METHODS ENGINEERING ANALYSIS OF LOOSE HOUSING DAIRY BARNS

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Walter M Carleton
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METHODS ENGINEERING ANALYSIS OF LOOSE HOUSING DAIRY BARNS

By

Burton F. J. Cargill

AN ABSTRACT

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

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THESIS

BURTON F. J. CARGILL ABSTRACT

Farm power and machinery have greatly reduced both the time and work on field crops. However, dairying time requirements have been reduced very little over the past twenty years. Dairying is important to Michigan farmers because it averages about 40 percent of their cash farm income; yet a review of literature reveals that the dairy farmers are not receiving a satisfactory return for labor and management.

A check on milk production costs shows that labor amounts to one third and feed about 45 percent of the total costs. Feed costs have been investigated; however, literature reveals that very little research has been done on the reduction of labor costs. A substantial reduction in the dairy cow time requirement could net the farmer a satisfactory income for his labor and management.

A methods engineering analysis of any operation is necessary to determine the relative importance of the various jobs and their job elements. Previous literature revealed an analysis of stall barns, but no publications were found that gave the relative importance of the jobs in loose housing barns.

The major objective of the research was to determine the relative importance of the dairy chore jobs and determine the value of operating efficiency on return for labor and management.

BURTON F. J. CARGILL ABSTRACT

A representative group of farms with loose housing barns were selected for a methods engineering analysis and it was determined that the relative importance of the jobs were as follows:

Milking and care of milk equipment	80%
Bedding the cows	6%
Feeding silage (once per day)	6%
Feeding hay (hay self-fed)	2%
Miscellaneous	6%

The work methods and barn arrangements on the farms analyzed were responsible for a variation in financial return. The average return on the 21 farms was $.91 per hour and on one third of the more efficient farms, $1.86. Therefore, the degree of efficiency with which an operator performs his work is responsible for an unsatisfactory labor return ($.91) or a satisfactory return ($1.86).

Further research was deemed necessary after milking was found to have such a dominating time requirement. The additional research was conducted in two well-arranged milking rooms (elevated double tandem) with two operators who had better than average milking time requirements. The work places were not changed; only the milking units and work methods were altered.

An annual saving (based on milking twenty cows) of only 63 man hours resulted from the changes in milking room "A". However, the changes enabled the operator to milk with greater

ease and used better milking practices, which in themselves require more time, after the changes were made.

Work on the 21 farms and the additional experience gained from further research in two milking rooms made possible the development of a recommended milking procedure for a double tandem milking room. The procedure will enable one operator, using recommended milking practices, to milk at the rate of 28 cows per hour.

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The writer appreciates the splendid cooperation received from the many farmers upon whose farms the data were taken; and also to Mr. Harry DeLaere, Chore-Boy Milking Machine Company for the use of his farm and equipment in the development of an experimental milking machine.

TABLE OF CONTENTS

LIST OF FIGURES

Figure Page

LIST OF TABLES

INTRODUCTION

It is not out of the realm of imagination that loose housing* had been practiced previous to the 20th century. In fact it is possible to imagine that loose housing was the first method of handling the domesticated cow. Perhaps the method started by tieing the cow to a post and progressed to crude shelters where the cows were milked; convenience prompted the farmer to partition off a corner of the barn -- thus the milking room*.

A limited amount of research pertaining to loose housing has been published over the past half century. An intensive review of the literature shows that the investigators were only concerned with obtaining information relative to the "effects of cold housing" on dairy animals and presenting the advantages and disadvantages of loose housing over the conventional stall barn*.

The author's intention is for the reader to receive a clear picture of the relative importance of the job and the effectiveness of various work methods and arrangements. The author chooses not to devote any space in the investigation to a discussion of the advantages and disadvantages or the effects of cold housing. An extensive review of literature

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*Defined in glossary, Appendix I.

is deemed adequate.

Information regarding the relative importance of the dairy chore work is available for the stall barn and the results of this research can be compared to this data to determine the relative importance of the jobs in one barn with respect to the other.

REVIEW OF LITERATURE

Historical Background

The first reported work in the United States on turning cows loose in a barn, confining them only for milking, was done at the University of Illinois.

This work at Illinois was carried on by W. J. Fraser [12], in July, 1905. A preliminary survey of eighteen dairy barns in the state where the method was in use, showed that in some instances the cows were either: (1) milked in the feeding barn or (2) taken into an adjacent stable for milking. In the first, the cows were allowed to run loose, except at milking time when they were confined in stanchions and fed concentrates. An example of the second was on a farm where a three stall, walk-through milking room was used for a herd of thirty-three cows, Figure 1. A few years after the work at Illinois, Buckley and Lamson [3] of Maryland Agricultural Experiment Station ran a three year comparative test on the "open stable"* versus a stall barn of standard design. The open stable had concrete walls, 5'-0" high with 3'-6" posts above supporting the roof. All the spaces between the posts were left open except where a milking barn* was attached. The barn was divided in two parts by two mangers and a gate, Figure 2. At milking

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*Defined in glossary, Appendix I.

time the lactating cows were driven to one end of the barn, "B" Figure 2, and the gate connecting the two mangers closed. The cows were then passed through the milking barn emerging on the opposite side of the mangers, "A" Figure 2.

Buckley made significant statements relative to temperature.

> The experiences gained in the open and closed stable comparison indicate the evil effects of low temperature have been greatly over estimated....there is no instance in this experiment in which there has been a decided decrease in production of milk, temporary or permanent, which can be attributed to low temperatures or to sudden fluctuation in temperature unless at the same time exposed to rain.

Minimum temperatures recorded in the open and closed stables were -14^{o} and 11^{o} respectively.

The advantages claimed for the open stable were: (1) economy of construction, (2) economy of labor, (3) fewer stanchions and mangers, (4) better manure, (5) cleaner cows, (6) greater comfort of cows, (7) slightly cheaper cost of feed in production of milk and (8) production of milk of lower bacteria content.

> On the other hand, there have been only two disadvantages suggested against the use of open stables which it has not been possible to refute by the results of actual experience. One of these is the low temperature of the milking room in extreme weather in winter....and the second is the arrangement for feeding the roughages to the cows.

It is interesting to note that the loose housing barn was not generally adopted by the Maryland dairy farmers, despite the favorable results of the experimental work. Maryland Experiment Station discontinued the use of the open barn for dairy cattle after the experiment. Long [22] stated that a

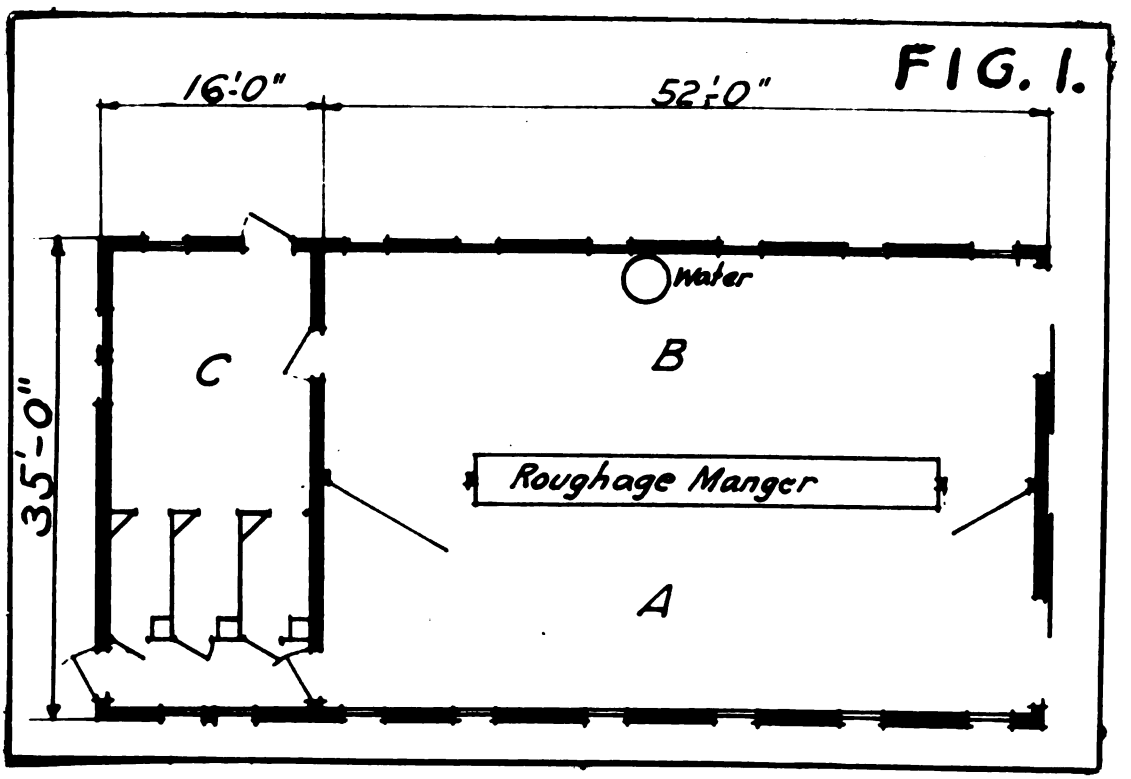

Figure 1 The floor plan of a loose housing barn referred to by W. J. Fraser [12].

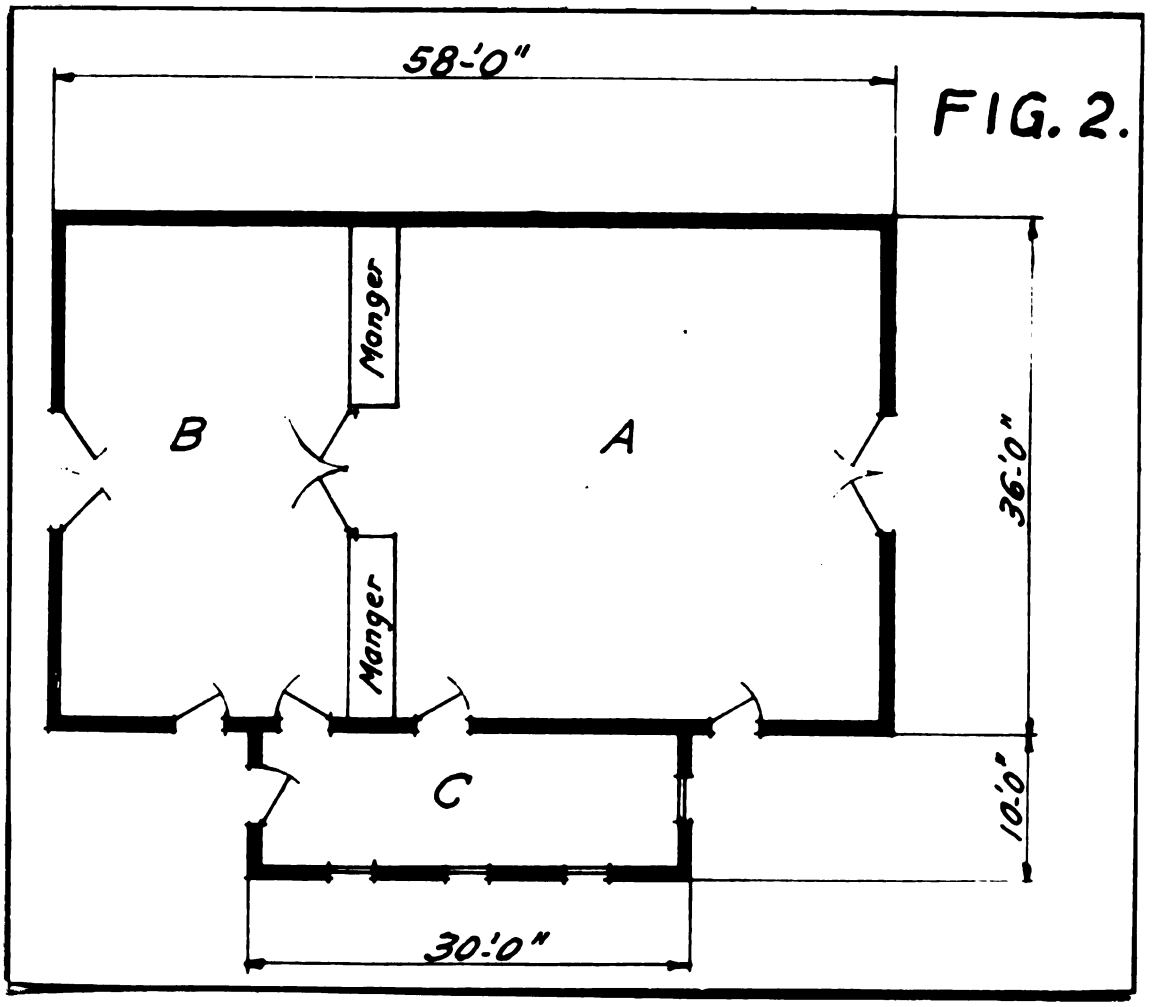

Figure 2 The floor plan of the loose housing barn used at the Maryland Agricultural Experiment Station.

recent letter received from Dr. H. J. Patterson, Director of the Maryland Agricultural Experiment Station, had comments as follows:

> We still continue to use the open barn described in our Experiment Station Bulletin 177 for young stock, but have not used it for several years for cows in the manner described in the bulletin....due to the fact it was not as well suited to some of the experimental work in hand as the other types of stables. This type of stable did not conform to the arbitrary regulations of City Boards of Health and consequently it is not adopted to any extent for the dairymen in our state. In the changes of personnel in our own staff I have found it difficult in the case of this barn, as with many other things, to overcome the prejudices which seem to be instilled in people according to the environment in which they were raised....I believe that all of the points set forth by Dr. Buckley in favor of the open type barn still hold true....I feel quite certain that if I had the planning and management of a practical and commercial herd I would use some modification of the barn described in bulletin 177.

Davis [4] was conducting research on loose housing in Pennsylvania about the same time as Buckley [3].

The United States Department of Agriculture also recognized this new loose housing system and in 1914 undertook experiments to determine its worth and general practicability. Woodward [35] reported that in general practice the loose housing barn included a loafing barn* which was enclosed on three sides and open on the south or east. Roughage was usually fed in the loafing barn. The floor space ranged from 35 to 150 square feet per cow. The United States Department of Agriculture conducted their experiments in a 35'-0" x 58'-0" frame barn. An area 18'-0" x 35'-0" was partitioned off in one end of the barn

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*Defined in glossary, Appendix I.

for an eight stall milking room. Sixteen cows were housed in the barn, an area allowance of 75 square feet per cow. Woodward reported the average daily bedding consumption at 8.3 pounds per cow but did not mention the kind of bedding material used. He also stated:

> On damp, rainy days more bedding was needed than in dry weather....regardless of climatic conditions, however, the more space allowed each cow the less bedding will be required.

In 1924 Fraser [13] wrote that the loose housing barn and the round barn were gaining a little public favor. It is of interest of note here that a round barn was built on the W. Jensen farm Grant, Michigan, in 1914.

Although considerable experimental work had been conducted on loose housing, college bulletins published around 1924 gave very little space to this new system for handling dairy cows. Fish [11] stated that the lack of published material indicated that the farmer acceptance of loose housing had not arrived, at least in the northern states. However, Mac Innes [23] stated that in new South Wales loose housing was generally accepted but chose to use separate structures for milking and feeding. He stated,

"The parallel walk-throu milking barn is in favor."

Long [22], in 1931, said that California had been advocating the dual structure system for the past eight years and in various forms it is now widely accepted.

> Due to the varying conditions in the state, climatic and otherwise, the dairies during the past years have

> exhibited a hodge-podge of structural design. A barn with a central hay mow extending from the ground and sheds on either side has been most widespread. When health authorities prohibited whole milk production in these barns the trend swung to one-story stanchion barns* large enough to contain the entire herd at milking time. Concentrates were fed in the barn and roughages in the open corral. The cows spent about six hours of the 24 in the barn during the two milking periods and the remainder of the time in the open, in the mud or the hot sun of the feedlots.

Long also stated that Animal Husbandry men believe this exposure is detrimental to economical production, and tests and data secured from practical dairymen substantiate this view. Either the production dropped as the cows suffered exposure and required additional heat units to maintain their body temperature or additional feed, as high as 25 per cent in some estimates, was required in order to maintain their production. Preliminary shelter studies by Dice [8] in 1926 refute the statements previously made in Long's report.

> The purpose of the studies was to demonstrate the assumed folly of turning milk cows outdoors all day during cold winter weather.

Comparisons of warm and cold housing were conducted on two similiar groups of dairy cows. Feed consumption, temperature and milk production records were kept during October, November and December 1926, and January 1927. Both groups were handled identically during October and the record for this month was used as the "check". Identical rations were fed to the groups except that the cows in the loose housing group had access to hay at all times from an outdoor feeder, Figure 3. The cows in the loose housing group gained more

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*Defined in glossary, Appendix I.

Figure 3 Loose housing barn with outdoor hay feeder used by Dice [8] in 1926.

weight (207 pounds compared to 184 pounds), produced more milk (84.7% of the check as compared to 78.1%) and consumed more hay. The temperature range was -22° to 36° for the loose housing group and seldom below 50° in the stall barn. Based on data collected on numerous experiments from 1928 to 1942 Dice made the following conclusions:

> Both observation and data assembled indicate that in the cold dry climate of North Dakota milk cows can stand considerable exposure to low temperatures. The idea that dairy cows receiving an adequate ration need to be kept in a warm barn to be comfortable seems to be an assumption rather than a fact. Provided dairy cows are liberally fed on adequate rations, have shelter from wind, snow or rain, and have a dry place to bed down, they can withstand exposure to cold temperature and produce practically the same in a cold shed as in a barn where the temperature is about 50° F. Apparently milk cows on full feed, when housed in a cold place while masticating, digesting, and assimilating their ration, produce sufficient surplus heat over usual maintenance requirements to maintain body temperature without using additional nutrients for that purpose. In these experiments cows housed in a cold shed required no more nutrients for milk and butterfat production than other cows, or the same cows, when kept in a standard dairy barn. These results indicate producing dairy cows in a cold shed tend to gain somewhat more weight than cows in the dairy barn.
>
> The comfort and convenience of the caretaker and the protection of the watering system rather than the need of the cow are apparently the only justification for the type of barns that are common today. About a third more bedding is required in the shed than in the dairy barn. More trouble with frosted teats may be expected from exposed cows when the udder is tightly distended with milk and when udders are pendulous. The cows exposed to long periods of fall and winter weather developed heavier hair coats than the cows which were kept in the barn.

It is significant that none of the descriptions of early-day loose housing mention the existence of any kind of a milk-handling room, therefore, it is evident that the common practice

of the day was to have a milk house* entirely separate from the building where the cows were milked or housed. Kelly [20] states in 1915 that,

> For convenience the dairy house should be near the barn, yet so far from it that no barn odors can be detected in the house....The principle purpose in building a dairy house is to provide a place where dairy products may be handled apart from anything else. To carry out this idea it is necessary to divide the interior of the building so that the utensils do not have to be washed in the same room where the milk is handled.

Figure 4 is a floor plan of the milk house recommended by Kelly.

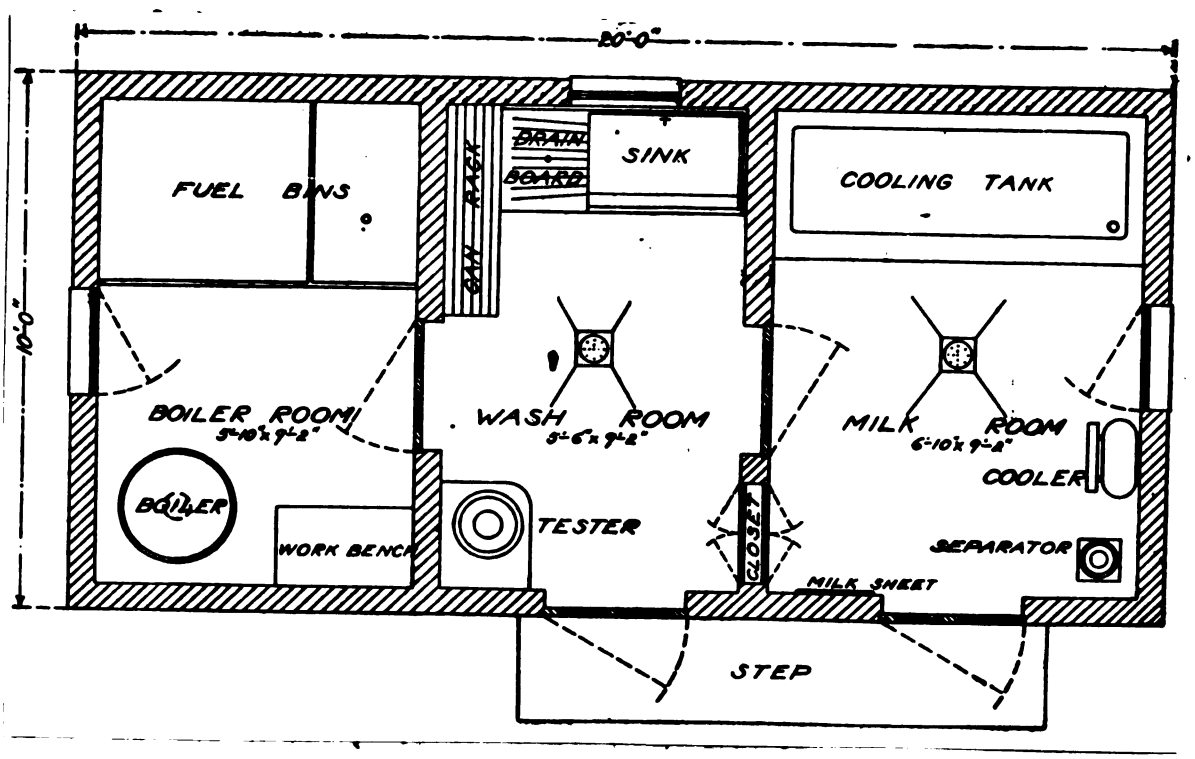

Figure 4 A recommended floor plan for a milk house in 1915. Two rooms were considered necessary, a milk storage room and a washing room.

*Defined in glossary, Appendix I.

In 1921 Kelly [21] changed his requirements on milk house location and illustrated a one room milk house, Figure 5.

> Building the milk house adjacent to the stable is not objectionable....if the milk room is far removed from the stable it will take much additional labor to carry the milk.

McColly and Dice [24] continued with Dice's preliminary work started in 1926. They illustrated a milk house attached to the dairy barn in two of their plans, Figure 6, and made the following conclusions regarding their loose housing studies,

> About the same amount of labor is required in the pen barn as in a barn with stalls. The difference is that in the pen barn the labor involved in cleaning out the stables can be centered at one time during the month and the job of bedding the cows and even feeding the hay and roughage can be done in more of a wholesale way....The cost of building a pen barn is about the same as for building a standard barn, altho in some details the pen barn will require less expensive construction. The great saving is in the equipment of the pen barn. Stalls and concrete floors are not necessary except in the milking room and with the cows loose, ventilating the barn is a simple problem....Work done at the North Dakota Experiment Station and elsewhere indicates that they (the cows) are not 'thin skinned' and that they will adapt themselves to varied conditions, especially low temperatures, provided their stable is dry and free from drafts. Therefore, the cow stable does not need to be kept above freezing temperature and cows that are loose will adjust themselves far more comfortably under any conditions than cows tied in stalls or stanchions.

Research on loose housing in Michigan started in 1928. Jefferson and Weaver [19] report that,

> When Michigan State College began a study of pen barns* in 1928 there were only a few such barns in rather closely confined areas in Michigan. Today (1945) we have records of 139 pen barns.

Jefferson and Weaver sent questionnaires to 137 people operating pen barns, and an analysis of the returned questionnaire

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*Defined in glossary, Appendix I.

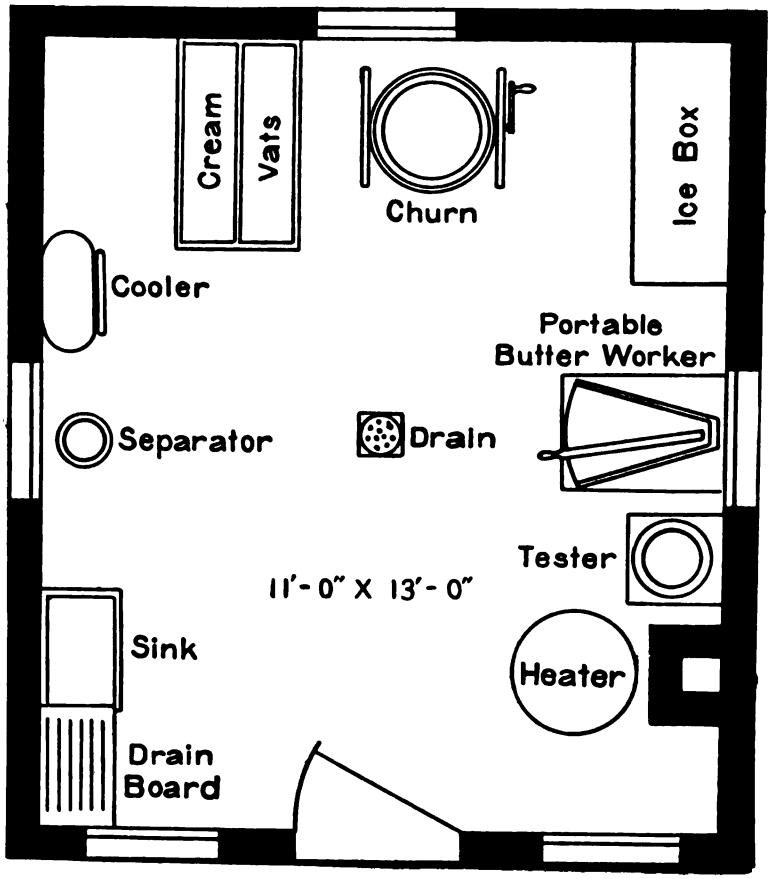

Figure 5 The milk house requirements changed by 1921. Illustrated is a one room milk house recommended by Kelly [21] in 1921.

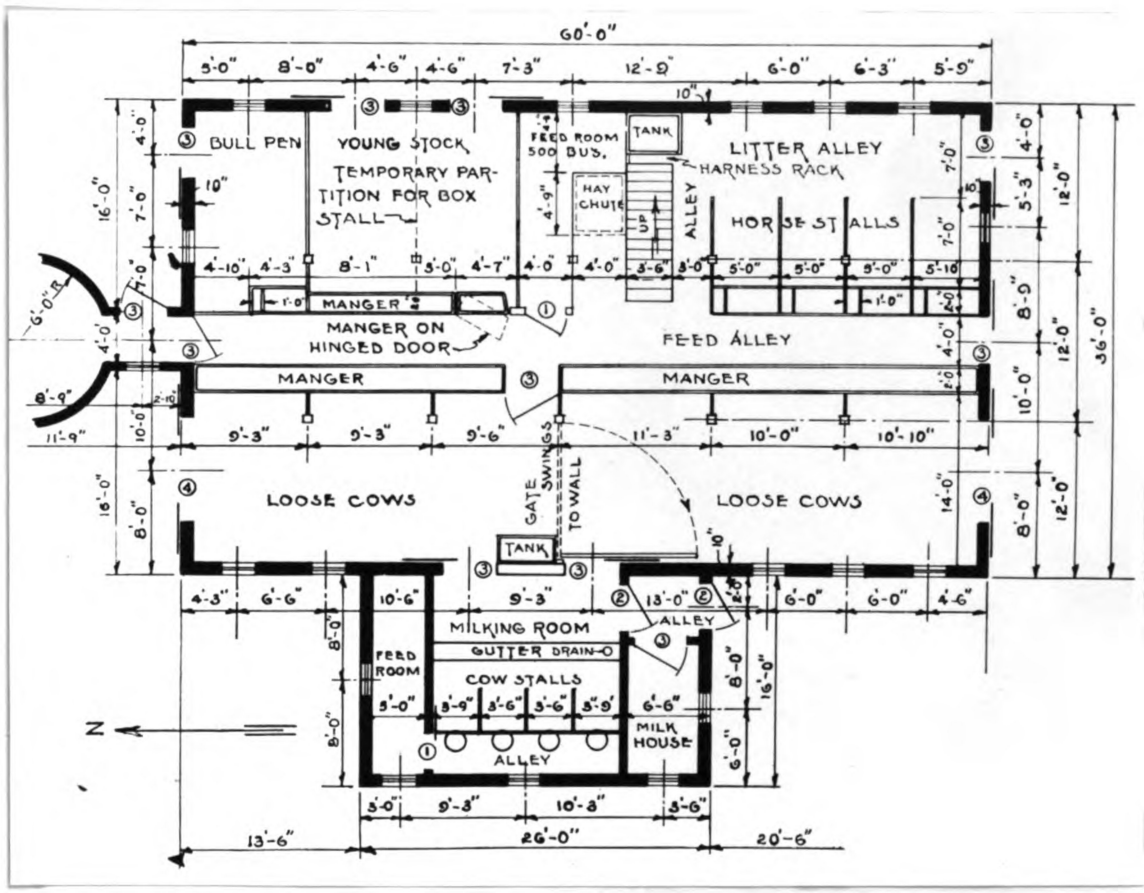

Figure 6 A loose housing barn floor plan illustrated by McColly and Dice [24] had a milk house directly attached to the barn.

was made.

> One dairyman reports that loose housing has been used in the vicinity of Hamilton, Michigan, Allegan County for more than 80 years.

They also stated that several farms had used a pen barn for more than 25 years. Two common arrangements for milking were mentioned, the tandem* and the abreast*.

> "The one chosen will depend upon the individual preference."

Long [22] stated in 1931 that there was considerable interest in the parallel walk-through milking barn (abreast stalls) and also a developing interest in the tandem walk-through milking barn. The parallel walk-through milking barn was introduced to California from New Zealand and Australia.

Long stated that along with the walk-through barns came the original releaser type* of milking machine. The original make of releaser milker caused mechanical difficulty, even to the extent of flavoring the milk, and had no facilities for production testing*. The entire system was generally condemned for years in California. A few converts, however, have demonstrated that the structure could be used with hand or bucket milking and "successful releaser milkers are now being built", Figure 7. Long stated also that in the walk-through type milking barn the cows are admitted one at a time from the holding corral and find their way to a vacant stall. Until they are accustomed to the system the cows are held in a stall by chains passed behind them. In the door, which forms a

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*Defined in glossary, Appendix I.

front wall of the stall, there may be placed a feeding bucket. It may be filled from the feed alley or by the milker from a small grain supply kept in the space between each pair of stalls.

> An interesting feature which is being suggested is placing of the milker (operator) on a level below that of the cow to minimize the stooping necessary.

In 1932, Strahan [32] discussed the increased interest in the use of barns for milking only, shelter and feed being provided elsewhere.

> The principle impetus to the latest trend (separate milking barns) was contributed by Dr. R. R. Graves.

Graves said, "Bring the work to the machine," a well known principle in factory management.

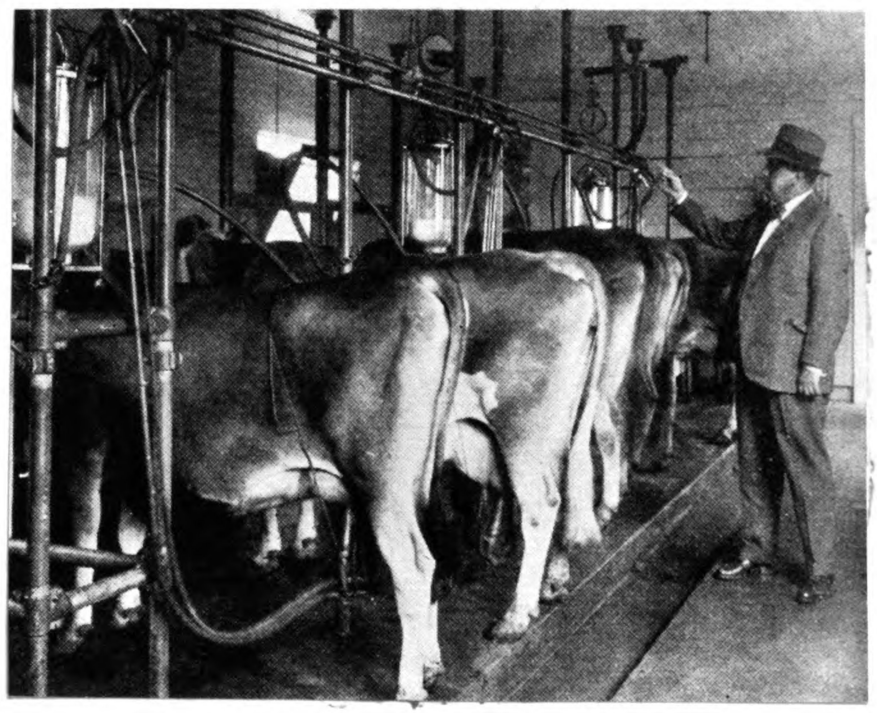

Figure 7 A releaser type milking machine developed by R. R. Graves delivers the milk directly from the cow to the milkroom.

Strahan wrote in 1932 that a revolutionary trend -- the milking barn -- was coming into the dairy industry. He stated that for larger herds there were two types: (1) the elevated tandem stalls and (2) the floor level abreast stalls. He even had visions of the future

> And now, what of the future? In the realm of speculation one man's guess is as good as another's, and the man with the weirdest imagination often wins the game. But it is not unreasonable to expect even the smallest herds ultimately to come under the influence of this revolutionary trend.

He also foresees the day,

> Suppose three or four milking stalls were mounted on a truck - the owner might buy the milk in the cow.

In his article Long [21] mentions a portable field milking barn (Figure 8). He states,

> Another type of dairy management which is bidding for attention and which involves different structural designs is that wherein the herd is kept continuously on pasture and the buildings consisting of a portable walk-through barn, parallel stalls and milk house are moved from place to place in the pasture as frequently as may be required for feed, water and soil conditions.

It might be expected that this method originated in England, probably as a descendant of New Zealand and Australian methods. The chief advantages claimed for the open air system were (1) decreased cost in production, (2) improved pastures and (3) improved herd health.

1900 to 1930 was a period when loose housing was considered only as a means for greater production by increased cow comfort. Labor efficiency had not been emphasized. Farrall [10] in 1931 mentioned labor saving designs and

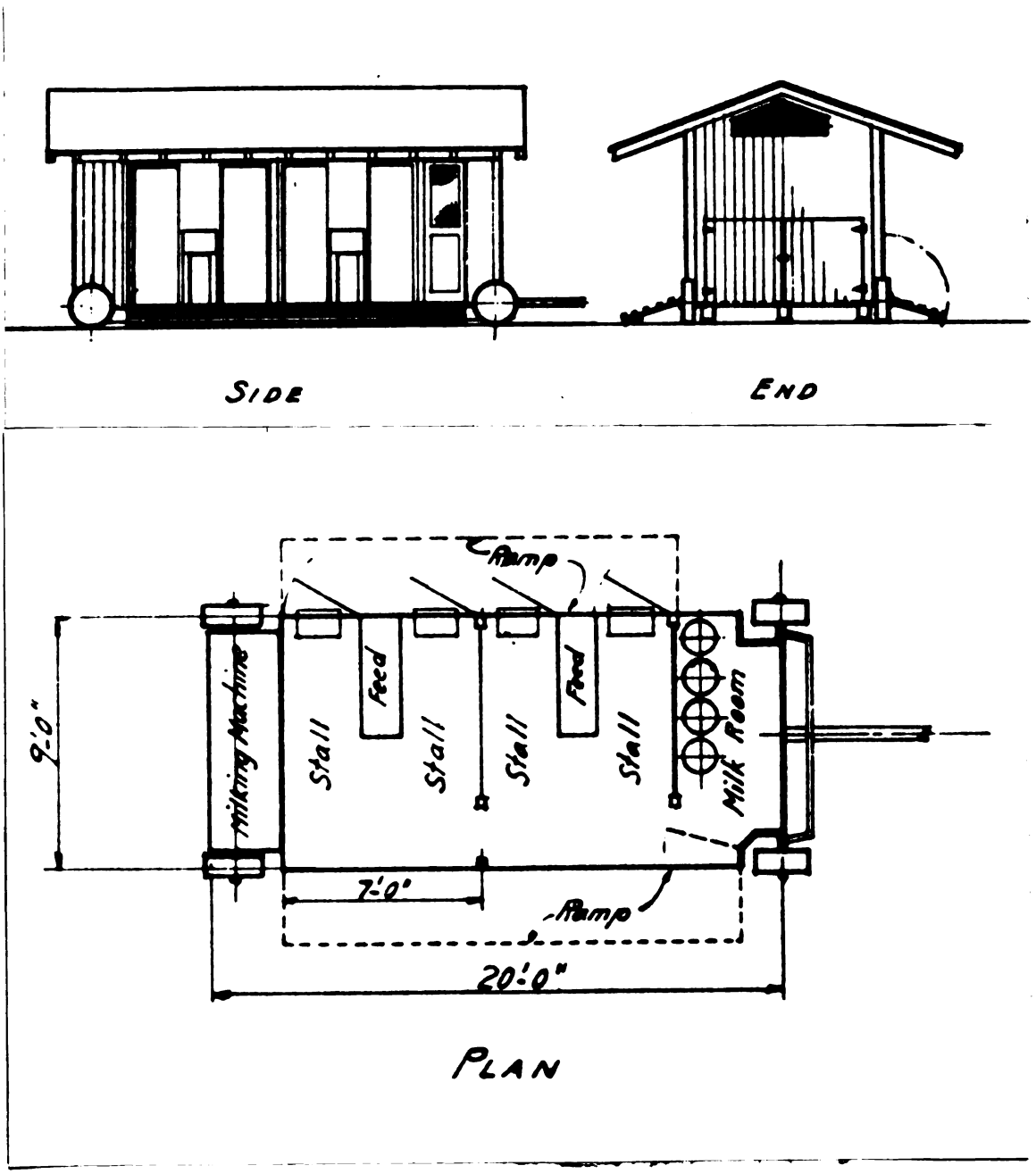

Figure 8 A portable field milking barn described by Long [21].

discussed a revolutionary design - the rotary milking platform - the "Rotolactor" (Figure 9). One complete revolution of the platform in 12-1/2 minutes enabled the operators to prepare and milk 50 cows. It was developed on the Walker - Gordon farm, Plainsboro, New Jersey, and put into operation in October 1930.

Huff [18] reported that the milking barn was introduced into Missouri about 1932.

> Some of the early systems employed old barns as loafing barns, and built two or three stall milking barn - milk house combination structures to handle the milking operation. The tandem walk-through type of milking barn was used, without having an elevated platform.

In 1939 Huff predicted that for Missouri the future for loose housing was good.

> It has been gaining in popularity and acceptance since it was first introduced.

In 1944 Morrow [26] of New Hampshire reported on eleven years of experience with a pen type barn*. Later Woodworth [36] conducted an efficiency study on dairy barns in New Hampshire. He states,

> The study is only on stanchion barns. Pen barn studies are not possible because there is little opportunity in the State to observe chore work....The problem of bedding has restrained farmers from developing this type of housing.

An article about Washington State in 1941 [14] reported that loose housing barns had been used in that State for 20 years and were well developed. A later report from Washington

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*Defined in glossary, Appendix I.

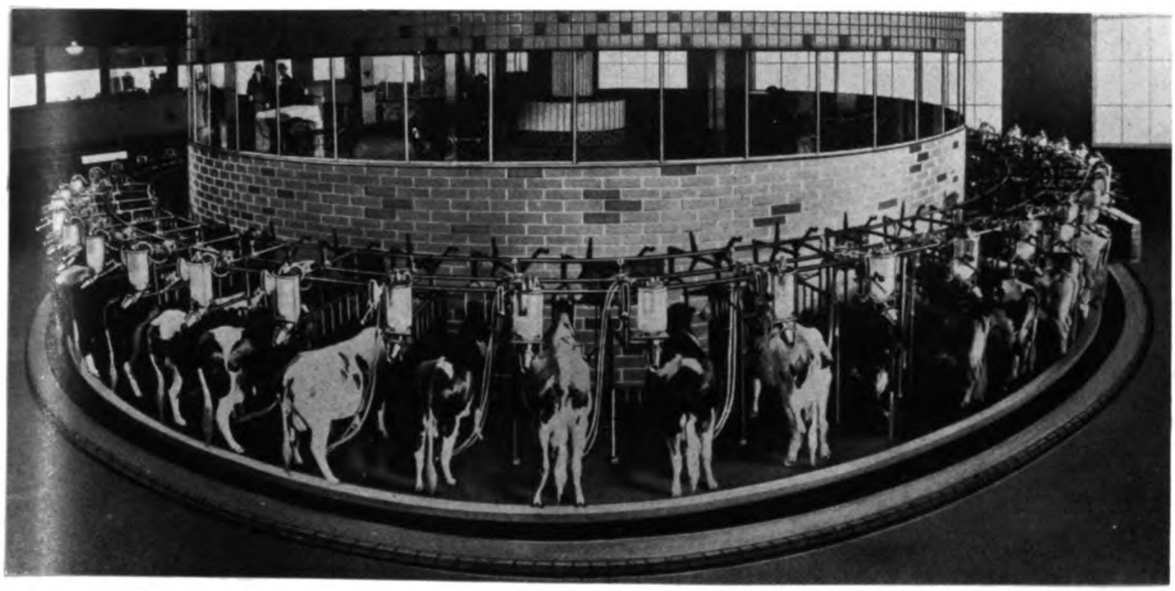

Figure 9 The "Rotolactor" developed on the Walker-Gordon farm, Plainsboro, New Jersey, was put into operation in October, 1930.

State by Smith [31] stated that there was a trend toward separate open areas for feeding and housing.

The Montana State College developed an elevated stall in 1945-46 [33]. The cows stand abreast in pairs on an elevated platform with an operator area* between each pair. This milking room was called the "Montana Type". Eugene [9] in 1948 reported that the "Montana Type" milking room was being used in Minnesota. He also said,

> Cold housing is considered entirely feasible in non-insulated, freely ventilated barns with open windows and doors.

This brief review of the historical background has been prepared from reports of research conducted during the past 45 years (1903 - 1948). The literature cited includes all the major publications and a few popular articles that could be found in the Agricultural Engineering Library and the Michigan State College Library. Literature on loose housing research in the United States previous to that reported by Fraser [12] in 1905 could not be located.

There is some evidence that loose housing was introduced into this country from New Zealand and Australia. The influence upon dairy farmers of the United States came about the turn of the 20th century. The popular belief that lactating dairy animals need warm barns and the unwillingness of health authorities to approve of loose housing have retarded the widespread acceptance by dairy farmers.

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*Defined in glossary, Appendix I.

Current Literature on Relative Importance of Dairy Chores

Previous loose housing investigations have been concerned only with providing data which showed that:

(1) Cold or open housing has very little or no effects on dairy animals.

(2) Increased milk production is due to increased animal comfort.

(3) Fewer animal diseases and udder injuries occur.

(4) Higher quality milk is produced.

(5) Better quality manure is produced.

(6) Bedding consumption is greater than in stall barns.

In January 1948 when the collection of data started for this thesis no previous research, to the writer's knowledge, had been completed on the relative importance of the various dairy chores or the total labor requirements for loose housing barns.

Munger [27] in 1921 mentioned labor as an item in the cost of milk production. He made a study of 58 farms in Cerro Gordo County, Iowa, and found that the average stall barn labor requirements were 147.4 man hours per cow per year. He said that the labor involved in the production of milk was milking, feeding and hauling.

Headley [15] wrote on the efficiency in dairying in 1930. He mentioned that loose housing existed in Nevada, but did not attempt to determine the labor requirements. He stated that the average labor consumed per cow per year was 143 man hours,

but he did not attempt to determine the importance of each job.

Woodworth [36] in 1933 made some efficiency studies in dairying, but again as with previous studies he was concerned only with the stall barn. However, his work appears to be the first attempt at determining the relative importance of the various dairy chores. He gathered his data from 38 stall barns in New Hampshire. The average man hours per cow per year were 129. He divided the dairy chore work into milking, feeding, cleaning stables and watering.

A dairy cost study was made in Michigan in 1936 [6]. Dairy chore labor was mentioned as milking, feeding and other work. The data were based on a survey of 123 stall barns and the average man hours per cow per year were 147.3.

Buck [2] in 1940 determined the average annual per cow labor requirement on 10 Iowa farms with stall barns. The average was 143 man hours per year.

Carter [4] in 1942 made a detailed time analysis of one stall barn in Vermont. He developed new work methods from the analysis. But not until 1946 did researchers actually start analyzing the dairy chore work with a definite goal in mind for determining the relative importance of the various jobs. Previous work except for Carter had not been time and motion analysis work, but merely survey type investigations.

Bookhout [1] in 1946 analyzed the dairy chores in 10 Michigan stall barns. His time and motion analysis was a definite step toward determining the relative importance of each job with respect to the total hours spent (Table I).

Smith [30] analyzed the dairy chore time on 15 farms with stall barns in Maryland during the summer of 1946. Milking time averaged 68.7 per cent; whereas it was 48 per cent for Bookhout. However, hay was not fed during the summer when Smith made his study.

Woodworth [37] analyzed a series of stall barns. It is interesting to note here that the work by Bookhout and by Woodworth are very similar (Table I).

Comparable data, such as obtained by Bookhout [1] on the relative importance of the dairy chores, are necessary for the loose housing barn.

Witzel [34] in February 1948 prepared a report after an inspection trip of milking rooms in the western United States. He analyzed the time spent milking in various types of milking rooms. Witzel's report is the first published data, to the author's knowledge, on the analysis of the milking operation in a number of milking rooms.

Previous literature cited illustrates the lack of available information pertaining to loose housing work methods and arrangement. Perhaps Long[21] when he said "loose housing barns had grown by 'hodge-podge' methods" realized the lack of design data.

TABLE I

DAIRY CHORE JOBS IN STALL BARNS

(Percentage distribution of winter chore work on dairy farms with stall barns in Michigan and Maryland)

Item	Michigan	Maryland
Milking	48	49
Care of milk equipment	13	12
Care of milk	6	1
Feeding and cleaning mangers	16	13
Cleaning stables and bedding	13	14
Cows in and out of barn	4	4
Miscellaneous		7
Total per cent	100	100

JUSTIFICATION

Dairying is one of the most important industries in the United States. In value, the product is second only to iron and steel [15]. The capital wealth of our Michigan dairy industry is 2-1/2 billion dollars [28]. In Michigan dairying utilizes a huge physical production plant spread over 105,990 [5] dairy farms and extensive processing and marketing facilities. Together these constitute one of the state's largest industries, providing 39.6 per cent of the total farm cash income [25] and an important and dependable share of the income of city people. Michigan's annual milk production of nearly six billion pounds would fill a line of milk tank trucks from Detroit past Denver. This production creates 300,000 jobs and supports 600,000 people on an annual payroll of over 2-2/3 million dollars [28].

The Public Health Service [29] states:

> Of all the factors of man's environment none is more important to his welfare than food. Of all foods, none is more important than milk.

Dairy products make up over 30 per cent of the food we eat, yet cost only 15 per cent of our food dollar. (Table XVI, Appendix Page 71.)

Michigan ranks fourth among the states in the number of milking machines, and sixth in value of cows, number of heifer calves kept for milk, value of whole milk delivered to plants and value of cream sold as butterfat. Michigan ranks seventh

in farm value of milk produced, number of milk cows, value of dairy products sold, and number of heifers one to two years old. (Tables XVII and XVIII, Appendix Pages 72 and 73).

The above figures paint a very impressive picture regarding the Michigan dairy industry, farm, and otherwise. However, an analysis of the average Michigan farmer with dairy animals reveals that he is not receiving a satisfactory labor income. The average farm has a herd of 7.5 cows producing 5,910 pounds of milk containing 230 pounds of butterfat. A cow must produce 200 pounds of butterfat to pay for her food, housing, veterinarian and other expenses leaving little or no return for labor and management [17].

Labor, the second largest cost item in producing milk, makes up 31 per cent of the total costs per cow. (Table II). Labor, buildings and equipment make up approximately 40 per cent of the total milk production costs without regard for the effect of management's choice of feed and cow removals (Table XIX, Appendix Page 74).

A review of literature reveals that Michigan, the location of the original Dairy Herd Improvement Association[1] has conducted research on increased production by animal selection

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[1] "Old Newaygo", the first cow testing association in the United States was founded on August 10, 1905, in Newaygo County, Michigan. Jens Mogensen, a Danish-trained cow tester being hired by the association. The first year's records listed 31 herds and 239 cows. The cows averaged 5336 pounds of milk and 215 pounds of butterfat. "Old Newaygo" was so successful that it prompted the organization of four more associations in 1906 at Coopersville, Bay City, Caro, and Lapeer, Michigan.

TABLE II

MILK PRODUCTION COSTS

(Costs per dairy cow and percentage distribution on 83 herds in the Detroit milk shed in 1948 - 1949 [16])

Item	Cost	Per cent
Feed	$169.44	48
Labor	106.76	31
Building and Equipment Use Electricity Bedding	28.88	8
Other Miscellaneous	44.86	13
Total	$344.94	100

and improved feeding. However, very little research has been conducted on increased labor income by improved arrangement and management practices. The author believes that considerable improvement can be brought about if (1) a methods engineering analysis is made of the various work methods and (2) the relative time requirements for the dairy chores are known.

The importance of the dairy industry to Michigan, along with the shortage of competent farm labor and rising farm wage rates, justifies research directed at improved work methods, reduced man hours per cow, and improved barn arrangement on increased labor income.

INVESTIGATION

Objectives of the Research Project

1. To determine the variation in time requirements for feeding hay and silage and bedding with different work methods and arrangements in loose housing barns.
2. To determine the time requirements for the various jobs of the complete milking operation.
3. To determine the time spent caring for young stock and calves.
4. To determine the relative importance, with respect to the time requirement, of all winter dairy jobs.
5. To determine the value of operating efficiency (work methods and arrangement) to the dairy farmer's income for labor and management.

Procedure

I. Preliminary Survey (Appendix III for sample forms)

- A. Prepare a questionnaire to be sent to County Agricultural Agents in Michigan (page 76)
    1. Request names and addresses of farmers operating loose housing barns
    2. Request estimated number of loose housing barns in the county

B. Visit each farm mentioned by County Agent (page 77) and note:

1. General comments of the farmer
2. Size of the herd
3. Size of the barn area provided
4. Type of hay fed and bedding used
5. Length of feeder
6. Ceiling height
7. General barn arrangement
8. Number of milking stalls and position with respect to the operator area
9. Number of men milking
10. Number of milking units

C. Analyze information obtained from farm visit

1. To locate twenty to thirty farms for intensive analysis

a. Group must have a variety of work methods and arrangement
b. Group must use different forms of hay, bedding and silage

2. To reduce mileage and travel time on final visits

II. Preparation of Field Work

A. Make detailed analysis at one farm (Appendix III)

1. To gain experience in recording time data
2. To determine the job elements that could be timed
3. To set up standard procedure for recording time
4. To prepare a code for taking time data

B. Prepare final forms (Appendix IV and V sample forms)

1. Survey data forms

a. Farm data form, page 81
b. Questionnaire on loose housing, page 82
c. Job analysis form, page 83
d. Farmstead information, page 84
e. General barn information, page 85
f. Barn space allotments, page 86
g. Storage space allotments, page 87
h. Milk house information, page 88
i. Milking room information, page 89

2. Time data sheets

a. Time recording sheet, page 91
b. Individual cow time analysis, page 92
c. Coding and recording sheet, page 93
d. Evening and morning coded record, page 94
e. Evening and morning analysis, page 95
f. Twenty-four hour job record (other than milking), page 96
g. Space and area analysis, page 97
h. Job analysis (hay), page 98
i. Job analysis (silage), page 99
j. Job analysis (bedding), page 100

III. Notify Farmers of the Visit Date.

IV. Field Work

A. Make time record of all dairy chores over a twenty-four hour period

B. Complete survey forms

C. Take photographs when possible (Appendix VI for examples)

D. Record temperature

1. Interior of barn temperature
2. Open lot temperature
3. Manure pack temperature

V. Office Work

A. Time study analysis

1. Milking operation

a. Cows milked per man-hour
b. Machine efficiency in percent equals

$$\frac{\text{actual total machine time}}{\text{total possible machine time}} \times 100$$

Actual total machine time equals a total of all of the machine minutes for each cow

Total possible machine time equals actual clock time the machine was taken off the last cow minus the actual clock time the machine went on the first cow multiplied by the number of milking machine units

c. The total time spent on various job elements for evening and morning milking

2. Other dairy chores

a. Estimate the manure hauling time
b. Determine the percent of time the various job elements of the chores are of the total dairy chore work

B. Sketches prepared for each farm (Appendix VII for examples)

1. The milk area*, pages 109 and 110
2. The barn area, page 111

C. Motion study analysis

1. Milking -- the distance traveled per milking determined by retracing the path of the farmer on a scale drawing of the area

2. Other dairy chores -- the distance traveled per job determined the same as for milking

D. Master data sheets prepared combining data from all farms

Results

Hay Feeding.

In seventeen loose housing barns with an average of twenty cows per farm, feeding hay required an average of .77 minute per cow per day (Table XX, Appendix page 113). The range in time per cow was .1 to 1.9 minutes. The difference was due to the feeding interval and type of feeders. The daily per cow average on farms where hay was fed twice per day was .94 minute with 45 percent of the time spent after the hay left the mow (Table III). The total hay feeding time was reduced to .50

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*Defined in glossary, Appendix I.

TABLE III

ANALYSIS OF HAY FEEDING TIME REQUIREMENTS

(Average daily winter chore time required for feeding hay to dairy cows on seventeen farms using loose housing [Table XX, Appendix page113])

Job element	Minutes Required								
	Hay fed 2/day			Hay fed 1/day			Hay fed in self feeders		
	per cow	20 cow herd	%	per cow	20 cow herd	%	per cow	20 cow herd	%
Out of mow	.36	7.2	38	.29	5.8	58	.22	4.4	82
Total time after hay left mow	.42	8.4	45	.11	2.2	22	.03	.6	11
Miscellaneous	.16	3.2	17	.10	2.0	20	.02	.4	7
Total	.94	18.8	100	.50	10.0	100	.27	5.4	100

minute per cow on farms where hay was fed once per day and averaged .27 on farms where self feeders were filled from overhead mows. When self feeders were used 82 percent of the hay feeding time was spent getting hay out of the mow.

The method and type of feeders alone on the basis of a twenty-cow herd caused a variation of 82 man hours per year, more than enough time to care for an extra cow. The number of times the hay is handled is also important. Hay was handled once in self feeders, but twice when fed in ordinary mangers; once in the mow and once in the manger. Often it was found that hay was handled three or four times. The type of hay fed affected the total time; farmers using baled hay required more time than farmers feeding chopped hay.

1. As the frequency of feeding hay increased, the time spent per cow per day increased, feeding three times per day required nine times longer than feeding twice per week.
2. Rehandling hay in the mow increased the time required to get hay out. Hay handled once required one third as much time as hay handled twice.
3. Time spent getting baled hay out of the mow was less than chopped or loose hay, but the total feeding time was greater because of the additional time needed to open and shake out the bales.
4. Feeding hay in self feeders saved 13 minutes per day for a twenty cow herd.

5. Long-cut chopped hay or loose hay was preferred to baled hay when fed in self-feeders.

Silage Feeding.

On fourteen farms where silage was fed there was an average of eighteen dairy cows per farm. The total silage feeding time ranged from .17 to 2.97 and averaged 1.34 minutes per cow (Table XXI, Appendix page 114). On farms where silage was fed once per day, the average per cow time was .84 minute (Table IV); and 1.47 on farms where silage was fed twice per day, an annual difference of 44 man hours for a twenty cow herd. The greatest difference in time spent occurred after the silage was thrown out of the silo and the cause for this difference was mainly (1) silo to manger distance, (2) method of handling, and (3) feeding interval.

1. An overhead silage carrier, loaded directly from the silo, saved 25 percent of the silage feeding time.
2. Silo to manger distance affected the silage feeding time. Farmers with silos within 15 feet required approximately one half as much time as those with silos greater than 15 feet.
3. Feeding interval affected silage feeding time. Farmers feeding twice per day required 75 percent more time than those with a once per day feeding interval.

TABLE IV

ANALYSIS OF SILAGE FEEDING TIME REQUIREMENTS

(Average daily winter chore time required for feeding silage to dairy cows on fourteen farms using loose housing [Table XXI, Appendix page 114])

Job elements	Minutes required					
	Silage fed 2/day			Silage fed 1/day		
	per cow	20 cow herd	%	per cow	20 cow herd	%
Up and down silo[1]	.05	1.0	3	.04	.8	5
Throw down silage	.34	6.8	23	.28	5.6	33
Load silage - travel to manger - dump	.89	17.8	61	.45	9.0	54
Miscellaneous	.19	3.8	13	.07	1.4	8
Total	1.47	29.4	100	.84	16.8	100

[1]All farms analyzed had vertical silos.

Bedding Cows.

On sixteen farms where the bedding operation was analyzed, bedding time ranged from .2 to 1.4 minutes per cow (Table XXII, Appendix page 115) and averaged .85 minute (Table V). The arrangement of the barn caused most of the variation and determined the number of times the bedding was handled. Farmers handling bedding the least number of times had straw chutes centrally located over the resting area.

1. The arrangement of the barn affected the amount of bedding used.
2. Farmers handling bedding three times after it left the mow required 50 percent more time than farmers handling bedding once.
3. Farmers preferred chopped or loose straw to baled.
4. For an efficient operation two or more chutes should lead directly from an overhead storage to the resting area.
5. Bedding should not be moved horizontally over thirty feet in the resting area.

An analysis of efficient work methods and arrangements for feeding hay and silage and bedding dairy cows showed that, if the total time for the three items was taken as 100 percent, bedding required 43.4 percent and once per day silage feeding 42.8 percent. Hay fed in self feeders required only 13.8 percent (Table VI). Approximately 40 percent of the total time was spent throwing silage out of the silo and hay and bedding

TABLE V

ANALYSIS OF BEDDING TIME REQUIREMENTS

(Average daily winter chore time required for bedding dairy cows on sixteen farms using loose housing [Table XXII, Appendix Page 115])

Job elements	Minutes required		
	Per cow	20 cow herd	Percent
Bedding out of mow	.23	4.6	27
Spread bedding	.40	8.0	47
Total time after bedding left mow	.45	9.0	53
Miscellaneous	.17	3.4	20
Total	.85	17.0	100

TABLE VI

RELATIVE IMPORTANCE OF FEEDING AND BEDDING TIME REQUIREMENTS

(Relative importance of the average daily winter time requirements for self feeding hay, feeding silage once per day and bedding dairy cows in loose housing barns [Tables XX, XXI, XXII, Appendix pages 113 to 115])

Job and elements	Time required		
	Minutes		
	per cow	20 cow herd	Percent
Feeding silage (1/day)			
Up and down silo	.04	.8	2.0
Throw down silage	.28	5.6	14.3
Load - travel - dump	.45	9.0	23.0
Miscellaneous	.07	1.4	3.5
Total	.84	16.8	42.8
Bedding			
Bedding out of mow	.23	4.6	11.7
Spread bedding	.40	8.0	20.4
Total time after bedding left mow	.45	9.0	23.0
Miscellaneous	.17	3.4	8.7
Total	.85	17.0	43.4
Feeding hay (with self feeders)			
Hay out of mow	.22	4.4	11.3
Total time after hay left mow	.03	.6	1.5
Miscellaneous	.02	.4	1.0
Total	.27	5.4	13.8
Total (hay, silage & bedding)	1.96	39.2	100.0

out of a mow, and 50 percent was spent distributing the material to its proper place. Material handling methods and arrangement play a very important role regarding the efficiency with which hay, silage and bedding are handled. The range in time spent for the three jobs was 225 man hours per year based on a twenty cow herd. A difference in time large enough to pay for the average annual dairy building costs based on depreciation, interest, repairs, taxes and insurance or the man hours difference could care for 3.5 more cows and increase the gross income by $1180.

Milking and Care of Milk Equipment.

The milking room operating efficiency was studied on twenty-one farms with a herd average of fourteen cows (Table XXIII, Appendix page 116). The average number of cows milked per man hour was 15.3 and varied from a low of 7.8 to 23.8 (Table VII).

The variation in milking time alone amounts to 63 man hours per year per cow or 158 eight-hour days per year on the basis of a twenty cow herd. The operator's technique (work method), the rate of milk removal from individual cows and the arrangement and equipment in the work place are the main causes for the variation.

The operator's work method and arrangement is largely responsible for the machine efficiency.

The average farmer, while milking, kept the milking units operating approximately 75 percent of the time; however, the

TABLE VII

ANALYSIS OF MILKING ROOM OPERATING EFFICIENCY

(The range and average in milking room operating efficiency on twenty-one farms with loose housing barns [Table XXIII, Appendix page116])

Item	Average	Range	
		Low	High
Cows milked per hour	19.2	10.7	28.0
Cows milked per man hour	15.3	7.8	23.8
Cows milked per unit hour	9.1	5.4	14.0
Range in individual cow machine time			
Low time (minutes)	3.0	1.1	5.8
High time (minutes)	7.9	5.3	10.7
Range in average machine time per cow			
On cow (minutes)	5.1	3.5	8.0
Idle time (minutes)	1.6	.3	5.2
Machine efficiency (percent)*	78.6	45.0	93.2
Number of cows per herd	14.0	6.0	42.0

*Defined in glossary, Appendix I.

range between operators was 45 percent to 93 percent (Table VII). This means that the interval between the time the unit is removed from one cow and placed on the next is very short (approximately 18 seconds).

The rate of milk removal also affects the time required. The average machine time for 591 cows was 5.1 minutes and ranged from an average of 3.5 in one herd to 8.0 in another. The lowest machine time per individual cow was 1.1 minutes and the highest was 10.7 minutes.

The number of milking units per operator affected the cows milked per unit hour and machine efficiency. Individuals operating more than two units had a below-average machine efficiency and cows milked per unit hour. The relationship of the number of operators to units and stalls is important. Farms No. 6 and No. 14 (Table XXIII) show that one man using more than two units is below average in machine efficiency and cows milked per unit hour. Farms No. 5 and No. 11 illustrate that, with identical arrangement and equipment, two men milk at the rate of 8.9 cows per man hour and 82 percent machine efficiency; whereas one man in the same work place averages 16.5 and 87 percent machine efficiency.

An analysis of the complete milking operation (Table VIII) revealed that, with average methods, 75 percent is spent at the time milk is removed from the cow, 15 percent for the care of the milk and milking equipment and 5 percent each for cleaning the milking room and getting cows into the holding

TABLE VIII

ANALYSIS OF THE COMPLETE MILKING OPERATION

(Average daily winter chore time required for the complete milking operation on twenty-one farms with loose housing barns)

Job	Minutes required					
	Average methods[1]			Average of the more efficient one-third[2]		
	per cow	20 cow herd	Percent	per cow	20 cow herd	Percent
Milking	8.2	164	75	6.0	120	81
Care of milk and milking equipment	1.7	34	15	1.0	20	13
Cleaning milking room	.6	12	5	.2	4	3
Getting cows into holding pen	.5	10	5	.2	4	3
Total	11.0	220	100	7.4	148	100

[1]Time required for the "average farm" was determined by computing the average of all methods observed for the job.

[2]Time required for the"more efficient" was determined by computing the average of the time consumed by one-third of the farms with a low time required for the job.

pen. On one third of the more efficient farms milking required 81 percent, care of milk and equipment 13 percent and 3 percent each for cleaning the milking room and getting cows into the holding pen. The variation between the two methods represents a difference of 72 minutes per day with a twenty cow herd (Table VIII).

Table IX shows the relative importance of the daily time requirements for various job elements of the winter dairy chore time. An analysis of this time reveals that the complete operation of milking consumes 80 percent of the total time -- a startling figure when one's mind toys with the importance of the figure. Minutes saved, hours saved or even the omission of the feeding and bedding time would not greatly alter the daily winter chore time required for caring for the dairy cow. For example, the time per cow spent caring only for the milk and milking equipment was greater than the combined time for bedding cows and feeding silage and approximately twice as much time was required for getting the cows into the holding pen as was spent feeding hay.

Bookhout [1] determined the relative importance and time requirements for the daily winter dairy chores on ten farms with stall barns. The results appear in Table X. A comparison of Tables IX and X shows that the time for the bedding, silage feeding and miscellaneous jobs are approximately the same. The difference in total time requirements occurs because (1) loose housing allows the operator to concentrate certain jobs

TABLE IX

RELATIVE IMPORTANCE OF DAILY TIME REQUIREMENTS

(Relative importance of the job elements of average daily winter chore time requirements for dairy cows in loose housing barns [Tables XX, XXI, XXII, XXIII, Appendix page 113 to 116])

Job and elements	Minutes required		Percent
	per cow	20 cow herd	
Milking and care of milk & equipment			
Milking	8.2	164	59
Care of milk & equipment	1.7	34	12
Cleaning milking room	.6	12	5
Getting cows into holding pen	.5	10	4
Total	11.0	220	80
Bedding cows			
Bedding out of mow	.2	5	2
Total time after bedding left mow	.4	9	3
Miscellaneous	.2	3	1
Total	.8	17	6
Feeding silage (1/day)			
Up & down silo	less than .05		
Throw down silage	.3	6	2
Load - travel - dump	.4	9	3
Miscellaneous	.1	2	1
Total	.8	17	6
Feeding hay (fed in self feeders)			
Hay out of mow	.2	4	2
Total time after hay left mow	less than .05	less than .5	
Miscellaneous	less than .05	less than .5	
Total	.3	5	2
Miscellaneous time	1.0	20	6
TOTAL	13.9	279	100

TABLE X

RELATIVE IMPORTANCE OF TIME REQUIREMENTS IN STALL BARNS

(Relative importance and the average time required for daily winter dairy chores on ten farms with stall barns [1])

Job	Minutes per cow	Percent
Milking and care of milk & equipment		
Milking	10.2	47
Care of milk & equipment	3.3	15
Total	13.5	62
Feeding cows		
Hay	1.0	5
Silage	1.0	5
Grain	.8	3
Cleaning mangers	.5	2
Total	3.3	15
Cleaning stables and bedding		
Bedding cows	1.1	5
Cleaning stables	1.4	6
Total	2.5	11
Getting cows in & out of barn	1.2	6
Miscellaneous	1.2	6
TOTAL	21.7	100

so that more work can be done with one trip, (2) the job comes to the man rather than the man going to the job, and (3) certain jobs can be combined which must be done separately in stall barns.

Caring for Dairy Young Stock and Calves.

On eighteen farms, where an analysis was made of the time spent caring for young stock and calves, there was an average of seventeen adult animals and seventeen young stock. The time requirements varied considerably from farm to farm. The average daily time based on the number of young stock was 1.48 minutes per head and ranged from .10 to 4.11 minutes (Table XXIV, Appendix page 117). The total time averaged 25.2 minutes and ranged from 1.2 to 89.6 minutes. The variation was due to the method of handling and not to the number of head. Three farmers spent more time per head caring for young stock than was spent per cow for feeding and bedding.

Value of Operating Efficiency.

Table XI shows that man hours per cow per year vary with the efficiency of the work method and barn arrangement. The average of all farms analyzed required 133 man hours per year as compared to 65 on one third of the more efficient farms. The value of the hours saved by the more efficient farmers is three times greater than the annual building and equipment costs.

TABLE XI

ANNUAL PER COW TIME REQUIREMENTS

(Daily and annual per cow dairy chore time requirements for loose housing barns with different operating efficiencies [Tables XX, XXI, XXII, XXIII and XXIV, Appendix pages 113 to 117])

Job	Time required								
	Average of all farms[1]			Average of more efficient one third[2]			Best practical job time[3]		
	Minutes per day	Hours per year	%	Minutes per day	Hours per year	%	Minutes per day	Hours per year	%
Complete milk handling operation	11.0	101.0	66	7.4	45.0	72	6.2	37.7	71
Bedding[4]	.8	3.3	5	.4	1.7	4	.3	1.2	3
Feeding silage[5]	1.3	4.6	8	.8	2.8	8	.7	2.4	8
Feeding hay[4]	.8	3.3	5	.2	.8	2	.2	.8	2
Care of young stock[4]	1.5	6.2	9	.6	2.5	6	.6	2.5	7
Cleaning barn & hauling manure[6]		4.0			4.0			4.0	
Cleaning open lots[7]		1.0			1.0			1.0	
Getting cows from pastures		2.0			2.0			2.0	
Miscellaneous	1.2	7.3	7	.8	4.9	8	.8	4.9	9
TOTAL	16.6	132.7	100	10.2	64.7	100	8.8	56.5	100

[1]Time required for the "average of all farms" was determined by computing the average of all work methods and arrangements observed for the job.

[2]Time required for the "average of more efficient one third" was determined by computing the average of the time consumed by one third of the farms with a low time requirement for the job.

[3]The "best practical job time" was found on farms where:
a. Cows were milked at the rate of 25 per man hour.
b. Cows were bedded from an overhead storage that had more than two chutes leading directly into resting area.
c. Silage was fed by filling a large carrier directly from the silo chute or where farms had a double silage bunk within five feet of the silo.
d. Hay was fed in a self feeder filled with loose hay from an overhead mow.

[4]Hours per year based on daily time requirements for 210 days and one quarter time for 155 days.

[5]Hours per year based on 210 days.

[6]Hours per year estimated from conversation with farmers cleaning loose housing barns with manure loaders.

[7]Hours per year estimated by author.

The design and layout of the building, the work methods and the equipment substantially influence the efficiency with which labor can be utilized. Labor utilized in the average buildings amounts to more than one third of the dairy production costs; whereas building and equipment charges are only 5 percent.

The return per hour for labor and management based on average barn operating efficiency is $.91, in one third of the more efficient barns, $1.86, and with the best practical job time, $2.16 (Table XII).

Therefore, it is possible through improved arrangement and management practices to increase the income for labor and management.

TABLE XII

LABOR RETURN BASED ON OPERATING EFFICIENCY

Item	Man hours per cow per year[1] 133 Dollars	%	65 Dollars	%	56 Dollars	%
Costs per cow per year[2]						
Feed	162.17	46	162.17	55	162.17	57
Labor[3]	119.70	34	58.50	20	50.40	18
Building & equipment use	16.68	5	16.68	6	16.68	6
Overhead	16.16	4	16.16	6	16.16	6
Bedding	6.71	2	6.71	2	6.71	2
Miscellaneous	32.64	9	32.64	11	32.64	11
Total costs	354.06	100	292.86	100	284.76	100
Income per cow per year[2]						
Milk sold & used	337.29	95	337.29	95	337.29	95
Calves at 5 days	9.28	3	9.28	3	9.28	3
Manure	9.00	2	9.00	2	9.00	2
Total income	355.57	100	355.57	100	355.57	100
Return for labor & management	121.21		121.21		121.21	
Return per hour for labor and management[5]	.91		1.86		2.16	

[1]Based on Table XI.

[2]Wright, K. T. and Hodge, T. L. Dairying for Profit. Michigan Agrl. Exp. Sta. Bulletin 373. 1951

[3]Labor was computed at $.90 per hour

[4]Return for labor and management = Income - Costs + Labor cost.

[5]Return per hour = Return for labor and management/man hours per year per cow.

Further Research.

The major objective of this thesis was to analyze the relative importance of loose housing work methods and determine their effect upon labor income. However, with this objective accomplished, it was felt that milking had such a dominating time requirement that further work on this job was deemed necessary.

Two milking rooms ("A" and "B") were selected for further work; the milking rooms had an arrangement which according to the methods engineering analysis should provide a very efficient work place. The operator, in milking room "A", milked 16 cows with two milking units (short-tube type). The operator was conscious of good milking practices.

(1) The udders were washed with warm chlorine water

(2) The strip cup was used

(3) An average interval of 1.4 minutes was provided between washing and milking

(4) The machine time for the herd averaged 5.2 minutes.

Two experimental milking units replaced the former units in milking room "A". A comparison of the job element time requirements and operating efficiency for the two methods is shown in Table XIII. The experimental units replaced the surcingle* with a claw support arm* and omitted the following operations:

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*Defined in glossary, Appendix I.

(1) Putting the surcingle on each cow

(2) Dumping milk after each cow

(3) Straining milk in the open air

(4) Carrying milk to the milkroom

(5) Handling cans of milk (by hand) from the milking room to the milkroom.

The operating time was improved by only .26 minute per cow; however, the operation was performed with greater ease than with the conventional method. The operator was convinced that hand stripping (.56 minute per cow) was necessary. Avoidable delay during milking, due to a poorly designed claw support arm[1] was responsible for a loss of .22 minute per cow and also grain feeding time more than doubled. The author believes that, with additional work on the items causing a loss in time, further improvement could have been made.

Four time studies were made over a period of approximately one year in milking room "B". The operations, when the time studies were made were as follows:

First Study: Fifteen cows were milked, with two conventional bucket machines (long-tube type) by two men; one man full time, the other one half time. The operators brushed off the udders by hand, dumped the milk into ten-gallon cans in the operator area, hand stripped all the cows and carried the full ten-gallon cans to the milkroom.

---

[1]The teat cup assembly would fall off cows with small teats. The claw support arm was redesigned for use in milking room "B".

TABLE XIII

MILKING METHOD COMPARISONS, FARM "A"

(Comparison of job element time requirements and operating efficiency using a conventional and an experimental method in the same work place)

Time code	Job element	Minutes per cow	
		Conventional method[1]	Experimental method[2]
b	Feeding grain	.11	.25
w	Washing udders	.51	.53
Sc	Using strip cup	.11	.09
x	Putting on surcingle*	.27	---
E	Machine on and off	.48	.30
Ea	Adjusting claw assembly	---	.08
Ms	Machine strip	.28	.27
Hs	Hand strip	.62	.56
d	Dumping milk in milking room	.12	---
K	Carrying milk to milkroom	.02	---
gh	Handling cans of milk (by hand) from the milking room to the milkroom	.06	---
gm	Handling cans of milk (by carrier)	---	.02
ADwm	Avoidable delay - work methods	---	.06
ADm	Avoidable delay - mechanical	.01	.22
V	Miscellaneous	.05	---
	Total	2.64	2.38
	Machine efficiency, percent	86	94
	Cows milked per man hour	19.3	20.0

[1]Conventional method: Sixteen cows were milked by one man using two short-tube milking units. Good milking practices were used by the operator.

[2]Experimental method: Twenty cows were milked by one man using two experimental milking units. Milk was released directly into ten-gallon cans. Omitted were (1) putting on the surcingle, (2) dumping milk and straining in open air, (3) carrying milk to the milkroom, and (4) handling cans of milk by hand from the milking room to the milkroom.

*Defined in glossary, Appendix I.

Second Study. The operations and equipment for the second trial were the same except that only two cows were hand stripped. The men were trying to omit the operation.

Third Study. The men were convinced that one man could milk the herd alone and the third time study was made after the operation was considered normal for one man. The operation and equipment were the same as for the first and second studies except that the milk was dumped in the milkroom and not the milking room. A few cows still had to be hand stripped.

Fourth Study. The fourth and last time study was made after the experimental milking machine had been put into operation (Figures 10 and 11). Hand stripping was omitted and the udders were washed with a warm chlorine solution.

A comparison of the job element time requirements and operating efficiency for the four time studies is shown in Table XIV.

The first time study indicated that the operator in milking room "B" had above average time requirements as compared to the 21 farms analyzed. The results obtained from the improved method indicate that time and work can be reduced. Time was reduced by 1.42 minutes per cow and machine efficiency increased from 88 to 92 percent. Avoidable delay, again due to the experimental milking machine, caused a loss of .23 minute per cow.[1]

---

[1]The experimental unit replaces the conventional milker bucket with ten-gallon cans. Vacuum seal in the cans was frequently lost due to damaged rims on the shipping cans.

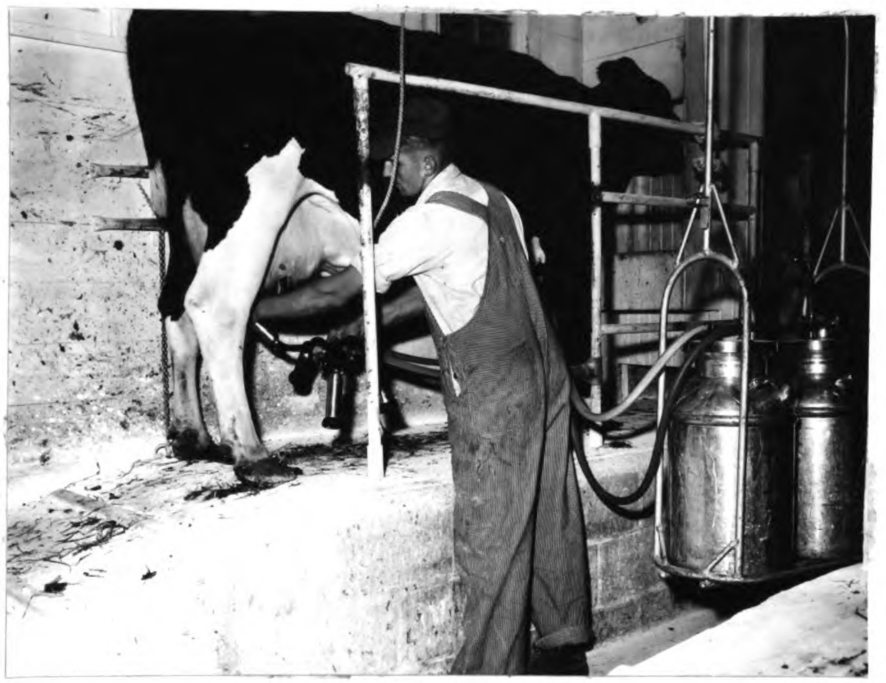


Figure 10 Dumping or straining in open air is not necessary with this experimental milker.

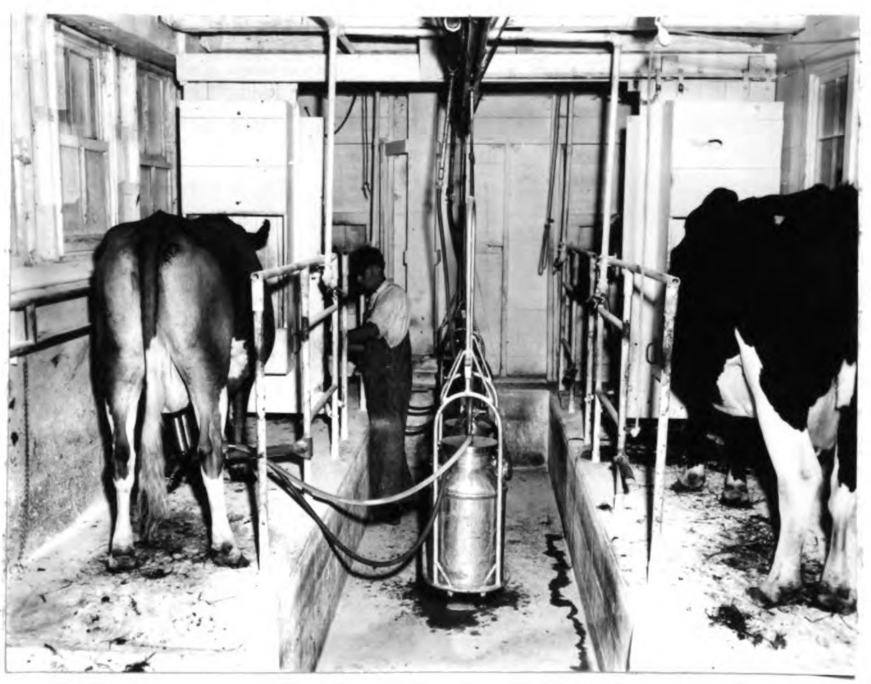


Figure 11 Two cows on each side of an operator area provide an arrangement designed for maximum efficiency with one man.

TABLE XIV

MILKING METHOD COMPARISONS, FARM "B"

(Comparison of job element time requirements and operating efficiency for a series of four time study trials in the same work place)

Time code	Job element	Time study trial			
		1[1]	2[2]	3[3]	4[4]
b	Feeding grain	.33	.33	.25	.28
w	Washing udders	.22	.15	.11	.30
E	Machine on and off	.46	.54	.46	.23
Ea	Adjusting claw assembly	---	---	---	.24
Ms	Machine strip	1.66	2.03	1.37	1.46
Hs	Hand strip	.58	.05	.13	---
d	Dumping milk in milking room	.25	.22	---	---
K	Carrying milk to milkroom	---	---	.48	---
gh	Handling cans of milk (by hand)	.04	.06	---	---
gm	Handling cans of milk (by carrier)	---	---	---	.01
ADwm	Avoidable delay - work method	.69	.76	.02	---
ADm	Avoidable delay - mechanical	---	---	---	.23
ADd	Avoidable delay - dumping milk	---	---	---	.06
	Total	4.23	4.14	2.82	2.81
	Machine efficiency, percent	88	92	94	92
	Cows milked per man hour	16.5	18.3	17.7	18.9

[1]Two conventional long-tube milking units were used to milk fifteen cows. Two men (one man full time, one man half time) did the milking. The men dumped the milk into ten-gallon cans in the operator area, hand stripped the cows and carried the full cans to the milkroom. The udders were brushed off before milking and not washed.

[2]This operation was the same as the first except that only two cows were hand stripped.

[3]One man operated the two units and milked twenty cows alone. The operation was the same as the first and second except that the milk was dumped in the milkroom and not the milking room.

[4]Two experimental milking units were used that eliminated dumping milk, carrying milk to milkroom and handling cans of milk by hand. The udders were washed with a warm chlorine solution and no cows were hand stripped.

The results obtained by the additional research conducted in milking rooms "A" and "B" made possible the development of a recommended milking procedure for double tandem milking rooms (Table XV). The recommended procedure allows sufficient time for all the necessary operations of good milking practices and enables the operator to milk at the rate of 28 cows per man hour and a machine operating efficiency of 93 per cent. Therefore it is possible to reduce the annual man hours per cow per year below 56.5 (Table XI). Because this annual figure was based on a milking rate of 25 cows per man hour an additional annual per cow time saving of three hours and ten minutes and a $2.27 per hour labor income would be possible if the recommended milking procedure were followed along with above average feeding and bedding work methods.

TABLE XV

RECOMMENDED MILKING PROCEDURE

(For one man using two experimental milking units in a four stall double tandem milking room [Figures 10 and 11])

Estimated time (minutes)	Job element	Clock time
.2	Basic grain ration to cows - 1 and 2A[1]	0.0
.4	Cows in - 1 and 2A	0.2
.5	Prepare, wash udder and use strip cup - 1A	0.6
.5	Prepare - 2A	1.1
.1	Machine on - 1A	1.6
.4	Grain - 1 and 2A	1.7
.1	Machine on - 2A	2.1
.2	Basic grain - 3 and 4A	2.2
.5	Delay (3 to .5)	2.4
.4	Cows in - 3 and 4A	2.9
.2	Check for milking rate - 1 and 2A	3.3
.4	Grain - 3 and 4A	3.5
.5	Prepare - 3A	3.9
.6	Machine strip and off - 1A	4.4
.1	Dip teat cups	5.0
.1	Machine on - 3A	5.1
.5	Prepare - 4A	5.2
.6	Machine strip and off - 2A	5.7
.1	Dip teat cups	6.3
.1	Machine on - 4A	6.4
.2	Cows out - 1 and 2A	6.5
.2	Basic grain - 1 and 2B	6.7
.4	Cows in - 1 and 2B	6.9
.2	Check - 3 and 4A	7.3
.2	Grain - 1 and 2B	7.5
.5	Prepare - 1B	7.9
.6	Machine strip and off - 3A	8.4
	Continue above till all cows are milked	9.0

[1]The cows on the right side of the operator area are numbered 1 and 2, the cows on the left side are numbered 3 and 4. The first cow to occupy a stall is lettered "A", the second cow in the same stall is lettered "B", etc.

CONCLUSIONS

1. The average and the range in time requirements in loose housing barns for feeding hay and silage and bedding were as follows:

   a. Feeding hay (time based on minutes per cow per day)

      (1) Average -- .77 minute
      (2) Range -- .1 to 1.9 minutes
      (3) Average when hay was fed twice per day -- .94 minute
      (4) Average when hay was fed once per day -- .50 minute
      (5) Average when hay was self-fed -- .27 minute

   b. Feeding silage (time based on minutes per cow per day)

      (1) Average -- 1.34 minutes
      (2) Range -- .17 to 2.97 minutes
      (3) Average when silage was fed twice per day -- 1.47 minutes
      (4) Average when silage was fed once per day -- .84 minute

   c. Bedding (time based on minutes per cow per day)

      (1) Average -- .85 minute
      (2) Range -- .2 to 1.4 minutes

2. The average time required for the complete job of milking on 21 farms with loose housing barns (based on minutes per cow per day) was as follows:

   a. Milking -- 8.2 minutes

   b. Care of milk and milking equipment -- 1.7 minutes

   c. Cleaning the milking room -- .6 minute

   d. Getting cows into the holding pen -- .5 minute

3. An anlysis was made of the young stock time requirements on 18 farms. The results (based on minutes per day) were as follows:
   a. Average per head -- 1.48 minutes
   b. Range per head -- .1 to 4.11 minutes
   c. Average (total time) -- 25.2 minutes
   d. Range (total time) -- 1.2 to 89.2 minutes
4. The relative importance of the dairy jobs, with respect to average time requirements, on farms analyzed was as follows:

a. Complete milking operation	80%
b. Bedding cows	6%
c. Feeding silage (once per day)	6%
d. Feeding hay (fed in self feeders)	2%
e. Miscellaneous	6%

5. The return per hour for labor and management, based on the average operating efficiency on the 21 farms analyzed, was $.91. On one third of the farms with more efficient work methods and arrangements, the labor return was $1.86 per hour. The best practical work method should enable the farmer to obtain a return of $2.16 per hour for labor and management.
6. Two farmers working at above average operating efficiency were selected for further research. Limited trials with an experimental milking machine and improved work methods in the two milking rooms made possible a reduction in time requirements even though better milking practices (which in themselves take more time) were used. Milking was

also performed with greater ease after the original methods had been replaced.

7. A recommended milking procedure was developed that will allow one operator to milk 28 cows per hour with a machine efficiency of 93 percent.

APPENDICES

APPENDIX I

Glossary of Terms

GLOSSARY OF TERMS

Barn: An enclosed covered building for the keeping and care of livestock or storage of dry roughages and bedding. It may include some but not necessarily all feed and bedding storages and feeding facilities for livestock.

Loose Housing: A management system for dairy cattle wherein the adult animals are given access to a feeding area, a resting area and adjoining open lot. At milking time the lactating herd is passed through a milking room. Other dairy animals are in separate pens, lots and/or buildings.

Stall barn: (It is sometimes referred to as stanchion barn.) It is a structure for sheltering dairy cattle and/or young stock where the adult animals are confined to stalls by means of stanchions, straps, halters or chains during most of the year and usually for milking. Roughages and concentrates may be fed in mangers at the individual stalls. None, part or all of feeds and bedding may be stored in the structure. Usually there are one or more rows of stalls and pens.

Holding Area: A section of a barn, shed or open lot where cows are confined while awaiting their turn to be milked.

Feeding area: An area of a barn, shed or open lot where cows are fed roughages, water and sometimes concentrates. It may or may not include feed storages.

Resting Area: (Sometimes referred to as a bedded, lounge or loafing area). A secluded area of loose housing where cows are bedded but not fed. The manure pack is allowed to accumulate during all or part of the year.

Milking Room: (Sometimes called a milking parlor). A room where cows are milked but not housed. It is an essential part of loose housing but optional with the stall barn. It may have any one of the following stall arrangements:

a. Elevation with relation to the floor level of the operator area.

    (1) Elevated
    (2) Floor level

b. The position of the stalls with relation to each other.

    (1) Tandem -- single or double in-line "U", "L", square, circular, etc.
    (2) Abreast

c. Method of stall entrance and exit.

    (1) Side entering
    (2) Walk through
    (3) Back cut

Operator Area: Is the area within the milking room used by personnel who performs the routine milking operation.

Cow Alley: The area within the milking room used by the cows for entering and leaving the milking room stalls.

Milk Area: Is that area which includes the milking room and and milkroom or milk house. Utilities and office may be included in this area.

Milkroom: A room with one or more sections for handling raw milk, wholly or partly enclosed by the structure which houses the milking room.

Milk House: Same as milkroom except that it is not a part of, but may or may not be connected with any other structure.

Releaser-type Milking Machine: A milking system whereby milk is removed from the cow and transported by sanitary milk lines to receiving containers located in the milk house or milkroom.

Surcingle: A harness, used on each cow during milking for the support of short-tube type milking machines.

Claw Support Arm: A movable arm used during milking and mounted on milking stalls for the support of the teat cup claw assembly of long tube type milking machines.

Production testing: The practice of weighing and recording milk weights after each lactation.

Machine Efficiency or Milking Machine Operating Efficiency: One of the measures for determining milking room operating efficiency.

$$\text{Machine efficiency percent} = \frac{\text{Actual total machine time}}{\text{Total possible machine time}} \times 100$$

Actual total machine time equals a total of all of the machine minutes for each cow.

Total possible machine time equals actual clock time the machine was taken off the last cow minus the actual clock time the machine went on the first cow multiplied

by the number of milking machine units.

Terms meaning loose housing that are being discontinued.

1. Open stable
2. Cold housing
3. Pen barn
4. Pen-type barn
5. Loafing barn
6. Tramp shed
7. Loose stabling
8. Lounging barn

Terms meaning "milking room" that are being discontinued.

1. Milking parlor
2. Milking barn

APPENDIX II

Justification Tables

Table XVI	Nutrients Contributed by Livestock Products
Table XVII	Value of Farm Dairy Industry
Table XVIII	Numerical Comparison of Farm Dairy Industry
Table XIX	Cow Removals

TABLE XVI

NUTRIENTS CONTRIBUTED BY LIVESTOCK PRODUCTS

(Comparison of total nutrients contributed by livestock products, excluding butter, to grain products, Agricultural Statistics 1951)

	Livestock Products (excluding butter) Percent	Grain Products Percent
Food energy	28.8	23.3
Protein	63.1	23.2
Fat	44.1	1.4
Carbohydrates	7.7	39.7
Calcium	80.7	3.8
Iron	37.6	27.3
Vitamin A	26.8	.3
Thiamine	36.4	34.1
Riboflavin	69.5	15.0
Niocin	48.0	27.4
Ascorbic acid	7.5	0.0
Average	40.9	17.8

TABLE XVII

VALUE OF THE FARM DAIRY INDUSTRY

(Comparison of the value of Michigan's farm dairy industry to other leading dairy states and the United States, Agricultural Statistics 1951)

Item	U.S. Million Dollars	Mich. Million Dollars	Wis. Million Dollars	N.Y. Million Dollars	Penn. Million Dollars	Cal. Million Dollars	Minn. Million Dollars	Ohio Million Dollars	Iowa Million Dollars	Texas Million Dollars	Ill. Million Dollars
Farm value of milk produced	4,625	201	484	379	283	266	230	209	160	200	174
Rank		7th	1st	2nd	3rd	4th	5th	6th	10th	8th	9th
Value of cows and heifers 2 years old and over	4,342	198	520	328	214	175	290	186	220	178	189
Rank		6th	1st	2nd	5th	10th	3rd	8th	4th	9th	7th
Value of all cattle and calves (including cows and heifers)	9,848	276	647	387	285	377	459	284	635	892	433
Rank		14th	2nd	8th	12th	9th	5th	13th	3rd	1st	6th
Value of combined sales of milk, cream, and butter fat	3,763	177	460	248	346	238	207	186	139	121	151
Rank		7th	1st	3rd	2nd	4th	5th	6th	9th	11th	8th
Value of whole milk delivered to plants (wholesale)	2,882	151	442	324	208	208	115	162	32	82	121
Rank		6th	1st	2nd	4th	3rd	8th	5th	--	11th	7th
Value of farm butter sales	22	0.4	0.1	0.9	2.0	0.1	[1]	0.6	0.1	3	0.2
Rank		15th	---	9th	4th	---	---	11th	---	1st	21th
Value of cream sold as butterfat	480	23	12	1	3	2	86	10	101	11	17
Rank		6th	11th	--	--	--	2nd	14th	1st	13th	9th
Value of milk and cream retailed by farmers	381	3	5	20	35	28	6	13	6	25	12
Rank		39th	30th	4th	1st	2nd	24th	5th	22nd	3rd	6th

[1] Less than $50,000.

TABLE XVIII

NUMERICAL COMPARISON OF FARM DAIRY INDUSTRY

(Comparison of Michigan's farm dairy industry to other leading dairy states and the United States, DHIA Letters 28:2 1952 and Agricultural Statistics 1951)

Item	U. S.	Mich.	Wis.	N. Y.	Penn.	Cal.	Minn.	Ohio	Iowa	Texas	Ill.
Number of milk cows on farms (thousand)	22,779	968	2306	1366	964	813	1371	1013	1088	1171	925
Rank		7th	1st	3rd	8th	11th	2nd	6th	5th	4th	10th
Number of DHIA cows on farm (thousand	1,185,880	54,915	85,006	128,341	99,254	194,286	52,698	31,525	41,100	14,044	43,466
Rank		5th	4th	2nd	3rd	1st	6th	12th	8th	---	7th
Percent of total dairy cows in DHIA program	5.2%	5.4%	3.5%	8.7%	9.8%	22.0%	3.6%	3.0%	3.5%	1.1%	4.5%
Rank		18th	29th	15th	10th	2nd	27th	31th	28th	----	21th
Relative position of number of DHIA herds		4	3	1	2	7	5	9	6	----	8
Number of cows and heifers 2 years and over (thousand)	24,573	1,016	2432	1483	1020	903	1486	1060	1182	1283	992
Rank		8th	1st	3rd	7th	11th	2nd	6th	5th	4th	9th
Number of heifers 1 - 2 years old kept for milk (thousand)	5,582	260	529	305	252	217	374	264	273	274	252
Rank		7th	1st	3rd	8th	9th	2nd	6th	5th	4th	8th
Number of heifer calves kept for milk (thousand)	6,847	288	545	322	276	283	397	279	317	394	322
Rank		6th	1st	4th	9th	7th	2nd	8th	5th	3rd	4th
Number of milking machine installations (thousand)	365	27	66	41	20	11	38	21	21		19
Rank		4	1	2	7	10	3	6	5	----	8
Average pounds of milk produced per cow	5,292	5970	6770	6590	6160	7410	6020	5480	5460	3390	5600
Rank		15th	4th	6th	11th	1st	13th	23rd	22nd	----	20th
Average pounds of butter fat produced per cow	209.8	233	250	244	237	289	217	222	207	151	216
Rank		15th	7th	9th	13th	1st	21st	17th	25th	---	22nd

TABLE XIX

COW REMOVALS

(Reasons for and number of cow removals from DHIA herds in Michigan from December 1, 1950 to November 30, 1951, Dairy Herd Improvement Association Letters 27:1 1951)

Reason	Number	Percent
Low Production	5,466	48.6
Sterility	1,198	10.7
Udder Trouble	1,090	9.7
Died	463	4.1
Old Age	270	2.4
Bangs	245	2.2
Accident	60	.5
Bloat	38	.4
Dairy Purposes	1,758	15.6
Other Purposes	655	5.8
Total Removals	11,243[1]	100.0

[1]Total DHIA cows reported in Michigan (1951) 54, 915.

APPENDIX III

Preliminary Forms and Time Study Trial

PEN BARN QUESTIONNAIRE

NAME	ADDRESS	MILES
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____
		___N ___E ___S ___W of_____

Approximate number of pen barns in County_____

County Agent_____

County_____

PRELIMINARY PEN BARN FORM

Name Carl Buboltz Address Ossineke, Michigan

Location: Two miles north of Hubbard Lake.

MILKING PARLOR QUESTIONS: (Please CROSS-OUT words that are NOT correct)

Building parlor now

1. When was parlor built 1948 ? 2. Number of Milking stalls 4

Montana type

3. Number of men milking 1 4. Is operator: Owner ~~Manager~~ ~~Head man~~

5. Kind of milker used De Laval 6. Number of units 2

7. The level at which the operator works is ~~Same as~~ lower than (20") the cows.

Milk house is off the center back

LOUNGE QUESTIONS:

Building remodeled

1. Was barn ~~built~~ remodeled for) a pen barn? 2. When 1948

3. Size of pen area 40 x 60 4. Ceiling height 7'
(Milking room 15' - 0" x 15' - 0")

with mangers

5. Number of cows in pen area 14 (2175 sq. ft.) 155/cow

Chopped and

6. Bedding used: ~~Baled~~ straw. // some wood shavings
~~Loose~~

7. Is bedding stored in the same barn Yes ?

8. Total length of feeders 60' 4.3/cow 9. Hay is fed: ~~Chopped~~ ~~Baled~~ Loose

Will chop next year

10. Is hay stored in same barn Yes ? 11. Is silage fed Yes ?

COMMENTS: This man has a "lift door" to his barn yard.

It is counter balanced and operates easily.

A very good idea.

C. Trial analysis on one farm.

1. A summary of the time data taken during the morning and evening milking was as follows:

Job	Time (min.)	Distance (ft.)
Getting cows into holding pen	3.5	282
Feeding grain in milking room	3.0	116
Getting cows in & out of milking room	14.0	72
Washing udders	1.6	144
Using strip cup	4.4	
Putting machines on cows	8.0	---
Machine stripping	13.6	---
Dipping teat cups	2.1	---
Carrying milk to milk house and return	1.9	340
Straining milk	1.1	---
Handling cans of milk	1.0	24
Caring for milking equipment	20.4	220
Cleaning parlor	3.1	210
Miscellaneous	5.2	300
Feeding calves	9.8	200
Total (11 cows)	91.7	1908
Average, per cow	8.3	173

2. Other pertinent information obtained from the work place and time data was as follows:

Number of milking stalls	4
Relationship of stalls to operator	elevated
Position of stalls	abreast
Type of stall	walk-thru
Number of operators	1
Number of milking units	2
Type of milking unit	pail
Number of cows milked	11
Cows milked per man hour	21.4
Average time machine is on cow	5.5
Average time cow has to eat grain	8.5
Average idle machine time	.5

APPENDIX IV

Survey Data Forms

AGRICULTURAL ECONOMICS DEPARTMENT
PROJECT FMA - MC - 3

FARM NO. Trial DATE Jan. 1948

NAME Arthur and Carl Ballenger

ADDRESS Breckenridge, Michigan

COUNTY Gratiot T.W.P. SECTION

LOCATION 2 Mi. West - 1 Mi. South of Breckenridge

			Tillable		
STOCK:	COW & HEIFER	228	XXXXXXX	98	HOGS 68
SOIL:	(Type & Topography)	Clay loam - level			
Hay:	Alfalfa (Jersey)	14			13
	Timothy	14			16
	Pasture	1			14
Corn:		35			19
Oats:		5	Barley		5
Wheat:			Rye		7
Total:		325			40.5
			Beets		4.5
			Beans		37
			Buckwheat		10
					166
					40
					5
					17
					228

Father - 60 years old

Son - 30 years old, married, 5' 7", 150 pounds, Short course at M.S.C.

None

X

Trial

1943

Old stable inconvenient - we built it to save steps.

Mr. Ruehs (Caledonia, Mich.) and other barns.

Yes

Put hay mangers on the side instead of the middle, milking platform 7'-6" instead of 7'-0", stall 28" or 30" instead of 20".

Saves labor, cleaning is easier, cows more comfortable, cows are cleaner, less injuries, cheaper to construct, flexible (can change to other livestock).

Cows have to be dehorned - boss cow bothers a little.

Cows don't need to be warm.

Yes Racks are filled once per day direct from the mow.

4955

300 5.5

Trial

West side of road

None

Drainage ditch on south side (county ditch)

a flat farmstead

in the barn
in the barn
160'
connected

Trial

Frame - low gambrel

1943 fair

Dirt in resting area

Wood 8'-6"

Fiber wallboard on parts

See plan.

18'

39'

Low gambrel

Steel

Window

Very little condensation

Natural

Drainage ditch on south side of barnyard - open lot on south side of barn - yard not paved.

Doors are closed during extreme cold weather

1. Glazed tile 10 feet

30 5 35

2. 10 x 35 concrete stave - no pit (located at another farm)

Trial

	3700	
	1380	18 - 19
	430	14
	140	

	196	
	103	
	2249	

Trial

36' x 64' average depth 13'

30,000

overhead

chopped

Overhead in a wing of the main barn

35' x 40' depth 13'

18,000

See above

Chopped

Would like to have a granary above the milking room.

Barn

800 crates plus some temporary

2 - 10 x 35

Trial

Concrete block

Concrete

10'-10" x 9'-6"

Floor drain under sink

2 (east & west wall) 4 light 10 x 12

windows tip in from top - screens on outside

None

None except ceiling is covered

Yes	Yes	10 gal. electric heater
4 can		Esco
Rite-way		2 bucket units

Sink (24 x 16), teat cup rack

By entrance door

One duplex outlet south wall

FARM Trial

NO

DATE

MAIN UNIT

TYPE OF CONSTRUCTION Frame

FLOOR MATERIAL Concrete

SIZE (Feet) 14'-6" x 13'-6" 1943

FEATURES sloped concrete floor

LOCATION OF WINDOWS Two windows north wall

6 lt. 8 x 10 49" above floor

DOORS None

VENTILATION Windows tip out at top

MILK HOUSE No

MANURE DISPOSAL Lime with broom and shovel

STANCHIONS 4 stall elevated abreast

30" 7'-0"

5'-6"

20" 24"

4'-0" 7'-0"

30" 5'-6"

Center back

Operator area

2 - 60" above operator area

Radio

APPENDIX V

Time Data Sheets

TIME AND MOTION STUDY

Sheet No.________ Date________________ Farm No. and Name________ ______________________

Time	Operation	Interval	Distance	Time	Operation	Interval	Distance

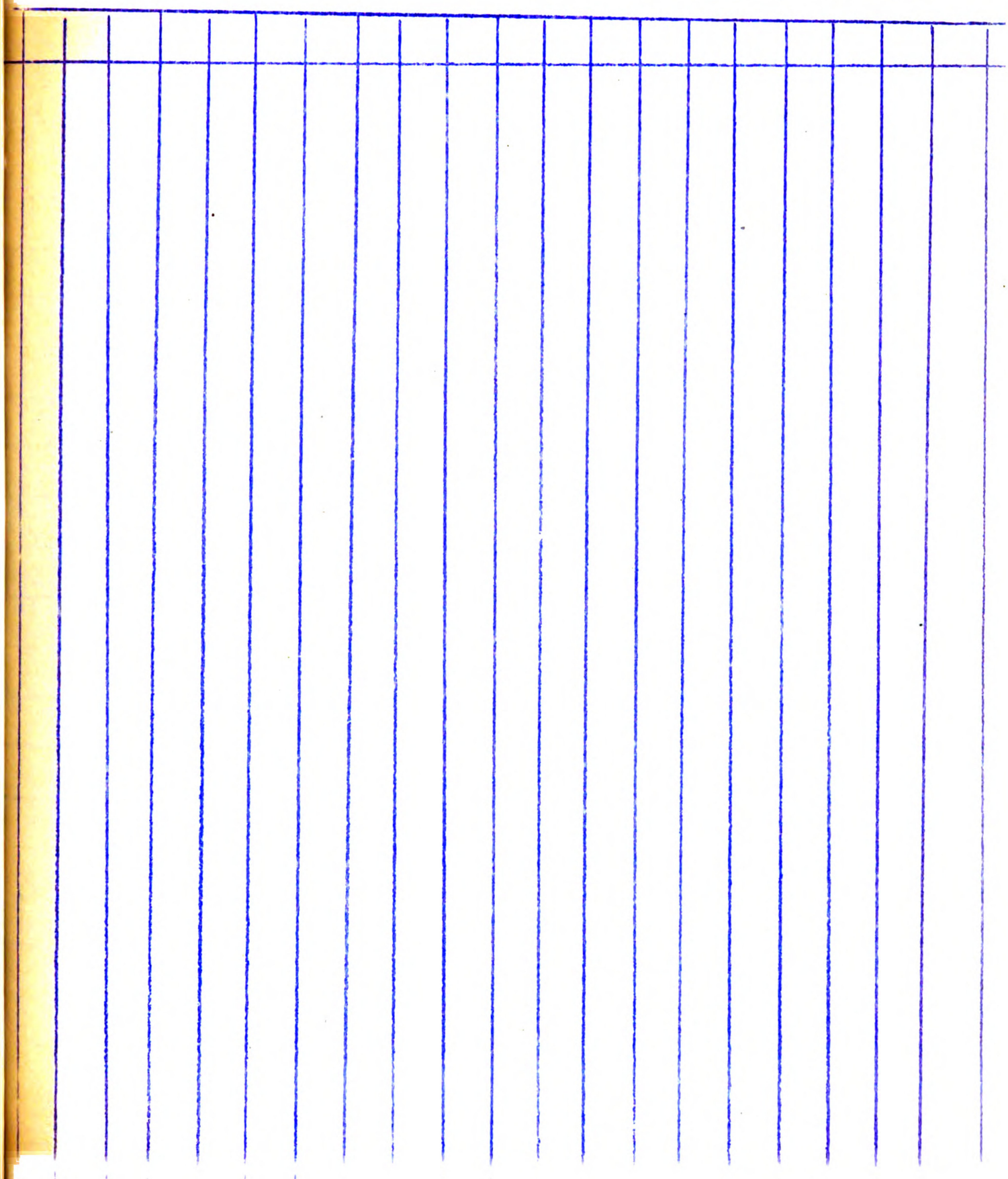
CYCLIC STUDY OF ANALYSIS — Item No 5 Name — Page

CON No	IN end	GRAIN total	STRIP CUP start	STRIP CUP end	STRIP CUP total	WASH start	WASH end	WASH total	INTENSION Rod	MAGNETIC STRIP start	MAGNETIC STRIP total	OFF (Pipette) end	OFF (Pipette) total	AS (Pipette) total	OUT end

TIME AND MOTION STUDY

FARM NO. _____ NAME _____ INTERVAL

DATE _____ TIME _____ MIN.



TIME AND MOTION STUDY

NAME _____

DATE _____

	OPERATION	TIME INTERVAL		DISTANCE TRAVELED	
		BEGINNING	ENDING	BEGINNING	ENDING

TOTALS

FIELD STUDY ASSISTS

PARK NO. _____ DATE _____

TYPE OF PATROL _____ NO. OF UNITS _____

24 Hour Time Record

HAY

Type of hay fed	
Stored where	
Kind of feeders (a)	
(b)	
Location of feeders	
Total length	
aver. length per cow	
Feeding Intervals	
Minutes spent feeding hay	
aver. time per cow	

SILAGE

Type of silage	
size of silo	
Location of silo	
Feeders used	
Location of feeders	
how is silage handled	
Feeding Intervals	
Minutes spent feeding silage	
aver. time per cow	

BEDDING

Type of bedding used	
stored where	
whose location	
Minutes spent handling bedding	
aver. time per cow	

CARE OF OTHER DAIRY LIVESTOCK

Total minutes spent	
aver. time per head	

SPACE AND AREA ANALYSIS

No. Men Working	
Age of Men	
Wt. of Bull	
No. Milking Cows	
pen area provided	
area sq. ft. per cow	
No. Dry Cows	
pen area provided	
average sq.ft. per cow	
Total cows	
total area provided	
average sq.ft. per cow	
Total young dairy animals	
pen area provided	
total area provided	
No. head dairy animals	
total area provided	
No. of Barns	
area of each	

Use of Each

Milking cows _____ Hay _____

Dry cows _____ Straw _____

Young calves _____ Grain _____

Age: to approx. 18 mos. _____ Cleaning area _____

Bred heifers _____ Corn _____

Bull _____ Milking parlor _____

Horses _____

Tools _____

HAY ANALYSIS

Farm No. _____ Date _____

Number of cows _____

Number of non-ward hay _____

Type hay fed _____

SILAGE ANALYSIS

Farm No._____ Date_____

Number of cows_____

Number of men working_____

Type silage fe_____

Silo size and number_____

Location of silo_____

Nearest distance to feeder_____

Greatest distance to feeder_____

Kind of boiler_____

Diameter of fe_____

Speed of conveyor_____

Length of blower pipe_____

Feeding time_____

Time for filling_____

Time for feeding_____

Time for unloading_____

Time for cleaning_____

Time for repairs_____

Time for oiling_____

Time for miscellaneous_____

BEDDING ANALYSIS

Farm No. _____ Date _____

Number of cows _____

Number of men working _____

Type bedding used _____

APPENDIX VI

EXAMPLE OF PHOTOGRAPHIC RECORD OF FARMS ANALYZED

Figure 12 An interior view of the milking room on the farm selected for a trial detailed time analysis. The arrangement is classed as an elevated abreast walk-thru type.

Figure 13 Shows a cow entering the milking room from the holding pen area.

Figure 14 A ramp aids the cows when entering the elevated milking stall. Cows are handled in pairs with this milking room arrangement.

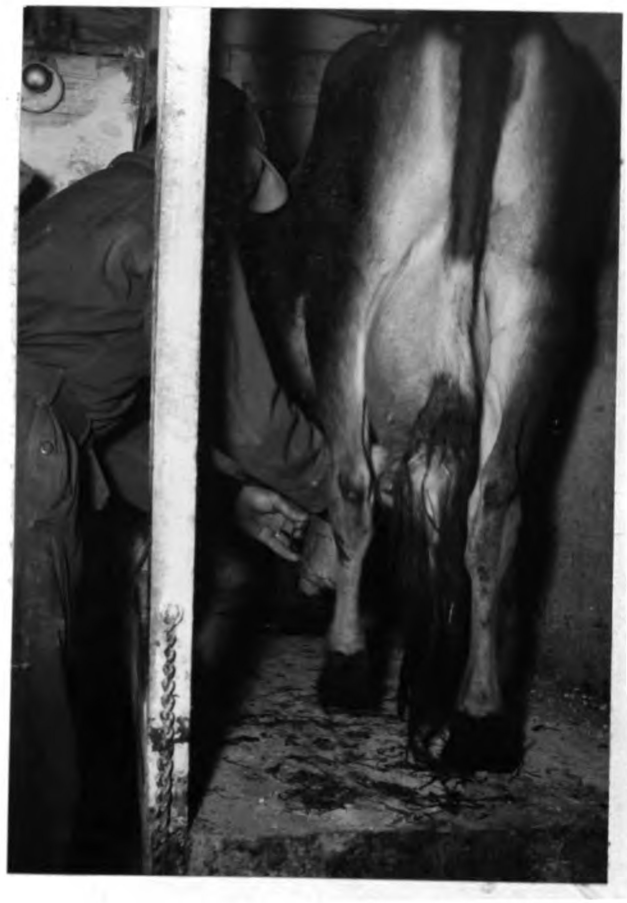


Figure 15 The udder of each cow is washed and the strip cup used previous to milking.

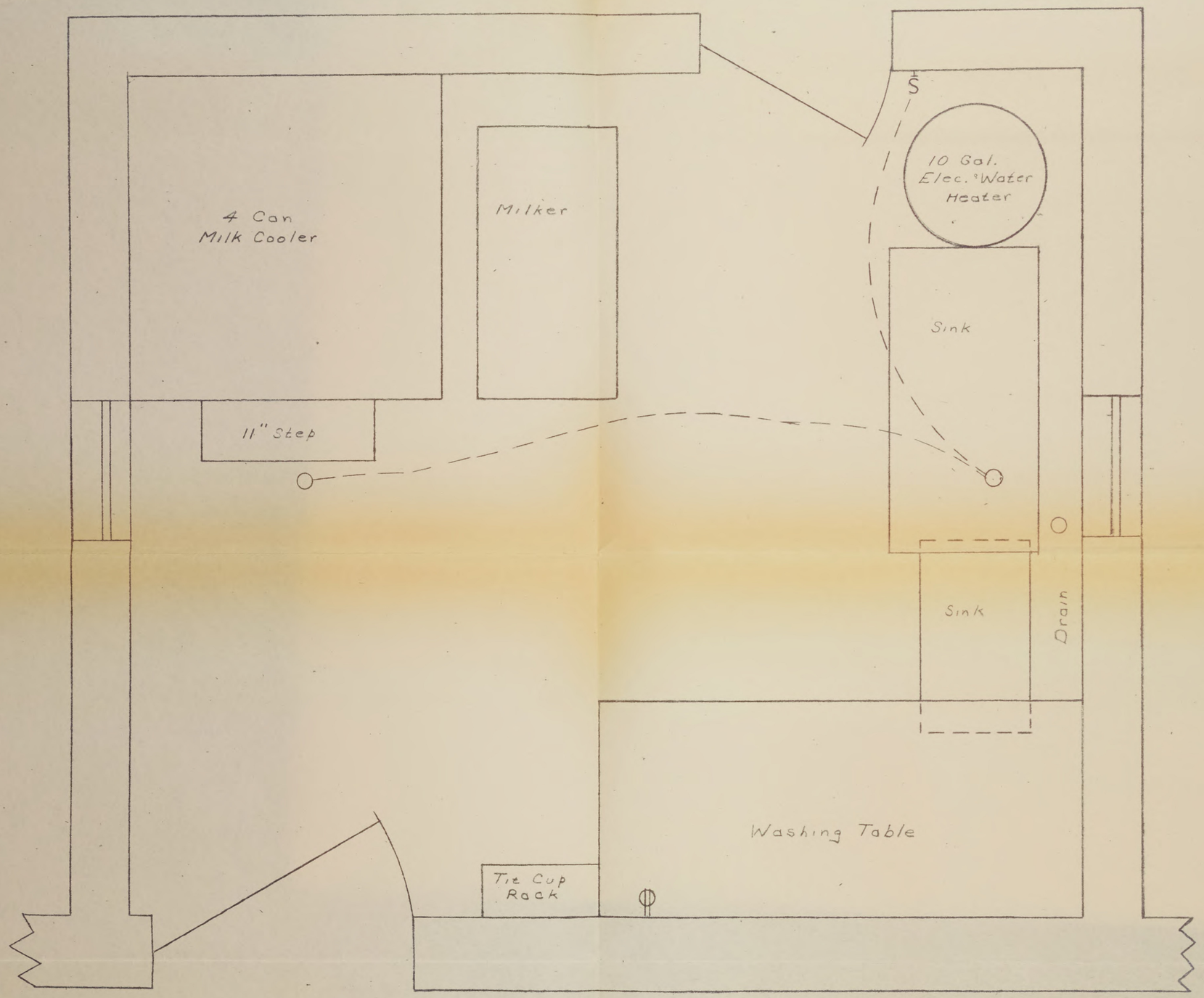
Figure 16 The operator puts a milking unit on a cow that has been previously prepared. One operator handles two long tube milking machines in this four stall elevated milking room.

Figure 17 Each cow is machine stripped to stimulate the let-down of the last portion of milk.

Figure 18 Cows leave the milking stalls through doors located in the front of each stall. The doors are roped controlled (opened and closed) from the operator area.

APPENDIX VII

Examples of Sketches
Prepared for Motion
Analysis on Farms Analyzed



MICHIGAN STATE COLLEGE
AGRICULTURAL ENGINEERING DEPT.
EAST LANSING, MICH.

MILK HOUSE
BALLINGER FARM

PLANNED	APP. BY		
DRAWN GTC	DATE Jan 8 48	SHEET	2
TRACED	SCALE 1"= 1'	NO.	1
CHECKED			

Shelf

Radio

To Milk House

To Holding Room

3'-6" Sliding Door →

To Calf Pens

← 3'-6" Sliding Door

Ramp

Ramp to Stall

Ramp

Milking Stall Elevated 20"

Milking Pit

Milking Stall Elevated 20"

Milking Stall Elevated 20"

Milking Pit

Milking Stall Elevated 20"

Air Cock

Pipe Line To Milking Machine At Ceiling Height

Feed Storage

Feed Storage

Grain Box

Grain Box

Grain Box

Grain Box

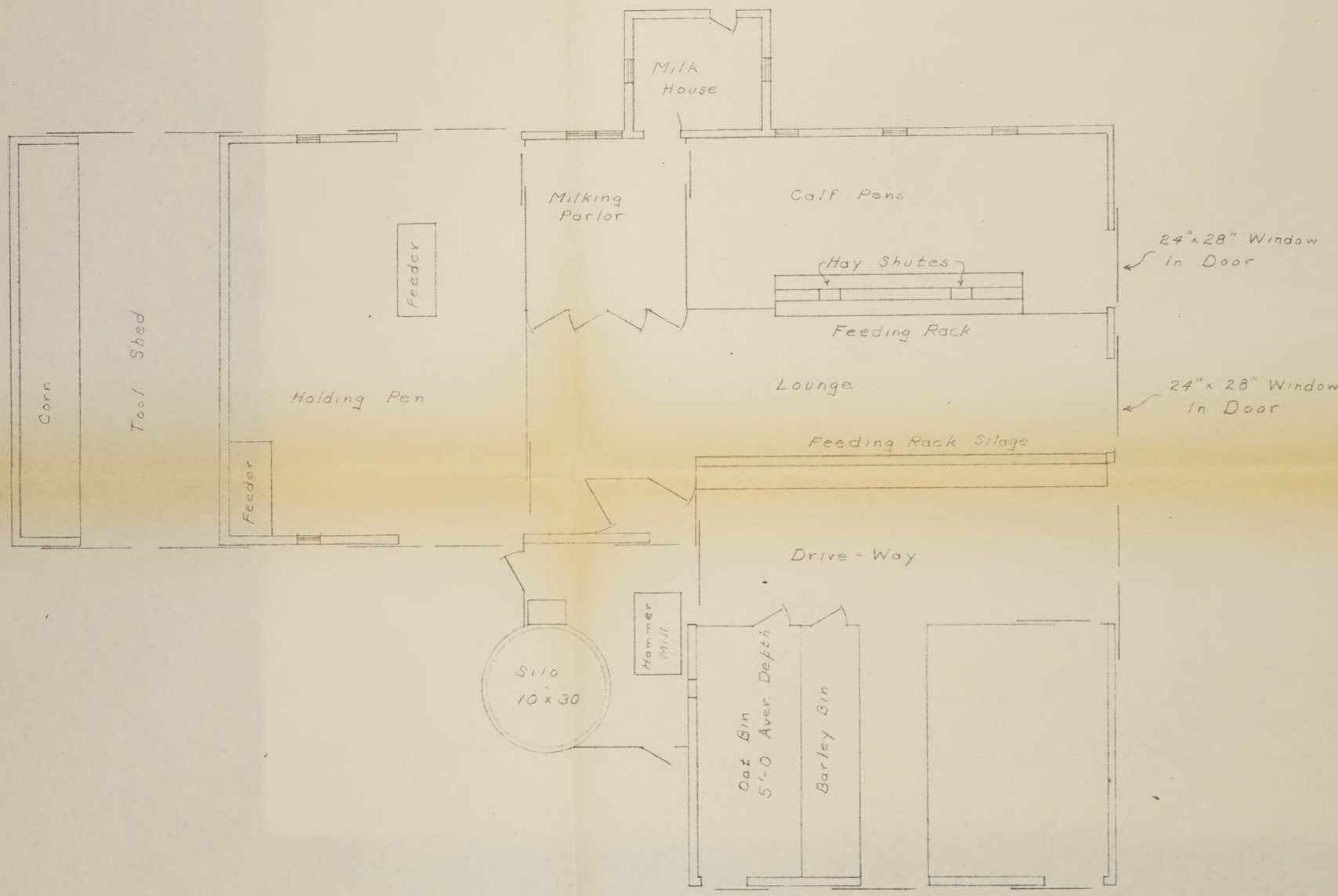
Lounge

MICHIGAN STATE COLLEGE
AGRICULTURAL ENGINEERING DEPT.
EAST LANSING, MICH.

MILKING PARLOR PLAN
BALLINGER FARM

PLANNED	APP. BY	
DRAWN G.J.C.	DATE Jan. 8, 48	SHEET 1
TRACED	SCALE 1"=1'	NO. 1.
CHECKED		

110



MICHIGAN STATE COLLEGE
AGRICULTURAL ENGINEERING DEPT.
EAST LANSING, MICH.

BARN FLOOR PLAN
BALLINGER FARM

PLANNED DRAWN BJG TRACED CHECKED	APP. BY DATE Jan 8, 48	SHEET 3 SCALE 1/8" = 1' NO. 1.

APPENDIX VIII

Basic Data Table

Table XX	Hay Feeding Data
Table XXI	Silage Feeding Data
Table XXII	Bedding Data
Table XXIII	Milking Data
Table XXIV	Young Stock Chore Time

TABLE XX

20		Average							
		All Farms		Feeding 2/day		Feeding 1/day		Self Feeders	
Min.	%	Min.	%	Min.	%	Min.	%	Min.	%
.19	14.4	.32	41.6	.36	38.3	.29	58.0	.09	33.3
.87	65.9	.32	41.6	.42	44.7	.11	22.0	.16	59.3
.26	19.7	.13	16.8	.16	17.0	.10	20.0	.02	7.4
1.32	100.0	.77	100.0	.94	100.0	.50	100.0	.27	100.0
14		20		20		17		28	
2									
1									
Loose									
2/day									
Overhead									
Double Center									
5.3		3.2		3.6		3.2		.9	

TABLE XXI

e	
Feeding 1/day	
Min.	%
.04	4.8
.28	33.3
.45	53.6
.07	8.3
.84	100.0
14	
2.3	

Avezag	
All Farm	
Min.	%
.23	27.
.40	47.0
.45	52.9
.17	20.0
.85	100.0
20	

TABLE XXII

Average	
All Farms	
Min.	%
.23	27.1
.40	47.0
.45	52.9
.17	20.0
.85	100.0
20	

16

20

13

10

4

1

74

3

6

0

AIL

2

1.5'

LEVE

EAST

HROUG

4

TABLE XXIII

	16m	17e	17m	18e	18m	19
	20.5	22.5	21.6	23.4	19.3	19
	13.6	11.2	10.8	23.4	19.3	9
	10.2	11.2	10.8	11.7	9.6	9
	4.3	4.3	4.6	4.1	4.8	4
	1.3	.6	.4	.8	.9	
	74.4	88.0	92.0	83.5	84.0	83
	3.1	3.0	3.4	2.2	3.2	2
3	6.7	5.8	6.7	7.9	8.9	7
	0	11		12		
	AIL	PAIL		PAIL		
	2	2		2		
	.5'	2		1		
	LEVEL	ELEVATED		ELEVATED		FL
	EAST	TANDEM-SINGLE IN LINE		TANDEM-SINGLE IN LINE		A
	THROUGH	SIDE ENTERING		SIDE ENTERING		WAI
	4	3		3		

TABLE XXIV

YOUNG STOCK CHORE TIME

(Average winter chore time spent for the care of young stock and calves on 18 farms with loose housing barns)

Farm number	Number of young stock and calves	Total time required	Average minutes required		Number of dairy cows on farm
			Based on number of young stock	Based on number of dairy cows	
1	9	6.2	.69	.48	13
3	11	1.2	.10	.09	14
4	19	33.0	1.74	1.74	19
6	13	11.4	.87	.60	19
7	21	32.8	1.56	1.43	23
8	21	23.2	1.10	1.01	23
9	6	10.1	1.68	.51	20
10	18	45.1	2.50	2.65	17
11	21	14.1	.67	1.76	8
12	10	41.1	4.11	1.52	27
13	9	6.5	.72	.54	12
14	52	45.2	.86	1.56	29
15	9	11.4	1.26	.88	13
16	13	11.2	.86	1.02	11
17	10	9.5	.95	.73	13
18	15	32.9	2.19	2.19	15
19	29	89.6	3.08	3.90	23
20	15	29.9	1.99	2.14	14
Average	17	25.2	1.48	1.37	17

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