

October, 1925

Circular 93

DAIRY BARNS AND EQUIPMENT

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

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AGRICULTURAL ENGINEERING AND
DAIRY HUSBANDRY SECTIONS



AMES, IOWA

DAIRY BARNs AND EQUIPMENT

By W. A. FOSTER and EARL WEAVER *

The efficient operation of a dairy farm necessitates good buildings. This applies to the dwelling houses for the owner and workers, all buildings needed for housing the livestock, for storage of feed, and to care for the products of the farm. So far as the dairy cattle are concerned many reasons can be advanced for the provision of proper buildings, but they can be summed up in two words — sanitation and economy.

Milk is one of the food staples of the country and enormous quantities of it are consumed raw. From the standpoint of public health, cleanliness in its production is essential. Good barns are easy to clean and keep sanitary and so they are an aid in producing milk fit for human consumption. The public is now paying attention to the condition in which dairy barns are kept and there are legal restrictions as to the conditions under which milk may be produced. Consequently, good barns are not only sanitary and economical but they will be imperative ultimately. Sanitation is important for another reason, because good, sanitary, well-lighted, well-ventilated barns promote health and prevent the spread of disease among livestock. Attention to this means much in a financial way to the farmer.

Undue exposure of the cattle causes enormous losses to dairy farmers, mainly because of decreased production. The losses due to exposure are brought about by the severe weather in winter and by the heat of summer. Good, comfortable barns which can be adapted to either summer or winter conditions cut down these losses. Exposure also causes lack of thrift in animals and increases their susceptibility to disease. Where cattle are exposed to the elements during cold weather, a large amount of feed is necessary to provide heat for their bodies; good barns reduce the amount of feed required by conserving the body heat of the animals. They make conditions more favorable for the cattle and everything which adds to the comfort of the cows will tend to increase their production of milk and butterfat, lower the cost of production, and so ultimately enhance the profits of the dairy farmer.

Well arranged barns decrease the labor necessary to care for

* A. C. McCandlish, now resigned, represented the Dairy Husbandry Section when the investigation of the subject of this circular was opened.

the cattle and so aid in keeping expenses at a minimum. There is also an indirect saving in labor cost because good barns result in contented help and contented help works efficiently.

There are certain features which are absolutely necessary in constructing a satisfactory dairy barn, while there are others that are not essential, but very desirable. Both the essential and desirable features are briefly discussed in the following pages.

ESSENTIAL FEATURES

Light and Sunlight. Without sunlight the dairy barn is dark, damp and unsanitary. Since a dark barn is hard to work in, uncleanness follows and an inferior quality of milk and butter-fat is produced. Sunlight adds cheerfulness to any surroundings; it destroys germs, promotes warmth and ventilation and is a great aid in keeping the barn dry, clean and sanitary.

Ventilation. Animal life suffers more from air starvation than from lack of food and water. Dairy cows should be supplied with pure air in large quantities.

Feed Storage. The dairy cow consumes large quantities of roughage and grains and so these should be stored nearby to reduce the labor in feeding to the minimum. Mow space should be provided for hay and bedding; feed storage bins and mixing rooms are essential for mixing and preparing the concentrates.

Sanitation. Sufficient window area and ample ventilation greatly aid in sanitation. Walls and floors that have no ledges, sharp corners and crevices also promote sanitation because disease germs lodge and harbor in such places. The accumulation and blowing of dust carries germs which are likely to be breathed by the cows or fall into the milk pails. Sloping floors and gutters which readily drain off the liquids and permit frequent scrubblings induce sanitation. Ease of cleaning encourages clean, sanitary conditions.

DESIRABLE FEATURES

Conveniences. The efficiency of any barn is determined by the amount of labor required in working about it. Any convenience which aids in cleaning, promotes sanitation and conserves labor is a good investment. Careful attention should be paid to planning, location and arrangement.

Warm Construction. A warm barn saves feed by conserving animal heat in the winter, and it is comfortable for the barn help. A type of construction material should be selected that will provide proper insulation. With proper insulation, the temperature inside the barn can be more nearly controlled. This condition provides for the necessary heat in winter and for comfort in the summer. Only expert workmanship should be employed to insure properly filled joints.

Economical Construction. The dairy barn is an investment and economical construction is desirable. One should build well but simply. Decorative features which have no structural value should be omitted. They are expensive and require time and money to keep them up.

Permanence. Materials should be selected which will resist the action of the weather and withstand the hard usage to which a dairy barn is subjected. Permanent materials such as stone, brick, hollow block, or concrete for walls and slate, asbestos or tile for roofing will lengthen the life of the building many years. The fire risk is also greatly reduced by their use.

Cost. While the initial cost should be kept low, the cost per cow or the cost per year of service should be figured. A \$3,000 building which will last 50 years is a much better investment than a \$2,500 building which may last 30 years.

Painting, renewal of roofing, replacement of windows and hardware comprise the big items in the cost of upkeep. Carefully selected materials and equipment made by reputable manufacturers should be selected in preference to an unknown brand, which may be cheap. It is not good policy to experiment with unestablished materials or equipment.

Appearance. An attractive dairy barn and yards add to the value of the farmstead and help build the reputation of the farm and herd. A properly proportioned dairy barn whose windows are well grouped, and spaced and which is painted in colors that harmonize with the other farm buildings need not cost any more than a poorly planned, ugly building.

LOCATION OF THE DAIRY BARN

Locating the buildings of a dairy farm should be done with care. Future development, as well as immediate requirements, must be given consideration. In planning the buildings for a dairy farm, the following factors are important:

Shelter. The provision of shelter is essential in handling dairy cattle in this section. Natural shelter, whenever available, should be utilized. Shelter for the lots is a great convenience and lots are generally best protected when located south of the barns. Frequently, buildings that are not used for livestock, such as machine sheds and cribs, may be located so as to act as a windbreak.

Sanitation. Sunlight is one of the cheapest and most effective factors in maintaining sanitary conditions. The long axis of the cow barn should extend north and south so that the best use of sunlight can be made. Any arrangement which locates cow stalls at the north side of a barn should be avoided as stalls so located are invariably unsanitary. If a feed room or storage is attached to the barn it should be placed on the north end.

Drainage. Good drainage is essential for a dairy barn and the buildings should be placed on a slope. If the ground slopes plenty of fall can be obtained for the drains and the surface water is removed readily. A porous soil is important in getting good drainage. Dairy barns on level ground or in bottoms are usually surrounded by soft, poorly drained lots.

Convenience. The buildings on the dairy farm should be located near a good main road. This reduces the cost of hauling purchased feeds and of marketing the products. Proximity to a good road with easy access to town also improves living conditions on the farm. The buildings should be so located that the labor in caring for the livestock will be reduced to the minimum. (Fig. 1). Long distances between the dwellings and the barns are inconvenient. The barns should be so arranged that unnecessary exposure in going from one building to another is avoided. Crowding of the buildings should be avoided, however, because this leads to unsanitary conditions and increases the fire risk.

The distance the cows must travel to and from the pasture, the distance feed will have to be hauled from the fields and the distance manure must be hauled are important considerations.

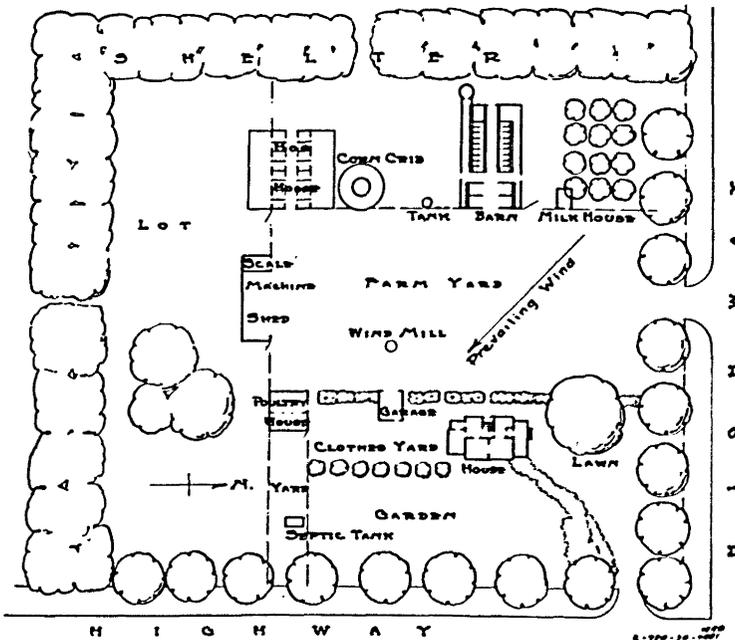


Fig. 1. Farmstead layout.

Attention to this will reduce the cost of the farm operations, and ultimately the cost of the milk production.

The installation of good modern equipment within the barn greatly reduces labor requirements. Overhead tracks for feed and litter carriers render the work of tending the cattle easier and more agreeable. Proper flooring and gutters make it easier to keep the barn clean. All factors which tend to reduce labor should be considered in equipping the barn.

INTERIOR ARRANGEMENT AND CONSTRUCTION

The interior arrangement must be carefully considered to insure efficient working conditions.

Facing the Cows In or Out. Whether the cows should face in or out is much discussed. There are advocates for both systems. The main argument given for facing the (Fig. 2) cows in is that it makes feeding much more convenient because there is one central feeding passage. In addition, this center passage can be narrower than where the cows face out. Where the lower openings of the outlet flues of the ventilating system are near the floor the flues can be built at the sides of the barn and are thus kept out of the way.

Where the cows face out there is a wide central passageway which makes cleaning out the barn very convenient. (Fig. 3). The manure spreader can be driven into the barn at cleaning time even if an overhead track has been provided. A barn in which the cows face out is also very convenient at milking time.

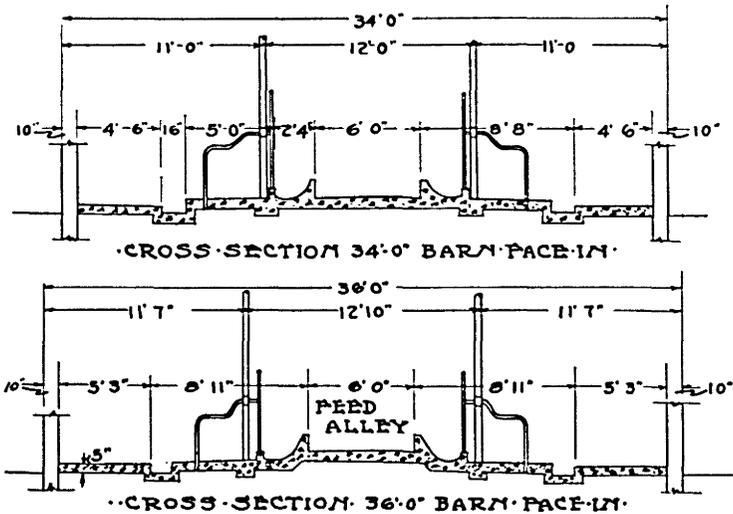


Fig. 2. Section of floor facing in 34 and 36 feet.

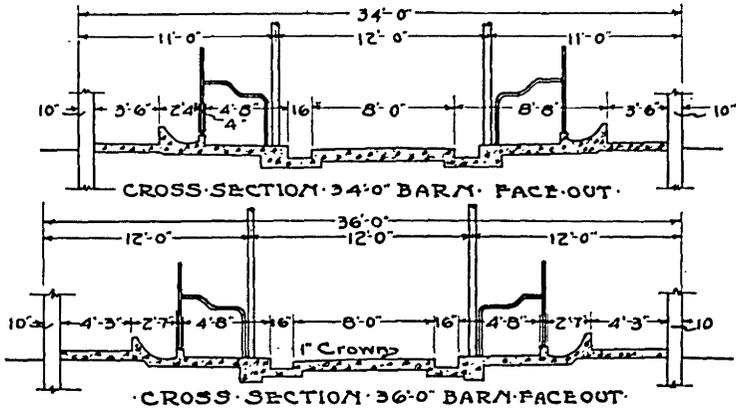


Fig. 3. Section of floor facing out 34 and 36 feet.

The cows may be turned in or out of the barn more easily and this is important from the standpoint of safety of the cows. The barn walls are easier to keep clean when the cows face out.

When the cows face out, the prevention of such a disease as tuberculosis is facilitated to a certain extent. In looking over a herd most attention is generally given to the udders, so facing the cows out is an aid to the appraisal of the herd. On the whole, facing the cows out is preferable.

Dimensions. The size of barn is dependent upon the number of stalls needed and the provision that is made for other stock. Each cow requires a certain minimum of floor space for manger and stall and additional space for feed and litter alleys.

The width and length of the stall platform is very important. If the stall platforms are too short the cows often injure their udders on the edge of them while lying down and the cows are forced to stand in the gutter and become dirty. A further disadvantage of too short stalls is the discomfort caused the cows. When the platform is too long, the manure drops on it and the cows are kept clean with difficulty. The length of the platform must be made to suit the animals. Suitable lengths of platform for the various breeds are given in the following table:

BREED	Length				Width			
	Minimum		Maximum		Minimum		Maximum	
	feet	inches	feet	inches	feet	inches	feet	inches
Jerseys.....	4	4	4	8	3	2	3	8
Guernseys.....	4	6	4	10	3	6	4	0
Ayrshires.....	4	6	4	10	3	6	4	0
Shorthorns.....	4	8	5	4	3	6	4	0
Holsteins.....	4	10	5	8	3	10	4	2

From the above table it is apparent that about three and

one-half feet must be allowed for each cow plus the cross walks, box stalls and any other space that may be desired. The width of three stalls is approximately $10\frac{1}{2}$ feet, of four stalls 14 feet, either of which gives a good spacing for posts.

Experience has established the 36 foot width as best for the two row barn. This width is most economical for materials and space. The narrower widths, 32 and 34 feet, are frequently used but they are not recommended. The 32 foot width is too narrow and crowded while the 34 foot width requires practically the same material lengths as the 36 foot.

A height of nine and one-half feet from floor to ceiling is recommended for the dairy barn. This insures ample head room when the girder drops down one foot and it does not make a high barn which is usually cold. The temperature of the dairy barn will depend somewhat upon the space allowed each cow.

Alleyways. The feed alleys at the front of the mangers should be wide enough for passage of a feed cart or carrier. They may vary somewhat in width, but they should be about four feet wide for ease in feeding.

Litter Alley. The litter alley or passageway back of the gutter should be wide enough for the manure spreader when the cows face out, or about eight feet. When the cows face in, the litter alley is next to the side wall and should not be less than 4'6". A wide litter alley prevents soiling of the walls so readily. The litter alley should have a slope to the gutter of about one-fourth inch to one foot.

Cross Walks. The connecting corridors of litter and feed alleys are known as cross walks. They should be about four feet wide to allow the passage of a cow or for a cart to pass and turn into the alleys.

Mangers. The mangers may be built of wood or concrete. Wood is not recommended because it is neither permanent nor sanitary and it affords a harbor for rodents. Concrete is suitable because it may be built into any desired shape and it is permanent and sanitary. In addition, concrete makes it possible to use or replace the equipment from standard sized stock.

Box Stalls. The dairy barn should have two or more box stalls. When an animal is sick or a cow is calving, freedom of movement and careful handling are necessary. This cannot be secured except in a box stall. The box stall should be not less than eight feet square and have a gate, manger and feed box.

Calf Pens. Calf pens in the dairy barn have the advantage of convenience and warmth with the disadvantage of odors. The calf pens should be provided with feed trough and stanchions so that calves may be fed individually. The pen may be

square or rectangular in shape with seven feet or more for the short dimension.

Bull Pen. The bull pen should be strong and substantial and be nine or more feet each dimension. It should have strong, high walls, a strong manger and a safe, accessible gate.

Floors. The floors are of prime importance in the dairy barn — both in the alleyways and in the beds of the cows. On them depends largely the ease with which the barns can be kept in a sanitary condition and the comfort of the cows. A dairy barn floor first of all should be impervious to moisture. This renders it easy to keep in a clean, sanitary condition. The beds for the cows should be floored with material that will give the greatest comfort to the cows. The passageways should be rough concrete because slippery passages often lead to accidents. The flooring material should be durable. This consideration with the first cost will determine the relative economy of the various types of floors.

The dirt floor, generally fitted with wood or cement gutters, is cheap, but it is unsanitary and inefficient. It is not impervious to moisture, is apt to puddle if the barn is poorly located and cannot be kept clean. A floor of wood is costly and because it absorbs moisture it cannot be kept sanitary. Wood decays and so lacks durability. Even when creosoted, planks do not make a good floor.

Brick floors are costly; they are too hard to be comfortable for the beds of the cows and they tend to be slippery in the passageways. A concrete floor is durable and sanitary but is too hard and cold to be comfortable for the cows. It makes a good floor for the passageways, provided it is given a rough finish to prevent the cows from slipping.

Cork brick is used only for the beds. It is comfortable and quite sanitary but is costly and wears rapidly. Creosote block makes an economical floor for the beds and is comfortable and sanitary. It is probably more durable than the cork brick. The best materials for flooring are, therefore, concrete with a rough finish for the alleyways and creosote block or cork brick, set in cement, for the beds of the cow stalls. In laying the block or brick allow an expansion joint at one side and one end so moisture will not heave or push out the retaining curb at the gutter.

FEED STORAGE

The hay mow, silo, feed bins and feed room are as necessary a part of the dairy barn as the stalls and mangers. They provide economical storage space and save labor.

Mow Space. The modern dairy barn utilizes the loft or space under the roof for mow storage.

A ton of cured hay after settlement will require 512 cubic feet of space, or roughly four pounds to a cubic foot. One should allow at least 700 cubic feet for new hay. Additional space should be allowed for bedding.

Modern construction such as the gambrel roof and the curved or Gothic roof provide a great spacious mow which is free from posts and beams. This makes it easy for both mowing and removing the hay.

Feed Room. While a feed room is not essential to a dairy barn, it is desirable since it saves a great amount of labor. It serves as a storage for carts and baskets, a place for the grinder and elevator and it prevents loose animals from reaching the feed bins.

Feed Bins. The cheapest space for feed bins is in the loft or mow. An elevator should be used for lifting the grain or feeds and they may be drawn off thru spouts leading to the feed room. When bins are built in the mow the joists should be spaced on one-half spacing and the bins should be shallow to prevent overloading.

Small bins may be placed in the feed room. These should hold at least a week or ten days supply of feed.

Silo. The silo is a necessary part of the dairy equipment. It provides cheap storage for a large amount of feed. It should be connected to the barn either at the south end or on the east side where it is sheltered from the prevailing winds. A tight fitting door should shut off the silo chute to prevent heat loss and to exclude odors from the barn.

FOUNDATION AND FOUNDATION WALL

The life of any structure largely depends upon the foundation.

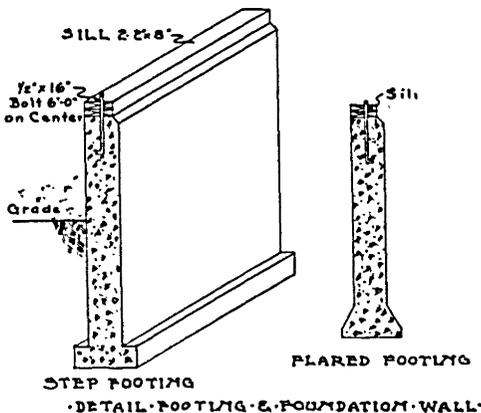


Fig. 4. Detail footing and foundation wall.

The condition of the soil, that is, the bearing value should be considered. The footing must be wide enough so that it will not heave or crack the wall when the ground freezes.

The footing for the two story dairy barn is usually made 16 to 20 inches wide and should be placed

not less than three and one-half feet below grade. While some prefer a deeper footing, reinforcement with old rods will prevent upheaval or cracking due to frosts.

Grading should be done to have the water flow away from the building. If there is danger of surface water soaking into the ground, this may be removed

by placing a four inch drain tile about the wall, probably eight inches away and just above the footing level. This will receive and drain the water away so that it will not penetrate and soften the soil under the footing. (Fig. 5.)

The foundation wall is the part of the foundation which extends from the footing to six or eight inches above the grade where the superstructure begins. Stone may be used, laid in cement mortar but it will require a greater thickness than a brick, hollow tile or concrete wall. Brick or hollow block if used should be hard burned and laid up in cement mortar.

Concrete is much used for both the footing and the foundation wall. It is cheap; it can be built by common labor; it may be reinforced and is adaptable to any form or shape. A rich mixture, 1:2:4, should be used.

SUPERSTRUCTURE

The portion of the building above the foundation wall is called the superstructure and includes the walls and roof.

Wall. The wooden barn is cheaper than other types but the difference in cost is not so great at present owing to higher lumber prices. Wood construction is not as durable

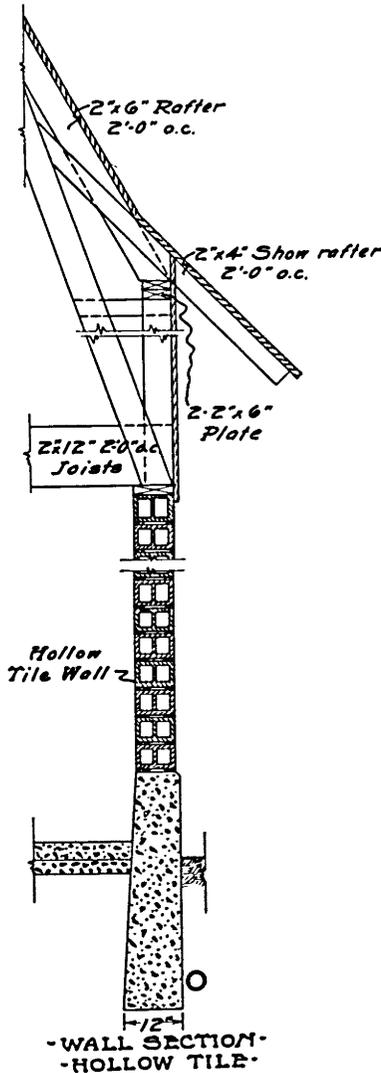


Fig. 5. Hollow tile and frame wall section.

as masonry. Wooden barns require painting, their cost of upkeep is greater and they are more liable to destruction by fire.

Masonry walls may be built of stone, clay products or concrete in its various forms from small units to a monolithic construction. They should be laid with a cement mortar, slightly lime tempered. Stone may be used but the wall should be not less than 16 inches thick. Both hollow blocks and concrete are being extensively used for walls. Any of these materials make a wall which is strong, attractive and durable. (Fig. 5). The hollow tile has an added advantage in that it provides proper insulation.

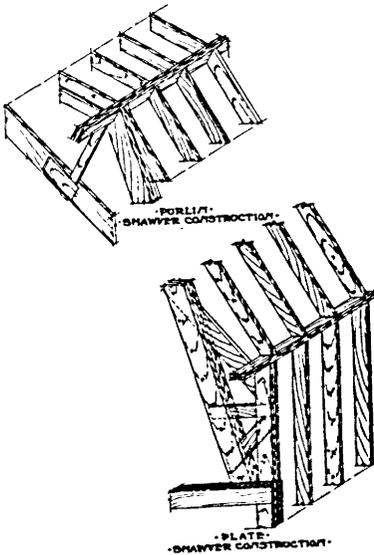


Fig. 7. Shawver details.

The Windows. They should begin at four to four and one-half feet above the floor and extend well towards the ceiling. Height is to be preferred to excessive width in the windows. The best lighting of the center of the barn can be obtained with high windows and they must be some distance above the floor to prevent breakage by the cows or

by tools in the hands of the workers. All windows should open and when fitted with side shields of galvanized iron they can be used as an aid to the ventilating system without causing draughts. Such windows can be kept open at the top alone or at both top and bottom. Single sash windows are more convenient than double sash as they can be opened easily. As a rule four square feet of glass should be provided for each cow in the milking barn. The same amount of glass to each 100 square feet of floor area for calves and young stock should also be allowed.

Roof Construction. The dairy barn roof shape should be determined before designing or selecting the construction. The shed and monitor roof do not give mow space. Where a limited amount of mow space is required a low pitch roof of the gable type will do. A large mow space demands a high roof, such as the gambrel, the curved or "Gothic" type.

(a) *Shed Roof.* The shed roof is the low pitch, nearly flat roof of one slope. It is used in the narrow, one stall row barn or the lean-to, built against the side of a building.

(b) Gable Roof. The gable roof is the type which has two roof slopes meeting in a ridge over the center of the barn and is the most common type. The high pitch roof is preferable because it is less likely to leak. The low pitch does not allow much mow space unless the walls are extended above the mow floor.

(c) Monitor Roof. The monitor roof has proven unsatisfactory because no mow space is provided and the barn is unduly cold. While it provides light for the center of the barn and is cool in summer, it is unsatisfactory in Iowa where the weather is severe and the feeding periods are long.

(d) Gambrel Roof. The gambrel roof is frequently termed the "Hip roof." It is a two pitch, symmetrical roof meeting in a ridge like the gable type. This type increases the mow space and is popular for that reason. When the rafter lengths are well proportioned and the correct slopes used it makes an attractive barn.

(e) Curved or "Gothic" Shape Roof. The curved roof has become popular in recent years due to its pleasing appearance. It affords a large open mow.

THE SUPPORTED ROOF TYPE

The supported roof is one which is partially supported by posts within the walls. The timber frame, the old plank frame and special constructions belong to this class.

The Timber Frame. The timber frame followed the log barn. It consisted of heavy hewn or sawed timbers fastened together by means of pinned mortises and tenons. While a strong construction, the mow space was broken by posts and beams. It was practical only when native timbers were available and labor was cheap. It involved a great amount of labor in framing and raising the heavy timbers into place.

The Plank Frame. The plank frame was a later model of the timber frame in which commercial or dimension lumber was built up into sills, posts, plates, beams and braces. The mortise and tenon joints were dispensed with and the joints were spiked and bolted together. Less labor was required in framing and raising them. While not so strong as the timber frame, it was a good substitute and was used for some years until the self supported roof replaced it.

Special Frames. Many special constructions have been developed locally, usually by carpenters. Some are good, others are bad. Under no consideration should an unknown construction which has neither stood a satisfactory test nor been approved by a reliable engineer be used.

THE SELF SUPPORTED ROOF

The self supported roof is wholly supported by the side walls.

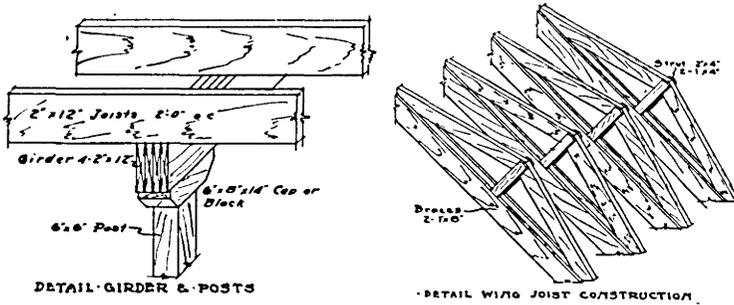


Fig. 9. Detail wing joist and girder, joist and post detail.

The more common kinds are the Shawver truss, the braced rafter truss and curved construction.

The Shawver Construction. The shawver construction utilizes commercial timbers and provides a large mow space which is free from obstructions. It is a strong construction which is easier and cheaper to build than the timber or plank frame. (Fig. 6). While two-inch materials are used, the chief disadvantage is the long lengths required for purlin posts and purlin support. These are not kept in stock and are usually expensive and hard to secure.

In this construction a purlin is used which is supported by trusses. The trusses are placed 10 to 14 feet on centers and the intermediate space is called a bent. The trusses support a purlin which carries the upper end of the lower rafter and the lower end of the upper rafter. The lower rafter is set on a 60 degree angle or about a 21 to 12 cut and the upper rafter at 30 degrees with horizontal, or a 7 to 12 cut.

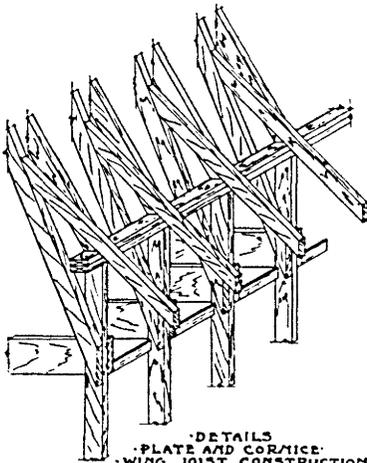


Fig. 10. Details plate and cornice wing joist construction.

The Braced Rafter Construction. The braced rafter or wing joist construction is another popular gambrel shape roof construction which is strong and safe for a 36 foot width or less and is easily built. The materials used in the construction are of stock size and length which are available in any lumber yard. Each set of rafters is built into a complete unit or

light truss independent of all others. This permits simple construction. The trusses are easily raised into position and the barn may be made any length in units of two feet, the usual rafter spacing.

The weakest points of this construction are the joints which are nailed and the mid-point of the lower rafter where the lower and upper braces meet. Care should be taken to have all the members fit snugly and rigidly at the joints. The braces should bear end to end at the joints. A strut should be placed at the roof break and another at the plate.

The Curved or Gothic Roof Barn. The Gothic roof construction has become popular in some communities because of its attractive appearance and the free mow space secured.

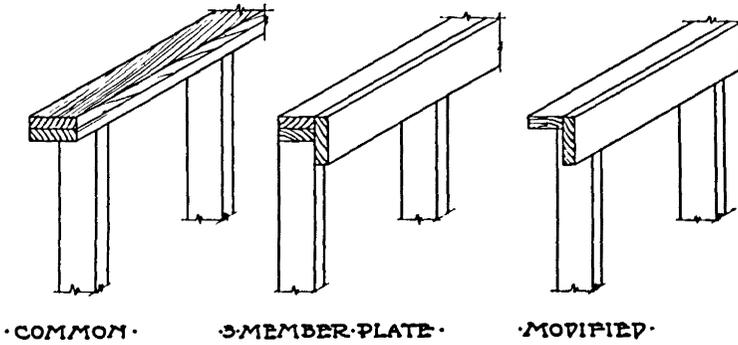
The rafter or rib may be built up of one inch boards sawed to the desired curvature, or by bending straight grained, clear 1"x4"'s over a form and building up to five or more thicknesses, or by a combination of the two. In the former, the labor cost of sawing is high and the bent rafter is not so rigid as the former. The combinations appear good since it combines the rigidity of the former and the simplicity of the bent rafter and in this case 1"x10"'s or 1"x12"'s of 10 or 12 foot length are sawed and built up to five or more thicknesses, breaking joints. These are spaced eight feet apart and spreaders nailed between. The intermediate ribs are made of bent rafters consisting of three to five 1"x4"'.

VENTILATION OF THE DAIRY BARN

A 1,000-pound cow inhales about 225 pounds of air in one day — about double the weight of her feed and water and almost one-fourth of her own live weight. The necessity of a plentiful supply of fresh air is apparent. To maintain a desirable purity about 3,600 cubic feet is required per hour. Air moving at the rate of 250 feet per minute thru a flue two feet square would be sufficient to supply 16 cows or one square foot of flue area for four cows. The amount of cubic space allowed per animal is not so important as ventilation. The air in a barn is rapidly polluted and becomes unfit for use. Consequently a good system of ventilation is necessary to keep the air in circulation and fresh.

Expired air contains about three times as much moisture, 100 times as much carbon dioxide, and only three-fourths as much oxygen as pure air. This expired air is of course mixed with the unused air in the barn, but if a good system of ventilation is not in use the carbon dioxide and moisture rapidly increase in concentration while the oxygen decreases until ultimately the air in the barn will become unfit for respiration.

There are two main types of ventilation — forced and natural. Forced ventilation is generally obtained by means of blowers



TYPES OF WALL PLATES

Fig. 12. Plate details — three types.

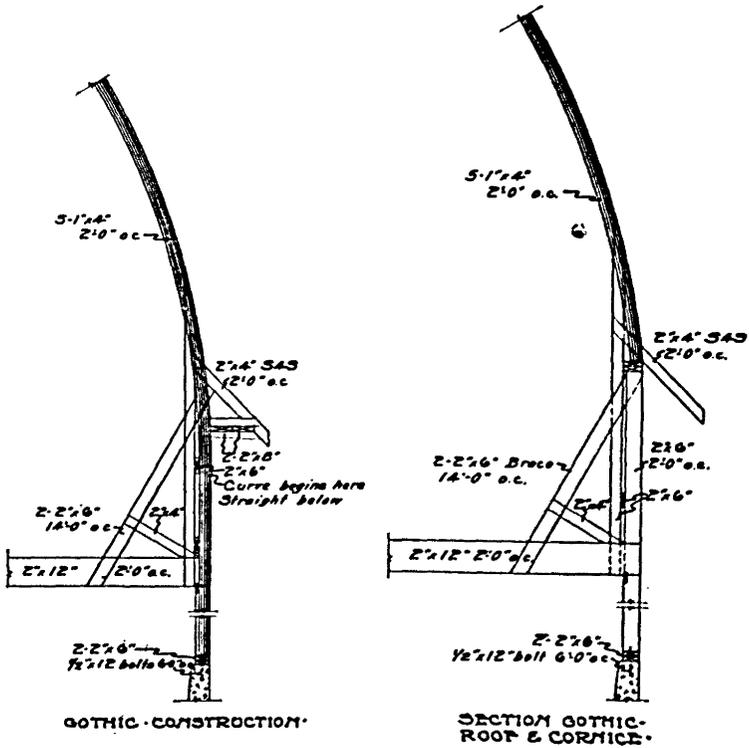


Fig. 13. Gothic details

and fans and is adapted for use in mines and large buildings. Natural ventilation, the only type considered here, is suitable for dwellings and barns.

The main forces tending to produce natural ventilation are:

- (1) The wind pressure against the side of the building tends

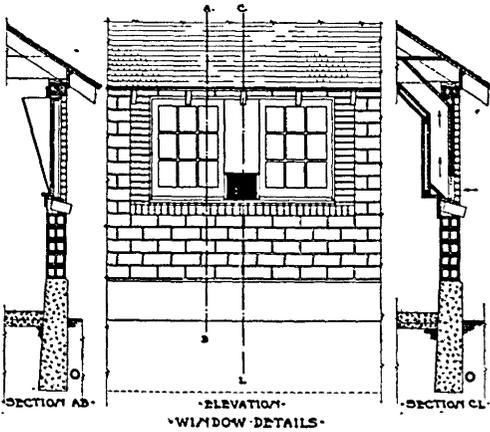


Fig. 14. Window group.

to force air into the building and out at the opposite side or up thru the outlet flues of the ventilating system. Where the walls of the barn are properly constructed this force can act only thru the intake and outlet flues of the ventilating system as the remainder of the structure should be comparatively air tight.

(2) The wind in blowing across the tops of the outlet flues produces an upward suction which draws the air upward thru the flues from the barn. This reduces the pressure of the air within the barn and so more air tends to come in thru the inlet flues.

(3) The temperature of the air in the barn tends to be higher than the outside air. Since warm air is lighter than cold air, it rises in the outlet flues and relieves the pressure in the barn, which induces more air to come in thru the inlet flues.

Several types of ventilating systems have been proposed but only two, the King system, and a combination of the King and Rutherford systems are in general use in this section. They are adapted for use in practically any type of barn. The principle of the King system is that the foul air of the barn, being heavily charged with carbon dioxide and moisture, is heavier than pure air and sinks to a low level in the barn. Consequently, the intakes deliver the fresh air near the ceiling while the outlets take the foul air out near the floor.

The Rutherford principle is the reverse. The outlet opening is at the ceiling and the fresh air inlets are placed near the floor. This system is extensively used in Canada but not in the States. A combination of these systems, combining the best features of each, has been developed which is coming into general use and is proving successful.

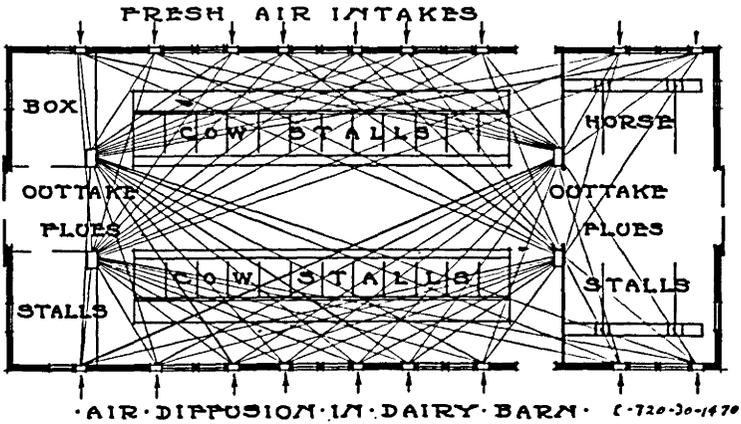


Fig. 15. Diffusion of air in barn.

This system removes the foul air from the ceiling and brings the fresh air inlets in near the ceiling.

The following are some of the conditions necessary for the success of these systems.

(1) The barn walls, including windows, and ceiling should be as nearly airtight as possible, consistent with good economy. This prevents the entrance or exit of air thru undesirable channels from interfering with thoro ventilation. Where air can pass thru openings other than the regular ventilating flues, ventilation cannot be carried out efficiently. An open or broken window will interfere with a ventilating system and often makes it useless.

(2) The material of which the walls and ceiling are constructed should be poor conductors of heat. This aids in maintaining the difference in temperature between the air within the barn and the air outside and so assists in ventilation.

(3) The outlet flues should be of air tight construction and their walls built of material that is a poor heat conductor. This prevents too rapid cooling of the foul air as it goes out and minimizes the risk of moisture condensing within the flues. The flues should be at least 25 feet in height and the entrance to them should be about a foot above the barn floor for the former system. The outlet flues should be straight and large to insure thoro ventilation.

(4) The foul air outlets should be so located as to insure thoro diffusion of the fresh air thruout the stable, (Fig. 15) leaving no "dead" spots of foul air at the ends or sides of the barn.

(5) Ventilators added at the top of the flues for the outgoing air give a forced draught and so help to take the foul air out.

(6) The fresh air intakes should be airtight, not more than 12 to 14 feet apart, and have a combined capacity slightly exceeding that of the outtakes.

(7) The inlets for the intake flues are about midway between the floor and the ceiling, or slightly lower, while their outlets are within eight inches of the ceiling.

(8) In practice it is best to have the inlet flues of comparatively small size while a smaller number of larger flues are used for outtakes.

(9) Where the cows face out, the air enters within eight inches of the ceiling at the walls and is taken out by the flues located at the floor near the center of the barn for the King system and at the ceiling for the new system.

(10) Where the cows face in, the fresh air enters thru pairs of registers in the center of the ceiling — one for each side of the barn — and is taken out thru the outtakes located at the walls.

(11) When the barn does not contain the number of cattle for which it was designed the intakes may be partially closed to restrict ventilation proportional to the number of cattle in the barn. There must be a sufficient number of cows present to generate the heat necessary to maintain the difference in temperature between the air in the barn and that without the barn, otherwise ventilation will not be efficient.

The cubic space allowance per cow is not the important thing in a barn, altho 600 to 800 cubic feet of air space per cow should be provided, but an efficient system of ventilation must be installed. The cross-sectional area of outlet flues recommended is 36 square inches per cow with these systems while a greater total area is required in the intake flues.

TYPES OF BARNs

The many types of dairy barns may be grouped into a few general classes. There is variation of opinion as to which is the best type of barn, but some types stand out as being much better suited than others for the housing of dairy cattle under Iowa conditions. For convenience, dairy barns will be classified as to kind, viz: the covered yard, the one story barn, the basement barn, the two story barn and the round barn.

COVERED YARD

The covered yard or double system of housing is occasionally a convenient method of utilizing an old barn that has been designed for other purposes. The cows are kept in a covered yard which is generally divided into pens where they are fed their hay and ensilage. At milking time the cows are brought in

groups to the barn, which is usually small, where they are fed grain and milked. The main advantage of such a system is that the cows get plenty of exercise in winter and some state that less labor is required in handling the cows, but this is doubtful.

Before such a system can be made really practicable the cows should be dehorned or many injuries are likely to result. If the cows are not carefully sorted out and allotted to the various pens they will get uneven allowances of roughage because there is usually a boss in each group. The amount of bedding needed in this system is large and the handling of the cows in small groups at milking time is inconvenient. The problem of removing the manure from the pens is difficult.

ONE STORY BARN

This type of barn is both sanitary and convenient. It is ordinarily of low initial cost and is easily enlarged as the growth of the herd demands. Primarily, it is adapted for warm climates where little feed storage is needed. In this section where a large amount of feed storage space is necessary, this type is not recommended except as a wing or part of a group of barns. The single-story barn is generally built with a tight ceiling or with a monitor top. If a tight ceiling is used the dead air space between this and the roof helps to keep the barn cool in summer and warm in winter. When a monitor roof is built the barn is usually too cold in winter due to the large air space, altho the lighting is generally good and it is ideal for summer.

Under Iowa conditions the single-story has several distinct

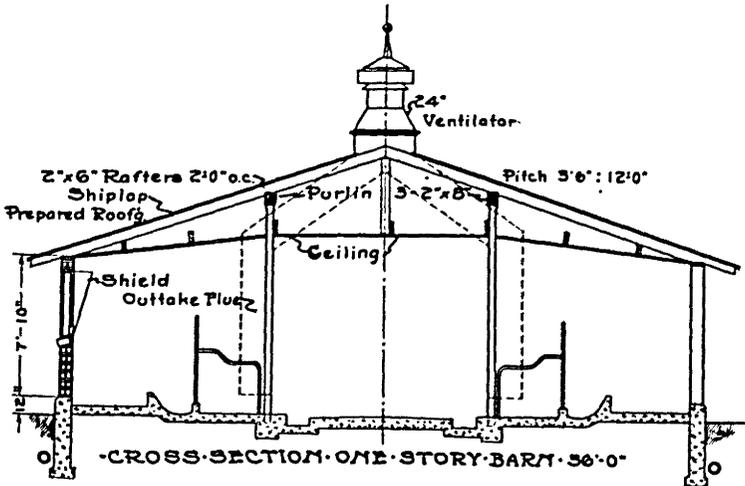


Fig. 16. One story barn section.

disadvantages. It is generally cold in winter. It is hard to ventilate properly. A single-story barn does not allow overhead storage room for feed, hay and bedding. The single-story barn is cheap in itself but it makes the feeding of the animals more laborious because the feed has to be transported from another building when needed.

BASEMENT BARN

The main advantages of the basement barn, built in a hill-side, are that it is warm and one may drive into the upper story to unload feed. There are disadvantages, however. The ventilation in such a barn is usually poor, light is lacking and water is apt to come into it from the high ground around the barn. This leads to damp, unsanitary conditions. It is difficult to keep animals healthy and to produce clean milk in such surroundings. The basement barn has been popular in some of the colder northern sections, especially in the eastern states. While a number of them are to be found in Iowa, they cannot be recommended under the conditions usually found in this region.

The modified basement barn, often called the "bank barn," serves the same purpose and meets modern requirements as to ventilation and sanitation. The entire wall is kept out of the ground or (Fig. 17) above grade, but it requires a natural or built up approach to the barn floor. It offers the same advantages as the basement barn without the undesirable features.

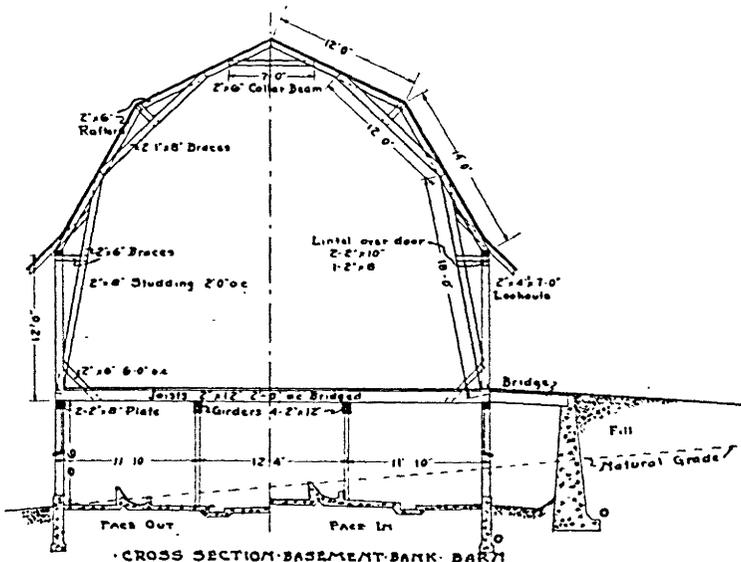


Fig. 17. Bank barn section.

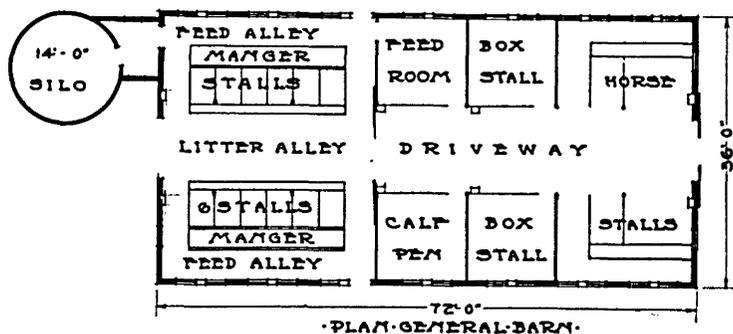


Fig. 18. Plan for a general dairy barn that will house horses.

TWO STORY BARN

This is the type of barn best suited to general farm conditions in the middle west. It is easily kept sanitary when it is properly built; light and ventilation can be provided efficiently. Copious storage accommodation can be obtained on the second floor, especially if a gambrel shape roof is used, and this overhead space tends to prevent great temperature variations in the barn below. A two-story barn may easily be kept warm without restricting the ventilation. A tight ceiling is essential to prevent the dust in the hay mow from falling to the stall space below. The cost of such a barn will be less than a single-story barn which has a feed storage barn attached. The labor of feeding can be greatly reduced by having the hay chutes conveniently located and by delivering the grain to the feed room by spouts from the bins above.

The two-story barn is easily adapted to individual needs and there are several modifications of it in common use. (Fig. 6.) Perhaps the most common shape is a rectangular barn with all the feed storage above. This is the type best adapted for small herds. In some cases the barn is used only for the cows in the milking herd while some house the young stock and frequently the horses with the cows. Where this system is followed the cows should be located at the south end of the barn and a tight partition should separate them from the other livestock.

One of the drawbacks of this system is that the calves are in the north end of the barn. By properly locating the other units, this condition can be somewhat alleviated. (Fig. 19). Sometimes the herd bull is kept in the barn, but under no conditions can this be recommended. The best place for the herd sire is in an open shed with an exercising paddock attached. Such treatment keeps him more healthy, more tractable, and a better breeder than will any other system.

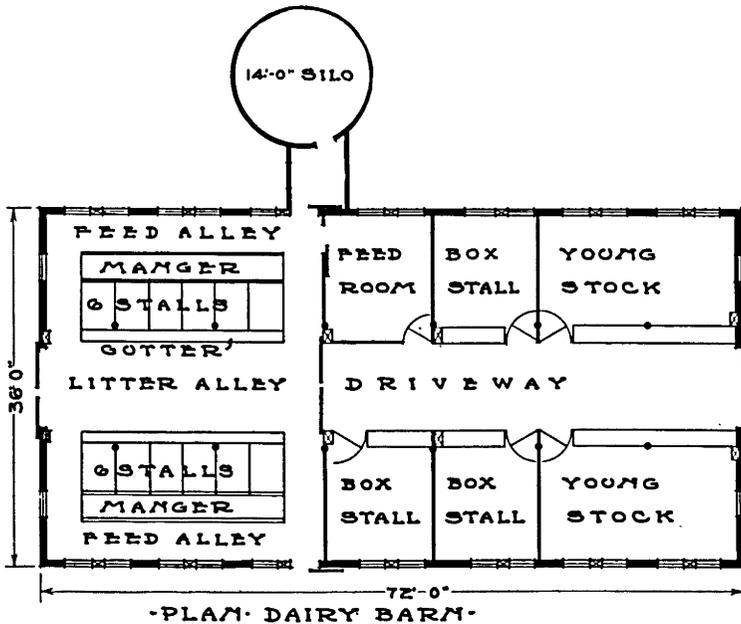


Fig. 19. Plan for a dairy barn that will take care of young stock.

ROUND BARN

The round barn has sometimes been advocated for housing dairy cattle, chiefly because of economy of construction. It takes about 25 percent less wall than is necessary with a rectangular barn to provide the same space and from 35 to 50 percent less material is required in the construction of the whole barn. It is a strong type of construction, but it has many disadvantages.

The lighting and ventilation of a round barn are quite difficult, especially where it is of a large diameter. The location of a silo in the center of a round barn is not satisfactory and it is placed there since the space is unsuitable for any other purpose. Such a silo is difficult to fill, interferes with light and ventilation and allows the silage odors to permeate the barn.

It is difficult to unload hay in a round barn. Where a driveway is used on the second floor there is a large amount of space wasted. In addition, there are generally too many supporting timbers on the first floor, which interfere with light and ventilation, cause difficulties in the interior arrangement, and are a hindrance to work in the barn. While the round barn may meet some requirements, it is not recommended.

THE "L", "T" AND "U"-SHAPED BARN

Two other modifications are the L-shaped and T-shaped (Fig. 20) barns. The section for the cows runs north and south and the other section is located at its north end, running east and west. In this extra section, accommodation for calves, cows that are ready to freshen, test cows and young stock is generally provided. Horses may also be kept here. Barns of this type are suited for large herds. By properly locating the pens and other equipment in the section running east and west, they can be made quite convenient. (Fig. 21.) The space above the cows is used for hay storage while that above the other part of the barn can be used for grain bins, storage of hay and bedding.

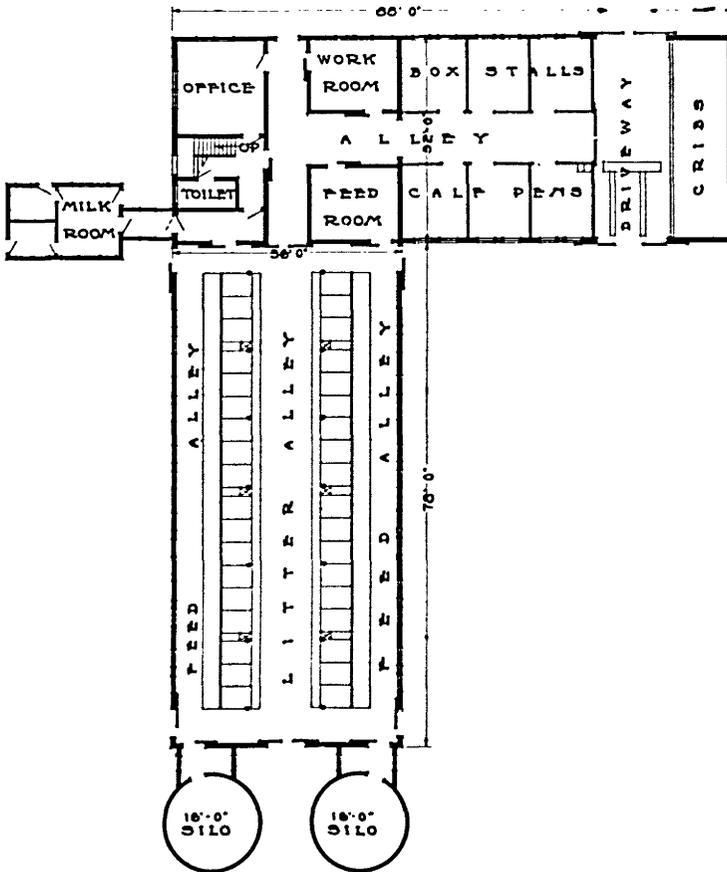


Fig. 20. Plans for an "L" shaped barn.

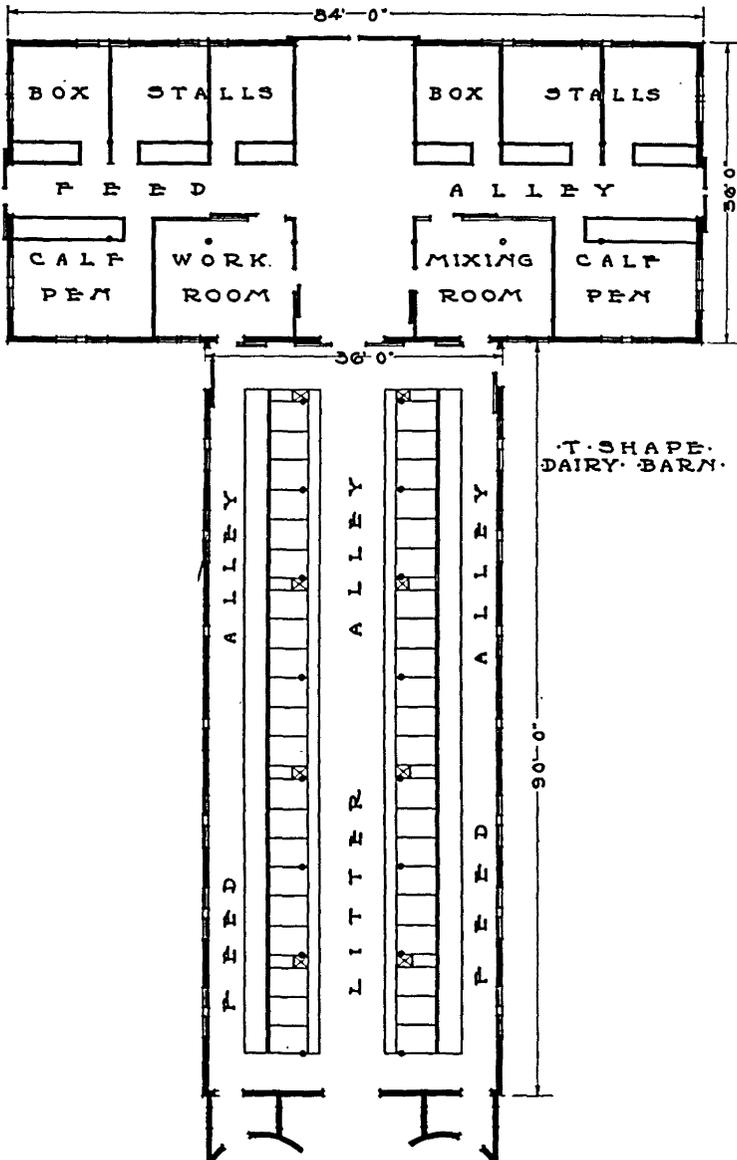


Fig. 21. Plans for a 'T' shaped barn.

A still further adaptation is the U-shaped barn. The two sections running north and south can be used for cows, or one of them can be used for calves, young stock or test cows. The (Fig. 22) disposition of the other or east and west section is the same as for the L or T-shaped barn. A barn of this type is suited for the needs of large herds but care has to be exercised in the location of feed rooms, silos and hay chutes so that the minimum amount of labor will be required in feeding the livestock.

Occasionally the north section of the L, T, and U-shaped barns are of two stories, while the other sections are single story. The objections to single-story sections for housing cattle in this region have already been discussed and need no further consideration.

REMODELING OLD BARN

There are probably more occasions when one is confronted with the problem of remodeling an old barn than of building a new one. A recent purchaser of a farm, a new tenant or a farmer who wishes to change to dairying often is confronted with difficulties in finding satisfactory housing facilities for his dairy

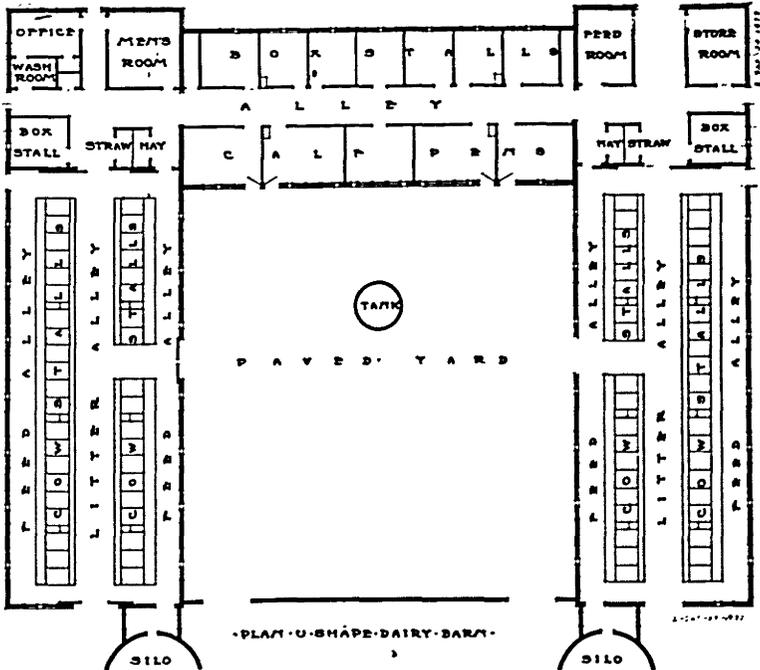


Fig. 22. Plans for a "U" shaped barn.

herd. There are a great many barns in use today that demand attention before they can adequately house dairy cattle. A very large percent of these barns were built with utter disregard for comfort, ventilation, sanitation and labor efficiency.

Among those barns which are more than 25 years old can be found a great many that would be very expensive if built today because of the quality of workmanship and lumber used in their construction. However, these barns are almost invariably unsatisfactory for dairy herds and yet they are too valuable to be torn down. If torn down a part of their materials could be used again, but only a small part could be so employed. Many more recently constructed barns are in a good condition of repair but to be satisfactory they often need to be rearranged and enlarged. Some old barns might well be torn down and entirely replaced, but the majority of them can be remodeled quite easily and with one-fourth the expense of a new barn.

Specific suggestions as to the details of remodeling barns so that they may properly house dairy cattle are impossible. The arrangement of each old barn naturally determines the rearrangement that would be desired.

The foundation and lower part of the framework has rotted out in many of these older barns. The best plan to correct this condition is to install a concrete foundation and continue this as a part of the wall the desired distance. Often in making this improvement it is an advantage to raise the entire barn. Raising may be desired for the sole purpose of elevating the ceiling or it may be to allow the attaching of a lean-to, or another wing. The ground floor is often used for hay storage and for housing horses and cattle. These can be improved by constructing an addition along the east or west side large enough to accommodate one row of cows facing in. At times it is desirable to make this addition at the south side when the old barn extends east and west.

Another method of improving such a barn is to construct a one-story wing for cows only, which may constitute a "T" or "L" type.

One of the most common faults in barns has to do with the poor facilities for carrying on the barn work quickly and efficiently. Many times the feed storage is so located that a maximum amount of labor is demanded in feeding the stock. Those men who do not have dairy cows do not appreciate the seriousness of such an arrangement. In summer seasons the general farmer has comparatively little barn work to do and in the winter he has more time for chores than the dairymen. On dairy farms labor is the second largest item in production costs, so labor must be utilized efficiently. Many times an inconvenient barn alone constitutes the drudgery of dairying.

An arrangement which places the feed room where the cows, calves, and young stock can be most quickly fed is an improvement. Provision should be made so that manure from the cows can be hauled out easily. Litter carriers simplify this problem, but they may cause trouble unless too many switches and turns are avoided. Quite frequently a change in the location of even the manure pile can effect a saving in time and patience of the barn worker.

It is not necessary that a dairy barn be exceedingly warm. Freezing temperatures are not to be entirely shunned inside the barn. Of course the barn should not get so cold that the water pipes are frozen on very cold mornings or that the manure in the gutter will be frozen solid, but a good brisk temperature is all right. One common fault of cold barns is that the barn men are apt to get too cold while working and so are tempted to close up the air intakes and thus prohibit any fresh air entering. It is far worse for a cow to spend a night in a stuffy barn, covered with condensed moisture, than in a cold barn that is dry.

Practically all old barns are improperly ventilated. In rearranging the barn, due consideration must be given to secure an adequate ventilating system.

Proper regard for sanitation can not be ignored in remodeling barns. Many of them have plank floors and altho they may be satisfactory for horses, floors for dairy cows and the gutters and alleyways behind the cows must be replaced with concrete. Likewise the proper kind of flooring material for the stalls must be provided.

A common objectionable feature of old barns is the lack of sunlight. Dairy cow stalls must not be located at the north side of a barn. Any other side will provide them with some sunlight and rearrangement should be made accordingly. It is almost invariable that old barns lack materially in window space. Under this restricted sunlight, sanitation is impossible.

In general, to remodel a barn for dairy cattle the suggestions previously made for new barns should be simulated as largely as possible. There are many conditions which make it impossible or impractical to duplicate new barns entirely, but they may serve as a guide. Under such conditions certain facilities may have to be omitted and certain dimensions reduced but under no condition should the comfort of the cows, proper ventilation and sanitation and the efficiency of labor be sacrificed to a too great extent.

