



THE FUNCTIONAL DESIGN OF A
MILK HOUSE FOR MICHIGAN

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE
James Sterling Boyd
1948

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By
James Sterling Boyd

A Thesis

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
In partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Agricultural Engineering

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ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation for the counsel and helpful suggestions of Professor Arthur W. Farrall, Head of the Department of Agricultural Engineering and to Professor D.E. Wiant for assistance in preparing material for this thesis. Also to fieldmen from the Arctic Dairy and the Lansing Dairy for help in locating milk houses and to Swift and Company for financial assistance.

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Milk is an important food in American diets and, for this reason, milk ordinances have been enacted to regulate the production of milk. Twelve large cities and many smaller cities have milk ordinances and there have been some differences in these ordinances. Because of these differences, it has been difficult to draw milk house plans which could be used state wide. One section, common to all ordinances, is that milk must be handled in a milk house when it is market or fluid milk.

As a result of conferences with dairy authorities and investigations of milk ordinances, it was found that the following functions are performed in a milk house: (1) cooling and storing milk, (2) washing and sterilizing utensils, and (3) storing utensils and equipment between milkings. To provide for these functions, the following equipment is necessary: a milk cooler, a water heater, a double wash vat, and a can rack. When this equipment is provided, it will encourage the production of clean milk. However, the use made of this equipment depends upon the location of the milk house.

It was found, from time and motion studies made

by the Farm Management Department, that the time spent in the milk house varied inversely as the distance between the milk house and stable. When the equipment is convenient, it will be used and producing clean milk will be made easier.

A milk house located in the barn will be approved by the major milk markets and is most convenient. A milk house connected to the barn with the entrance to the stable through two doors, or through a vestibule, will be approved by all Michigan milk ordinances when constructed as shown on the plan, and provided with adequate ventilation and drainage.

APPROVED:

Major Professor

3/20/43

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INTRODUCTION

History

Milk is one of our most valuable foods. Food technologists generally agree that the food value of milk is higher than that of most other foods. For this reason, health authorities are interested in an abundant supply of clean milk and are constantly watching for means of improving its quality. Because milk cannot be cleaned, it is different from all other farm products; in fact, Jensen and Bell² describe milk as "perhaps the most delicate food the farmer handles". Pasteurization will kill any harmful bacteria which may enter the milk; however, these dead bacteria cannot be removed. There are even some types of bacteria which cannot be killed by pasteurization. For this reason, milk should be kept free from contamination from the beginning.

Milk production is one of Michigan's largest industries, accounting for 23% of the annual farm income.¹⁶ 60% of this production is handled in the farm milk house. Much of the milk is produced on general farms and it has been found that chore time accounts for half of the yearly work on these farms. Bookhout,⁴ in a survey made of ten

Michigan farms, indicates that 18% of the chore time with dairy cattle is spent cleaning utensils and caring for milk. Through observations, it has been found that these chores were accomplished more effectively in a properly designed milk house.

There are two general classes of milk sold from the farm -- market milk, and manufacturing milk for the condensary and cheese plant. These two types of milk markets require different sanitation standards; the fluid milk market is very strict in its requirements while the condensary market is rather lenient. Fluid milk is consumed in essentially the same form as it is produced and cannot be cleaned like other farm products. Pasteurization renders good milk safe but will not make poor quality milk good. Efforts to improve on milk supplies have been gradual throughout the United States, but they have noticeably accelerated as the use of market milk has increased in comparison with that of manufacturing milk. It is generally accepted that a suitable milk house is essential to a quality milk production program. The attitude of the Health Departments regarding milk houses has changed, and not by accident. For example, Parker¹², in 1917, indicated that the best location for a milk house was from 150 feet to 200 feet from the stable. Since that time, changes have been made in procedure and equipment which make possible a much more convenient location. For instance, the installation of pressure water systems is simplified by attaching the

milk house to the stable. The cleaning of milking machines with vacuum lines from the milking machines, the use of electric coolers, and new methods of controlling flies have made it possible to increase the usefulness of a milk house by attaching it to the barn. Figure 1 shows two milk houses which have been used to handle milk in the past. These structures were merely shelters for the milk coolers (usually water coolers). They were located between 150 and 200 feet from the stable and the other chores of caring for the milk and washing utensils were performed in the stable and the kitchen because it was thought that milk would absorb odors from the stable. McMillan¹², however, found that milk did not absorb odors from the air. Milk which has been exposed to stable odors for one and one-half hours did not absorb them unless the foreign matter causing the odors was allowed to enter the milk. Because of this and other similar studies, it was generally agreed that the milk house could be located close to the barn without contaminating the milk with odors.

In 1942, the Milk Ordinance Committee of the Michigan Allied Dairy Association drafted the Michigan Milk Ordinance²⁴ which was to be used as a pattern for city ordinances drafted for the regulation of the milk production in that area.

REASONS FOR THE STUDY

In 1946, the health authorities started a program to improve the quality of market milk. It was generally accepted



Figure 1. Above and Below-Inadequate Milk Houses
Which Have Been Used In Michigan.



that a milk house was important to such a program and a building plan which could be used throughout the state would help this program. It was estimated that ten thousand new milk houses would be constructed in Michigan in the following five years. Health authorities and dairy inspectors, who were interested in the program, desired a plan which would fulfill the milk ordinance requirements. The farmers, who were to build these milk houses, wanted to be sure that they would not have to rebuild in a short time because their milk house would be out of date. The average cost of the milk houses would be about three hundred dollars, depending on the amount of native materials and the farmer's own labor used.

Ten thousand milk houses, costing approximately three hundred dollars per unit to build, would represent an investment of three million dollars. If this investment were to be made by industry, very careful planning would be employed to be sure that the best possible building would be constructed. It is equally important that a farmer give careful consideration to the construction of each unit he builds.

OBJECTIVES OF THE STUDY

The two objectives of this study are as follows:

1. To determine the functional requirements of a milk house used by the average farmer to produce and sell grade A market milk.
2. To prepare a milk house plan which will be accepted by all milk ordinances and milk inspectors in Michigan.

REVIEW OF LITERATURE

From the literature reviewed, it was observed that there were two types of milk houses being used in the United States: (1) the porch type, in which the operator must go out-of-doors between the stable and the milk house, and (2) the vestibule type, which has a covered walk between the stable and the milk house.

Belton and Long³ stated that the milk house should not be part of any other building than the barn. Two rooms were recommended for a dairy of fifteen to twenty cows producing both milk and cream. Because many of the herds in California are larger, it is practical to use steam for cleaning and sterilizing purposes. A ventilation system is necessary to remove excess moisture, and insulation in the ceilings and side walls will reduce the trouble caused by the moisture. Smith,¹⁴ working with health authorities in Washington, also indicated that ventilation was important to control dust and to prevent decaying of the walls and ceiling.

Huber,⁷ working in Maine, recommended that walls be made easy to clean and that adequate light and ventilation be provided. Jefferson and Trout⁸ state that "the purpose of a milk house is to provide adequate facilities for handling milk on the farm". Bell and Jensen,² also working in Michigan, emphasize the importance of cooling as a factor in high quality milk.

Fogle and Lucas⁵ found that, for good quality milk, cleanliness and prompt cooling are essential. Harrington and Bremer⁶ in Massachusetts also stated that cleanliness and refrigeration were the two essentials for high quality milk. They recommended a cooling tank, a can rack, running water, and a water heater as necessary equipment in a suitable milk house. They suggested the following sizes for the various amounts of milk produced.

cans produced per day	size
4	6' x 7'6"
6	7'6" x 10'
8	9' x 12'
10	10'6" x 12'
12	12' x 12'
14	12' x 13'6"

LaRock and Witzel¹¹ stated that an important consideration was locating the milk house for convenience. The milk house may be attached to the barn, providing there is no direct opening to the barn. There must be a passage or a porch between the door to the milk house and the door to the barn. Locating the milk house close to the well is suggested. This location would not be recommended if mechanical cooling is to be used, which is necessary when the market regulations require milk to be cooled to 50°F. in one hour. They recommended a minimum size of 10' x 12' for single room houses and 12' x 16' as minimum for a two room milk house. Strahan¹⁵ suggested that the recommended size for fifteen to twenty cow herds is 9'8" x 8'4" and for more than twenty cow herds, 10' x 14'.

A water heater, a sink, a cooler and a can rack are necessary items of equipment.

Jennings⁹, working at Cornell, also made extensive studies on the location of milk houses with relation to the barn. He found that for each three and one half feet between the barn and the milk house, the dairyman walks one mile per year to strain the milk from each cow. The following is a summary of the estimated distance to be traveled per year to strain the milk from a twenty cow herd.

If the milk house is:

10' from the barn	60 miles
25' from the barn	150 miles
50' from the barn	300 miles
100' from the barn	600 miles

Jennings also made a survey of milk houses to determine the size and found that one out of eighty milk houses was too large, while only one in four milk houses was too small. The equipment necessary to accomplish a good job of milk handling was a cooling tank, a wash vat, a can rack, and hot water. Ventilation was suggested to eliminate the problem of excessive condensation on ceilings and walls. The following room sizes are recommended for the various levels of production. (See Table 1)

Table No. 1 Milk House Sizes Recommended by Jennings

Milk produced per day (cans)	Floor area per can (sq. ft.)
2	29
4	21
6	18
8	13
10	12
12	11
16	10

Recommended size of milk house attached to barn

Milk produced per day (cans)	Size	Floor area per can (sq. ft.)
2	8' x 8'	32
4	8' x 10'	20
6	10' x 10'	17
8	10' x 12'	15
10	12' x 12'	14
12	12' x 12'	12
16	12' x 14'	11

Recommended size of milk house separate from barn

Milk produced per day (cans)	Size	Floor area per can (sq. ft.)
2	6' x 8'	24
4	8' x 10'	20
6	10' x 10'	17
8	10' x 10'	13
10	10' x 12'	12
12	10' x 12'	10
16	12' x 12'	9

Krueger¹⁰ stated that three operations are necessary to insure a quality product.

1. Production of milk with low bacteria count.
(from clean cows)
2. Handle the milk to prevent outside contamination.
3. Quickly chill the milk to 50°F or lower.

The milk house should not connect directly with the barn, should be built of non-absorbent material,

should be ventilated and should have window area equivalent to ten per cent of the floor area. In addition to the cooling facilities, a wash vat and a can rack should be provided. The floor space necessary to operate this equipment is shown below.

Cans of milk produced	Size
4	7' x 11'
6	9' x 11'
8	11' x 11'
10	13' x 11'
12	15' x 11'

The milk ordinances in the state are the governing rules in milk house construction and will regulate the type of milk house built in the different areas of the state. Twelve large cities in Michigan have dairy plants buying milk and have ordinances controlling the production of this milk. These ordinances have been reviewed and the sections pertaining to milk house construction summarized as shown in Table 2.

Table No. 2 Milk Ordinance

AREA	SIZE	OLING AND REFRIG.	UTILITY RACK
LANSING ²¹ 1946		NON ° WITHIN E HOUR	
MICH. MILK ²⁴ ORD. 1945		NON ° WITHIN E HOUR	12" ABOVE FLOOR
GRAND RAPIDS ²⁷ 1942		NON 50° E DEDIATELY	
BAY CITY ¹⁸ 1940		NON ° WITHIN E HOUR	
PONTIAC ²⁶ 1945	20 GAL 20-50 " 50-100 " 100 "	NON ° IMMED- E TELY	12" ABOVE FLOOR
DETROIT ¹⁹ 1947	10' x	WITHIN RECOMIE HOUR	12" ABOVE FLOOR
CHICAGO ²³ 1937		NON ° WITHIN E HOUR	
(KALAMAZOO) ²⁹ FED. SECURITY AGENCY 1939		NON 50° E DEDIATELY	
FLINT ²²	0-15 GAL 15-25 " 26-50 "	NON ° WITHIN E HOUR	
ANN ARBOR ¹⁷ 1947		NON ° WITHIN E HOUR	12" ABOVE FLOOR
SASINAW ²⁸ 1942		NON 50° E MPTLY	WELL VENTILATED
BATTLE CREEK		NON ° WITHIN E HOUR	METAL 12" ABOVE FLOOR
JACKSON ²⁰		NON ° E DEDIATELY	REQUIRED

MATERIALS AND EQUIPMENT

The milk house shown in Figure 2 was constructed to investigate the effects of size, and the proper arrangement of equipment in a milk house. Cinder blocks were used for the walls and standard wood construction in the roof. The ceiling was constructed using two types of insulation. The north half was covered with three inches of vermiculite fill and the south half insulated with aluminum foil. The north half of the east wall was filled with the same vermiculite insulation as was used in the ceiling and the south half was filled with cinders to determine the desirability of insulating masonry walls by filling the cores.

The milk house was built adjacent to a remodeled dairy barn on Michigan State College property, one mile east and one half mile south of the campus. Since cows were not housed in this barn during the winter, the milk house could not be used for this study. Because of this fact, four other milk houses, located through the assistance of fieldmen from Lansing dairies, were used for the studies.

Milk house No. 1 was of cinder block construction with four sides exposed to the weather as shown in Figure 3. The ceiling was made of one half inch insulation board and the roof was of standard construction. The milk house was connected to the barn through a porch. Equipment used included an electric cooler (6 can), a ten gallon water heater, and a double wash vat. During the cold days in January and February, a fifteen hundred watt electric space

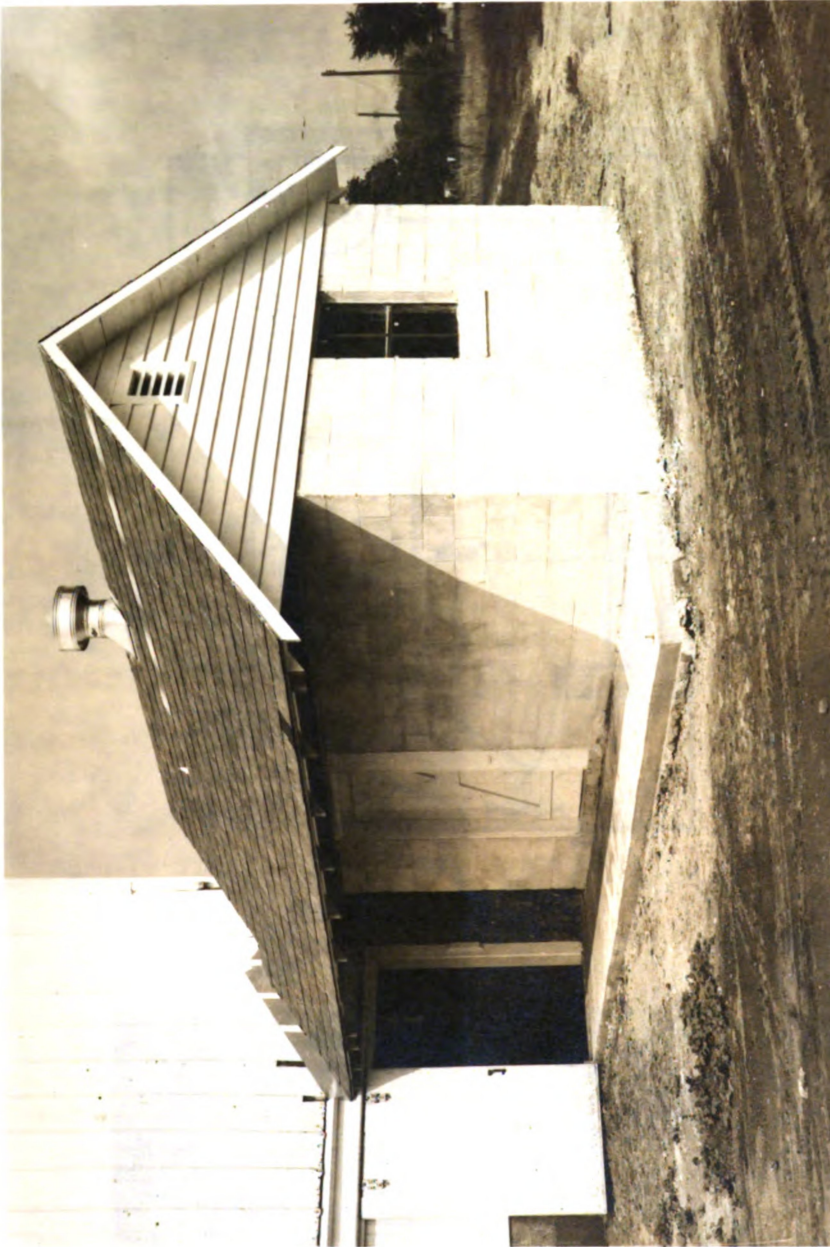


Figure 2. Experimental Milk House, Michigan State College.

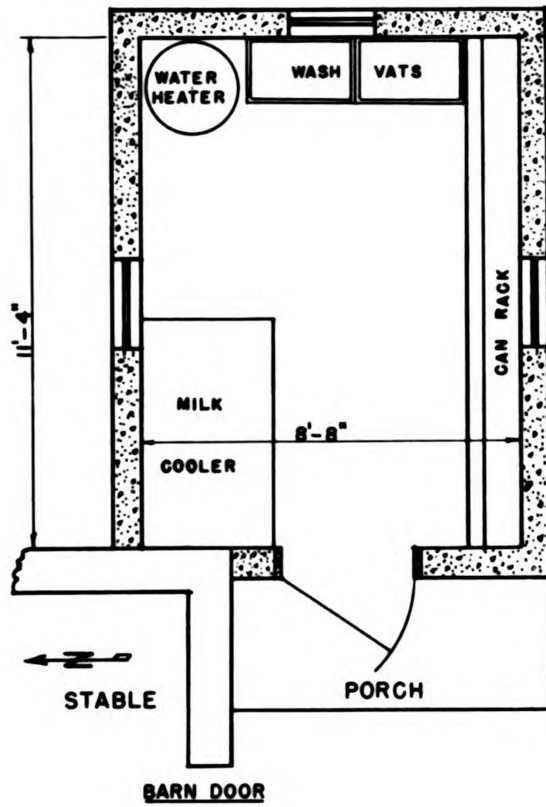


Figure 3. Number 1 Milk House Studied.

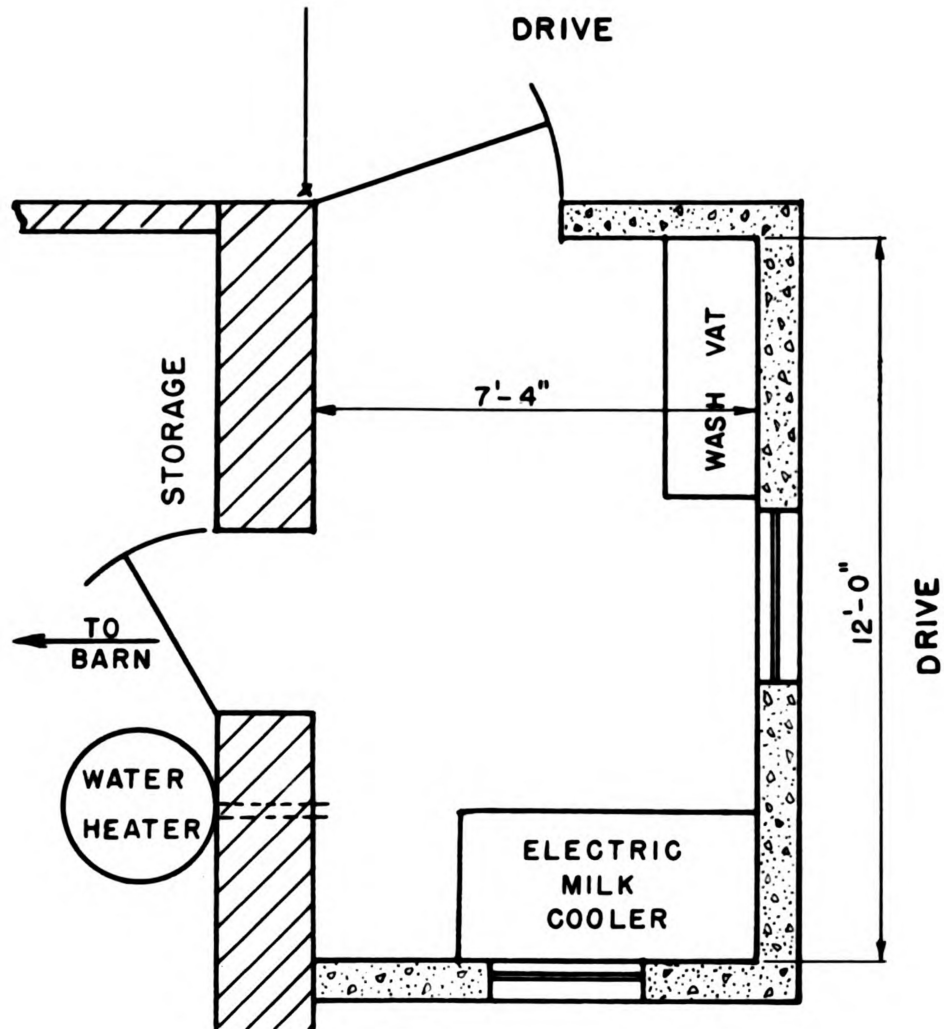
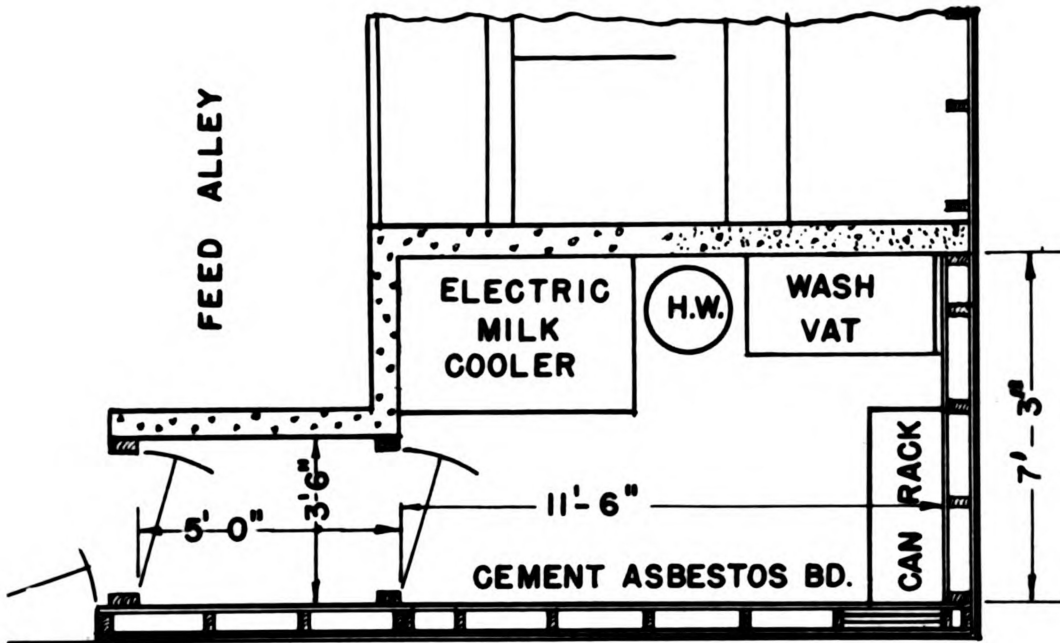


Figure 4. Number 2 Milk House Studied.



DRIVE



1. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.

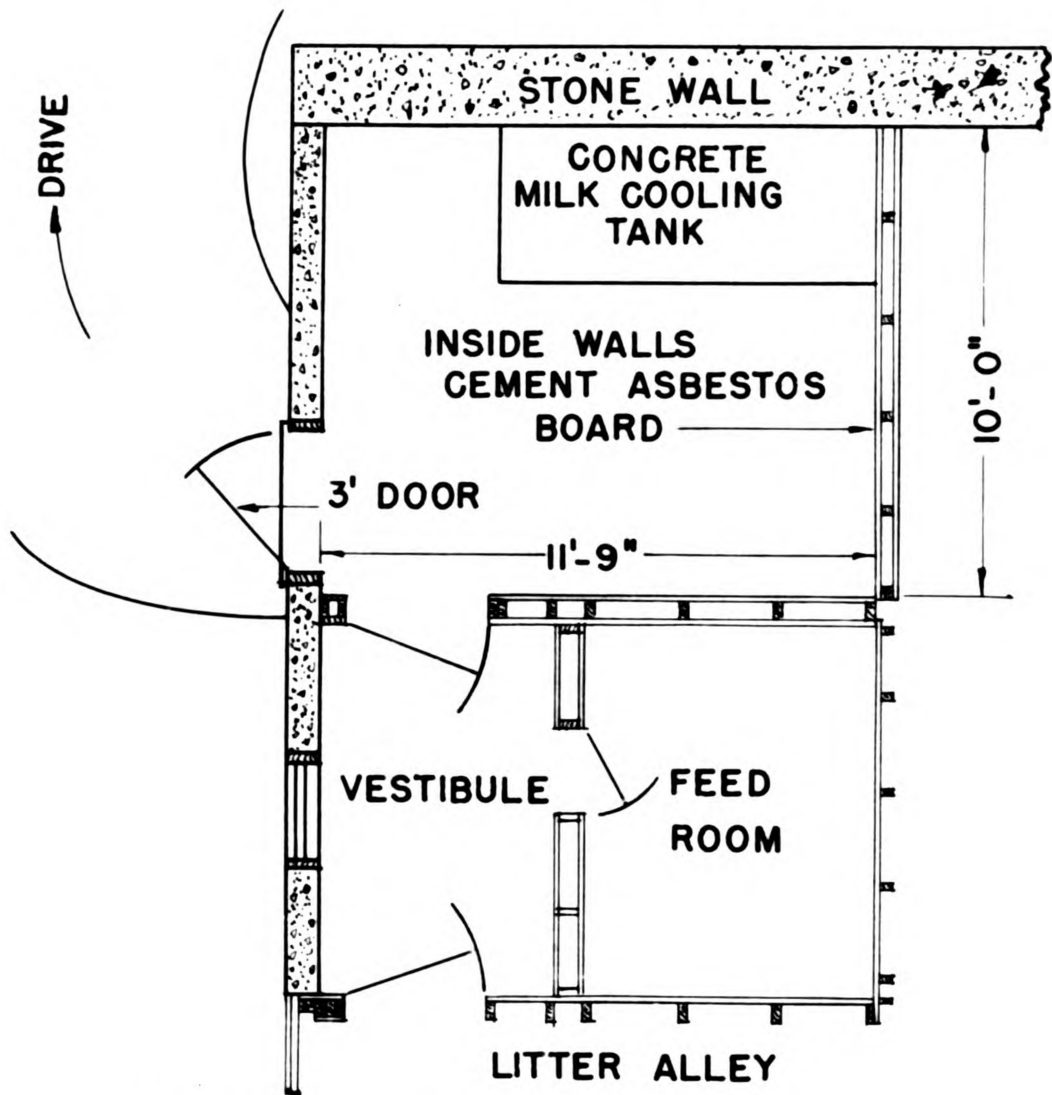


Figure 6. Number 4 Milk House Studied.

heater was used to prevent freezing. The farm was located two miles west and one and one half miles north of Mason, Michigan.

Milk house No. 2, Figure 4, was located five miles south west of Lansing, Michigan. It was built of concrete blocks with three sides exposed to the weather. This milk house had recently been completed and was not fully equipped. The ceiling was made of cement asbestos board with no insulation. Ventilation was provided through two small ventilators in either end of the attic. A six can electric cooler was used and the window was kept open during the tests.

Milk house No. 3, Figure 5, was located two miles east and two miles north of Charlotte, Michigan. It is built of concrete blocks in one corner of the barn as shown. The ceiling consists of cement asbestos board under the joists and baled hay was stored overhead. A six can electric cooler was used, a ten gallon water heater, a single wash vat, and a small rack for utensils. Several of the pails were stored on the concrete floor. The outside walls were constructed of one inch vertical siding on the outside and one quarter inch cement asbestos board on the inside. Water was piped to the milk house from the stable. Two doors were provided through a vestibule to the stable.

Milk house No. 4, Figure 6, was located two miles north and one and one half miles west of Grand Ledge, Michigan. It is situated in the south east corner of the barn

and is connected to the stable through a vestibule. The two inside walls were constructed of studding covered on both sides with cement asbestos board. The north wall is masonry twenty-four inches thick and the west wall is eight inch cinder blocks. The ceiling is nine feet high with hay stored overhead. This milk house was protected from the wind by a machine shed located twenty feet to the east.

A two pen, Brown recording thermometer was used in milk house No. 1. In houses 2, 3, and 4, a Taylor recording thermometer was used to record outside temperatures and a Foxboro recording thermometer and hygrometer was used to record the inside temperatures.

PROCEDURE

Interview with Farmers

Inspection trips were made with dairy plant field men and other authorities to interview the farmers operating these milk houses. The amount of equipment used, the material used in construction, and the location were studied. The farmers were asked whether their milk houses were adequate and their answers were discussed with them.

Survey sheets were prepared and distributed by these fieldmen to thirty farmers who indicated they would fill in the sheets and return them. Sixteen of these forms were returned with the required information. Since many of the farmers did not keep records of the construction, they did not know how much the milk houses had cost.

Calculations of Floor Area Requirements

The next step, after reviewing the literature and interviewing farmers and health authorities, was to determine the equipment necessary to handle, adequately, the milk and the milk-processing equipment. Since the purpose of a milk house is to furnish a place to use this equipment, it must, obviously, provide ample room to house and operate it.

Calculations of the floor space needed were made on the following basis. Floor space for the water heater and the wash vats was constant for the range of production we considered. Three standard brands of heaters were measured and found to be nearly the same size. Three standard makes of wash vats were also measured and found to be essentially the same. The space for the can rack and the milk cooler varies with the number of cans produced. Comparisons were made on the basis of cans produced rather than the number of cows milked because of the wide variation in the production of herds. The floor area allowed for the cooler was the average space of eleven manufactured coolers. This area represents the space necessary for one unit to handle the number of cans produced. When two smaller units are substituted for one large unit, this space will be somewhat larger. The space allowed for can racks was determined assuming that cans would be stored in pairs, one above the other. The work area was determined as follows: A working space of two feet was allowed in

front of a double wash vat; floor space for setting three pails and two milkers was provided, and four feet was allowed in front of the cooler. The total work area was then plotted on section paper. The space recommended by farmers was also plotted with the minimum requirements set up by the milk ordinances.

A conference was held with Bookhout to determine the time spent in the milk house from time studies made on ten Michigan dairy farms. From his data, the distance between the barn and the milk house, and the time spent in the milk house daily, were determined and plotted. Figure 13.

Investigation of Milk House Room Temperatures

During the winter of 1947-48, temperature measurements were made in the four milk houses described under "MATERIALS AND EQUIPMENT". In milk house No. 1, a two pen Brown recording thermometer was used to record the inside and outside temperature. The milk house was operated normally and the thermometer was placed so that it would not be disturbed by the operator. The outside bulb was located on the north side of the building where it would be protected from the sun during the day. The inside bulb was placed approximately eight inches from the ceiling. This recorded the room temperature and was not affected by the cold layer of air next to the walls. When the outside temperature was predicted to go below 0°F. a 1500-watt

electric space heater was used to try to prevent the water from freezing. The farmer using this milk house performed all of the milking operations used in the fast milking procedure.

In milk house No. 2, the outside temperature was recorded by a Taylor recording thermometer located on the east side of the barn close to the eave of the milk house. The sun shone on this thermometer during the late morning but there were only three or four days when the sun was out during that time. This milk house had just been completed and the cooler was the only equipment used.

Milk house No. 3 was located in the southeast corner of the barn close to the stable. The same two thermometers as used in No. 2 were used in this installation. The outside bulb was suspended approximately ten inches from the south wall. It was noticed that when the sun came out, the temperature rose unusually high and we found that there was a considerable amount of radiation coming from the barn wall, so a shade was made to cover the bulb. The resulting temperature would be similar to the outside temperature recorded in the other locations.

Milk house No. 4 was also located in the southeast corner of the barn. The inside thermometer was placed on the west half of the water cooler, which was not being used in the winter. The outside thermometer was suspended from the barn wall on the south side of the barn. The readings were made in this location in March and April when the

outside temperatures varied considerably between daytime and night time.

The temperatures recorded on the sheets were replotted on regular profile cross-section paper. The average temperatures were calculated by measuring the area under the curve and dividing this area by the length of time represented on the abscissa.

RESULTS OF THE STUDY

Equipment Recommended

The interviews and field investigations revealed three main operations that fieldmen and inspectors watched for, and which occur at each milking and have proved essential to the production of high quality milk. These operations are: (1) cooling and storing milk, (2) cleaning and sterilizing equipment, and (3) storing equipment between milkings.

To accomplish these operations most effectively, four items of equipment must be included in the milk house: namely, a milk cooler, a water heater, a double wash vat, and a can rack.

A milk cooler is very important in marketing milk of low bacteria count. In order to be safe for storage, milk should be cooled to 50°F. within one hour after it has been taken from the cow¹. Above 50°F., bacteria will multiply very rapidly but, by cooling the milk, the rapid growth of bacteria can be prevented. Cooling is accomplished most effectively by mechanical coolers, Figure 7.



Figure 7. Standard Milk Cooler For Farm Milk Cooling.



Figure 8. Combination Water And Space Heater For Use In Milk Houses.

In some areas in northern Michigan, the temperature of the ground water is low enough that effective cooling may be obtained by continually running water through a concrete cooling tank. This is not recommended by milk sanitarians, in general, because of the temperature of the water. It is difficult to cool milk effectively with water which is 50°F. Most milk plants encourage the use of electric coolers and feel they will benefit the farmer by allowing him to market a higher quality milk. Floor area requirements are calculated with the assumption that mechanical coolers will be used.

The milk ordinances for the state indicated that mechanical cooling was not required at that time. It was found that the farmers using electric cooling generally marketed a higher quality product. Individual dairies throughout the state were recommending mechanical cooling and had as high as 60% of their producers operating with this equipment. LaRock and Witzel state that where city ordinances require that milk be cooled to 50°F. or less, immediately, ice or mechanical refrigeration must be used.

A water heater should be included in the equipment of all milk houses. On some farms, hot water is carried from the house to the milk house at milking time but when this practice is followed, the water is usually too cold to accomplish its purpose in the milk house. There are two types of water heaters available for use, depending on the water supply. When water under pressure is available

in the milk house, the pressure water heater can be used and will furnish a good supply of hot water automatically. However, a non-pressure water system must be used in most milk houses because water under pressure is not available. With this type of heater, the amount of hot water to be used at one time is limited and, in many cases, will not be sufficient to effectively clean the necessary milking utensils. Figure 8 shows a non-pressure water heater. This particular one is an eighteen gallon unit and will usually be sufficient for the size of milk houses considered. This heater also has an additional feature in that it can be used to space heat the milk house in cold weather. Some of the houses not attached to the barn, are too cold for effective use during the winter. By supplying some heat, they can be made functional the year around. With this heater, winter operation of the milk house will not be curtailed because it is constructed so that there is an air chamber around the flue gas chamber, and, for winter operation, air is allowed to circulate in the air chamber, is heated, and blown out into the room with a small fan.

Jensen found that good hot water with the addition of an approved wetting type cleaner is necessary for cleaning dairy equipment. A supply of hot water is always required to clean the utensils. In six of the milk ordinances in the state, it is necessary to have the water heater in the milk house, a fact which would make it possible to heat the milk house with the same equipment.

Wash vats are necessary to effectively use the hot water provided. All of the utensils and pails should be washed in hot water, to which a good cleaner has been added, and then rinsed in a disinfectant solution. For effective cleaning, a double wash vat should be provided. In this way, the equipment can be washed clean in one vat and immediately transferred to the rinse vat to be sterilized and rinsed. Some farmers were using the practice of setting the pails and other milk containers on the floor and rinsing them. Although the floor of the milkhouse should be washed clean at all times, it cannot be free of bacteria and dirt because the operator will be continually walking in and out with the milk. Figure 10 illustrates an inexpensive double wash vat which will be adequate for proper cleaning operations in the milk house.

When the pails and utensils have been cleaned and sterilized, space must be provided to store them so that they will remain sterile until the next milking. Storage of milking utensils varied considerably. Some farmers believe it is the duty of the housewife to do the washing so that all of the equipment is carried to the house to be washed with the dishes, and stored in the kitchen between milkings. Other farmers will wash their equipment and store it in the barn where it becomes dirty and unsanitary, and still other farmers store equipment outside on racks and expect them to be clean enough to produce a high quality milk. As a result of visits to the various farms, it was



Figure 9. Can And Utensil Rack For Use In Milk Houses.



Figure 10. Double Wash Vats For Washing And Sterilizing Milk Handling Utensils.

found that can racks were necessary to keep the pails and utensils clean and sanitary between milkings. There are many different types of can racks available and the only requirement is that the bottom rack be at least twelve inches from the floor. Figure 9 shows the type used in many milk houses. It is a portable unit which can be moved about easily and can be moved outside into the sunshine to clean. Other types can be secured to the wall, in which case, they cannot be moved and, if care is not taken, the fasteners may pull loose if not properly designed.

These items of equipment are important to the marketing of clean milk but even when all these are provided in a milk house, the operator cannot be assured of the highest quality milk. This equipment will make the chore easier and help to encourage the production of clean milk but the farmer still has to do his part. His habits and practices will have a big effect on the quality of milk marketed.

Floor Area Requirements

The most variable requirement for milk house construction is the floor area required. Jennings⁹ found that the floor area per can necessary to provide adequate space varied inversely as the number of cans produced and varied somewhat according to the location of the milk house. With milk houses attached to the barn, he recommends a larger floor area than when the milk house is separate from the barn.

LaRock and Witzel¹¹ recommended a 10' x 12' milk house as a minimum size for the average farm. This also was considered as a minimum by various city milk ordinances.

The calculated floor area for the milk house equipment is shown on Figure 11. The space required for the water heater and the wash vats is constant for the range of production considered. The space required for the can rack will vary directly with the number of cans produced and space should be provided for the maximum daily production anticipated. The can rack provides the necessary facilities for keeping the milk cans clean after they return from the dairy plant. This rack should be constructed so that the other utensils used in the milking and cleaning operations may be kept clean.

The space necessary for the milk cooler will also vary directly according to the number of cans of milk produced. This area was calculated on the assumption that only one unit would be used to cool the daily supply of milk. The curve does not start at the origin of the chart because the space necessary for the compressor and motor would be constant for any type of cooler. When two units are to be used to cool the milk, the cooler space will be larger by the amount of space needed for the refrigeration unit.

Figure 12 indicates the floor area required to provide space for equipment and for operation of the equipment. Curve number 1 shows the work area necessary to

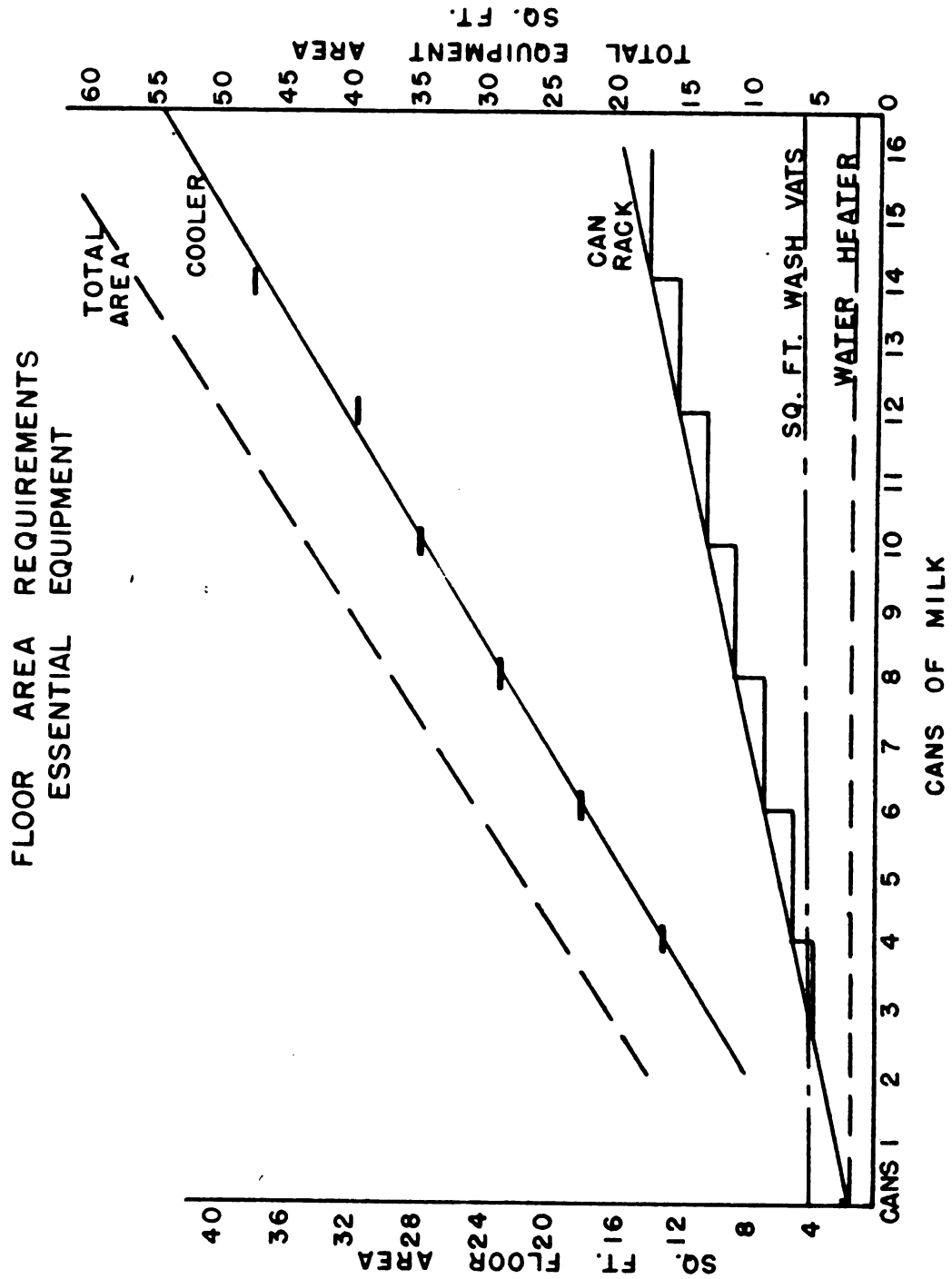


Figure 11. Floor Area Requirements For Necessary Equipment In A Milk House.

operate the equipment previously described. Curve number 2 shows the total calculated floor area, and the difference between curves number 1 and 2 represents the floor area required by the equipment. The area required by the milk ordinances is a straight line, curve number 3, and the size varies as the number of cans produced. Many of the ordinances do not state a definite size except that the floor space should be adequate. The farmers, in general, indicated that their milk house was adequate. As will be noticed on the graph, the minimum sizes suggested were not consistent but the average of these suggestions is similar to the minimum sizes required by the milk ordinances. This total area is somewhat higher than the calculated area because the general opinion is that it is better to have too much room than not enough. Jennings⁸ found that one out of four milk houses was too small, while only one of eighty milk houses was too large. A farmer should anticipate his maximum production and build his milk house accordingly, but the milk house should not be so large that there will be space for the accumulation of trash.

When a two room milk house, as recommended by LaRock and Vitzel¹¹ and by Belton and Long³, is used, the floor space will be larger. However, the Michigan study was made on milk houses for herds producing less than sixteen cans of milk daily and a single room milk house is adequate under these conditions. The storage of other farm products, such as eggs, vegetables, etc., is not

recommended in a milk house of any size and was not considered in this study. Frozen food lockers should be located some other place on the farm.

Location of Milk House Relative to Barn

Bookhout's studies show that the amount of work done in the milk house varied considerably. The time spent in the milk house, daily, varied from 5.2 minutes to 50.47 minutes. The farm operators studied were milking herds of various sizes but there was only slight correlation between the number of cows milked and the time spent in the milk house. This seemed to indicate that there must be some other reason for not using the milk house for a larger proportion of the milking operations.

A curve was plotted to show the relation between the distance from the stable to the milk house and the minutes spent in the milk house, Figure 13. This shows that the closer the milk house is to the barn, the more times it was used during the day. Individual farms were studied to determine the operations performed in the milk house and it was found that the farmer whose milk house was located conveniently to the stable performed more operations in his milk house. The farmer who built his milk house some distance from the barn found it more convenient to perform some operations in other buildings on the farm, which resulted in additional time and travel in doing the chores.

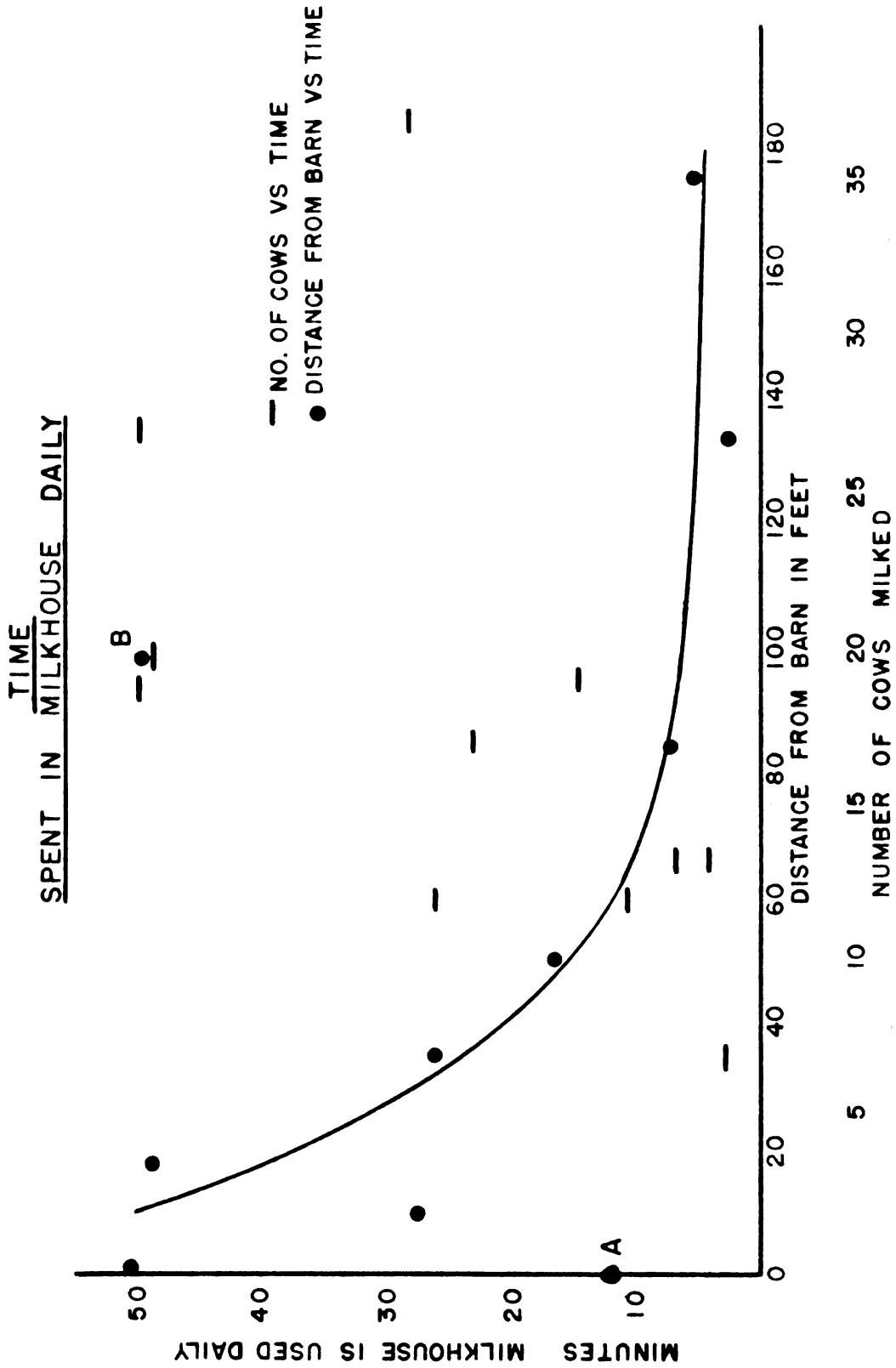


Figure 13. The Effect of Location And Number Of Cows On Time Spent In A Milk House.

The wide variation in the milking procedures used also affected the time spent in the milk house and the time required to milk the cows. The farmer represented by point A (Figure 13), attached his milk house to the side of the barn but was not using the available facilities. His utensils were carried to the kitchen to be washed and the milk house was used merely as a shelter for the cooler. The farmer represented by point B was also unusual. On this farm, the milk was taken to the milk house and the utensils to the house for washing and sterilizing. The farmer then returned to the milk house and cooled the milk with a small portable cooling unit that had to be changed from one can to the other until the milk cooled.

Relation Between Temperature and Location

As previously mentioned, some milk houses are used during the cold winter months only for cooling milk. This means that although a farmer builds a milk house according to the requirements and equips it satisfactorily, he can not make the best use of his milk house the year around. One solution to this problem would be to supply additional heat with a space heater or to locate the milk house to take advantage of any source of heat available. Insulation will reduce the loss of heat produced by motors and water heaters operating in the milk house.

Continuous temperature readings were made on three different types of milk houses (1) with four sides exposed to the weather, (2) three sides exposed to the weather,

and (3) two sides exposed to the weather. Figures 5 and 6 are plans of the two milk houses studied with two sides exposed to the weather. These milk houses were built in the corner of the barns and were protected by other nearby buildings and trees. Figure 4 shows the milk house with three sides exposed. This milk house was located on the northeast corner of the barn and was not as well protected as the other three buildings. Figure 3 is the unit with four sides exposed to the weather but, being located on the south-east corner of the barn, was protected from the cold north-west winds. During all this investigation, the prevailing winds, as recorded by the Lansing Weather Bureau, were from the north-west.

The findings of this study were summarized in Table 3. During this time, we were more interested in the low inside temperature than in the high temperatures because the lower temperatures would restrict the use which could be made of the milk house. The average inside minimum temperature in houses number 3 and 4 were very close to the freezing point. Although the outside temperature was below 32°F , the largest percentage of the time, the inside temperature did not fall below 32°F more than 61.6% and 53% of the time, respectively. These houses were not losing as much heat as houses 1 and 2 and were receiving additional heat from the stable. In milk house number 4, 86.6% of the days had outside temperatures below freezing, while 54% of the days had inside temperatures below freezing.

Table No. 3 The Effect of Location on the Temperature Maintained in the Milk Houses Studied

| Milk House No. | Average Temp. | | Maximum Temp. | | Average Temp. | | Minimum Temp. | | Daily Temp. Diff. | | Maximum Var. | | Average Var. | | Days Recorded | | Days Below 32° F. | | Days Below 32° F. Inside | |
|----------------|---------------|------|---------------|------|---------------|------|---------------|-----|-------------------|------|--------------|-----|--------------|------|---------------|------|-------------------|---|--------------------------|---|
| | In | Out | In | Out | In | Out | In | Out | In | Out | In | Out | In | Out | No. | % | No. | % | No. | % |
| 1 | 37.5 | 17.8 | 45.7 | 28.4 | 40.6 | 23.7 | 18.2 | 13 | 27 | 8.2 | 10.6 | 29 | 24 | 21 | 5 | 20.9 | | | | |
| 2 | 27.4 | 9.0 | 38.8 | 20.0 | 30.1 | 15.9 | 16.9 | 20 | 32 | 11.4 | 20.0 | 21 | 15 | 71.3 | 8 | 53 | | | | |
| 3 | 32.0 | 4.1 | 45.5 | 23.5 | 38.0 | 13.0 | 24.2 | 19 | 30 | 13.5 | 19.3 | 13 | 13 | 100 | 8 | 61.6 | | | | |
| 4 | 33.1 | 21.0 | 37.7 | 50.6 | 36.2 | 31.6 | 12.2 | 11 | 60 | 4.6 | 29.6 | 15 | 13 | 86.6 | 7 | 54 | | | | |

The average daily minimum temperature in houses 3 and 4 was 32°F and 33.1°F respectively. In milk house number 4, the temperature might have been kept above freezing at all times by the heat given off by a mechanical milk cooler. In milk house number 3, a light bulb attached to the water pipe prevented freezing in the pipes, even though water left on the floor would occasionally freeze.

In house number 1, the ratio of the days with freezing temperatures outside and the days with freezing temperatures inside is larger. The average minimum inside temperature was approximately five degrees higher than the average minimum inside temperature of houses 3 and 4. This was the result of using a 1500 watt heater during the days when the outside temperature was low. It is significant that although the outside temperatures were lower with houses 3 and 4, the inside conditions were very much better and with very little expense or equipment, could be made satisfactory during the entire winter season. The mean daily temperature difference was essentially the same except for house number 3, the last milk house in which readings were taken, at which time there was wide variation between the daytime and night time temperatures.

These figures show that, with four sides exposed to the weather, it is difficult to maintain adequate inside temperatures without the use of some type of space heater. With one or two sides common to the barn, the

heat ordinarily lost is saved and, in addition, heat may be gained from the barn through the common walls. In house number 3, it was possible to prevent the water pipes from freezing by attaching a 50 watt light bulb to the water pipe coming into the milk house.

In houses number 3 and 4, the room temperature went up very definitely whenever the milk cooler came on and the temperature remained higher than normal for as long as three hours after the cooler ceased to operate. In house number 1, the temperature raised an average of five degrees whenever the cooler came on but it returned to normal within two hours after the cooler stopped. The temperature curve for house number 2, with one side common to the barn, was similar to that of house number 3. This indicates that satisfactory temperatures could be maintained if the milk house were attached to the barn in some way, and a small amount of additional heat supplied.

DISCUSSION OF PHYSICAL CHARACTERISTICS

Size of the Milk House

The recommended size for a Michigan Milk House is shown in the following table.

| no. of cans
per day | dimensions
inside | area per can
sq. ft. |
|------------------------|----------------------|-------------------------|
| 2 | 8' x 10' | 40 |
| 4 | 9' x 10' | 22 |
| 6 | 10' x 10' | 17 |
| 8 | 10' x 12' | 15 |
| 10 | 10' x 14' | 14 |
| 12 | 12' x 12' | 12 |
| 14 | 12' x 14' | 12 |

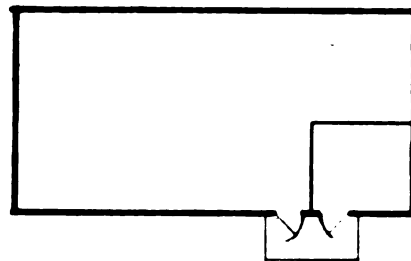
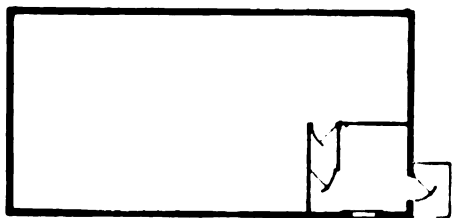
The inside dimensions are used in these recommendations to eliminate the variation in floor area caused by the different materials used in construction. These are minimum dimensions and should be considered as such. Frozen food lockers and other food storage should not be planned in the milk house.

Location of the Milk House

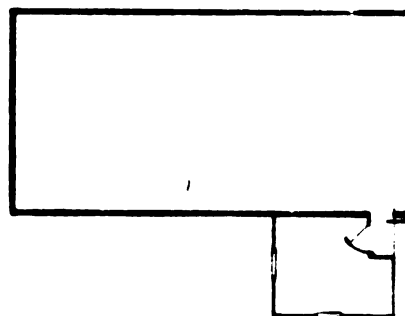
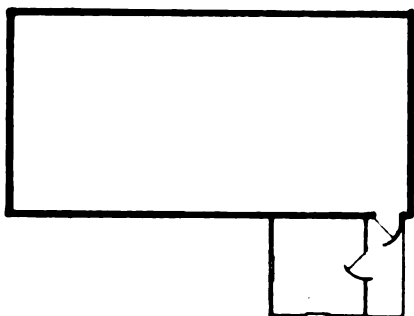
On the basis of the results of this study, the optimum location is in the corner of the barn. This will decrease the cost of construction when the milk house is being added to the present barn. In new construction, the milk house should be attached to the barn wall as close to the milking herd as possible, but there should not be a direct entrance to the stable. The entrance should be through a vestibule provided with two self-closing doors, if possible, or under a porch roof which may connect the stable entrance to the milk house entrance.

When the milk house is located in the barn, the walls must be air tight and the same entrance precautions must be observed. The milk house should be located on the side farthest from the cattle yards, if possible, and in no cases within fifty feet of a manure pile or other source of contamination. This location will usually be on the side of the barn nearest the drive, and will facilitate loading the milk on the truck.

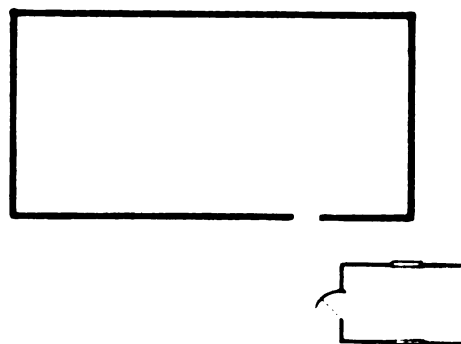
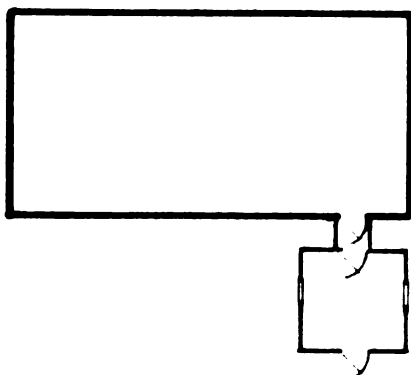
Figure 14 illustrates the recommended locations for suitable milk houses.



LOCATIONS
INSIDE OF BARN



PORCH TYPE MILKHOUSE



VESTIBULE TYPE
MILKHOUSE

Figure 14. Recommended Locations For Milk Houses In Michigan.

Functional Equipment Recommended

The following equipment is necessary to produce a high quality milk for market.

Cooling equipment

Mechanical cooling is recommended to insure adequate cooling in all weather conditions. Capacity enough for both morning and evening milk should be provided. The cooler should be located near the door to the loading platform, to eliminate unnecessary travel between the cooler and the truck.

In areas where water temperatures are below 50°F. at the milk house, insulated cooling tanks may be used but, because of the time required, the farmer living at the beginning of the milk route will find it difficult to cool the milk to 50°F. before it is picked up.

Water heaters

Some type of water heater should be provided in the milk house. When the milk house is located in the barn or attached to the barn, electric heaters are recommended to eliminate the fire hazard. Water under pressure is desirable in the milk house, in which case automatic water heaters should be used. When water must be carried in, an eighteen or twenty gallon gravity flow water heater is suggested. When water under pressure is available, a thirty gallon water heater is recommended. For milk houses connected to the barn by a vestibule, gas and fuel oil heaters

are available. These must be approved by the Underwriters Laboratories, and the installation should be carefully inspected to be approved by insurance companies.

Can and utensil racks

Provision should be made for storage of all milk cans and all equipment used in the milk handling process. These can best be made of galvanized iron pipe and either welded or assembled with fittings. The bottom shelf should be at least twelve inches from the floor.

Wash vats

A double wash vat should be provided close to the water heater. These two items of equipment should be located on the warmest side of the milk house to decrease the danger of freezing during the winter months.

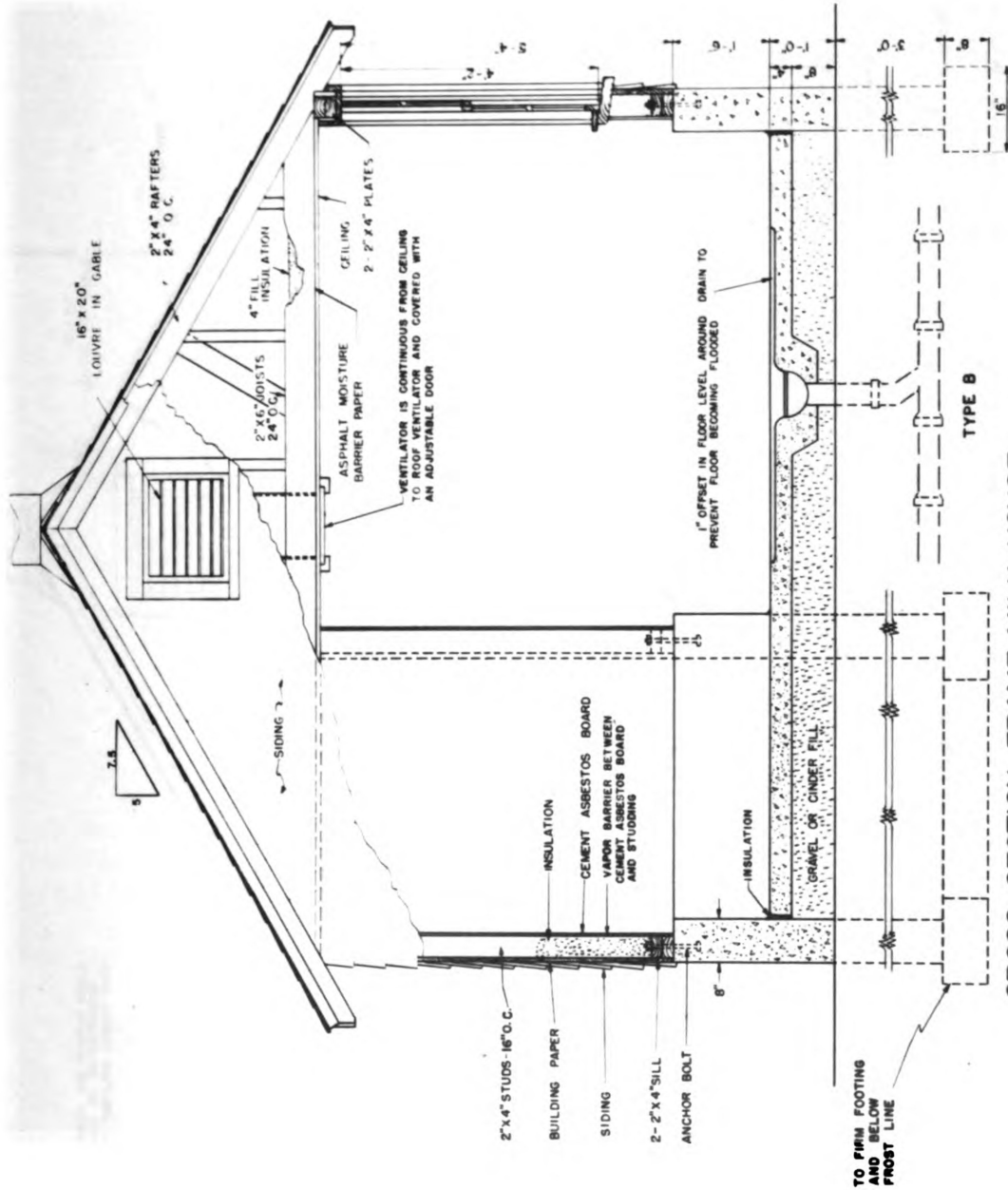
Space heaters

Whenever the milk house is too cold to be used during the winter season, some type of space heater should be used. For milk houses attached to the barn, a small electric heater will be sufficient. In other installations, where more heat is required, gas or fuel oil heaters will be less expensive. Coal and wood heaters are not recommended because of the dirt which usually accompanies this type of heat.

Construction Details Recommended

Materials

The milk house may be constructed of any type of



CROSS SECTION FRAME MILK HOUSE

Figure 15. Cross Section Type "B" Frame Milk House.

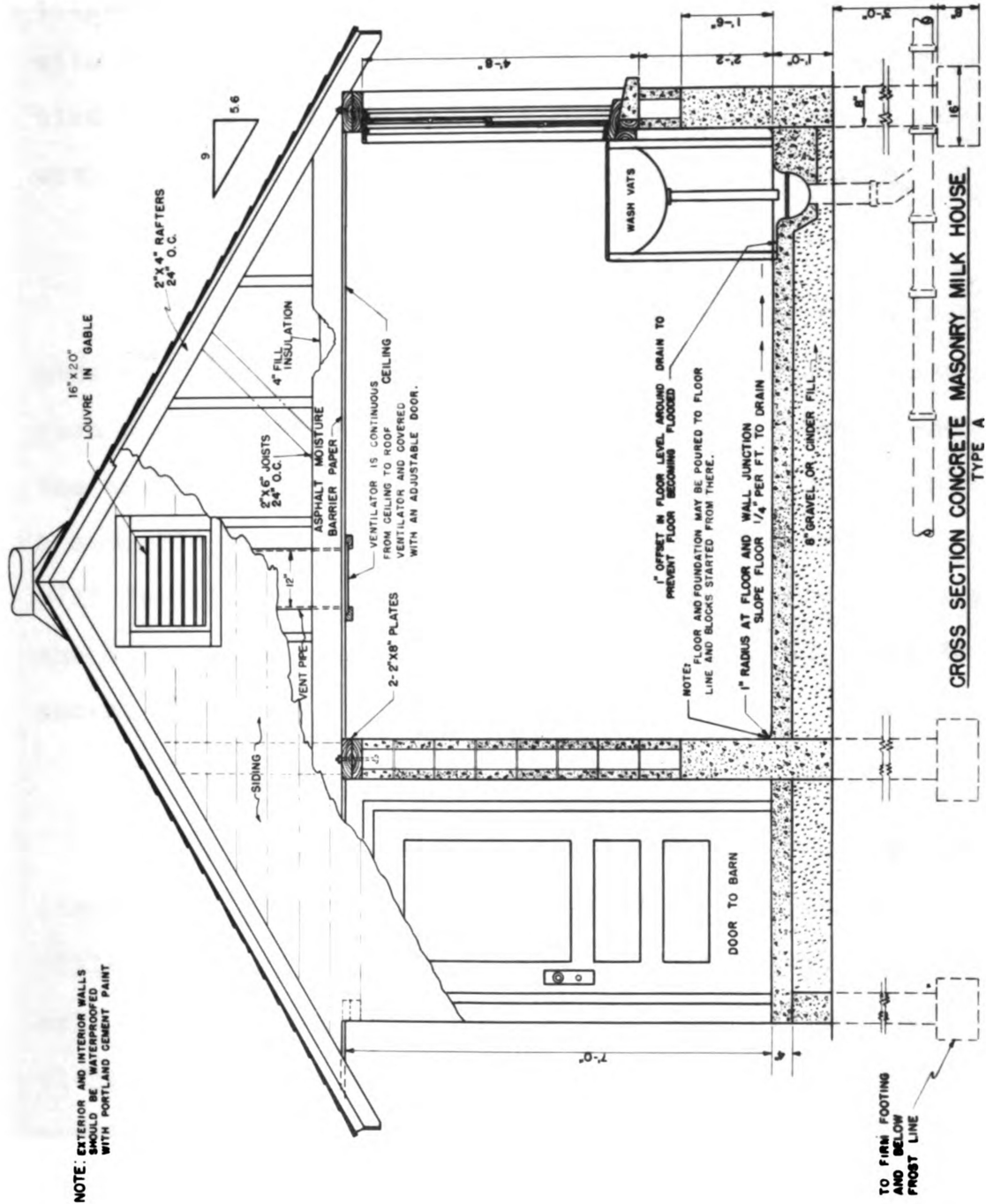


Figure 16. Cross Section Type "A" Masonry Milk House.

material available. The interior finish must be smooth and easy to clean. When frame construction is used, (figure 15) the inside should be plastered and painted with white water repellent paint. When masonry construction is used, (figure 16) the inside surface may be painted with two coats of water proof Portland cement paint.

Floors

Floors must be impervious to water and preferably made of concrete. They should be sloped one quarter of an inch per foot to the drain, which should be located under the wash vats. At the point where the wall joins the floor, a concrete cove should be made as shown in figure 17. This will facilitate cleaning and prevent water from standing in the corner. It can be formed easily with a milk bottle as shown.

Insulation

When frame construction is used, the walls should be insulated with two inches of commercial insulation, or filled with dry wood shavings. The inside surface of this wall should be painted with a primer coat of two applications of aluminum paint before the water repellent paint is applied.

When masonry construction is used, cinder blocks are recommended above grade. When additional insulation is necessary, furring strips may be attached to the wall and rigid insulation fastened to these strips. With this type



Figure 17. Construction Of The Cove Between The Walls And Floors Of Milk Houses.

of construction, the plaster should be applied to the surface of the insulation and finished as mentioned above.

Under all conditions, the ceiling should be insulated with three or four inches of commercial insulation or wood shavings.

Ventilation

A ventilation duct, at least one hundred inches in cross-sectional area, should extend from the ceiling to a ventilator in the roof. This should be fitted with a damper to control the flow of air when the temperature is extremely high or extremely low. Louvres should be provided in the attic to ventilate the space above the insulation, and should be screened to keep out birds.

Windows

Window area equivalent to 10% of the floor area should be provided and screens for these windows are required during the fly season.

Doors

Glazed doors are recommended wherever possible to eliminate accidents when more than one person is using the milk house. During the fly season, screen doors which will swing outward, must be provided. A removable panel built of wood should be installed as shown on figure 2. This allows coolers to be taken through the door without having to remove masonry sections. The panel should be on the latch side of the door frame so that the door will be

hinged from the solid frame bolted to the masonry wall.

CONCLUSIONS

On the basis of the work done and reported in this thesis, it may be concluded that:

1. A milk house should provide:
 - a. A place to handle and cool milk between the time it comes from the cow and the time it is picked up by the milk plant.
 - b. A place to wash and assemble utensils used in the milking process.
 - c. A place to store sterilized equipment between milkings.
2. The milk house locations shown in figure 14 will be approved by the twelve major milk markets in Michigan and will be conducive to efficient operation. One city, however, will not allow the milk house to be attached to the barn except by a vestibule.
3. Type A milk house, figure 18, may be used where there is no room available in the barn for a milk house. It is economical to construct and, with a small amount of additional heat, may be used the year around.
4. Type B milk house, figure 19, will meet the requirements of the milk ordinance and, with a small amount of additional heat, will be functional the year around.
5. Type C milk house, figure 22, known as the vestibule type, will be approved by all of the milk ordinance inspectors. It is preferred by certain inspectors.

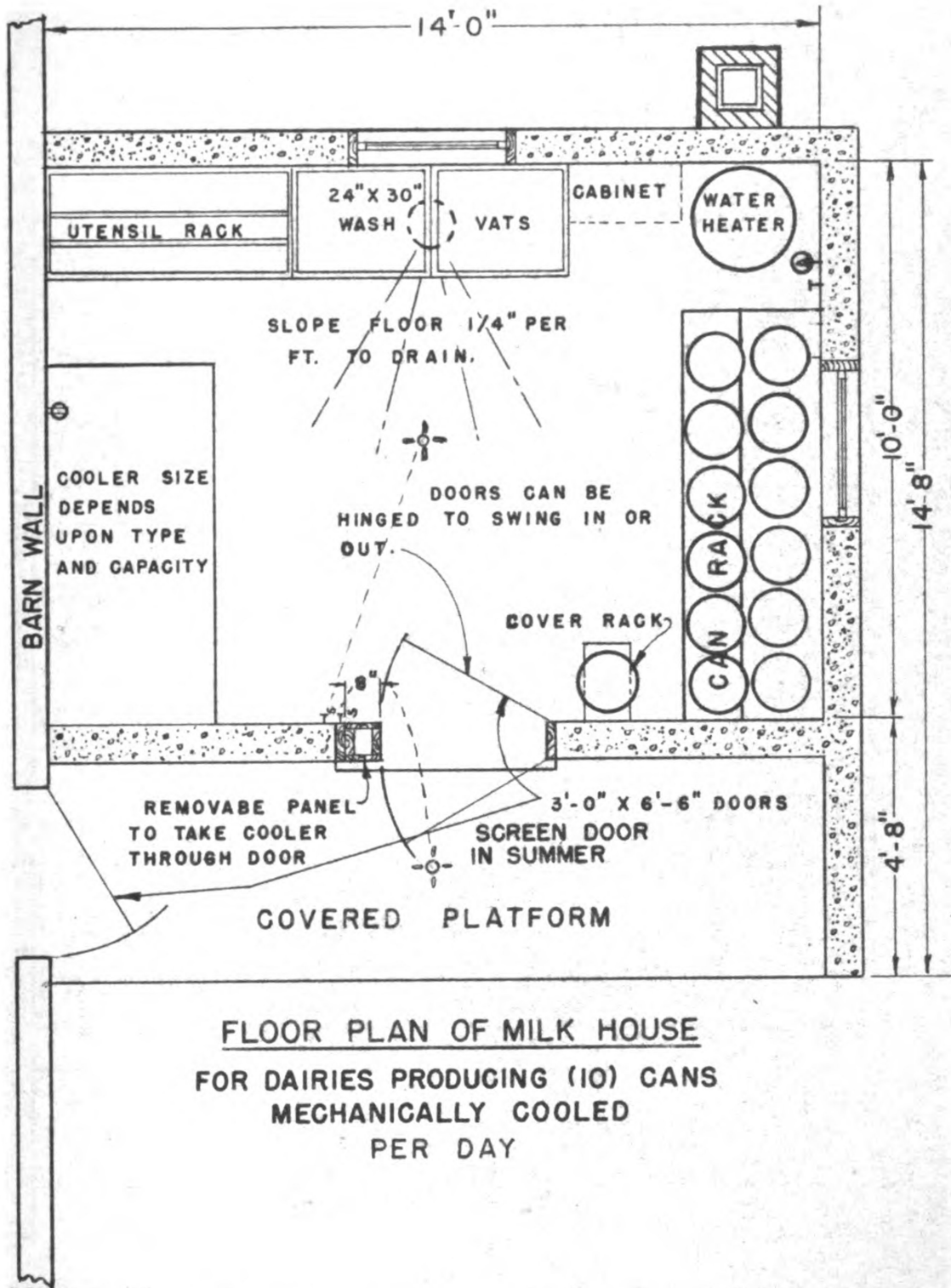


Figure 18. Plan For A Type "A" Milk House Approved By The Twelve Major Milk Markets In Michigan.

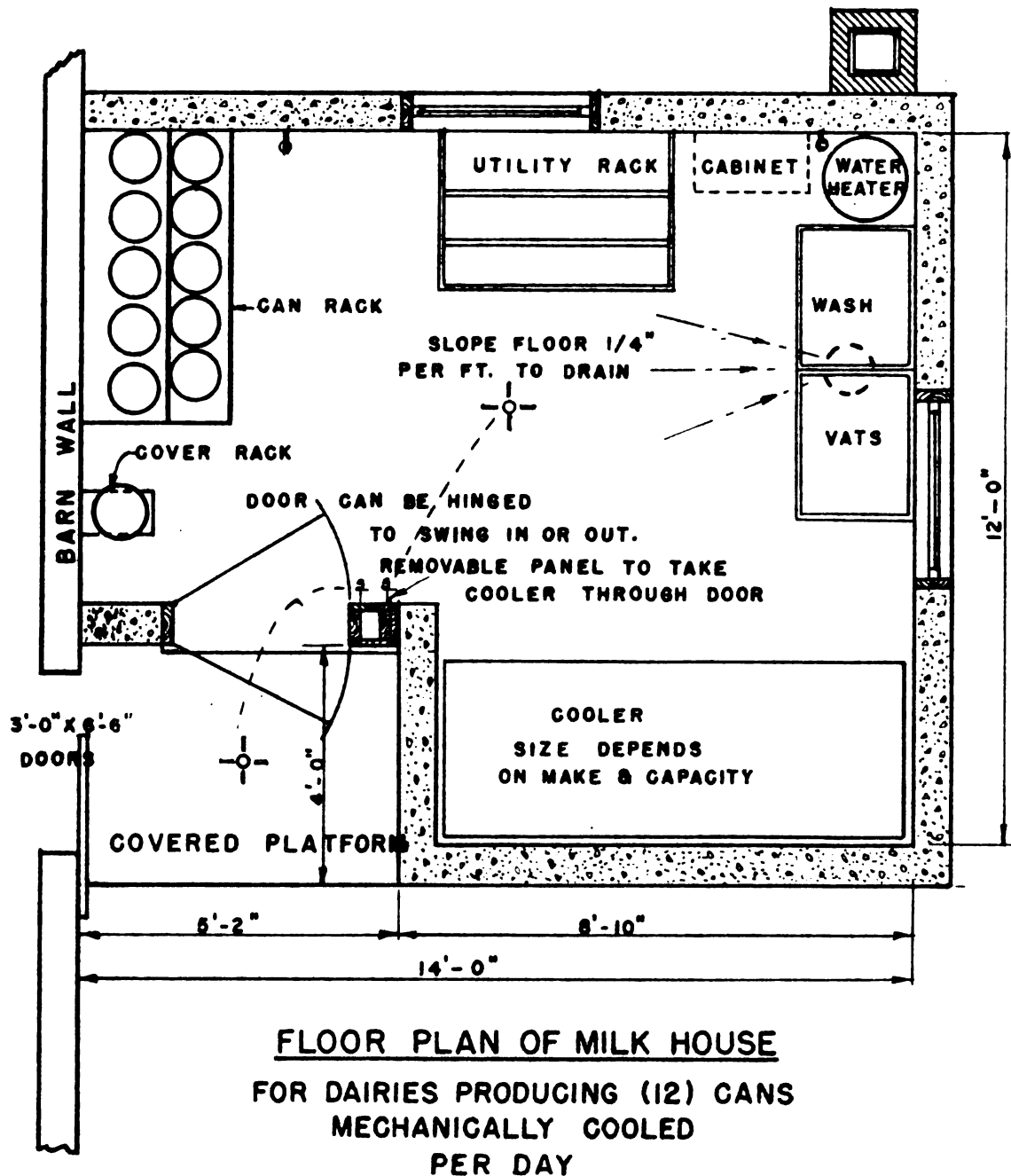


Figure 19. Plan For A Type "B" Milk House Approved By The Twelve Major Milk Markets In Michigan.

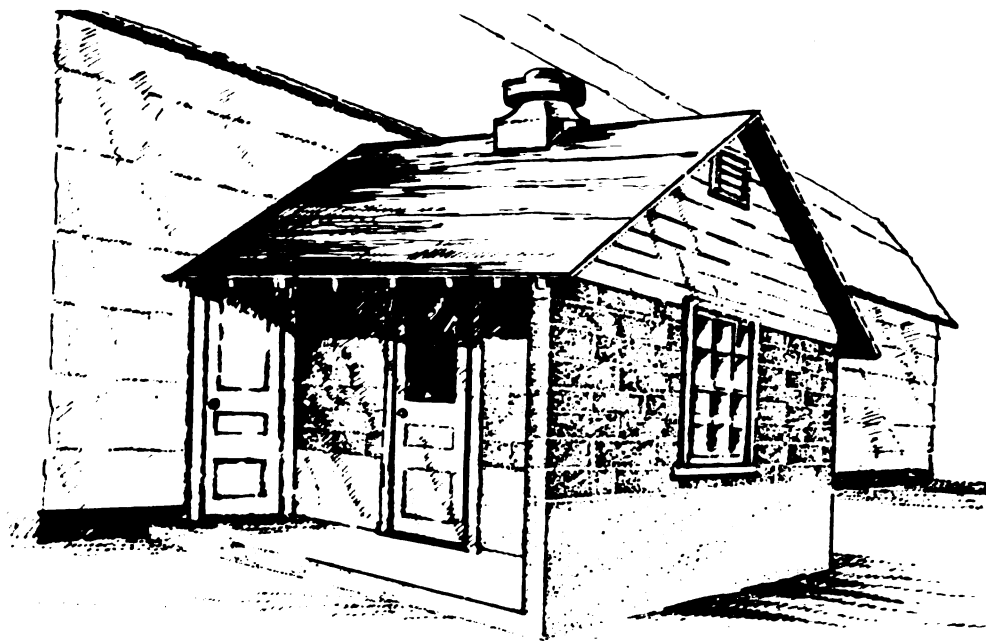


Figure 20. Elevation Of A Type "A" Milk House.

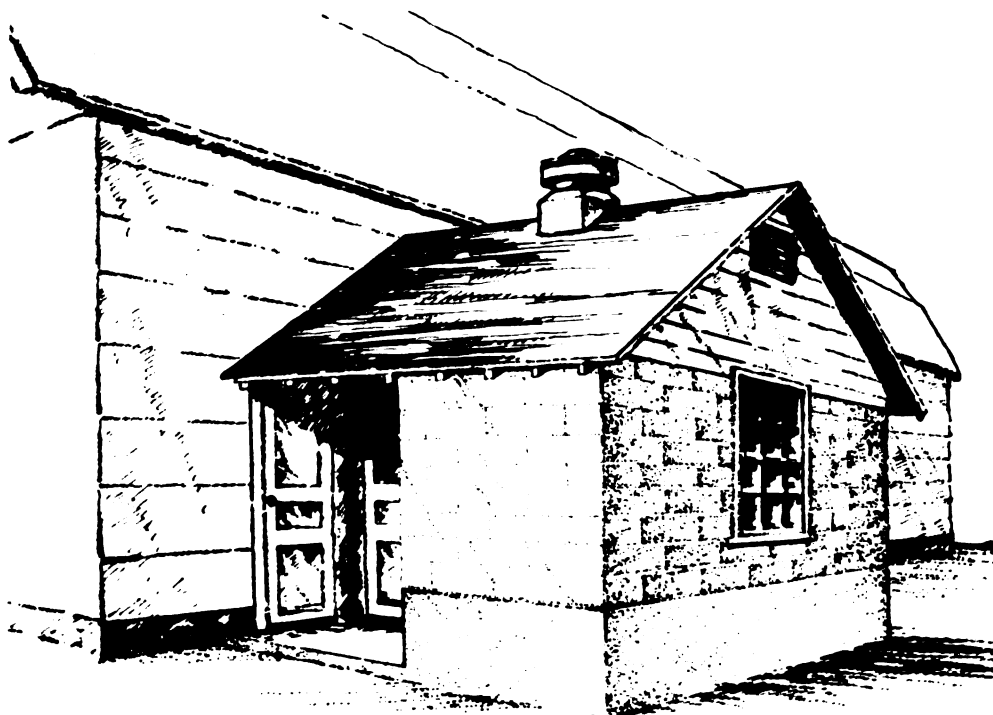
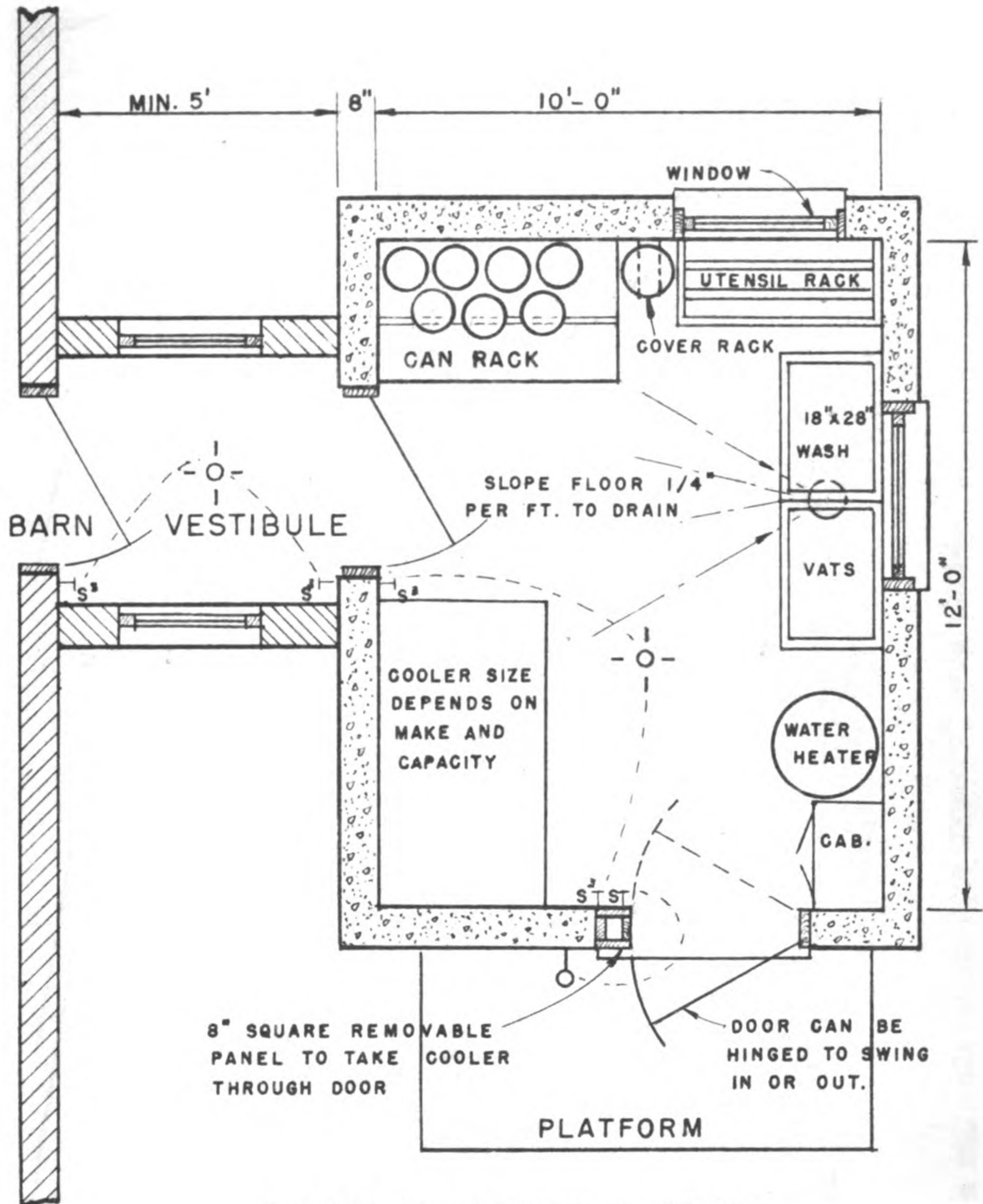


Figure 21. Elevation Of A Type "B" Milk House.



FLOOR PLAN OF MILK HOUSE
FOR DAIRIES PRODUCING (8) CANS
MECHANICALLY COOLED
PER DAY

Figure 22. Plan For A Type "C" Milk House Approved by All Milk Ordinances In Michigan.

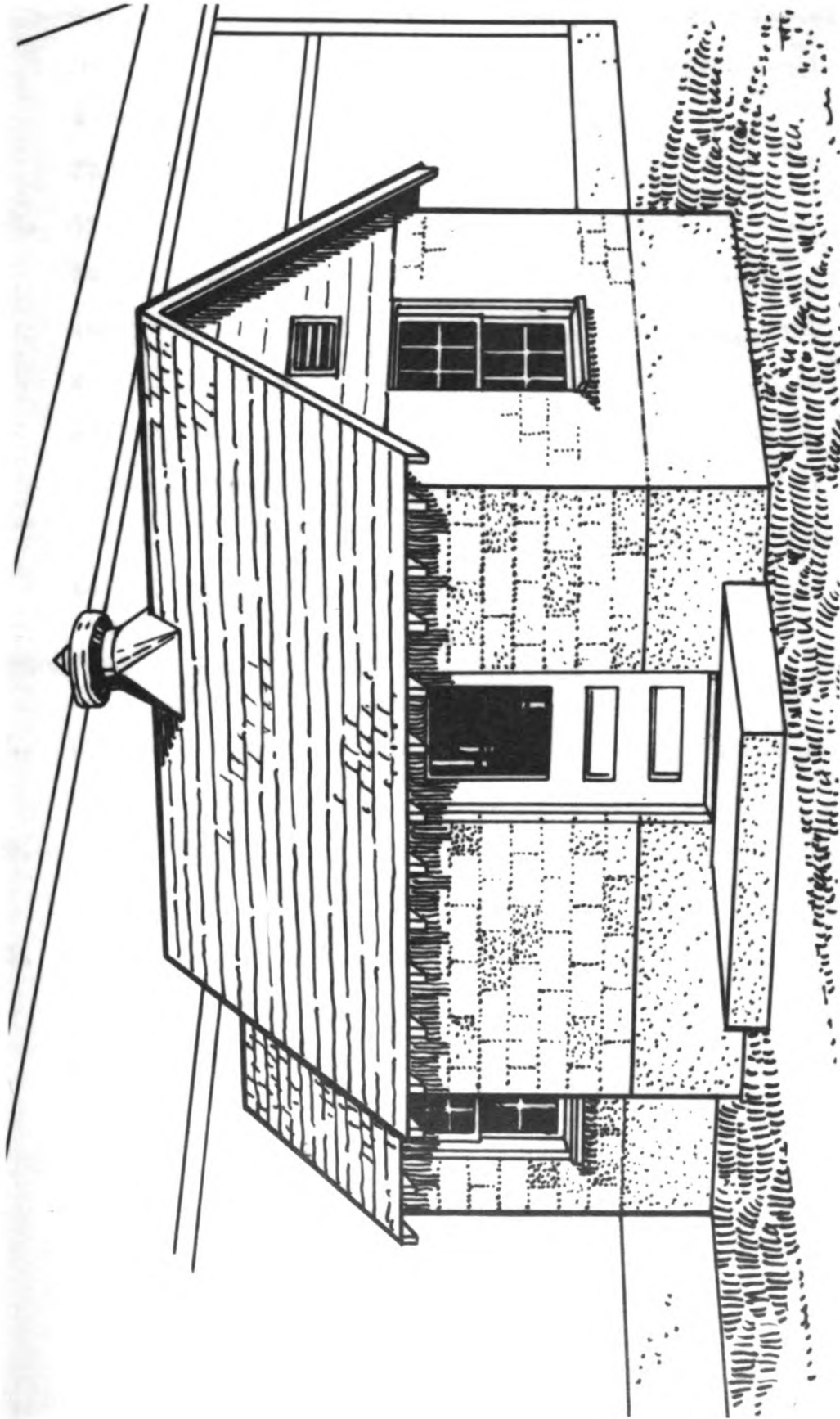


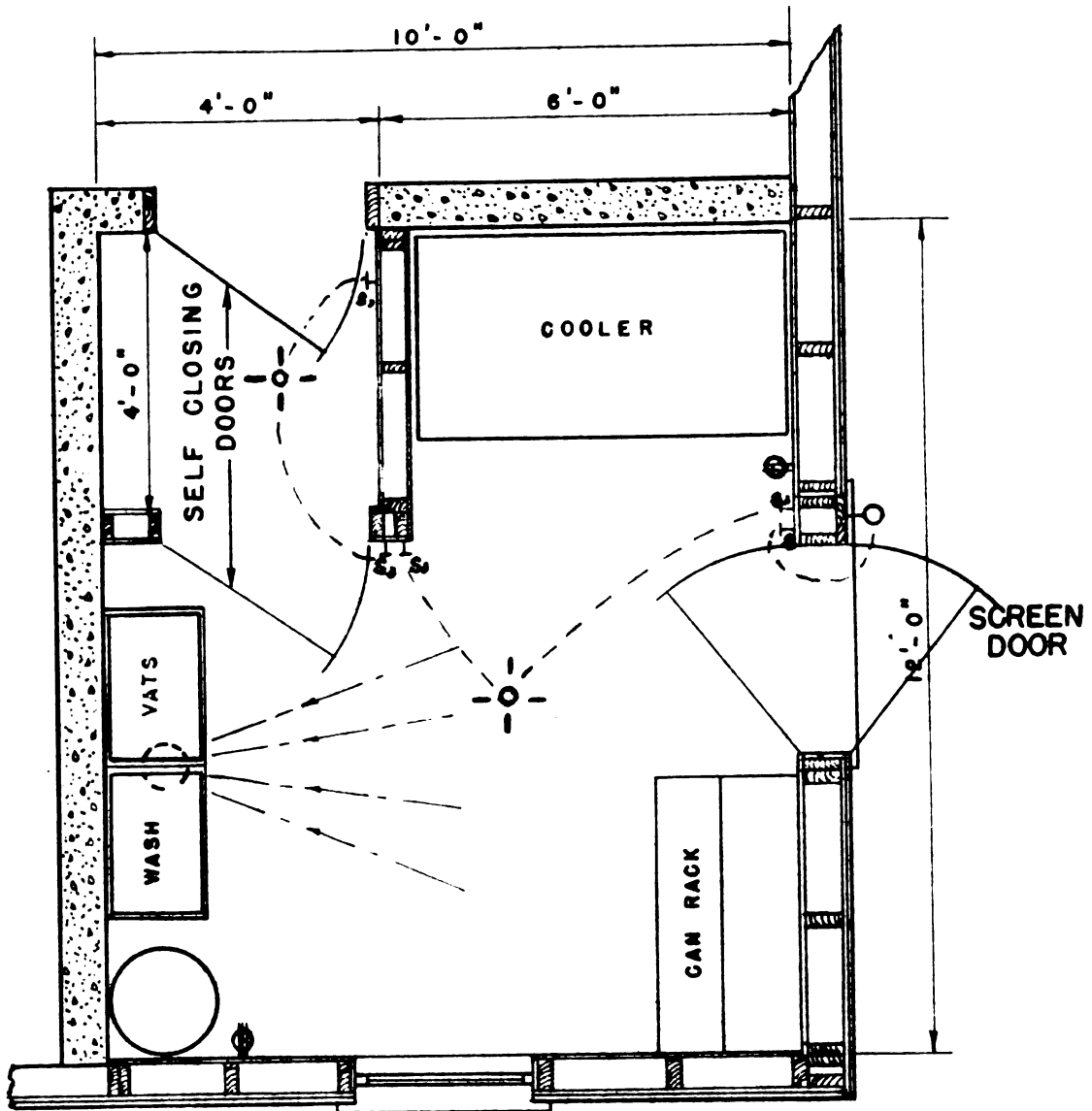
Figure 23. Elevation of A Type "C" Milk House.

Having four sides exposed to the weather, this milk house will usually be too cold during the winter season and must be insulated or heated to make it functional for twelve months per year.

6. Type D milk house, figure 24, represents the best location for a farm milk house. It is economical to construct and, with a small amount of heat, will be sufficiently warm for twelve months each year. When sufficient room is available in the barn, and when properly constructed, this type of milk house is recommended and will be approved by all except one of the major milk markets.

PROBLEMS RECOMMENDED FOR FURTHER STUDY

1. Extend the temperature studies for both summer and winter operation.
2. Study the types of heaters available for milk house space heating.
3. Determine the most adaptable materials available for use in milk houses. Investigate the possibilities of applying insulation for the conservation of heat.



SUGGESTED FLOOR PLAN
DAIRIES PRODUCING 6 CANS OF MILK
PER DAY

Figure 24. Plan For A Type "D" Milk House For Optimum Conditions. This Will By Approved By The Twelve Major Milk Markets In Michigan.

REFERENCES CITED

1. Anderson, T. G.
1941 BACTERIOLOGICAL ASPECTS OF FARM MILK COOLING. Pennsylvania Agricultural Experiment Station Bulletin 404: pp 12.
2. Bell, A. J. and Jensen, J. W.
1940 FARM MILK HOUSES. Michigan Agricultural Extension Bulletin 206: 1-11.
3. Belton, H. L. and Long, J. D.
1925 MILK HOUSES FOR CALIFORNIA DAIRIES. California Agricultural Experiment Station Circular 286: pp 4.
4. Bookhout, B. R.
1947 REDUCING CHORE LABOR ON DAIRY FARMS. Reprint Michigan Agricultural Experiment Station Quarterly Bulletin 30-1: 15-20.
5. Fogle, W. A. and others
1929 FARM MILK HOUSES. Michigan Agricultural Experiment Circular Bulletin 123: 1-7.
6. Harrington, W. C. and Bremer, H. E.
1936 MILK HOUSES. Massachusetts Agricultural Extension Leaflet 165: pp 3, 6-12.
7. Huber, M. G.
1940 MILK HOUSE FOR THE WHOLESALE PRODUCER. Maine Agricultural Extension Bulletin 276: pp 2, 8-9.
8. Jefferson, C. H. and Trout, G. M.
1933 MILK HOUSE AND COOLING TANK CONSTRUCTION. Michigan Agricultural Experiment Station Quarterly v16: 88-94.
9. Jennings, B. A.
1943 MILK HOUSE CONSTRUCTION. Cornell Agricultural Extension Bulletin 330: pp 3-5.
10. Krueger, W. C.
1932 MILK HOUSES. New Jersey Agricultural Extension Bulletin 93: 1-24.
11. LaRock, W. J. and Witzel, S. A.
1940 MILK HOUSES FOR WISCONSIN. Wisconsin Extension Circular 312: 1-23.

12. McMillan, D. Y.
1941 A STUDY OF THE ABSORPTION OF ODORS BY MILK.
Thesis M. S., Michigan State College.
13. Parker, H. N.
1917 CITY MILK SUPPLY. McGraw Hill Book Company,
New York.
14. Smith, L. J.
1946 APPROVED WASHINGTON MILK HOUSE. Washington
Agricultural Extension Bulletin 313.
15. Strahan, J. L.
1925 MILK HOUSES FOR VERMONT DAIRY FARMS. Vermont
Agricultural Department Bulletin 27: 1-23.
16. -----
1947 MILK FACTS. Milk Industry Foundation 1946-47
Edition.

Milk Ordinances

17. Ann Arbor, City of
1938 MILK ORDINANCE.
18. Bay City, City of
1940 MILK ORDINANCE. item 8r and 9r.
19. Detroit, City of
1946 MILK ORDINANCE. par. g and h.
20. Jackson, City of
1933 MILK ORDINANCE. Sec. 27-36 incl.
21. Lansing, City of
1936 MILK ORDINANCE. Sec. 6 item e and f.
22. Flint, City of, Department of Health
INSPECTION SHEET. Form D.F.-9.
23. Kelly, Mayor
1935 MILK ORDINANCE. Item 8r and 9r.
24. Michigan, State of
1945 MICHIGAN MILK ORDINANCE. Sec. 9-12 incl.
25. Michigan, Department of Agriculture.
1933 ACT NO. 169, PUBLIC ACTS 1929, Amended July
11, 1933.
26. Pontiac, City of
1945 MILK AND DAIRY PRODUCTS. Ordinance no. 1049:
sec. 9-12 incl.

- 27. Grand Rapids, City of
MILK ORDINANCE. Amended February 5, 1942:
sec. 16-20 incl.
- 23. Saginaw, City of
1939 RULES AND REGULATIONS FOR CONTROL OF MILK
SUPPLY. Health Service Series Bulletin no.2-1.
- 29. U. S. Treasury Department, Public Health Service
1936 PUBLIC HEALTH SERVICE MILK ORDINANCE AND CODE
1936. item 8r and 9r.

PREFACE TO BIBLIOGRAPHY

Most of the references on this subject are from magazine articles and State bulletins. Milk houses have been used for large herds, but small milk producers have handled milk under the most unsanitary conditions.

In the last three years, milk companies and milk inspectors have stressed the importance of handling and storing milk in an approved milk house.

This list was compiled from books in the Michigan State College Library and from magazine articles listed in The Agricultural Index from 1925 through April, 1947. Most of the information on the subject has been published in magazine articles included in the list.

The references are listed in the dictionary catalogue form, similar to that used in the Journal of Agricultural Research.

BIBLIOGRAPHY

- Bailey, D. H. and Haswell, J. R.
1931 MILK HOUSES. Pennsylvania Agricultural Experiment Circular 139: 1-12.
- Bell, A. J. and Jensen, J. M.
1940 FARM MILK HOUSE. Michigan Agricultural Extension Bulletin 206: 1-11.
- Belton, H. L. and Long, J. D.
1925 MILK HOUSES FOR CALIFORNIA DAIRIES. California Agricultural Experiment Station Circular 286: 1-37.
- Bendixen, H. A.
1943 MILK HOUSE CONSTRUCTION, EQUIPMENT, AND MAINTENANCE. Journal of Milk Technology 6: 175-82 May.
- Bennett, F. N.
1931 THIS MILK HOUSE AFFAIR. Purdue Agriculturalist 26:38 December.
- Berg, E. K.
1944 GOLDEN GUERNSEY MILK HOUSE. Guernsey Breeders Journal 65: 362-3 March.
- Carlson, E. E.
1946 WE RECOMMEND A MILK HOUSE. Editorial National Butter and Cheese Journal 37:50.
- Carter, Deane G., and Foster, M. W.
1946 FARM BUILDINGS. John Wiley and Sons Inc., New York, 214-218.
- Chase, F.
1926 MILK HOUSE TO FIT THE FARM. Dairy Farmer 24:6 May 15.
- Cushman, C. C. and others
1943 COMBINATION MILKING BARN AND MILK HOUSE: MEETING GRADE A SPECIFICATIONS. South Carolina Agricultural Extension Circular 245: (1-8).
- Fenton, F. C.
1929 RETAIL MILK MAN NEEDS A CONVENIENT AND WELL EQUIPPED MILK HOUSE. Dairy Farmer 27:35 May.
- Fenton, F. C.
1929 GET A GRADE A PREMIUM PLAN. Dairy Farmer 27:13 June

- Pogle, F. E., and Lucas, P. S.
1929 FARM MILK HOUSES. Michigan Agricultural Experiment Circular Bulletin 123: 1-7.
- Foster, W. A. and others
1931 PLAN FOR A MILK HOUSE. Illinois Agricultural Experiment Circular 371: 1-8.
- Grieve, P.
1942 DAIRYMAN BUILDS A MILK HOUSE. Successful Farming 40:24 March.
- Harrington, W. C., and Bremer, H. E.
1936 MILK HOUSES. Massachusetts Agricultural Extension Leaflet 165: 1-16.
- Huber, M. G.
1940 MILK HOUSE FOR THE WHOLESALE PRODUCER. Main Agricultural Extension Bulletin 276: 1-12.
- Hurley, J. Carlton
1913 A CONSIDERATION OF THE FACTORS OF A CITY MILK ORDINANCE. Thesis M. S. Michigan State College.
- Jefferson, C. H., and Trout, C. W.
1933 MILK HOUSE AND COOLING TANK CONSTRUCTION. Michigan Agricultural Experiment Quarterly v16: 88-94 November.
- Jefferson, C. H.
1938 MILK HOUSES AND QUALITY MILK. Hoard's Dairyman 83:170.
- Jefferson, C. H.
1936 PRACTICAL FARM MILK HOUSE. Hoard's Dairyman 82:578.
- Jennings, E. A.
1943 MILK HOUSE CONSTRUCTION. Cornell Agricultural Extension Bulletin 330: 1-31.
- Jones, E. R., and Hill, G. O.
1934 TIME SAVED AND CUSTOMERS GAINED WITH A GOOD MILK HOUSE. Successful Farming 32:23. April.
- Kelly, E., and Parks, K. E.
1932 FARM DAIRY HOUSES. Revised by Hotis, R. P. Farmers Bulletin 1214: 1-12.
- Kelly, E., and Babcock, C. J.
1932 PRODUCTION OF CLEAN MILK. Farmers Bulletin 602: 8-17.
- Kelly, J. B.
1933 KENTUCKY STANDARD MILK HOUSE. Agricultural Engineering Journal 14:76.

- Krueger, W. C.
1931 MILK HOUSES. New Jersey Agriculturalist v13:
12-13.
- Krueger, W. C.
1932 MILK HOUSES. New Jersey Agricultural Extension
Bulletin 93: 1-24.
- Kutish, F.
1946 PORTABLE MILK HOUSES. Successful Farming 44:39
December.
- LaRock, M. J., and Witzel, S. A.
1940 MILK HOUSES FOR WISCONSIN. Wisconsin Extension
Circular 312: 1-23.
- Larson, Carl William
1916 MILK PRODUCTION COST ACCOUNTS, PRINCIPLES AND
METHODS. Columbia University Press, New York.
- McMillan, Donald Young
1941 A STUDY OF THE ABSORPTION OF ODORS BY MILK.
Thesis M. S. Michigan State College.
- Mathews, I. J.
1929 THIS MILK HOUSE AVOIDS TAGS. Successful Farming
27:34 September.
- Mosely, L. A.
1939 PRODUCTION AND RETAILING OF MILK BY THE FARMERS.
Farming in South Africa 14: 321-4.
- Morley, L. W.
1925 BUILDING THE FARM DAIRY HOUSE. Pennsylvania
Agricultural Extension Circular 107: 1-9.
- O'Brien, H. P.
1946 DAIRY INDUSTRY DRIVES FOR QUALITY. Country
Gentleman 116: 26-7.
- Parfitt, E. H., and Hill, G. O.
1931 FARM MILK HOUSE. Purdue Agricultural Extension
Leaflet 155: 1-6.
- Parks, R. R.
1937 MILKING PARLOR...MILK HOUSE. Hoard's Dairyman
82:533.
- Parker, Horatio Newton
1917 CITY MILK SUPPLY. McGraw Hill Book Co., New York.
- Powers, D. J.
1930 INSULATION FOR MILK HOUSES. Hoard's Dairyman 75:7.

- Reed, C. H.
1942 FARM MILK HOUSE. Purdue Agricultural Extension Leaflet 155: 1-12 revised.
- Regan, M. J. and others
1931 MISSOURI TYPE MILK HOUSE. Missouri Agricultural Extension Circular 277: 1-12.
- Regan, M. J. and others
1924 MISSOURI TYPE MILK HOUSE. Missouri Agricultural Extension Circular 277: 1-12 revised.
- Roper, W. L.
1945 PRACTICAL SUGGESTIONS ON MILK HOUSE CONSTRUCTION. National Butter and Cheese Journal 36: 31-2.
- Ross, H. E.
1930 PLANS FOR A SIMPLE MILK HOUSE. Cornell Agricultural Extension Bulletin 200: 1-19.
- Schulz, W. E.
1946 MODERN FLUID MILK HOUSES ARE BEING BUILT THROUGHOUT THE MIDDLE-WEST. Milk Plant Monthly 35:54.
- Small, F. W.
1929 CONSTRUCTION OF MILK COOLING HOUSES AND INSULATED TANKS. Agricultural Engineering Journal 10: 383-4.
- Smith, L. J.
1946 APPROVED WASHINGTON MILK HOUSE. Washington Agricultural Extension Bulletin 313.
- Strahan, J. L.
1925 MILK HOUSES FOR VERMONT DAIRY FARMS. Vermont Agricultural Department Bulletin 27: 1-23.
- Tuftt, J. E.
1941 CALIFORNIA MILK HOUSES. Hoard's Dairyman 86:149.
- Turney, G. J., and Bryan, C. S.
1938 THE PRODUCTION OF HIGH QUALITY MILK. Lansing Department of Health Bulletin No. 2.
- Watkins, L. W., and Broughton, T. H.
1924 MILK SUPPLIES OF MICHIGAN CITIES. Michigan Department of Agriculture, Bureau of Dairying.
- Ward, W. G.
1942 MILK HOUSES FOR KANSAS. Kansas Agricultural Extension Bulletin 74: 1-18 revised.
- Wilkinson, J. F.
1946 WHERE SHALL I PUT THE MILK HOUSE. Hoard's Dairyman 9:95.

Wilkinson, J. F.

1947 MUSTS IN GOOD MILK PRODUCTION. Hoard's Dairyman
92:37.

Witzel, S. A.

1937 MILK HOUSES OF TODAY. Hoard's Dairyman 82:240.

Wooley, John C.

1946 FARM BUILDINGS. McGraw Hill Book Co., New York,
65-73.

1940 ATTRACTIVE AS WELL AS PRACTICAL NEW MILK HOUSES.
Successful Farming 38:42.

1946 BE SURE IT'S BIG ENOUGH. Country Gentleman
116:27.

1929 BUILDING A SANITARY MILK HOUSE. N. Y. Prod.
Review 63:1312.

1935 CLEAN COWS, CLEAN STABLES AND CLEAN MILK. Michi-
gan Department of Dairy and Food.

1944 CONCRETE MILK HOUSE. Rock Products 47:98

1946 DAIRY FARM BUILDINGS. PLANS AND SPECIFICATIONS
OF MILKING BAILS AND MILK OR SEPARATOR ROOM ARE
AVAILABLE. Ag. Gazette of New South Wales 57:
636-7.

1940 DE LUXE MILK HOUSE AND MILKING SPEEDS ORDER OF
THE DAY IN LOS ANGELES AREA. Milk Dealer 29:35.

1946 FACTORY BUILT MILK HOUSE. Milk Dealer 25:34.

1943 FARM MARKET STRUCTURES IN DEMAND. American
Builder 65: 52-3.

1926 GOOD MILK HOUSE SAVES MONEY. Successful Farming
24:44.

1923 HANDY ROOM FOR QUALITY MILK. Dairy Farmer 26:14.

1931 IOWA MILK HOUSE. Hoard's Dairyman 76:675.

1947 MILK FACTS. Milk Industry Foundation 1946-1947
Edition.

1942 MILK HOUSES. Hoard's Dairyman 87:631.

1941 MILK HOUSE CONSTRUCTION ON UTAH FARMS. Utah
Agricultural Extension Circular 110: 1-11.

1942 MILK HOUSE NEEDED; HOW TO PLAN AND BUILD. Amer-
ican Builder 64: 58-60.

1939 MILK HOUSE PLANS. Hoard's Dairyman 84:199.

1929 NOTES ON THE PRODUCTION OF CLEAN MILK. Reprint
Michigan Department of Agriculture.

1943 SANITARY MILK HOUSE. American Builder 65:50.

1942 THREE TYPES OF MILK HOUSES. Hoard's Dairyman
87:623.

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