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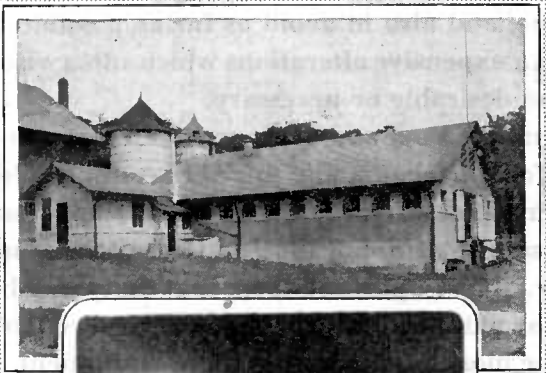
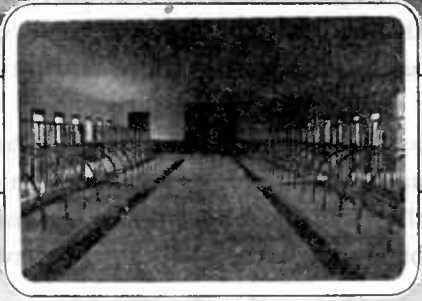
DAIRY-BARN CONSTRUCTION





THE plan, construction, and equipment of a dairy barn should receive careful consideration and study in order that the building may best serve its purpose, and also to avoid as far as possible having to make expensive alterations which otherwise might become desirable or necessary.

A well-planned and equipped barn saves time and labor for the farmer, and provides comfortable quarters for the cows, while the poorly planned barn is a daily source of annoyance and of wasted time and energy. It is important, then, that dairymen become familiar with the best principles of barn construction and the most satisfactory types of equipment, before building or remodeling their barns.

The subject covers such a large field that only the principal features of modern construction and equipment, together with practical plans for various types and sizes of dairy barns, will be presented in this bulletin.

Washington, D. C. October, 1923.

DAIRY-BARN CONSTRUCTION.

By K. E. PARKS, *Dairy Engineer, Dairy Division, Bureau of Animal Industry.*

CONTENTS.

TYPE OF BARN TO SELECT.

There are so many considerations which enter into the selection of the best type of barn for any particular case that the dairyman will usually have to rely on his own judgment as to what sort of barn will best meet his needs. Some of the more important factors to consider are climate, topography, drainage, location relative to other buildings, size and stage of development of his dairy project, fire risk, materials available for construction, and local regulations covering the production, handling, and disposal of milk. Of the various types of dairy barns only two of the most common will be described, as the others, with the possible exception of the round and octagonal types, are mainly modifications of these.

The most common types of modern dairy barns are the one-story cow stable, with feed in a separate building, and the two-story barn, in which the feed is stored on the floor over the cows. In the colder sections of the country the two-story barn is usually preferred, while in the South and in moderate climates the one-story barn is more common. Whatever the type of barn selected, there are certain features common to all, and these will be described before going into the details of construction.

THE BUILDING SITE.

A building site should be selected which is dry and well drained, and, if possible, the building should be placed with its length extending north and south, so that the interior of the barn will receive the

most sunlight. Such an arrangement allows the morning and afternoon sun to enter the windows on the sides and provides the greatest amount of light. The barn should be so placed in relation to other buildings that the sunlight will not be obstructed from the east, south, or west. A windbreak of trees or buildings on the north or in the direction of the prevailing cold winds will be found a great advantage in the winter.

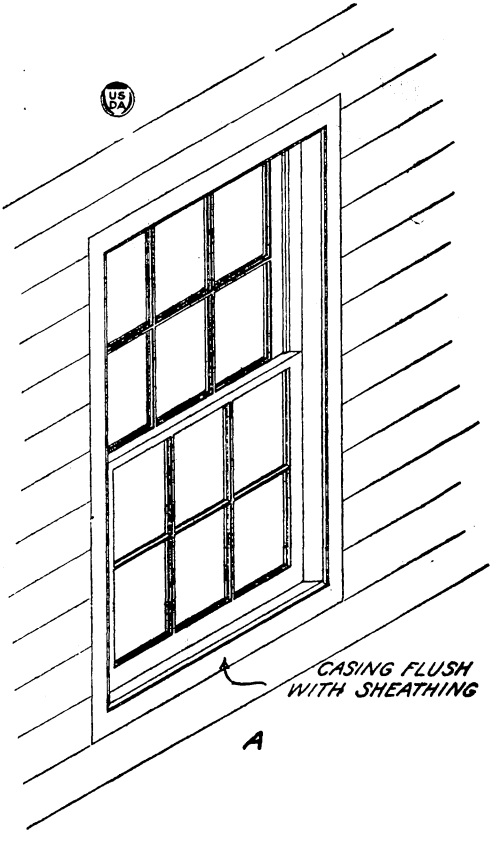


FIG. 1.—Twelve-light stock window.

Another point to consider in selecting the building site is its accessibility for unloading hay and feed and filling the silo, and the arrangement of yards and lanes. It is very inconvenient to have to drive through gates and yards to fill the silo or feed barn, and with careful planning it is generally possible to arrange the yards so that this will be unnecessary.

ESSENTIAL FEATURES IN DAIRY-BARN CONSTRUCTION.

After selecting the type of barn and the building site, the next step is to plan a building of the proper size and shape to house the stock and feed, fit the location selected, and at the same time harmonize with other buildings. The arrangement of the barn should be such that the daily work of caring for the animals can be accomplished with the least expenditure of time and labor. To accomplish this requires careful consideration of the location of the feed barn, silo, and milk house, and the method that will be used in handling manure.

In a cow stable there are certain features, such as light, floor space, ventilation, air space, stalls, mangers, and gutters, which are generally recognized as essential.

LIGHT.

Sunlight is considered essential to the health of the dairy cow, and it also tends to destroy disease germs which may be found in dark and dirty stables. It is necessary, therefore, that ample window space be provided. Four square feet of glass per cow is desirable, and a much larger amount is preferable, except in extremely cold climates. The height of the windows should always be greater than their width, as more floor area is exposed to the sun this way than with low, wide windows. In the Northern States objection is sometimes made to the use of too much glass on account of the loss of heat through the windows, which tends to lower the temperature of the barn. This difficulty may be remedied by using storm sash in the winter or by using double-glazed sash; either of these is better than small windows, which do not flood the barn with sunlight.

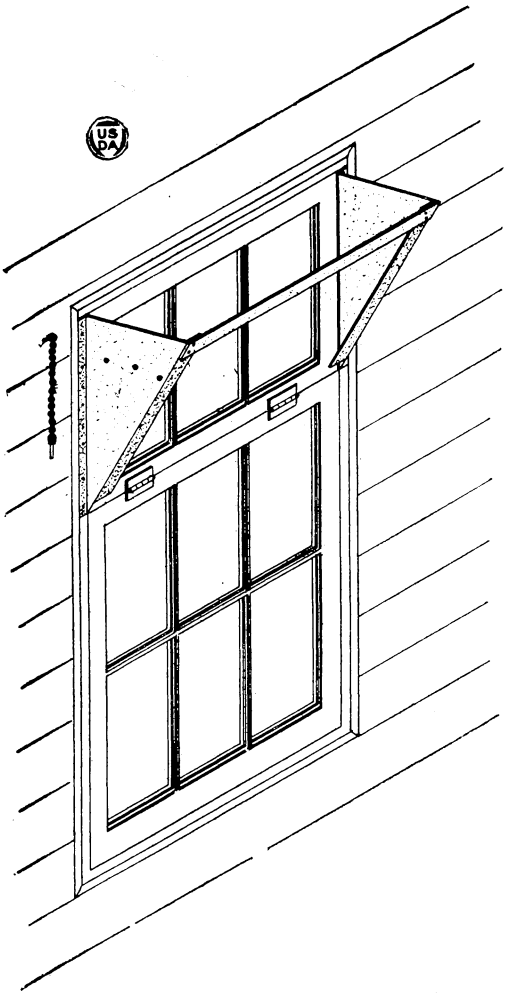


FIG. 2.—Six-light sash, with 3-light transom (to tip in).

In a barn extending north and south, 12-light windows of 8 by 12 inch glass, spaced 7 feet from center to center along the side walls, will provide 4 square feet of glass for each cow and will light a barn 36 feet wide in a very satisfactory manner. Windows should be placed with the sills at least 4 feet above the floor.

Figures 1, 2, and 3 show three types of windows suitable for cow stables. Figure 1 is the regular stock, 12-light window, while Figures 2 and 3 are windows which provide better ventilation.

AIR SPACE.

While the amount of cubic air space per cow in a stable is not necessarily an indication of either good or bad ventilation, it is considered desirable to have not less than 500 nor more than 1,000 cubic feet for each animal. In the North from 500 to 600 cubic feet are sufficient, and the stable may be uncomfortably cold if more air space is provided than can be kept at a reasonable temperature by the body heat of the animals. In the South 1,000 cubic feet per animal are more satisfactory, because of the long period of warm weather. A stable 36 feet wide, outside measurement, should have a ceiling 8 or 9 feet from the floor in order to furnish from 500 to 600 cubic feet of air space per cow.

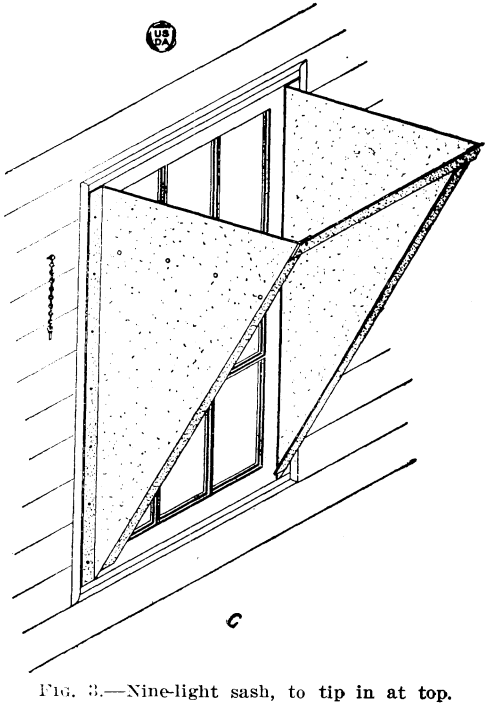


FIG. 3.—Nine-light sash, to tip in at top.

VENTILATING SYSTEMS.

The system of ventilation commonly used in cow stables is known as the King system, from its originator, Prof. F. H. King, of the University of Wisconsin. The system is designed to remove the foul air from the stable and at the same time provide for the entrance of fresh air through flues. It operates on the principle that warm air, being lighter than cold air, tends to rise, while the cold air tends to settle. This system of ventilation is probably more widely used than any other.

Often a failure of the ventilating system is due to improperly proportioned or constructed flues, loose-fitting doors and windows, and during an extended period of extreme cold weather to the clogging of the outlet flues with ice formed by the condensing and freezing of moisture thrown off by the animals. If properly constructed, the King system is generally very satisfactory.

In constructing such a ventilating system each outlet flue should have an area of approximately one-fifth square foot per cow, with possibly less area in cold climates and more in warm climates; that is, a flue having an area of 1 square foot should be considered suffi-

cient for 5 cows, and a flue 2 feet square, having an area of 4 square feet, would provide for 20 cows. The area of outlet flues is based on the principle that the air will rise in the flue at a certain rate or velocity, thus removing from the stable a certain number of cubic feet of air per minute. An equal amount of fresh air is drawn in through the inlet flues, thus establishing air circulation and maintaining a certain standard of air purity in the stable. The velocity of the air depends not only on the difference in temperature of the air inside and outside the stable, but also on the wind which blows across the top of the outlet flues and the action in the flues. While the amount of foul air removed by the flues may vary considerably, the cows continue to give off a constant supply of foul air and moisture, and if the outlet flues are not working properly the foul air will not be removed and the moisture will condense on the walls or ceilings, causing the stable to be damp and unhealthful for the cows. This condition, however, is more likely to occur in a stable where there is no ventilating system, and it is not wise to depend on window ventilation alone.

One or two large outlet flues of sufficient area are more efficient than a number of smaller ones of equal area. Such flues should be air-tight and as straight as possible, for bends in the outlet flues cause air friction which greatly reduces the flow of air. If bends are necessary, the area of the flue should be increased accordingly. In extremely cold climates the outlet flue should extend down to a point 12 or 18 inches from the floor, but in mild climates it need come only to the ceiling.

The fresh-air intakes should be small in area and should be placed from 7 to 10 feet, or, where necessary, 12 feet, apart along the side walls. These flues should be so arranged that the openings on the outside of the building through which the air enters the flues are at least 5 feet below the openings into the stable, which are placed just below the ceiling. The reason for arranging openings in this manner is to prevent the warm air inside near the ceiling from leaving the building through the intake flues, as it would do if the outside opening were at the same height as the opening inside of the barn, or higher.

In extremely cold climates the intake should be less than the outlet; but under most conditions the total area of all the inlet flues should be approximately equal to the total area of the outlet flue or flues; for example, if the outlet flue has an area of 4 square feet, the total area of the intake flues should equal 4 square feet. In a barn having one outlet flue 4 square feet in area there would probably be five inlet flues on each side, or 10 in all, each having an area of one-tenth of 4 square feet, or 57.6 square inches. Inlet flues 4 inches

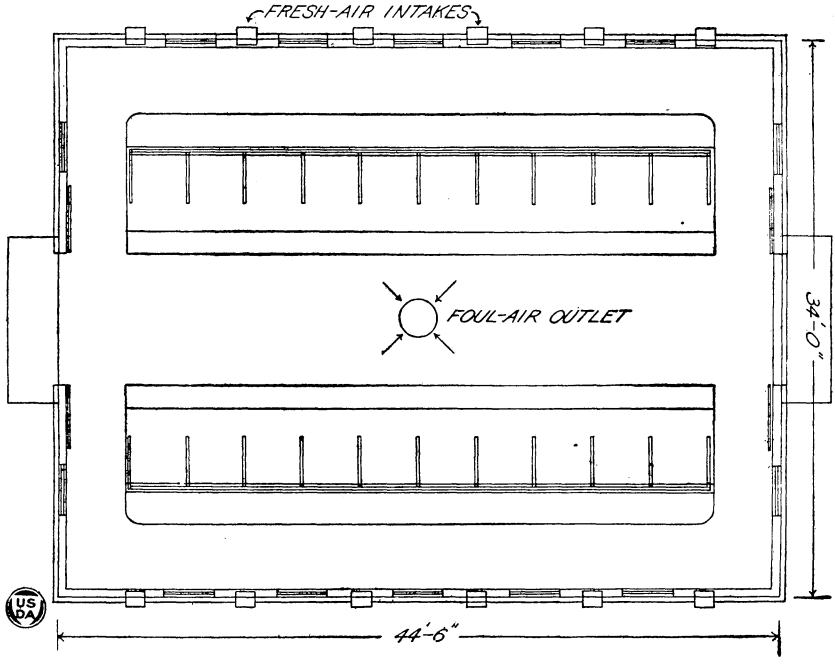


FIG. 4.—Plan of one-story cow stable, showing arrangement of ventilating flues.

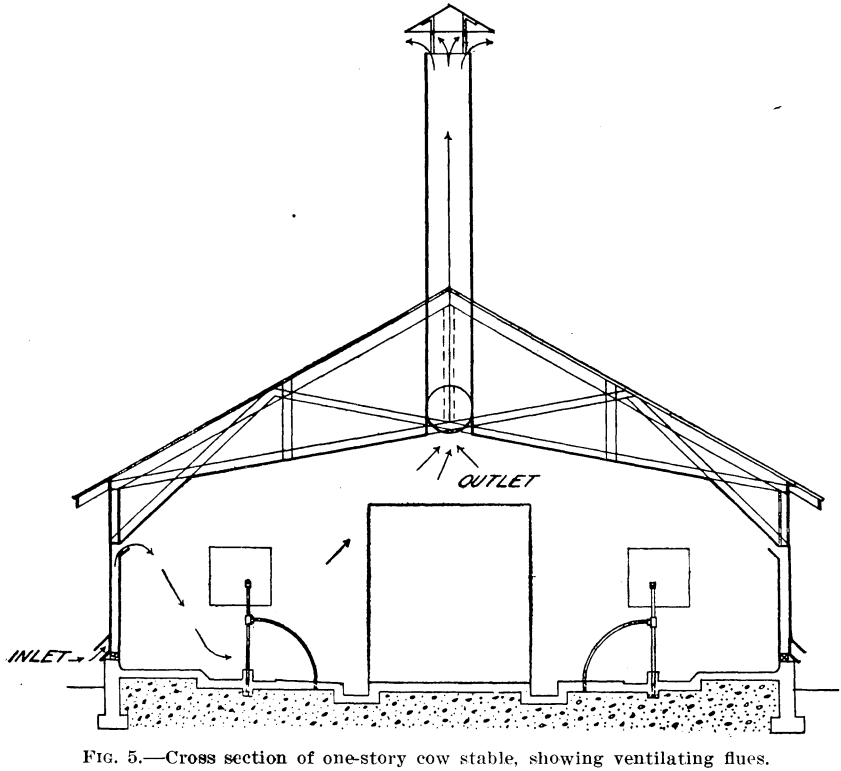


FIG. 5.—Cross section of one-story cow stable, showing ventilating flues.

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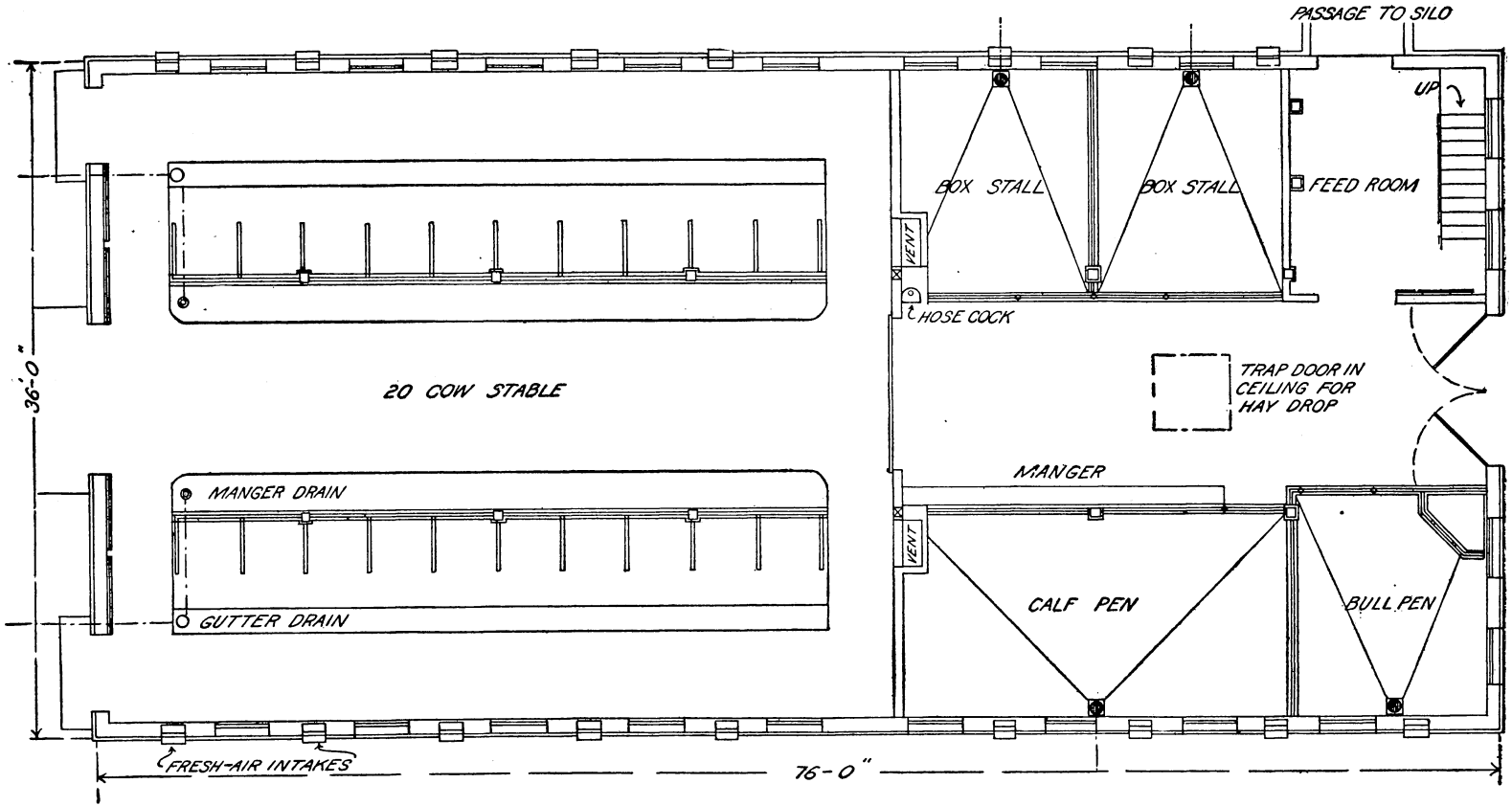

FIG. 6.—Plan of two-story barn, showing ventilating flues.

wide and 16 inches long would be of proper size for a one-story frame barn having 4-inch stud walls. A flue of this size could be arranged between studs placed 16 inches apart. The intake flues should be protected from the weather on the outside of the building by a hood, and dampers should be provided on the inside openings at the ceiling to permit closing some of the intakes when necessary.

Figures 4 and 5 show the plan and cross section of a one-story barn with what is called the modified King system of ventilation. The modification consists in starting the outlet flue at the ceiling instead of near the floor. This may be used in warm or moderate climates.

Details of installation of the regular King system of ventilation in a two-story barn will be found in Figures 6 and 7.

Figure 8 shows in detail the fresh-air intake flue as constructed in a frame barn. In barns that are plastered on the inside these flues should be protected with suitable insulating material between the flue and plaster; otherwise any moisture which touches the walls at the points where the flues are located will condense. One method of insulating such a flue is shown.

Figure 9 shows the details of an outlet flue constructed of wood, and also one of galvanized iron. The iron flue should be covered with insulating felt, especially in very cold climates. Outlet flues act like chimneys, and the higher they extend above the roof, the greater will be the draft. Dampers may be provided in straight flues having too much draft, but should not be placed in short flues or those containing many bends or other obstructions to a free circulation of the air above the roof. Such a damper is commonly made of galvanized iron. The outlet must be covered to keep out rain and snow, and the cover must be so shaped that the wind blowing across it will not make a draft down the flue instead of up. In a properly designed ventilator the wind will create an outward suction, and thus assist in removing the foul air from below. The old-style slatted cupola is not a satisfactory ventilator, as it is liable to give a down draft when the wind blows. Ventilators especially designed for stable use are on the market.

COW STALLS.

The size and arrangement of cow stalls have become nearly standardized in general practice, except in respect to a few details. The usual width of a stall is 3½ feet between centers of stall partitions, but it may vary from 3 to 4 feet. The length of the cow platform is usually from 4½ to 5 feet, depending upon the size of the animals to be accommodated. Sometimes a very large Holstein-Friesian cow needs a platform a little longer. As there are cows of different sizes in the same breed, it is a common prac-

tice to vary the length of the platform from one end of the row of stalls to the other. For Jerseys, this variation is from 4 feet 4 inches at one end to 4 feet 8 inches at the other; and for Holsteins from 4 feet 8 inches to 5 feet. The length of the cow platform is measured from the inside of the stanchion curb to the edge of the

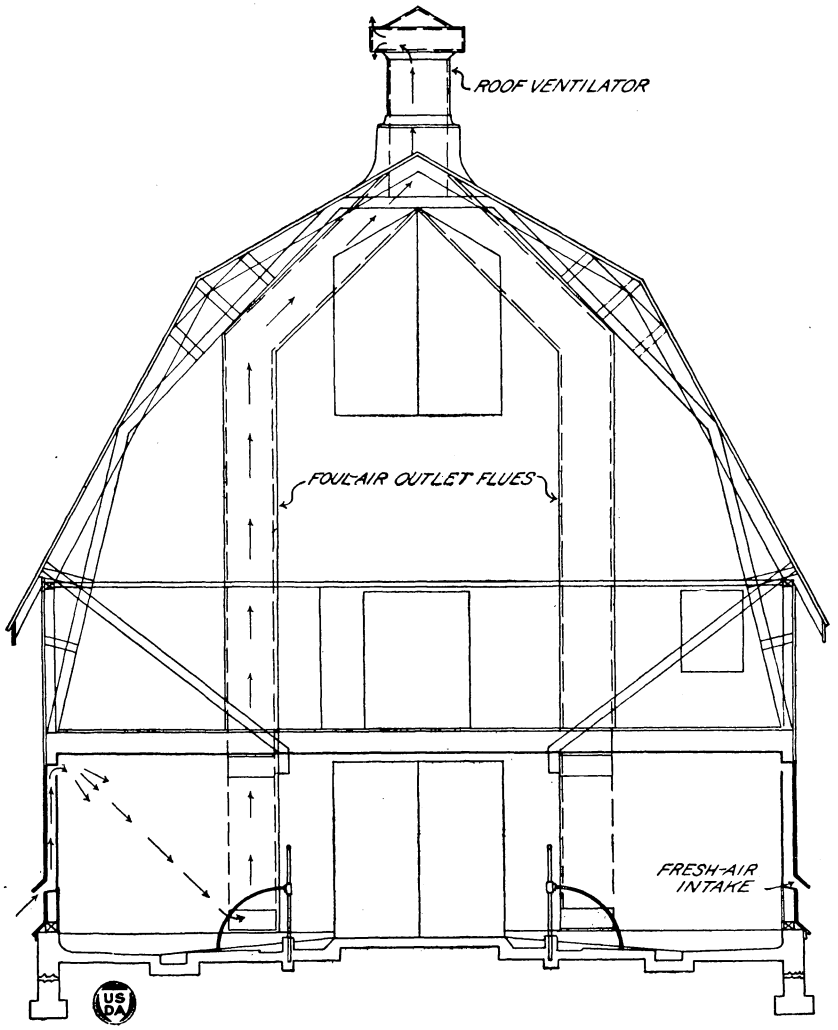

FIG. 7.—Cross section of two-story barn, showing ventilating flues.

manure gutter. Manufacturers of cow-stable equipment have adjustable devices which permit moving the stanchion supports either forward or backward to accommodate various sizes of cows. The reason for varying the length of the platform or using these aligning devices is to keep the cows lined at the gutter when standing,

so that the manure will fall in the gutter and not on the platform where they have to lie down.

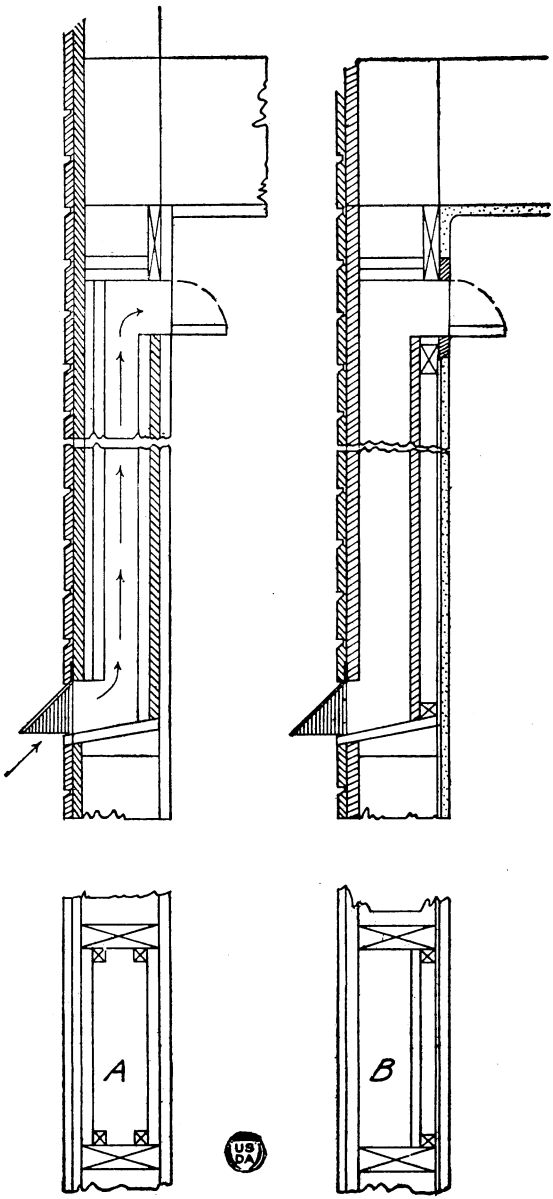

FIG. 8.—Details of inlet-flue construction: *A*, for barn with wood sheathing on inside walls; *B*, for barn with plastered inside walls.

To a certain extent the desired result is accomplished, but cows will usually become soiled even in a stall of this kind and will, of course, need to be groomed before milking.

The shape and size of the gutter and manger are points about which there is not full agreement. However, a good type of manger and gutter for a commercial dairy barn is indicated in Figure 10, which shows a cross section through a cow stall, the dimensions of which have proved satisfactory.

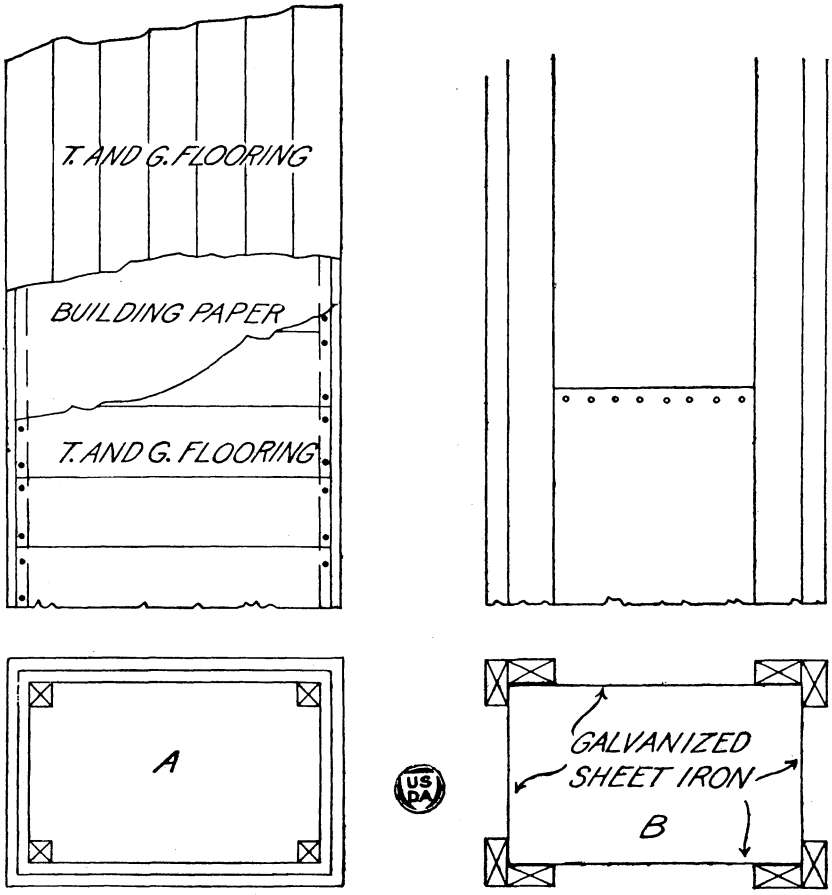

FIG. 9.—Details of outlet-flue construction: *A*, wood construction; *B*, galvanized-metal construction.

Figure 10 also shows the construction of stalls. Many manufacturers can now supply these stalls complete, to be assembled with clamp fittings, which save considerable time and labor in erection, as compared with the older method of using screwed pipe fittings.

STANCHIONS.

Comfort for the cow is important. The old-fashioned rigid wooden stanchion in which the cow was pilloried a portion of each day for a considerable part of the year has been replaced by the

swinging stanchion, which gives the cow more freedom and allows her to rest in a natural position. Such stanchions may be obtained in either steel or wood. The former is considered more sanitary, but has the disadvantage of being cold for the cow's neck unless the surrounding air is amply warm. A wooden lining to the steel stanchion may be used to overcome this objection.

STABLE FLOOR.

For the cow-stable floor concrete has become well established as the best material in alleys, driveways, gutters, and mangers, as it is durable and may be kept clean with the least amount of labor and expense. Concrete is also commonly used for the cow-stall floor, and while there are objections to its use for this purpose, it answers very well when plenty of bedding is used. Cork bricks, wood blocks, and planks are also used for stall floors.

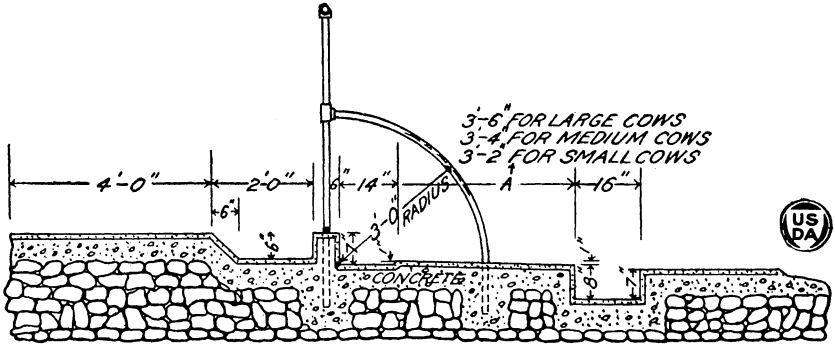

FIG. 10.—Longitudinal section of cow stall with concrete floor.

Concrete is a good conductor of heat, and consequently when the cow lies down the concrete chills her and has been known to cause serious trouble. With concrete a plentiful supply of bedding should be used, or else a removable plank overlay should be provided for each stall. This overlay may be used during the winter and taken up in the summer. Plank floors bedded permanently in the concrete are not satisfactory, as they soon become insanitary.

Cork brick, while expensive in first cost, makes an excellent floor when laid as shown in Figure 11. Formerly the bricks were laid with a 4-inch concrete curb at the edge of the gutter, but many cows have been injured on this kind of curb. When an angle iron is used as shown no trouble has been experienced.

Creosoted wood blocks have been used for cow-stall floors. They have to be laid in hot asphalt or pitch, as they swell when wet and would not have proper allowance for expansion if laid in cement.

Especial care should be exercised in laying the concrete floor of a dairy barn, as a floor which is not properly pitched to drain, and is

not properly finished, will be a constant source of annoyance and may result in injury to some of the animals.

In driveways and alleys, where teams or heavy silage trucks are to be used, the floor should be 6 inches thick, the base being 5 inches and the top finish 1 inch thick. All other parts of the floor may be 5 inches thick, with a 4-inch base and a 1-inch finish. The finish should be put on as soon as the base has set sufficiently to allow the finish to be applied; and on large floors only so much should be laid in one day as may be properly finished. The base may consist of 1 part Portland cement; 2½ to 3 parts clean, coarse sand; and 5 parts broken stone or screened gravel. The finish should be 1 part cement and 2 parts sand. The manger and gutter should be troweled smooth and hard on the surface with a steel trowel, while all alleys where the animals have to walk should be floated with a wood float, and when the cement has partially set it should be marked off in squares,

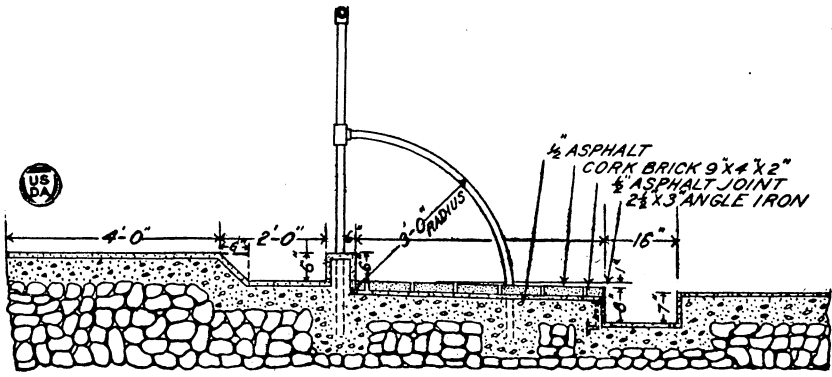

FIG. 11.—Longitudinal section of cow stall with cork-brick floor.

or thoroughly roughened with a wire brush or a whisk broom partially cut off. Roughening these walks is very important, as the animals are liable to slip if the concrete is troweled smooth.

In a stable not over 50 feet long the whole floor, including mangers, stanchion curb, cow platform, gutters, and alleys, should have a fall from one end of the building to the other of about 1 inch in 10 feet. In longer barns it may be desirable to pitch from the ends to the center. At the low end a drain should be provided from the manger to the gutter, and a gutter drain connected to glazed terra-cotta sewer pipe to carry the wash water away from the building.

These drains should be fitted with brass or wood plugs, and the gutter drain should have a water-sealed bell trap if the sewer pipe is connected to any sort of a cesspool or other sewage-disposal plant. Figure 12 shows a section through the manger and gutter drains.

Gutter drains are sometimes arranged so that the liquid manure will be collected in a concrete tank, from which it may be pumped

into a tank wagon and sprayed on the fields. This system has not been generally adopted, however, as it requires extra labor; and the most common method is to keep the gutter drain plugged with a tight cover and use bedding enough to absorb the liquid manure.

After the manure has been removed from the gutter the plug is removed from the drain and the floors and gutters washed off with a hose. In this way, practically no loss of manure occurs, and nothing but the wash water goes into the sewer system.

Sewer tile under the stable floor should be run in straight lines with a fall of one-fourth inch per foot, and the tile should be carried out from under the building as directly as possible in order that it may be easily cleaned if it becomes stopped up.

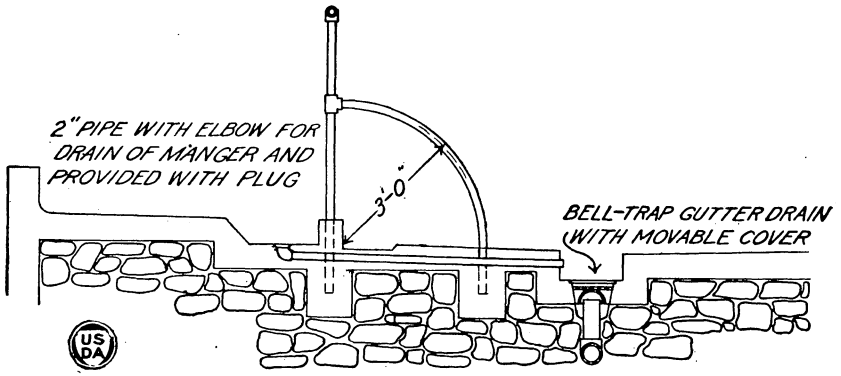

FIG. 12.—Longitudinal section of stall, showing manger and gutter drains.

STABLE EQUIPMENT.

If it is desired to install equipment, such as litter and feed carriers, milking machines, hay hoists, etc., consideration should be given to their installation while the building is being planned to avoid unnecessary cutting and fitting to erect the equipment.

WATER SUPPLY.

An ample supply of good water is a necessity on the dairy farm, and is highly essential in the dairy barn. There are several methods of watering the cows. Some dairymen prefer to water their cows at a watering trough outside, even in winter, employing heaters to bring the water to the proper temperature before permitting the cows to drink. Others advocate individual drinking cups attached to the stalls in order that the cows may drink whenever they like. Each system has certain merits, but the really important point is to see that plenty of water is provided both for watering the stock and for flushing the floors.

It is desirable to keep the floors as clean as possible, but the washing process is sometimes carried to extremes, with the result that the floors are always wet. This condition is unhealthful. It should be remembered that floors will not dry so quickly in cold weather as in warm weather, and the cows should not be made to lie on a wet floor, even though heavily bedded.

TYPES OF DAIRY BARNS.

THE ONE-STORY COW STABLE.

The more important features common to most dairy barns having been mentioned, the two types of barns in general use will be described.

The floor plan of a one-story cow barn for 20 cows is shown in Figure 4. This barn may be arranged with the cows facing toward the center or toward the side walls, as preferred. If the cows face out, the width of the barn need be only 34 feet outside measurement, while if the cows face in, the barn should be 36 feet wide, as otherwise the alleys behind the cows will be too narrow and the walls will be continually spattered and soiled. The dimensions across the building for a barn 34 feet wide and for one 36 feet wide are shown in Figure 13. The width of side alleys and length of cow stalls are omitted, as they vary in accordance with the length of cow stall selected.

The length of the building may be made to suit the size of the herd, but it is not considered good practice to put more than 50 or 60 cows in one building. In larger herds a better plan is to have several barns. This makes it possible to do the milking at a different time from the feeding and cleaning, in each successive barn. In barns containing more than 30 cows it is advisable to have a cross alley at the middle as well as at the ends. With 30 cows or less the end alleys will be sufficient. Cross alleys should be from 3 feet 6 inches to 4 feet wide.

The walls of the barn may be of stone, brick, tile, concrete, or frame construction; but if of stone, brick, or concrete an air space should be provided within the wall; otherwise the walls will be wet or frosted from condensed moisture.

Figure 5 (p. 6) shows a good type of roof construction for the one-story stable. In this stable no supporting posts or exposed framing are required, and the shape of the ceiling tends to eliminate dead-air pockets where moisture might condense. The natural circulation sweeps across the ceiling toward the outlet flues of the ventilating system.

The floor should be rounded or "coved" against the walls. These coved angles are much easier to keep clean than square angles between floor and wall.

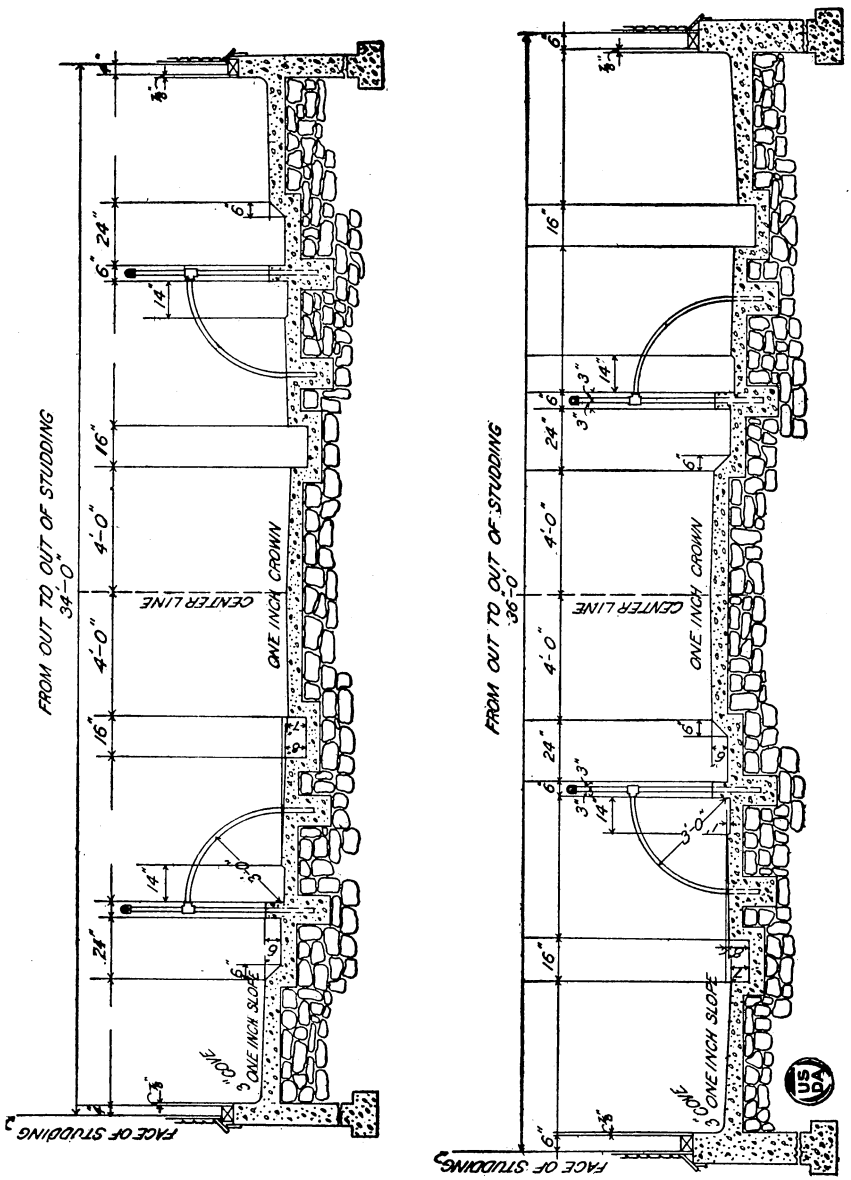

FIG. 13.—Cross sections of stables with cows facing out and cows facing in.

The barn shown in Figure 4 is intended only for stabling the cows and requires a separate building for feed. Figure 14 shows a general plan of this barn in connection with the feed barn, milk house,

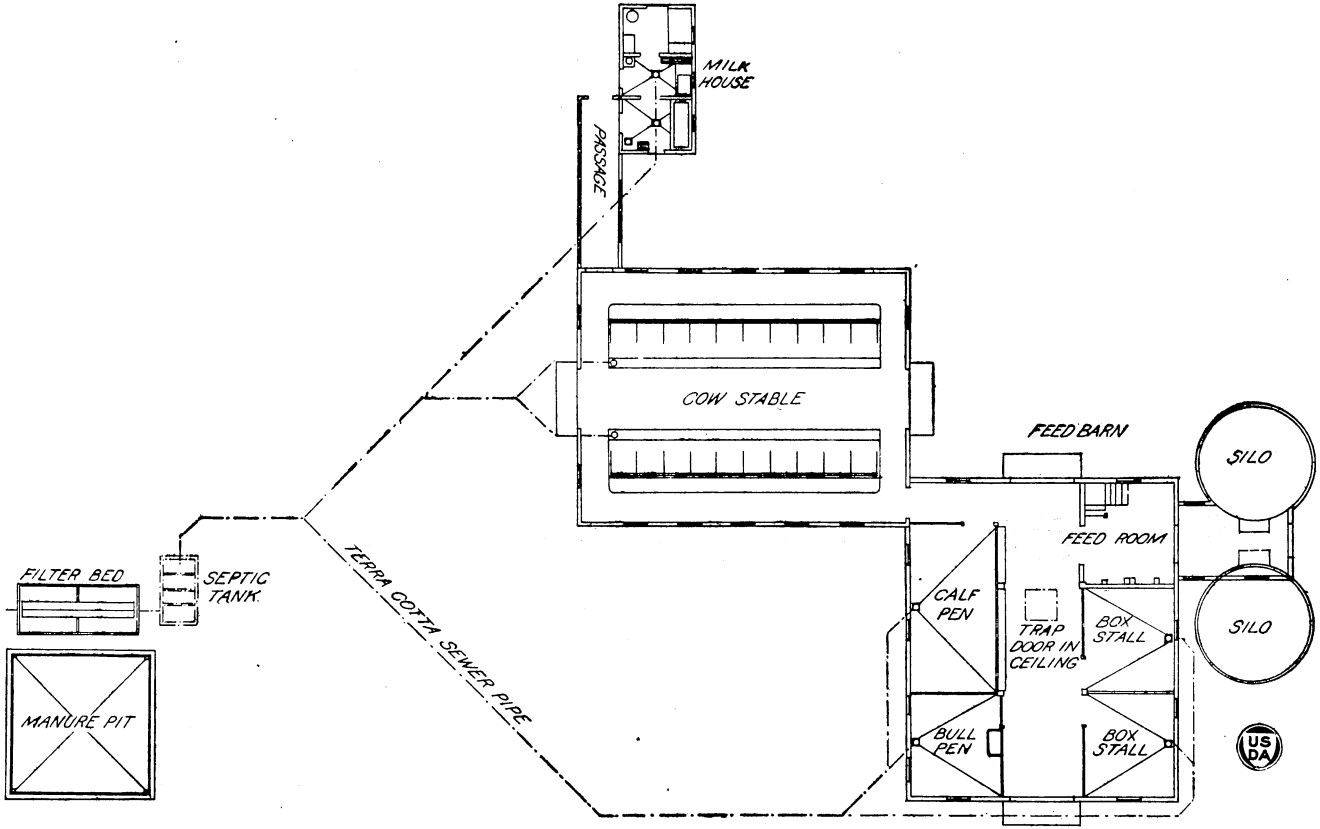

FIG. 14.—General arrangement of one-story stable, silos, milk house, and drainage system.

and silo. The plan also shows a manure pit and septic tank, both of which are desirable adjuncts to a well-kept dairy.

THE TWO-STORY DAIRY BARN.

If a two-story barn is desired, the plan shown in Figure 6 may be modified to suit the special conditions. This plan provides for 20 cows, with box stalls, calf pen, bull pen, and feed room on the first floor and storage spaces for hay, bedding, and grain above, as in Figure 15.

This type of barn may be constructed entirely of wood, or it may have concrete to the height of the window sills or to the underside of the second floor. If concrete is used it should be provided with an air space, as mentioned previously.

The barn shown in Figures 6, 7, and 15 is known as a plank-frame barn with a gambrel roof. All the members in the frame are built up from 2-inch plank and are light enough so that two or three men can frame up the whole building, thus saving in both labor and material over the old heavy-timber mortised frames. The plank frame is really stronger than the old type of frame.

The second story is clear of all framing, which is very desirable where hay is placed in the barn by means of hayforks or slings. A feed-storage room on the second floor is intended for storing grain in bags and has space for a mixing floor and feed bins, which are provided with chutes to the feed room below, where the feed may be drawn and weighed as required for feeding.

The silo also is connected to the feed room to centralize the feeding operations and to prevent silage odors from entering the cow stable proper, as they would were the silo to open directly into the stable.

A hay chute of ample size is provided and should be closed with a door on the first floor to prevent circulation of air through the mow above, which would interfere with the proper working of the ventilating system.

The plan shows two box stalls, and a calf pen which will accommodate about 10 calves. Box stalls should be not less than 10 by 12 feet. Calf pens should have about 30 square feet of floor space for each animal, and should be provided with stanchions for feeding. Calf stanchions may be purchased from manufacturers of cow-stable equipment or may be made of wood. Figure 16 shows a calf stanchion and manger constructed of wood.

The calf pen should have plenty of sunlight and in the plan additional windows have been provided for this purpose.

In a two-story barn cows should face toward the center, so that the posts supporting the second floor may be placed in line with the

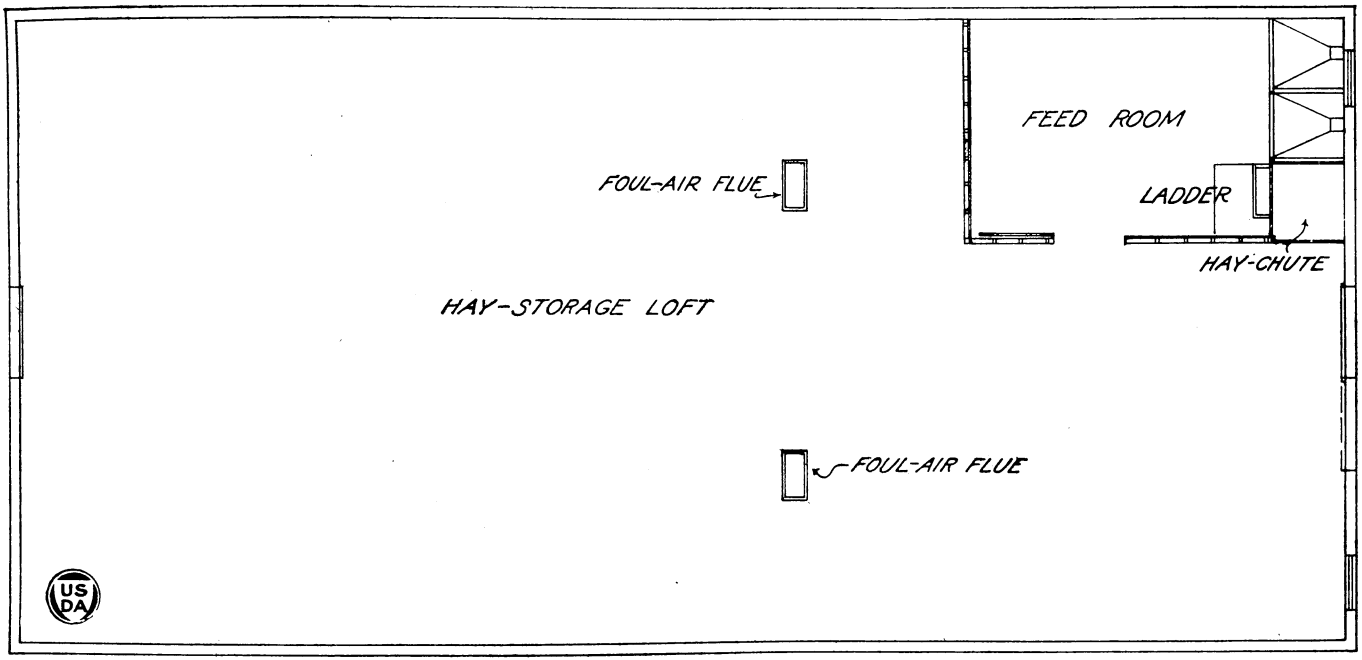

FIG. 15.—Second-story plan, two-story barn.

stanchions, whereas if the cows face out the posts will come near the back of the stalls, where they are more in the way.

When the cows face in it will be found more convenient to install a litter carrier to handle the manure; the carrier track is indicated in the plan. As the calf pen and box stalls do not require daily cleaning, the litter carrier is arranged for cleaning the cow stable only, for it will require less labor to clean the box stalls and calf pen with a manure spreader or cart driven through the barn. The track for the litter carrier should extend to a manure pit, where the manure can be stored under cover and screened from the flies. The manure pit should be at least 100 feet from the dairy barn and should be on the opposite side of the barn from the milk house.

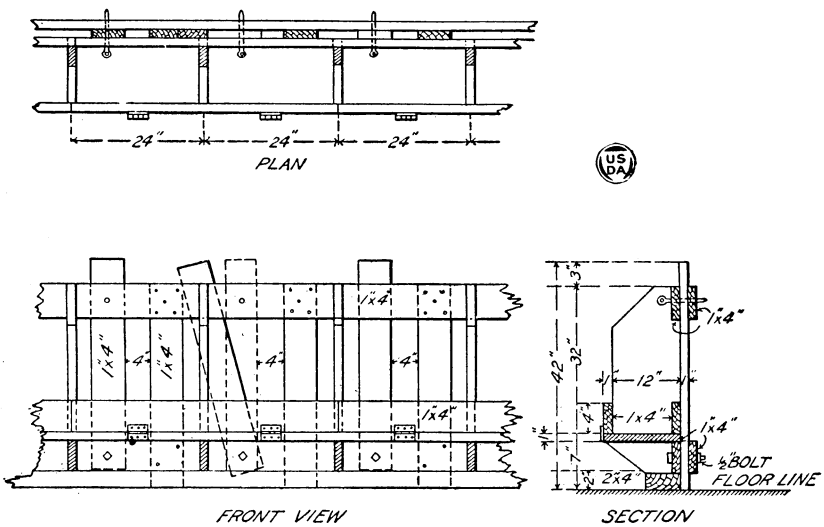

FIG. 16.—Details of calf stanchion and manger.

A milk house is considered necessary in a well-regulated dairy, and to serve its purpose best it should be located near the barn and connected to the barn by a closed passageway. This passageway should be provided with sash on the south side that may be replaced with screens in summer. A convenient location for the milk house is shown in Figures 14 and 17.

BLUE PRINTS OF DAIRY BUILDINGS.

Blue prints of various dairy barns, milk houses, and silos may be obtained free of charge from the United States Department of Agriculture or from the local county agents. In requesting barn plans, full information should be given, indicating the number of cows to be housed, whether facing in or out, and whether a one-story or two-story barn is preferred. If a one-story barn is desired, state whether

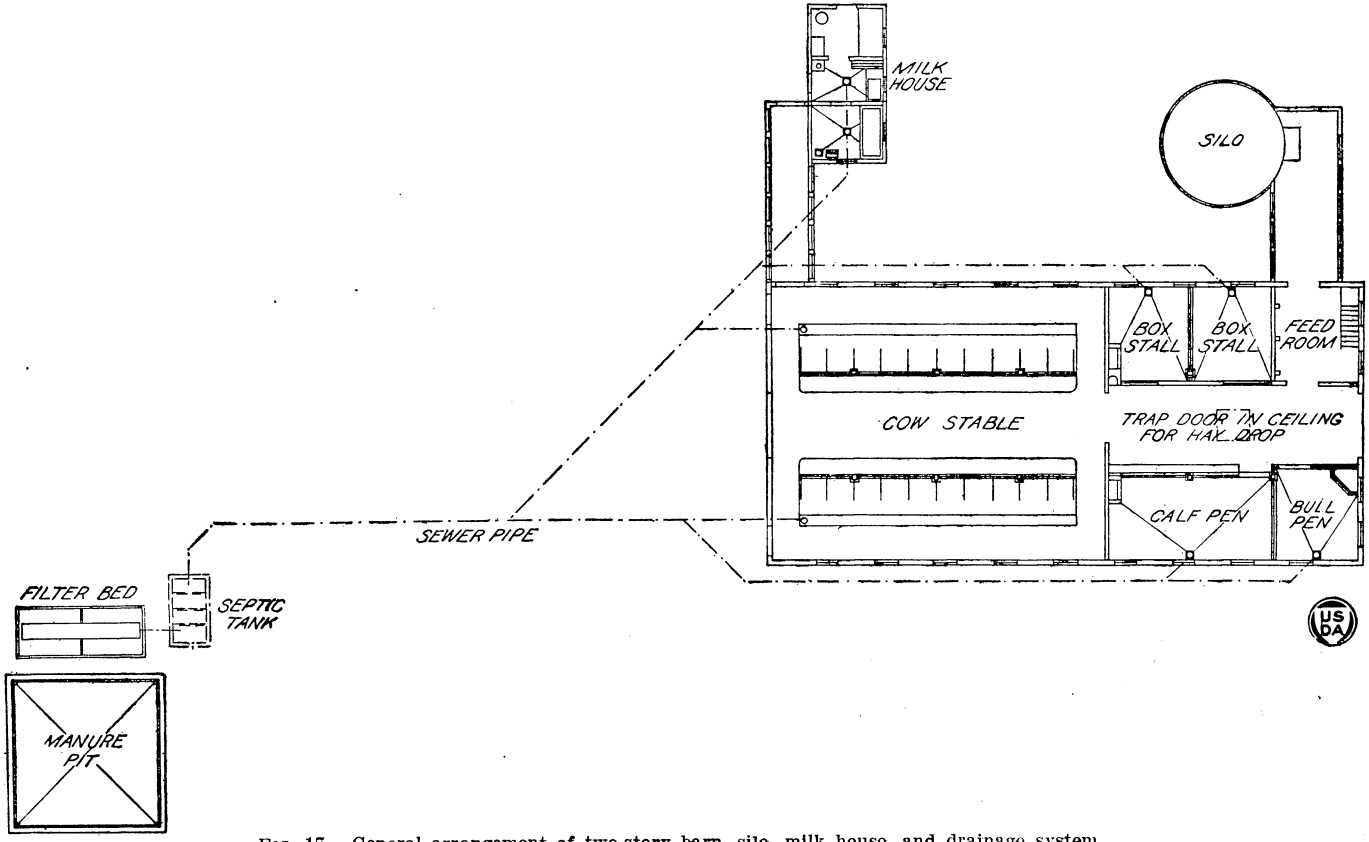

FIG. 17.—General arrangement of two-story barn, silo, milk house, and drainage system.

space is available in present buildings for feed and young stock, and if not, plans for a feed barn should be requested. If plans for a milk house are requested, state whether it is to be used for bottling market milk, handling whole milk in cans, separating cream, or making butter.

CONSIDERATIONS ON COST OF CONSTRUCTION.

Owing to constant fluctuations in cost of building material and labor, it is impracticable to state the cost of the various dairy barns described. Any person contemplating the erection of dairy buildings, however, should select plans in keeping with the earnings of the dairy enterprise conducted. Buildings of the more substantial kind, involving concrete foundations, floors, and sanitary conveniences, have the advantages of less depreciation and also of reducing labor costs, but the expense of building should not be allowed to go beyond the point where interest on investment, plus depreciation, will become an excessive overhead load.

Both the current and expected proceeds from a dairy need to be considered when determining the proposed outlay. In this connection, especially when the dairyman derives a portion of his income from the sale of surplus animals, it should be remembered that well-designed, attractive buildings have an appreciable advertising value.

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