neutrality zone and 45°F, the level at which stresses develop and egg production is affected.

Insulated side walls and ceilings minimize conduction heat losses during cold weather and radiation heat gains during hot weather. At 55°F. inside during cold weather, the major portion of the heat produced by the birds is available for warming the incoming ventilation air and evaporating excess moisture if the house is well insulated. *Heat produced* by the layers varies with their weight and the environmental temperature as shown by Figure 2. As shown, white leghorn layers will produce 9 Btu/hr. per pound of bird weight at a housing temperature of 55°F. This is approximately 40 Btu/hr. for a typical 4½-pound white leghorn hen.

Figure 3 shows how much heat is required to maintain various rates of ventilation air exchange with different outside temperatures. The total 40 Btu/hr. per bird cannot, however, be assumed as available for warming the ventilation air. You must first subtract the heat loss by conduction through the exposed surfaces of the building. This heat loss depends on the amount of insulation and the difference between inside and outside temperatures. It may be calculated as follows for each square foot of floor area in the house:

Conduction heat loss =

$$\frac{A \times \Delta T}{A_f R}$$

A = Total area of side wall and ceiling in square feet.

A_f = Total floor area in square feet

ΔT = Temperature difference between inside and outside.

R = Average R-value of insulation for all side walls and ceiling.

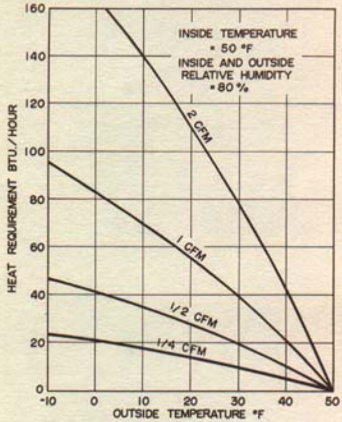


Fig. 3.—Heat required per hour for low rates of ventilation during winter operations.

For example, the conduction heat loss in a 40- x 200-foot house with an 8-foot ceiling, inside temperature of 55°F., outside temperature of 0°F. and an insulation value of R=10 would be:

$$\text{Heat loss/sq. ft./hr.} = \frac{11{,}840 \times 55}{8{,}000 \times 10} = 8.14 \text{ Btu}$$

This heat loss rate must then be subtracted from total heat produced before a ventilation rate may be estimated from Figure 3. If, for example, the birds are housed at one square foot per bird, the 8.14 Btu must be subtracted from the total of 40 Btu per bird, or in this case, also per square foot of floor area.

In planning your ventilation system and insulation requirements, make a calculation for 20°F. outside temperature which is a practical design temperature for Michigan. (This is approximately the average temperature for the coldest month of the year). At least ½ cubic foot per minute (CFM) per bird should be possible in your house at the outside design temperature and a minimum of 50°F. inside temperature. Also check the air flow rate possible in your house with 0°F. outside temperature. At this low temperature a minimum air flow of ¼ CFM per bird is necessary. This minimum ventilation rate of ¼ CFM per bird is the level for which the minimum continuous fan capacity should be designed. For an 8,000-bird house one 2,000-CFM fan should be installed to supply this continuous minimum level of ventilation. This fan should be thermostatically controlled to shut off when the inside temperature drops below 50°F. It will, however, run continuously except for prolonged sub-zero weather. One properly sized motor-operated shutter-type fan with an adjustable low-volume feature might be used to supply the minimum air flow requirements (2,000 CFM in the example). This type of fan, however, has a higher first cost and is more expensive to operate.

VENTILATION SYSTEMS

A *windowless poultry house* must have fan capacity and air inlet systems designed for both winter and summer ventilation requirements. A *house with windows* needs only a winter air inlet system as the windows may be used for summer ventilation. Windows on both sides of the house may be opened and the fans need operate only on the hottest days when there is little natural wind. When the fans operate, the windows on the same side of the house with the fans should be closed to prevent short circuiting of air.

Summer Ventilation

The summer ventilation air intake system for the windowless house is shown in Figure 4. The 6-inch over-the-plate slot opening (A) is continuous along the summer prevailing wind side of the house. The

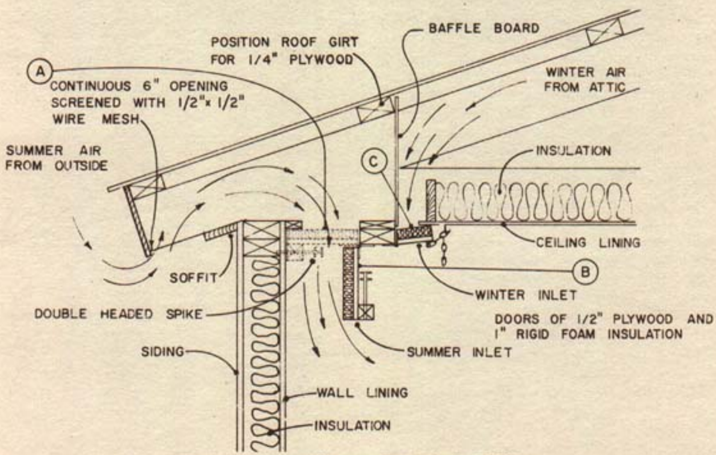


Fig. 4.—Ventilation inlet system for windowless biuldings.

baffle door (B) for closing the slot during the winter months should be left completely open all summer. It should hang vertically downward as shown in order to direct the incoming air to the floor. The exhaust fans on the opposite side of the house will pull the air across the floor. The air will automatically rise as it absorbs heat from the birds. The most effective drying of the droppings takes place at floor level either in a cage or floor management system.

The 6-inch slot is wide enough to keep incoming air velocity through the inlet at 500 feet per minute or less. Greater velocities are possible but with considerable reduction of fan air delivery. A ventilation rate of 4 CFM per square foot of floor area would come through the 6-inch slot inlet at 320 feet per minute in a house 40 feet wide.

Winter Ventilation

During the winter months, the insulated baffle board, (B) of Figure 4, closes off the summer overplate intake system. The bafflle over the 2-inch wide slot (C) is opened an inch wide as shown in Figure 5. This adjustment should be satisfactory without change throughout the coldest months of the northern United States. During warm periods in early spring, the baffle may be opened to allow the full 2 inches for air entrance. Late in the spring, close the winter system and open the summer inlet baffle.

The winter inlet system directs air from the attic in a thin horizontal blanket below the ceiling for maximum and immediate mixing with the warm air of the house before it reaches the chickens. The cooler winter-inlet air will drop to the floor automatically as it is heavier than the warmer air in the house. It is thus diffused down and across the house and eventually out through the exhaust fan.

The attic inlet system for winter serves as an indirect entrance for the cold outside air from the leeward side of the building. It should function essentially independent of outside wind direction or velocity. A few degrees warming of the incoming air will take place in the attic by the sun on a clear day. Also a large part of the conduction heat loss through the insulated ceiling is retrived by the incoming ventilation air.

The Winter slot inlet adjusted to one-inch in width will induce an air entrance velocity of 240 feet per minute when outside temperatures are 20°F. or slightly below and the maximum ventilation rate is about ½ CFM per bird. As outside temperatures rise and ventilation rates reach 2 CFM per bird, the slot inlet velocity must reach 1,000 feet per minute. If these outside temperatures persist in the spring or fall of the year, the inlet may be opened to its full 2-inch width to reduce the velocity by one-half. High inlet velocities are not critical during the winter as maximum output capacity of the fan is not required. High inlet velocities lower the output capacity of the fans, and therefore, should be maintained at 500 feet per minute or lower.

FANS AND CONTROLS

Fans for poultry house ventilation encounter low static pressures (in the range of ⅛-inch of water or less) as compared to the requirements for forcing air through grain or hay for drying purposes. Differ-

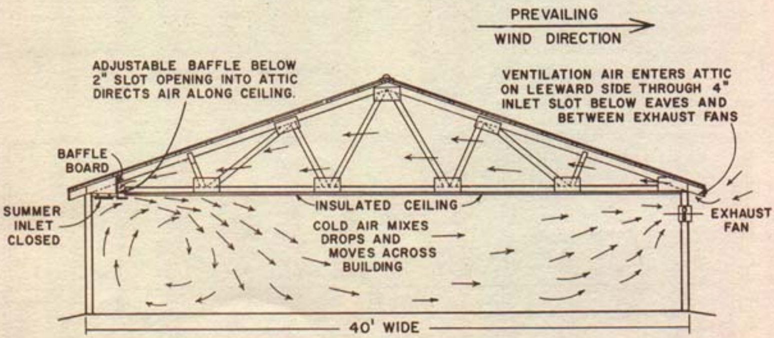


Fig. 5.—Winter ventilation system.

ent types of fans are required for the two operations. Propeller and axial flow type fans are used for ventilation purposes. They are simple, low cost in construction, operate efficiently at high velocities, and perform well against the low-pressure differences. Actual air delivery is dependent upon the shape of the blade, number of blades, shape of the fan orifice, and speed of operation. Diameter of the fan is not a good index of its capacity.

What to Look For

The manufacturer's literature on a fan should provide its air delivery capacity under specific static pressure differences at stated speeds, with specified size of motor and with accessories such as dampers, shutters, or hoods that it may be equipped with in the house installation. Air flow delivery for pressure differences equivalent to 0.10, 0.125 and/or 0.15 inches of water should be given.

It is of prime importance that the air delivery capacities of the fan as stated in the literature be *certified* by a recognized agency. The Air Moving and Conditioning Association (AMCA) is the accepted agency for this purpose. This association has adopted standard testing procedures.

Fan Types Available

There are several fan types available, such as:

- Single-speed single-volume.
- Single-speed dual-volume.
- Dual-speed dual-volume.
- Variable-speed variable-volume.

For laying houses, the single speed single-volume fan is recommended. It is the simplest, lowest in cost, and most efficient in air delivery. Laying houses normally are large enough to require three or more fans. One smaller single-speed single-volume fan can be sized to provide the minimum winter ventilation. The summer ventilation capacity is provided by several larger, single-speed, single-volume fans all the same size.

In no case is more than one multi-volume fan necessary for a laying house. The multi-volume is normally attained with motorized and thermostatically controlled shutters and dampers. If used, it would replace the one small fan for minimum winter ventilation air requirements. One multi-volume fan is more justified in a brooder house for starting and growing pullets. When the chicks are young and artificial heat is being supplied, the ventilation requirements are low and control at different low volumes is critical depending on the age of chicks and outside temperatures.

Fan Selection

Select the fan on its AMCA certified ability to deliver air against the house resistance and accessory equipment to be installed (generally about ⅛-inch of water, static pressure difference). Two fans with the same diameter, and even made by the same company may have entirely different rates of air delivery because of their internal design.

Direct drive fan motors of the split phase or capacitor type are preferred. Direct drives generally require less maintenance and involve less power transmission loss. Motors should be dust-tight and have built-in thermo-overload protection. If a fan is to be used in a vertical location, both it and the motor must have ball bearings.

The fan blades should be rust-resistant and surrounded by a smooth, streamlined ring or tube.

A fan should have a guard for protection and the shutters selected for their ease of cleaning blades.

Ventilation Control

Properly selected fans installed in a well insulated poultry house will provide an optimum environment only with *reliable controls* and *proper management.* Thermostats and inlet slot widths should be set properly and then left alone throughout each season to function as they are designed.

A recommended ventilation control system is shown in Figure 6. This illustration is for a 40 by 200-foot

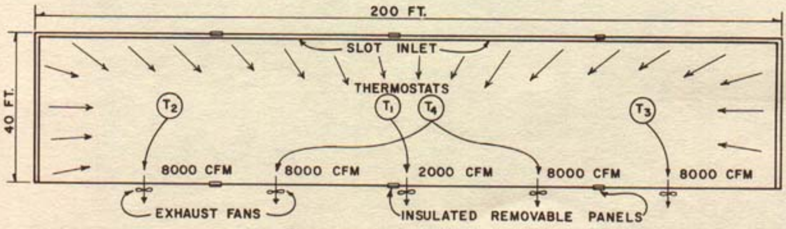


Fig. 6.—Ventilation control system.

house for approximately 8,000 layers, either on the floor or in cages. This basic system of controls may, however, be adjusted for houses of various sizes, or houses with a greater density of birds. The total fan capacity in any case should be based on the number of birds, and the number of fans should be based on the size of the fans.

For continuous *cold weather* ventilation, the center fan is sized to provide approximately 1/4 CFM per bird housed. For an 8,000-bird house as illustrated this would be a 2,000-CFM fan. Continuous operation of this fan will not affect the inside temperature unless there is prolonged sub-zero weather. To protect against the harmful effect of this event it should be thermostatically controlled to turn off if inside temperature drops below 50°F.

The two outside fans illustrated in the house of Figure 6 should have separate thermostats with T_2 set at 55°F. and T_3 at 58°F. They will then turn on as outside temperatures warm up to 20°F. and above during the winter season. These two additional fans will provide over 2 CFM per bird which is adequate until the changeover is made to the summer ventilation system.

The two additional fans are for maximum summer ventilation. They may be controlled by one thermostat T_4 set at 75°F. This will bring them into operation on hot days during the summer.

With the thermostats set as described there should be *no* need to change them. The only major adjustment in the ventilation system throughout the year will be the change from the summer to winter system in the fall and the winter to summer in the spring. There need only be one additional adjustment. For a while in early fall and late spring while the winter system is in use, the winter inlet slot may be adjusted to its full 2-inch wide opening. During the coldest weather this inlet is narrowed to one inch in width. The thermostats will take care of everything else.

The narrow slot inlet for winter operation should extend along one wall and may extend across both ends of the house, as shown in Figure 6. This will provide good air distribution during the cold winter weather when only the one central fan is operating. The 4- x 8-foot removable insulated panels spaced about 50 feet apart on both sides of the house are for emergency light and air in case the electrical supply should fail. Standby generator equipment should be considered for enterprises that are expanding to 10,000 birds or more.

MANAGEMENT SYSTEMS

Two types of systems for egg production are now in common use: (1) the floor system and (2) the cage system.

The floor system may consist of various arrangements of pits, litter, nests, feeders, and waterers. Figure 7 illustrates a combination pit litter system that has worked successfully in Michigan for a number of years with a bird density of about 1 1/4 square feet of floor area per bird. In some cases, mechanical cleaning equipment is used in the pit, in others the droppings accumulate for the laying period. Mechanical egg gatherers may be used (Figure 8, page 10).

The cage systems consist of various arrangements of cages having different sizes, shapes, and numbers of birds per cage. Birds per cage may vary from 1 to 25. Two per cage is, however, most desirable and popular at this time. The stair-step system of Figure 9 is being used extensively. The cages are all suspended from the ceiling. Two hens are normally confined in

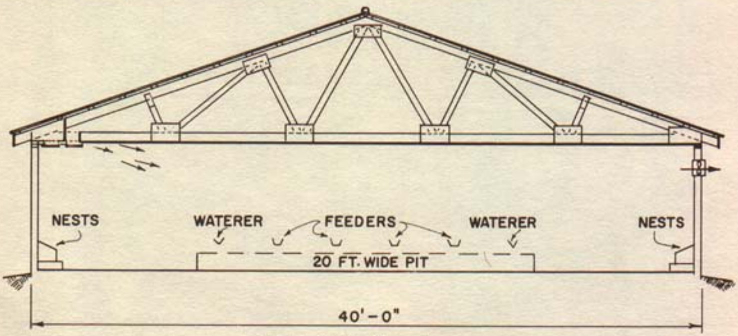


Fig. 7.—Pit-litter floor system.

an 8- by 16-inch cage (Figure 10). Feeding and egg collection are generally done with carts guided up and down the 30-inch wide alleys. A modified stair-step arrangement is sometimes used. In this system the lower deck cages are located partially below the upper cages. More rows of cages may be placed in a house with this arrangement if the house is the same width.

In a few cases, triple deck cages are being installed with each level of cages directly below the one above (Figure 11). A few inches are left between the rows of cages through which the droppings fall that are scraped from the dropping boards on top of the cages.

The flat deck system shown in Figure 12 is supported from the floor. Three hens are normally confined in each 12- by 18-inch cage. The feeders and egg gatherers are mechanical; therefore narrow alleys are adequate.

Manure removal is a critical problem in cage systems and has not been entirely solved in the floor systems. The suspended stair-step system of cages allows space and clearance underneath for operating a small tractor down the alley-ways with a blade on either side (Figure 13, page 12). The tractor moves the manure to the end of the building for loading into a spreader. Manure removal from below the flat deck system must be with a mechanical blade scraping mechanism. Mechanical cleaners have still to prove their effectiveness, economic value, and practicality of use over a period of years. The high surface tension and weight of droppings makes them difficult to remove from the pit. A penetrating odor persists for sometime after removal. The alkaline droppings are corrosive to structural metals. Cumulation of droppings during hot weather may bring about fly problems along with an undesirable odor.

CONSTRUCTION

Basically, a poultry house must be a shell: (1) of a size desirable for management of the enterprise, (2) with dimensions adaptable to the cages or pits and mechanical feeder, waterer, egg gathering, cleaning, and ventilation equipment, (3) with insulation adequate to preserve the bird heat and maintain adequate air exchange, and (4) constructed with durable economical materials with a minimum of labor.

Roof Construction

A cage layer system installed with all equipment suspended from the ceiling places additional loading requirements on the clear-span trusses. The modified stair-step system will weigh approximately ten pounds per square foot of ceiling area. Trusses must be designed to carry this long time ceiling load as well as expected short term snow and wind loads. A special truss plan has been designed to carry the stair-step or modified stair-step systems of equipment. It has an additional set of braces on either side of the center and is designed for 4-foot spacing. The cage hanger

Fig. 8.—This floor management system provides a partial slatted floor, feeders on a track, and mechancial egg gathering equipment.

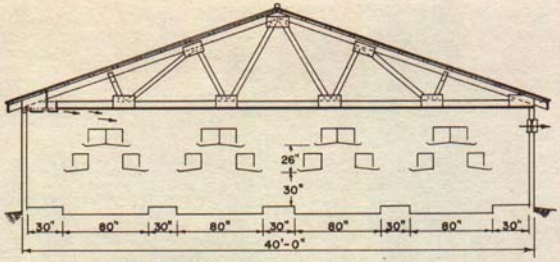


Fig. 9.—Full stair-step cage system (16 cages).

Fig. 10.—Stair-step cages are suspended from the ceiling to allow cleaning-out clearance below. Motorized feed carts are generally used for cleaning.

Fig. 11.—Triple-deck cages require care in providing proper distribution of ventilation air for all the birds throughout the house.

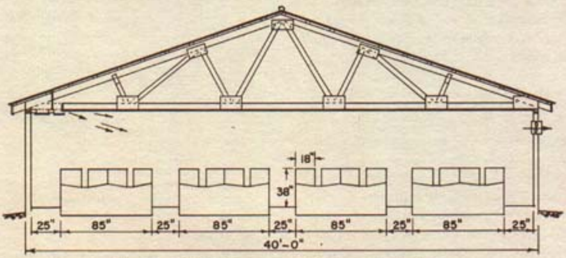


Fig. 12.—Flat deck cage sysem (fully mechanized).

Fig. 13.—A small tractor with a wing-blade on each side can be used conveniently for removing droppings from below ceiling-suspended cages.

straps may be attached anywhere on the 2" x 6" lower chords of these trusses without overstressing the members.

It is recommended that this truss or one of similar design be used for all new poultry house construction. A building should, and must, last for a number of years and management practices seem always subject to change.

Wood trusses must be securely anchored to the sidewall framing to resist wind damage. Metal clip angles may be used to fasten trusses to frame wall plates. In pole construction the trusses should be bolted to the poles or secured to vertical bridging with ring-shank spikes.

Wall Construction

Clear span trusses lend themselves to almost any type of wall construction. The structural and insulation requirements of poultry house walls may be met with either stud-frame or rigid column (square post) construction. Curtain-wall insulated structural panel design will also provide the basic requirements. Cost of materials, skill of local builders, availability of panelized systems, and personal preference will influence the decision.

Post Frame

The introduction of squared, not-tapering pressure-treated posts has made the so-called "pole" construction more adaptable for insulated, double-skinned buildings. Figures 14 and 15 illustrate two different post-type designs. Figure 14 shows the more conventional design with posts 8 feet apart and single horizontal side wall girts. Figure 15 shows a simple wall construction with the square 4" x 6" posts exposed on the outside of the building. Insulation in this side wall construction is limited to the thickness of the 2" x 4" girts. A 2-inch thick blanket can be used even though actual 2" x 4" thickness is 1⅝ inch for finished lumber. Ceiling insulation should provide an R-value of 15 to compensate for the minimum side wall insulation of about $R = 8$.

Stud Frame

This consists of typical frame construction with vertical 2" x 6" studs placed 24 inches on-center as illustrated in Figure 16. The frame wall is placed either on a poured concrete or concrete block foundation. Frame walls must be securely anchored to the foundation wall and to the roof framing with diagonal braces to withstand wind stresses. Blanket insulation is placed vertically between the studs.

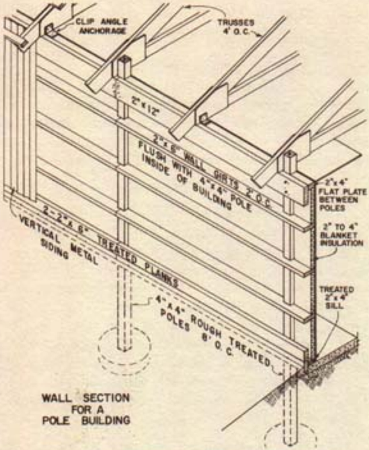


Fig. 14.—Square post wall construction with single 2" x 6" wall girts 2 feet on center.

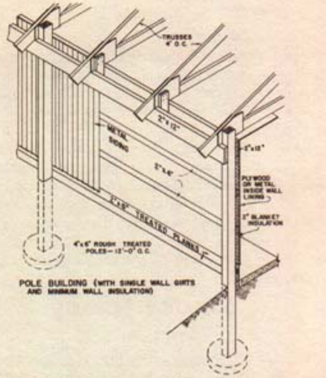


Fig. 15.—Wall construction with exposed square posts outside the building and minimum insulation. Bird population must be more than one per square foot to provide sufficient heat.

Panel Wall

Load-bearing frame-wall panels may be constructed in any convenient length for transporting to the site and assembly into the building. Wood trusses may also be fabricated at a central shop location to reduce on-site building time to a minimum. The panels may be similar to conventional frame construction or various versions of sandwich construction with covering materials over an expanded or extruded insulation material. A non-load bearing panel might be designed for a post-type construction.

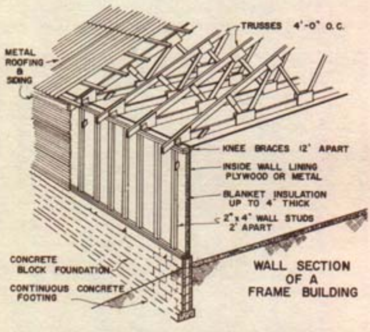


Fig. 16.—Vertical 2 x 4's placed 24 inches on center with poured concrete or block foundation.

COVER MATERIALS

Roofing

Sheet metal roofing over 2" x 4" roof girts 2 feet on-center is most durable and economical. The sheet metal may be either steel or aluminum. Steel roofing should be 28 gage, have a 2½-inch corrugation and be protected with 2-ounce per square foot galvanizing of metallic zinc. Aluminum should be a minimum of 0.021-inch thick and have a 2½-inch corrugation or equivalent.

Siding

Exterior siding materials should be selected for durability, low maintenance, appearance, and economy. Sheet metal materials meet these requirements satisfactorily. Some wood and hard board materials may meet the requirements but should be examined and considered carefully.

Sheathing

Interior sheathing (siding and ceiling) materials should be selected for durability, moisture resistance, and economy (Figure 17). A sheathing material should not necessarily be selected for its insulating qualities. "Insulation boards" seldom have the required amount of insulation without additional amounts in the wall, and are generally not desirably durable and water-resistant. The cage system in which birds are not in contact with the wall does, however, lower the durability requirement. New extruded foam-plastic materials have good insulation requirements so may be considered for lining cage houses. It must be protected from cart damage and spray materials.

INSULATION MATERIALS

Blanket

Blanket insulation may be obtained in thicknesses of 1½, 2, 3, and 4 inches and in widths of 16, 24, and 48 inches. It is adaptable to stud frame or post-type wall construction. The insulation fiber should preferably be of inorganic materials, such as rock, mineral, or glass which are resistant to fire, water, and decay (Figure 18). Most blanket insulation materials decrease in their ability to resist heat flow if moisture accumulates in them. For this reason, it is strongly recommended that all blanket insulation be covered on the warm side with a continuous sheet-type vapor barrier such as a plastic film (Figure 19) even though the blanket has a vapor barrier of its own on one or both sides.

Fill-Type

Fill-type insulation material is adaptable for use in the ceiling where it may be blown or placed over the ceiling material and a vapor barrier and between the lower chords of the trusses. The fill material should be durable and resistant to fire and moisture decay.

Foam Plastics

Expanded polystyrene or urethane are in a semi-rigid plank form. Polystyrene may also be expanded inside of panels for prefab construction. The expanded polystyrene, consisting of an independent cellular structure, is an effective vapor barrier as well as insulator. The 1- and 2-inch planks will sustain some compressive stresses but is very susceptible to physical damage from sharp objects. These materials are good insulators as will be seen from the table of "R" values; however, they are also quite expensive. For this reason, there is a tendency to use less insulation than is necessary.

Reflective Insulation

Reflectitve materials such as aluminum foil provide some resistance to heat transfer and are also excellent vapor barriers if free of joints. One or two reflective surfaces in a wall do not, however, provide adequate insulation for the wall or ceiling of a poultry house. (See table for "R" value)

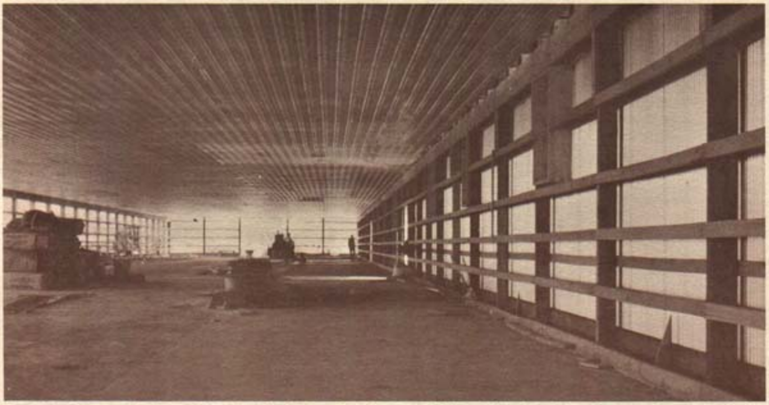


Fig. 17.—Square pole framing for a windowless poultry house. Building is lined inside and out with metal. Blanket insulation is placed in the wall horizontally.

R-VALUES OF VARIOUS INSULATING MATERIALS

MATERIAL—THICKNESS—DENSITY	R-VALUE
Plywood ½" (34#/cu. ft.)	0.63
Wood – Fir or Pine sheathing 25/32"	0.98
Asbestos – cement board ⅛"	0.03
Gypsum or Plastic Lath ½" (50#/cu. ft.)	0.45
Wood Fiber Board 1" (31#/cu. ft.)	2.00
Mineral Wool Blanket Fibrous form, processed from rock, slag or glass, 1"	3.70
Expanded Polystyrene (molded) 1" (1.0-1.25#/cu. ft.)	4.16
Expanded Polystyrene (molded) 1" (1.8#/cu. ft.)	3.50
Urethane, closed cell rigid, 1" (1.5-3.0#/cu. ft.)	5.90
Urethane, rigid with impervious skins, 1" (1.5-3.0#/cu. ft.)	6.70

MATERIAL—THICKNESS—DENSITY	R-VALUE
Mineral Wool, fill type, 1" (2.0-5.0#/cu. ft.)	3.33
Vermiculite (expanded) 1" (7.0#/cu. ft.)	2.08
Concrete, stone aggregate, 1" (140#/cu. ft.)	0.08
Concrete Blocks, stone aggregate, 8"	1.11
Concrete Blocks, light weight aggregate, 8"	2.00
Air space (¾ to 4 in.)	1.00
Air space with one reflective surface	2.00
Air space with two reflective surfaces	2.50
Outside surface film (15 mph wind)	0.17
Inside surface film	0.68

Insulation Values

The "R" value of a material is its numerically represented ability to resist the flow of heat from the warm side to the cold side. The "R" values are reciprocals or opposites of C or k values that sometimes are referred to for insulating materials. The C or k values represent the heat transmission ability from surface to surface in Btu/square feet of surface area per 1°F. temperature difference.

Some individual "R" values for a few common materials are given here. The overall insulation values for a wall may be found by adding the "R" values for each of the materials plus the surfaces and air spaces:

VAPOR BARRIER

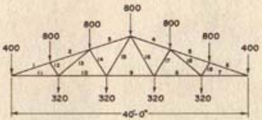
The vapor pressure inside a poultry house is high during the winter months as the relative humidity of the air may run as high as 80%. The vapor pressure of cold outside air is low even though it be nearly saturated with water vapor. There is the same tendency for vapor pressures to equalize through the transfer of vapor as there is for temperatures to become the same through the transfer of heat. Insulation is placed in the wall to minimize the transfer of heat from inside to outside the house. A vapor barrier must be placed on the warm side of the wall to prevent the transfer of vapor from inside the house into the wall.

The problem of water vapor, isn't that it must be conserved in the house, but that if allowed to proceed through the wall, it will condense and cause moisture problems. This is an extremely serious and undesirable condition. A continuous (no joints) sheet type vapor barrier is therefore required on the warm side of wall and ceiling insulation materials. The polyethelene films of 4 mil. thickness are recommended for this purpose. This material is low cost, easily applied, and an effective vapor barrier. It comes in rolls 8 and 16 feet in width, and therefore leaves a minimum number of joints in a building. Metallic aluminum foils and some specially designed asphalt impregnated papers are also satisfactory vapor barriers, although more expensive.

All moisture barrier materials *are not necessarily effective vapor* barriers. Water vapor will migrate through some materials that exclude water in the liquid form.

Fig. 18.—Blanket insulation is placed vertically between studs in frame wall construction.

Fig. 19.—A plastic film vapor barrier is placed over all blanket insulation to provide double protection against vapor transfer into the wall materials.



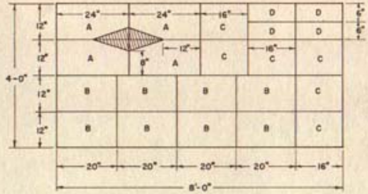
SPACE DIAGRAM

30 ROOF LOAD & 10 CEILING LOAD/FT²

0 5' 10' 15'

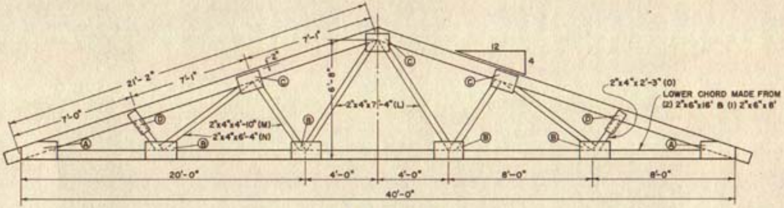
TRUSS SPACING 4' O.C.
ROOF LOAD 30 PSF (DEAD + LIVE LOAD)
CEILING LOAD 10 P.S.F.
CONSTRUCTION GRADE
DOUGLAS FIR OR EQUIVALENT
f = 1500 psi
c = 1000 psi

STRESS TABLE	
MEMBER	POUNDS OF FORCE
1	-8347
2	-7926
3	-5945
4	-5945
5	-7926
6	-8347
7	7519
8	5936
9	4352
10	5936
11	7519
12	-776
13	1540
14	-1353
15	1726
16	1726
17	-1353
18	1540
19	-776



CUTTING DIAGRAM FOR GUSSET PLATES

0 2'



TRUSS ELEVATION

0 2' 4'

GENERAL SPECIFICATIONS

1. USE EXTERIOR 1/2" C-C GRADE PLYWOOD FOR GUSSETS CUT OUTS ACCORDING TO DIAGRAM.
2. CUT WEB MEMBERS AS SHOWN AND POSITION TO GET MAXIUM WEB UNDER GUSSET PLATES.
3. ASSEMBLE TRUSS IN A HORIZONTAL JIG.
4. USE TYPE II (MOLD RESISTANT) CASEIN OR RESORCINOL GLUE.
5. MIX GLUE ACCORDING TO MANUFACTURERS SPECIFICATIONS.
6. APPLY AMPLE GLUE SO SOME SQUEEZES OUT AROUND ALL EDGES WHEN GUSSETS ARE NAILED IN PLACE.
7. NAIL GUSSETS WITH 6d NAILS 3" ON CENTER.
8. REMOVE TRUSS CAREFULLY FROM JIG AFTER ASSEMBLY AND STACK ON A LEVEL SURFACE.
9. CURE FOR 24 HOURS AT 70° TEMPERATURE, ALLOW AN EXTRA DAY FOR EACH 10° BELOW 70° F.

LIST OF MATERIALS			
MEMBER	NO. PCS	SIZE	BD. FT.
TOP CHORD	2	2"x8"x22'-0"	59
LOWER CHORD	2	2"x6"x16'-0"	32
LOWER CHORD	1	2"x6"x8'-0"	8
DIAGONAL (L)	2	2"x4"x7'-4"	10
DIAGONAL (M)	2	2"x4"x4'-10"	7
DIAGONAL (N)	2	2"x4"x6'-4"	9
DIAGONAL (O)	2	2"x4"x2'-3"	3
			128 BD. FT.
6d BOX NAILS	1-1/2 LBS.		
PLYWOOD GUSSETS	1	1/2"x4'x8'	32 SQ. FT.
CASEIN OR RESORCINOL RESIN GLUE	1-1/2 LBS.		

MICHIGAN STATE UNIVERSITY
COOPERATIVE EXTENSION SERVICE
AGRICULTURAL ENGINEERING DEPT. - EAST LANSING

40' GLUE AND NAIL TRUSS (TO SUPPORT CEILING LOAD)

PLANNED BLE	APPR.	SCALE SHOWN	
DRAWN RLB	DATE	SHEET 1 OF 1	
TRACED WBC	NO. 703-CI-91		
CHECKED			