EFFICIENCY STUDIES WITH DIFFERENT TYPES OF DAIRY BARN EQUIPMENT AND BARN ARRANGEMENTS

by

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I. INTRODUCTION

In recent years much interest has been shown in the management of dairy cows from the standpoint of different types of barn equipment and barn arrangements. This interest has been stimulated by the increased necessity on the part of dairymen to make the most efficient use of labor. Labor is a very important factor as it accounts for a very large percentage of the cost of producing milk.

The ease of doing a job with the aid of mechanical devices and improved barn arrangements is an important factor from the personnel standpoint, even though sometimes there is little or no saving in time. The mere fact that personal fatigue is reduced by the use of mechanical power greatly improves general working conditions of a particular dairy operation.

There are other factors however, that affect the over-all efficiency that must be considered. One of these is herd health and comfort. Conditions that allow discomfort and ill health of the cows do not contribute to a long productive life and in turn to an efficient operation. Another factor to consider is quality production. With the increased stress that is being placed on quality control down to the point of origin of dairy products a dairyman must assure the consumer that he is producing milk under sanitary conditions. Lastly but certainly not the least in importance is the level of milk production. The dairyman is in

business to produce milk and anything that he can do in the way of using different barn equipment and changing his barn arrangement to increase his level of production will pay off in increased milk checks.

There has been considerable work and experimentation done on management of dairy cows with regard to conventional stanchion type barns versus the loose housing and milking parlor arrangement, however very little has been done from the standpoint of different types of stalls and equipment and arrangements used in the conventional stanchion type barn.

II. REVIEW OF LITERATURE

A review of the literature reveals that there is a considerable variation in the time required for the management of dairy cows. Witzel and committee[10] state that in one study made in Minnesota in 1943, a farmer with 21 cows required an average of only 90 man hours per cow for the year while another farmer with the same number of cows averaged 193 man hours per cow for his operation. They further state that on an average the dairy cow requires in the neighborhood of 150 man hours of labor per year. Vaughan and Hardin[9] quoting from unpublished data, U. S. D. A. for the years 1942 through 1946 state that the average labor requirement for producing 100 pounds of milk is 2.9 hours. Hodge[6] reporting results of a study made in Michigan in 1948-1949 reveals that labor was the second largest cost item in the production of milk. It accounted for 31 per cent and was exceeded only by feed costs which was 48 per cent of the total.

Results of a study made at the University of West Virginia by Porterfield and others[8] showed that it required 6.48 seconds longer to clean the comfort stall than it did to clean the tie-chain stall. This difference was not found to be significant in that case.

In a study made on a 22 cow herd in Vermont in 1942, Carter[3] found that before substituting a manure cart for a wheelbarrow and making some rearrangements in the barn, it required 19.2 minutes to remove the manure from the barn as compared to 14.9 after these adjustments had been made.

In the same study Carter[3] reports that by the use of a silage cart instead of baskets and after the rearrangement of the barn had been accomplished it required 14.8 minutes to feed silage to the cows compared to 26.4 minutes before the changes had been made.

Porterfield and others[8] in their study report that results of bedding trials for a seven-day period and for a 14-day period revealed that there was no significant difference in the amount of bedding required between the comfort and the tie-chain stalls.

In the same study Porterfield and others[8] report that cows in the comfort stalls remained cleaner than when they were in the tie-chain stalls. Nageotte[7] indicates, that providing uprights not wider apart than 10 inches are used in tie-chain stalls, cows will remain as clean in them as they will in stanchions.

Bates[2] recommends that the comfort of the cow be considered in deciding on the size of the stall for her. He believes they should be "tailor made" by measuring the cow herself. He suggests that a measurement be taken along the top line from a point

perpendicular with the point of the shoulder and extending back to the tail setting. To this measurement add three inches in case of stanchion stalls and six inches in case of tie stalls, which will give the proper length of stall for that individual cow. The width should be 80 per cent of the stall length. Bates indicates that the proper size stall not only affords more comfort to the cow but also results in a cleaner cow.

Porterfield and others[8] report that during a 19-day trial when cows were confined in comfort stalls they averaged 10.2 hours out of a 24-hour period lying down as compared to 8.8 hours in the same length period in the tie-chain stalls. This was reported to be highly significant. Atkeson and others[1] report finding that dry cows and heifers on pasture spent an average of 13 hours lying down.

Nagoette[7] states that he had occasion to observe a herd of cows that were moved from a stanchion barn into a comfort stall barn and they increased in butterfat production 35 pounds per year. Porterfield and others[8] report that eight cows representing nine comparisons, produced from 12.0 to 97.2 pounds more milk per week while in comfort stalls than they did in tie-chain stalls. Drakely and White[5], concluding from an analysis of 6,566 records of production on cows exhibited at shows in England,

state that "the influence of stage of lactation appears to be the same for cows of all ages."

Espe[4] in his textbook indicates that it has been said that the heifer, due to the fact that she is increasing in size and amount of udder tissue is more persistent than the cow.

III. THE INVESTIGATION

This study was made to secure data on the use of different types of barn equipment and barn arrangements. The following outline lists the various phases of the study.

A. Outline of Investigation

1. Efficiency of labor with different types of barn equipment and barn arrangements
    a. Cleaning and brushing cows
    b. Cleaning stalls
    c. Removing manure from barn
    d. Feeding cows roughage and grain
        (1) Feeding silage
        (2) Feeding hay
        (3) Feeding grain
    e. Fastening and unfastening cows in stalls
    f. Location of milker vacuum lines
2. Efficiency of different types of stalls
    a. Amount of bedding required
    b. Cleanliness of cows
    c. Feed wastage
    d. Comfort of cows
    e. Production

B. Description of Facilities

This investigation was carried out for the most part in the newly constructed dairy barn at the Virginia Polytechnic Institute, Blacksburg, Virginia. This barn is of cinder block construction and is 137 feet long and 40 feet wide. Hay is stored overhead in a mow with a six-inch poured concrete slab floor. A mechanical gutter cleaner is used for manure removal. A small feed storage room is located at one side and midway of the barn into which the feeding chutes of two concrete stave silos open. There are four stall sections of equal size and each of these sections is serviced by an eight-foot by eight-foot hay chute attached to the outside wall of the barn and opening directly into the barn. The milk handling room is located directly opposite and on the other side of the barn from the feed room.

The stall sections have a total capacity of 56 cows. One section contains 15 conventional stanchions which are four feet wide and vary from four feet, ten inches at one end of the section to five feet, two inches long at the other end. This measurement is from curb to gutter. Another section contains 15 tie stalls which are four feet wide and vary from five feet, two inches to five feet, six inches in length. Both of these sections are on the same side of the barn and have a sweep-in type of feed manger.

The stanchion section has a five and one-half inch curb between the stall platform and feed manger and the tie stalls have a nine and one-half inch curb at this point. One of the two sections on the other side of the barn contains 14 tie stalls and the other 12 "Hoard type comfort" stalls. The tie stalls measure four feet, three inches in width and are of a uniform length of five feet, six inches. The comfort stalls are five feet wide and seven feet, eight inches long. They have a two by four inch wooden crossbar at the rear of the stall which is adjustable in five positions, giving a total adjustment of eight and one-half inches. This crossbar is parallel with the gutter and about twenty-five inches forward of it when in the longest adjustment position. The function of this crossbar is to hold the bedding up under the cow. An arrangement of pipes along the front of the comfort stall forces the cow to stand back in the stall with her hind feet behind the crossbar when she stands with her head up, thus preventing the droppings from falling into the bedding. When lying down, her head goes forward and allows her to lie forward of the crossbar on the bedding. This affords quite a protection to the udder. Another feature of the comfort stall is a three and one-half by four inch concrete curb between each stall which gives the cow a foothold and helps to eliminate possible injury to the cow in the next

stall. Both of these latter sections have a high-front type feed manger. The tie stalls have a five and one-half inch curb between feed manger and stall platform and the comfort stalls have a four-inch curb at this point. Figures 1 and 2 illustrate the comfort and tie stalls, respectively.

The milker vacuum line is located along the front of the stall in the conventional manner on the stanchions and on the comfort stalls. This line is located toward the rear of the stall and is supported from the metal supporting columns in both the tie stall sections. They are at a height of about six feet, seven inches. In the 15 stall tie section, the stall cocks point forward toward the feed manger while those in the 14 stall tie section point toward the litter alley.

A small portion of this investigation was carried out at the old dairy barn at Virginia Polytechnic Institute. This barn is a one-story dairy barn attached to a two-story feed barn in which the hay storage is located. This barn is not equipped with a mechanical gutter cleaner and the manure is removed by a conventional litter carrier.

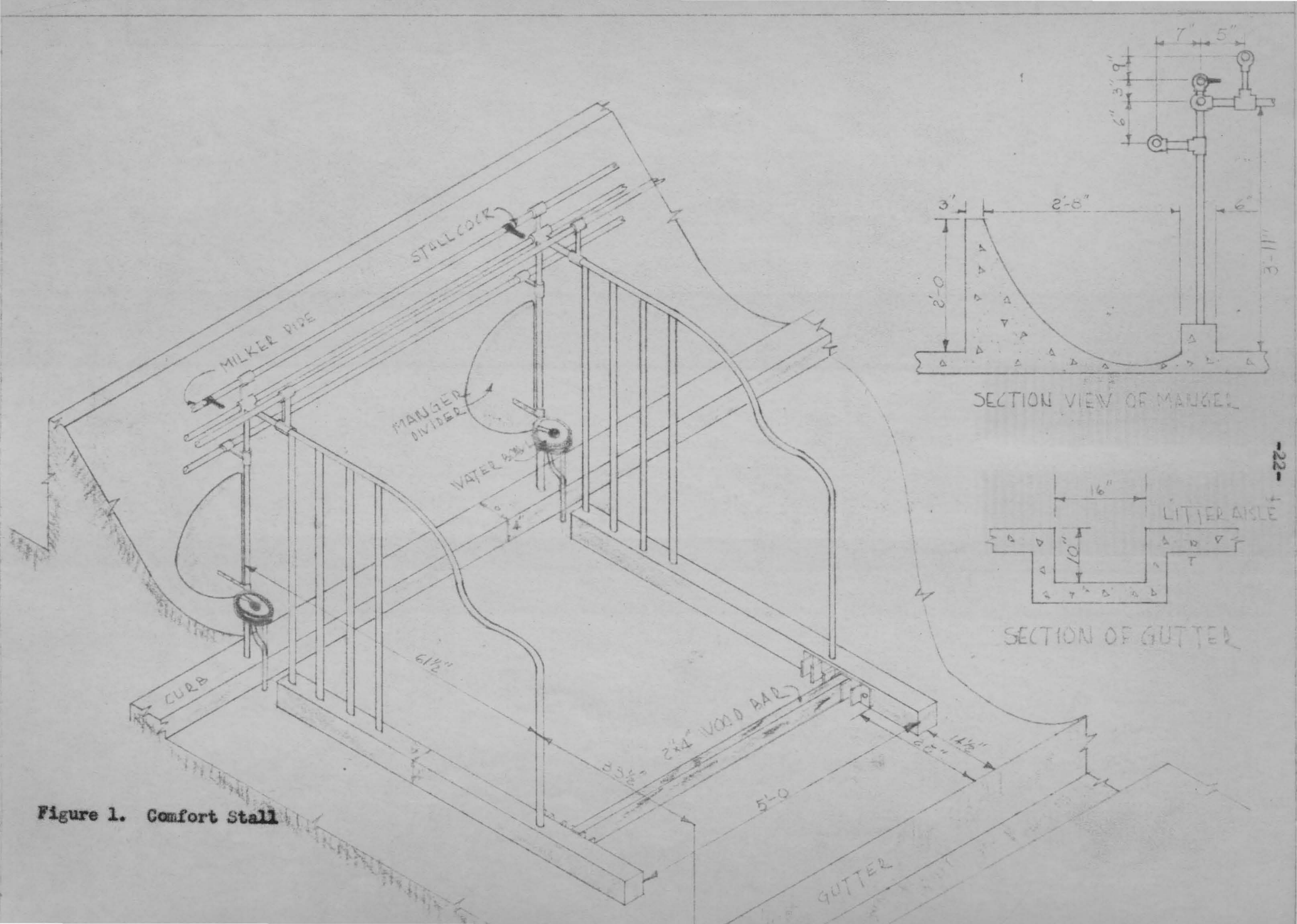

Figure 1. Comfort Stall

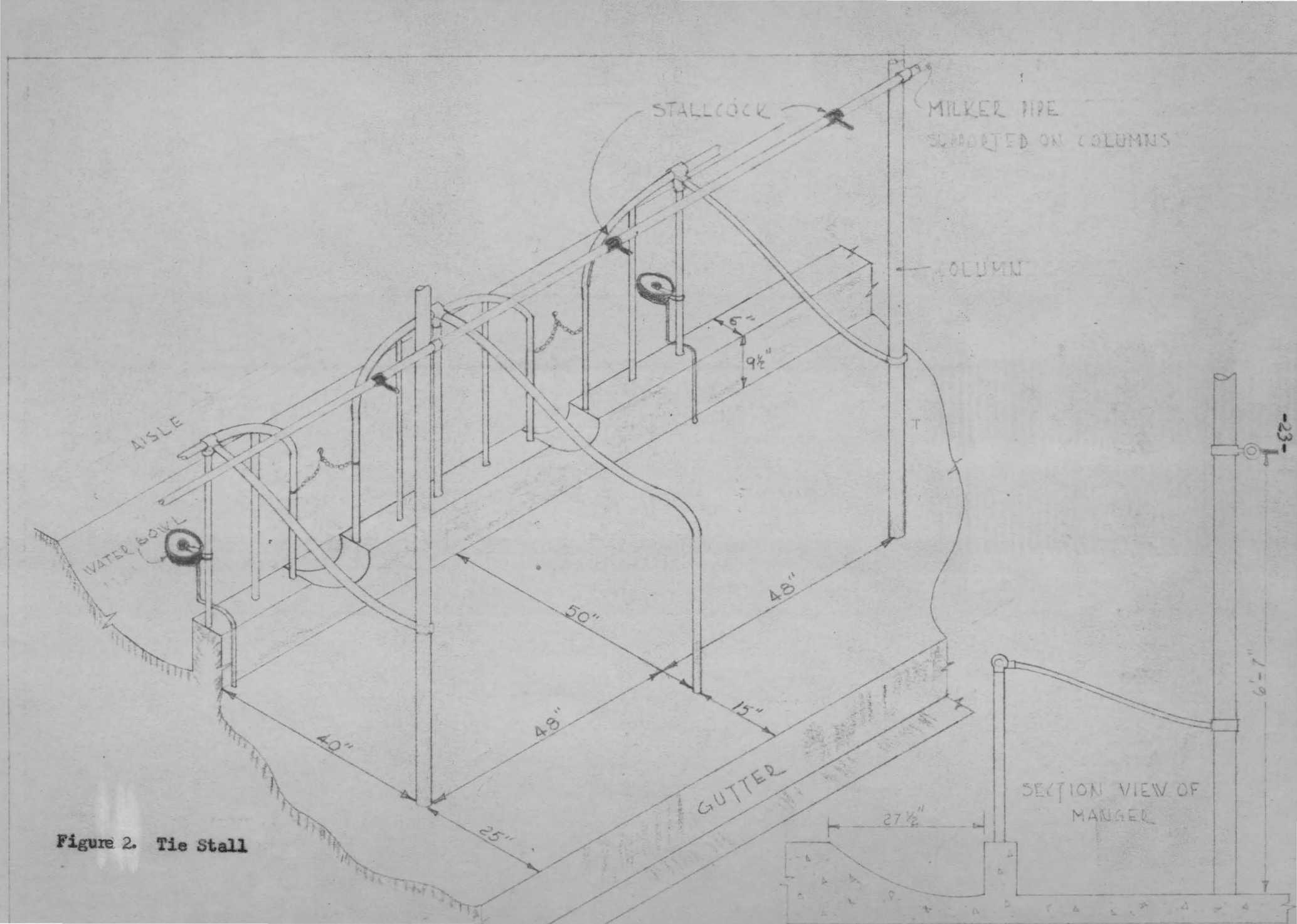

Figure 2. Tie Stall

C. Methods and Procedures

1. Efficiency of labor with different equipment and arrangements

a. Cleaning and brushing cows

A comparison was made of the time required to clean and brush the cows in the three types of stalls, stanchion, tie, and comfort stalls, in the normal preparation for milking. A stop watch was used to time the various operations. An effort was made to have the task as uniformly performed as possible throughout the study. No more time was spent on the cows than was necessary to render them in a proper state of cleanliness for the milking operation.

b. Cleaning stalls

The time required to clean each type of stall was studied. This involved the cleaning of the stall itself and the removal of the manure and soiled bedding from the stall platform into the gutter in preparation for its removal from the barn.

c. Removing manure from the barn

A comparison was made of the time required to remove manure from the barn by the following methods, conventional litter carrier, truck driven through the barn, and

mechanical gutter cleaner. In each case the time was recorded for the handling of the manure from the gutter to a point outside of the barn. The comparison of the truck with the mechanical gutter cleaner was made in the same barn. The study on the conventional litter carrier was made in the old barn because the new barn did not have facilities for using the litter carrier. Comparisons were made on the approximate amounts of manure handled in each case.

d. Feeding cows roughage and grain

(1) Feeding silage

A comparison was made of the time required to feed silage to cows with a cart and with a basket. Data were collected separately for the high and low manger sections for each method. In feeding with the cart, it was filled at the silo and the cows in each section were fed before it was returned to be refilled for the next section. The basket method involved carrying the silage for each individual cow in a basket from the silo to her stall. The two sections on one end of the barn were used for the cart feeding, while the two sections on the opposite end were used for the basket method. Arrangements

were made to ensure that the distances were comparable in all cases.

(2) Feeding hay

A comparison was made of the time required to feed baled hay from an overhead mow storage through a central hay chute and sectional hay chutes. Another comparison was made in the old barn of the time required to feed loose hay and baled hay from a central storage. This central storage is located in a separate barn attached to the dairy barn.

(3) Feeding grain

A comparison was made of the time required to feed grain to cows by a grain cart and a stationary grain bin. The data were collected for each method on the basis of both high and low feed mangers. A grain cart was filled with grain in the feed room, and then the cows in one end of the barn were fed in the conventional manner of pushing the cart along the feed alley in front of the row of cows as they were fed. The cows in the other end of the barn were fed from the feed cart, however it was stationed midway of each section and the cows were fed from the

central point by walking back and froth to each cow from the stationary feed cart. This assimilated a stationary feed bin located in each section.

e. Fastening and unfastening cows in stalls

The time required to fasten and unfasten cows in the three types of stalls in the barn was compared. This included only the actual time required to fasten the cows in their stalls after they had found their places in the barn and the time it took to unfasten them when they were turned out.

f. Location of the milker vacuum lines

Studies were made of the time required to attach and detach the milker vacuum hose with the vacuum line located as follows, at a height of about four feet along the top of the comfort stalls, at a height of about five feet along the top of the stanchion stalls, at a height of about six feet, seven inches toward the rear of the tie stalls with the stall cocks pointing toward the feed alley, and at a height of about six feet, seven inches toward the rear of the tie stalls with the stall cocks pointing toward the litter alley. The timing for the attaching operation was started just as the man stepped

across the gutter in preparation for plugging the milker hose onto the stall cock, and was stopped after the hose had been connected and the man grasped the teat cups to attach them onto the cow. The detaching operation was started as the man replaced the teat cups on the milker after removing them from the cow in preparation for disconnecting the vacuum hose, and was stopped as he crossed the gutter after he had disconnected the hose.

2. Efficiency of different types of stalls

a. Amount of bedding required

The amounts of bedding required for the different types of stalls were compared. Both straw and sawdust were used in a ten-day trial in which half of each section was bedded with straw and the other half with sawdust.

b. Cleanliness of the cows

The cows in the types of stalls were scored for cleanliness. The following standard for scoring was set up. For each area the size of an average hand that was wet or soiled, the cow was given a score of one. For each area of this size that had dirt or manure adhering to it, the cow was given a score of two. This

standard was applied to both sides of the cow and the score for the two sides added together to give the score for that cow. A completely clean cow was given a score of zero. The cows were scored daily just prior to the morning milking and before they had been brushed. The normal cleaning and brushing was carried out each day.

c. Feed wastage

Observations were made of the relative amounts of grain that were thrown back on the manger curbs and onto the stall platforms of the different stalls with high and low curbs. The amounts of grain thrown from the manger into the feed alley were recorded.

d. Comfort of cows

A record was made of the amounts of time the cows in each of the types of stalls spent lying down during a 24-hour period. Data were collected separately for the two tie stall sections as they represented different stall widths. Constant observation was maintained from 6:00 p.m. one day until the same time the following day.

e. Production

Production records were kept on the cows in each of the three types of stalls. In this study, as in the

preceding one, the data were collected separately for the tie stall sections because of the different stall widths represented. The period from December 1, 1950 through April 30, 1951, was used for the milk production data as these were the five full months that the cows remained in the barn. The production of the cows that calved between September 1, 1950 and December 1, 1950, and remained in the same section for the five months mentioned was used. Since this period of time did not allow for collecting data on the same cow in each type of stall and also because the large cows in the comfort stalls could not be placed in the shorter stanchion stalls, the production was compared on the basis of the drop in the lactation curve.

D. Results

1. Efficiency of labor with different equipment and arrangements.

a. Cleaning and brushing cows

Very little difference was found in the time required to clean and brush cows in the three different types of stalls. Table 1 shows the results of a nine-day trial in which this comparison was made. These data are based on two cleanings and brushings per day. It will be noted that it required 1.56 minutes per day per cow in the comfort stalls, 1.66 minutes for the cows in the stanchions, and 1.67 minutes for cows in the tie stalls. Analysis of variance shows these differences not to be significant.

b. Cleaning stalls

Time studies were made on the cleaning of the manure and soiled bedding from the stall platform into the gutter for the three different types of stalls. The information is contained in Table 2. The comfort stalls with an average of 1.47 minutes per stall per day required the greatest amount of time. This was followed by the tie stall with 0.82 minute and then the stanchions with an average of only 0.74 minute per stall. Analysis of variance

applied to these data indicate that the greatest amount of time required for the comfort stall is significant. When disregarding the comfort stall and applying analysis of variance to the stanchion and the tie stall data the difference was not significant.

c. Removing manure from barn

The results of the comparison of the time required to remove manure from the barn by three different methods are presented in Table 3. The study, having been conducted in two different barns, was made on the basis of the approximate amounts of manure handled. It can be seen that the litter carrier, with an average of 43.66 minutes per ton required the greatest amount of time. The truck driven through the barn required 24.44 minutes per ton. The least amount of time was involved with the mechanical gutter cleaner which required 18.55 minutes per ton. Analysis of variance showed the difference in time between the litter carrier and the truck to be highly significant. The difference was not statistically significant between the time required to clean the barn with the mechanical gutter cleaner and the truck. An important point with respect to the mechanical gutter cleaner, and one that should be considered in the comparison, is that the time involved is entirely machine time for the

mechanical gutter cleaner and for that reason is not a true comparison from the standpoint of man hours of labor.

In order to get a true comparison between the mechanical gutter cleaner and each of the other methods the results of the combined operation of cleaning the stalls in the entire barn and the removal of the manure by the different methods should be considered together.

d. Feeding roughage and grain

(1) Feeding silage

Table 4 presents the results of a trial in which the time was recorded for the feeding of silage to cows by cart and by basket. These two methods were compared in both the high and the low mangers. It was found that feeding with the cart required an average of 1.02 minutes per stall for the high mangers and only 0.79 minute per stall for the low mangers. These figures are in comparison with 1.44 minutes per stall for the high manger and 1.36 minutes for the low manger when the basket method was used. Analysis of variance showed these differences to be significant. Further analysis as to differences between mangers and differences between methods showed that the differences between cart and basket were highly significant for both high and

low mangers. The differences between high and low mangers when using the basket were significant while the differences between high and low mangers when using the cart were highly significant. In both cases less time was required for the low manger.

(2) Feeding hay

Time studies summarized in Table 5 revealed that it was necessary to spend an average of 62.66 minutes per day to feed loose hay compared to only 28.66 minutes for baled hay to 51 cows twice a day when the hay was stored in an adjacent barn. The same amounts of hay were fed in both cases. This is obviously a significant difference.

In comparing the central hay chute with the sectional chutes in feeding baled hay it was found to take slightly less time when using the sectional chutes. Table 6 shows the following results: 23.20 minutes per day to feed 28 cows when using the central chute and 20.75 minutes when using the sectional chutes. These differences are hardly significant at the five per cent point. Further study is needed in these two methods before definite conclusions can be drawn.

(3) Feeding grain

A comparative study of the time spent in feeding grain to cows from a cart and from a stationary feed bin in both high and low mangers showed highly significant differences in the time required. The following time requirements for the different methods are presented in Table 7: 0.527 minute per cow for the cart when feeding into the high manger, 0.436 minute for the cart and low manger, 0.561 minute per stall for the stationary feed bin when feeding into the high manger, and 0.543 minute per stall for the stationary feed bin and low manger. Analysis of variance was applied to these data separately for the differences between methods and the differences between mangers.

In the comparison between feeding from a cart and feeding from a stationary bin the differences were highly significant in favor of the cart when feeding was done in the low type mangers. When feeding into the high type mangers the differences were not significant. When the cart was used there were highly significant differences between the type of mangers in favor of the low manger. With the stationary bin, no significant differences were found.

e. Fastening and unfastening cows in stalls

The data show that it required an average of 0.167 minute per stall to fasten cows in the comfort stalls compared to an average of 0.119 minute for the tie stall and 0.096 minute for the stanchion. Table 8 gives the summary data on this study. In Table 9 it can be seen that much the same is true for the unfastening operation. It took 0.120 minute per day per stall for the comfort stall, 0.101 minute for the tie stall, and 0.079 minute for the stanchion. Analysis of variance applied to these results indicated that these differences were highly significant. Regarding the fastening operation the differences between the comfort stall and the tie stall and for the tie stall and the stanchion were both highly significant. In the case of the unfastening operation the difference between the comfort stall and tie stall was found to be highly significant while the difference between the stanchion and the tie stall was not significant.

f. Location of the milker vacuum line

A comparison of the time necessary to attach and detach the milker vacuum hose to the vacuum pipe line with the line located in various positions indicated that there was very little difference in considering both operations

together. Some difference was noted in the average of one operation in various locations, however in totaling the average for both operations the difference was not great for any of the locations. In Table 10 are the averages for the attaching operation. The location in the comfort stall required 4.87 seconds per cow to attach while the stanchion location required 5.30 seconds for attachment. The location in the tie stalls when the stall cock pointed toward the feed manger required 4.90 seconds and when the stall cocks pointed toward the litter alley used 5.87 seconds. Table 11 indicates it was necessary to spend an average of 4.00 seconds per cow to detach the milker hose in the comfort stall compared with 3.33 seconds for the stanchion location, 3.50 seconds for the tie stall with the stall cocks pointing toward the feed alley, and 3.10 seconds in the tie stalls when the stall cocks pointed toward the litter alley. Analysis of variance applied on the totals of both operations at the various locations showed the differences not to be significant.

2. Efficiency of different types of stalls

a. Amount of bedding required

Results of trials to compare the amounts of bedding required for the different types of stalls are presented in

Tables 12 and 13. Data are given for both straw and sawdust. The comfort stall required a daily average of 8.08 pounds of straw or 35.52 pounds of sawdust per stall. These figures were the highest for both types of bedding material. The stall requiring the lowest amount in each case was the wider tie stall which used an average of 5.67 pounds of straw per stall per day or 30.00 pounds of sawdust. The stanchions used an average of 5.99 pounds of straw or 31.73 pounds of sawdust per stall per day and the narrower tie stalls averaged 5.70 pounds of straw and 31.76 pounds of sawdust per stall per day.

b. Cleanliness of cows

Results of trials in which cows in the different types of stalls were scored on cleanliness indicate that the cows in the comfort stalls remained cleaner on the average than in any of the other stalls. This was the case for either straw or sawdust as the bedding material. It will be noted in Table 14 that with straw the cows in comfort stalls received an average score of 2.00 per cow, cows in stanchions received 2.99, cows in the narrower tie stalls 3.51, and cows in the wider tie stalls received an average of 3.66 per cow per day. Table 15, containing the data on cows bedded with sawdust, reveals that cows in the comfort

stalls scored 0.78 per cow per day, cows in the stanchions scored 1.47, cows in the narrower tie stalls received a 2.03 score, while those in the wider tie stalls averaged 2.08 per cow per day. Analysis of variance show these differences in both the straw and sawdust for the comfort stall compared with either type of tie stalls to be highly significant.

The difference between the comfort stall and stanchion when bedded with straw approached significance at the five per cent point. The difference between the comfort stall and stanchion when sawdust was used as bedding was not significant. The differences between the stanchion and either of the two tie stalls section were not statistically significant. Further analyses showed the differences in the cleanliness scores for the sawdust compared to the straw to be highly significant in each type of stall favoring the sawdust.

The stalls in the various sections differed in length. Also, the cows varied in size and length. The cows in the stanchions averaged 1.3 inches longer than the averaged stall length; those in the narrower tie stalls averaged 1.0 inch shorter, and those in the wider tie stalls averaged 2.0 inches shorter than the averaged stall length. Of course, the comfort stalls were considerably longer

than the averaged length of the cow in them because they were designed on a different basis than the other stalls. These data are listed in Table 20, Appendix A.

c. Feed wastage

Results of observations made on the amount of grain thrown back on the stall curb and on the stall platform by the cows are recorded in Table 16. Data are given for both high and low curbs. The low curb in the comfort stall section allowed grain to be scattered both on the curb and behind it on the stall platform. The higher curb in this section controlled this wastage almost entirely in that no grain was observed on the stall platform and very little on the curb itself. In the stanchion section, where a low curb was the only type observed, the cow did not appear to throw the grain back to the extent that was found in the low curb portion of the comfort stall. This was probably due to the lack of freedom of the cows' head in the stanchions compared with that of the cows in the comfort stalls. Regarding the tie stalls, the high curb seemed to control grain wastage quite well as no evidence was found of grain either on the stall curb or on the stall platform in the rear of the curb. The low curb section of the tie stalls

did show some grain to be scattered on the stall curb after the cow had finished eating, however none was observed to be on the stall platform.

An additional observation was made as to the amount of grain thrown out of the manger into the feed alley by the cows from the low, sweep-in type feed manger and the high-front type feed manger. These data were recorded by sections involving the different types of stalls. These amounts are summarized in Table 17. The average figures per day were 0.037 pound per stall for the low mangers in the stanchion section, compared with 0.041 pound for the low mangers in the tie stall section. The amount observed with the high manger in the tie stall section was 0.002 pound per stall. None was thrown out with the high manger in the comfort stall section.

d. Comfort

Observation over a 24-hour period on the average time cows spent lying down in the different types of stalls was made. This was used as an indication of the comfort of the cow. These averages are found in Table 18. This study revealed that the cows in the stanchions averaged 14 hours and one minute out of the 24 hours lying down, the cows in the comfort stalls averaged 13 hours and 33 minutes, only

28 minutes less. In the narrower tie stalls the cows averaged 12 hours and 58 minutes while those in the wider tie stalls averaged 12 hours and nine minutes lying down out of the 24-hour period. It should be noted here that the younger cows were in the stanchions and the narrower tie stalls.

e. Production

The average daily milk weight for each of the cows in the study was determined for each of the five full months that they were stabled and then averaged for each type of stall. These data are presented in Table 19 in actual pounds of milk produced. Figure 3 shows this information by means of lactation curves. The records showed that the cows in the comfort stalls averaged 62.4 pounds for the first month, 60.1 for the second, 53.1 for the third, 46.0 for the fourth, and 44.6 for the fifth. The monthly averages for cows in the stanchions were: 45.9, 46.7, 41.4, 39.0, and 37.6. In the narrower tie stalls the cows produced a daily average of 49.0 pounds for the first month, 47.5 for the second, 40.9 for the third, 36.3 for the fourth, and 35.4 for the last month of the trial. Cows in the wider tie stalls averaged the following for each

of the five months: 53.9, 53.6, 46.7, 41.8, and 41.3. It should be noted here that the older cows were in the comfort stalls and the first calf heifers were in the stanchions.

Table 1

Time Required for Cleaning and Brushing Cows in Different Types of Stalls

Type of Stall	No of Cows	No of Days	Total Time Required	Average Time Per Cow Per Day
			minutes	minutes
Comfort	12	9	169.0	1.56
Stanchion	15	9	224.0	1.66
Tie	29	9	435.5	1.67

Table 2

Time Required to Clean the Different Types of Stalls

Type of Stall	No of Stalls	No of Days	Total Time Required	Average Time Per Stall Per Day
			minutes	minutes
Comfort	12	9	159.0	1.47
Stanchion	15	9	100.0	0.74
Tie	29	9	213.0	0.82

Table 3

Time Required to Remove Manure from the Barn by Different Methods

Method	No of Days	Total Time Required	Approximate Amount Handled	Average Time Per Ton
		minutes	tons	minutes
Litter carrier	3	262.0	2	43.66
Truck	3	220.0	3	24.44
Mechanical gutter cleaner	3	167.0	3	18.55

Table 4

Time Required to Feed Silage by Cart and by Basket in High and Low Mangers

Method	Type of Manger	No of Cows	No of Days	Total Time Required	Average Time Per Stall Per Day
				minutes	minutes
Silage cart	High	12	11	135.5	1.02
Silage cart	Low	15	11	128.5	0.79
Basket	High	14	11	222.0	1.44
Basket	Low	15	11	224.5	1.36

Table 5

Time Required to Feed Loose and Baled Hay from an Adjacent Hay Storage Barn

Form in Which Fed	No of Days	Total Time	Average Time Per Day
		minutes	minutes
Loose	3	188.0	62.66
Baled	3	86.0	28.66

Table 6

Time Required to Feed Baled Hay from an Overhead Mow Using a Central Hay Chute and Sectional Hay Chutes

Method	No of Days	Total Time	Average Time Per Day
		minutes	minutes
Central chute	10	232.0	23.20
Sectional chute	10	207.5	20.75

Table 7

Time Required to Feed Grain from a Cart and from a Stationary Feed Bin in High and Low Mangers

Method	Type of Manger	No of Cows	No of Days	Total Time Required	Average Time Per Stall Per Day
				minutes	minutes
Grain cart	High	12	11	69.5	0.527
Grain cart	Low	15	11	72.0	0.436
Stationary bin	High	14	11	86.5	0.561
Stationary bin	Low	15	11	89.5	0.543

Table 8

Time Required to Fasten Cows in Different Types of Stalls

Type of Stall	No of Cows	No of Days	Total Time Required	Average Time Per Cow Per Operation
			minutes	minutes
Comfort	12	4	8.00	0.167
Stanchion	15	4	5.75	0.096
Tie	29	4	13.75	0.119

Table 9

Time Required to Unfasten Cows from Different Types of Stalls

Type of Stall	No of Cows	No of Days	Total Time Required	Average Time per Cow per Operation
			minutes	minutes
Comfort	12	4	5.75	0.120
Stanchion	15	4	4.75	0.079
Tie	29	4	11.75	0.101

Table 10

Time Required to Attach the Milker Hose to the Vacuum Line with the Line in Different Locations

Location of Milker Vacuum Line	No of Observations	Total Time Required	Average Time Per Operation
		seconds	seconds
About 4 feet high, along front of comfort stalls	15	73.0	4.87
About 5 feet high, along front of stanchion	15	79.5	5.30
About 6 feet, 7 inches high, toward rear of tie stalls, stall cocks pointing toward feed manger	15	73.5	4.90
About 6 feet, 7 inches high, toward rear of tie stalls, stall cocks pointing toward litter alley	15	88.0	5.87

Table 11

Time Required to Detach the Milker Hose from the Vacuum Line with the Line in Different Locations

Location of milker Vacuum Line	No of Observations	Total Time Required	Average Time Per Operation
		seconds	seconds
About 4 feet high, along front of comfort stalls	15	60.0	4.00
About 5 feet high, along front of stanchions	15	50.0	3.33
About 6 feet, 7 inches high, toward rear of tie stalls, stall cock pointing toward feed manger	15	52.5	3.50
About 6 feet, 7 inches high, toward rear of tie stalls, stall cock pointing toward litter alley	15	46.5	3.10

Table 12

Amount of Straw Required for Bedding in the Different Types of Stalls

Type of Stall	No of Stalls	No Days in Trial	Amount Bedding Required	Average Amount Per Stall Per Day
			pounds	pounds
Comfort	6	10	48.5	8.08
Stanchion	8	10	47.9	5.99
Tie, 4 feet wide	8	10	45.6	5.70
Tie, 4 feet, 3 inches wide	7	10	39.7	5.67

Table 13

Amount of Sawdust Required for Bedding in the Different Types of Stalls

Type of Stall	No of Stalls	No Days in Trial	Amount Bedding Required	Average Amount Per Stall Per Day
			pounds	pounds
Comfort	6	10	213.1	35.52
Stanchion	7	10	222.1	31.73
Tie, 4 feet wide	7	10	222.3	31.76
Tie, 4 feet, 3 inches wide	7	10	210.0	30.00

Table 14

Cleanliness Scores for Cows in the Different Types of Stalls when Straw Was Used as Bedding

Type of Stall	No of Stalls	No of Observations	Total Score	Average Score Per Cow
Comfort	12	5	120	2.00
Stanchion	15	5	224	2.99
Tie, 4 feet wide	15	5	263	3.51
Tie, 4 feet, 3 inches wide	14	5	256	3.66

Table 15

Cleanliness Scores for Cows in the Different Types of Stalls when Sawdust Was Used as Bedding

Type of Stall	No of Stalls	No of Observations	Total Score	Average Score Per Cow
Comfort	12	5	47	0.78
Stanchion	15	5	110	1.47
Tie, 4 feet wide	15	5	152	2.03
Tie, 4 feet, 3 inches wide	14	5	146	2.08

Table 16

Observations on Grain Wastage with High and Low Stall Curbs in the Different Types of Stalls

Type of Stall	Type of Stall Curb	Feed Thrown Back onto Stall Curb	Feed Thrown Back onto Stall Platform
Comfort	Low	Small amount	Very small amount
Comfort	High	Very small amount	None
Stanchion	Low	Small amount	Very small amount
Tie	Low	Very small amount	None
Tie	High	None	None

Table 17

Amounts of Grain Thrown Out of the Feed Manger into the Feed Alley with High and Low Mangers

Type of Manger	Type of Stall	No of Stalls	No of Observations	Total Amount Grain Thrown Out	Amount of Grain Thrown Out Per Stall Per Feeding
				pounds	
Low	Stanchion	15	3	1.70	0.0377
Low	Tie	15	3	1.85	0.0411
High	Tie	14	3	0.10	0.0023
High	Comfort	12	3	0.00	0.0000

Table 18

Amount of Time Cows Spent Lying Down in a 24-Hour Period in the Different Types of Stalls

Type of Stall	No of Stalls	Period of Observations	Average Age of Cows in		Average No of Times Cow Laid Down	Average Time Cows Spent Lying Down	
		hours	years	months		hours	minutes
Comfort	12	24	7	5	10.8	13	33
Stanchion	15	24	3	9	13.8	14	1
Tie, 4 feet wide	15	24	4	8	12.1	12	58
Tie, 4 feet, 3 inches wide	14	24	6	6	9.9	12	9

Table 19

Daily Milk Production of Cows in the Different Types of Stalls

Type of Stall	No of Cows	Average Age of Cows		Average Daily Production 1st Month	Average Daily Production 2nd Month	Average Daily Production 3rd Month	Average Daily Production 4th Month	Average Daily Production 5th Month
		years	months	pounds	pounds	pounds	pounds	pounds
Comfort	5	7	9	62.4	60.1	53.1	46.0	44.6
Stanchion	9	2	10	45.9	46.7	41.4	39.0	37.6
Tie, 4 feet	8	3	10	45.6	44.9	39.0	34.6	33.6
Tie, 4 feet, 3 inches wide	7	5	10	53.9	53.6	46.7	41.8	41.3

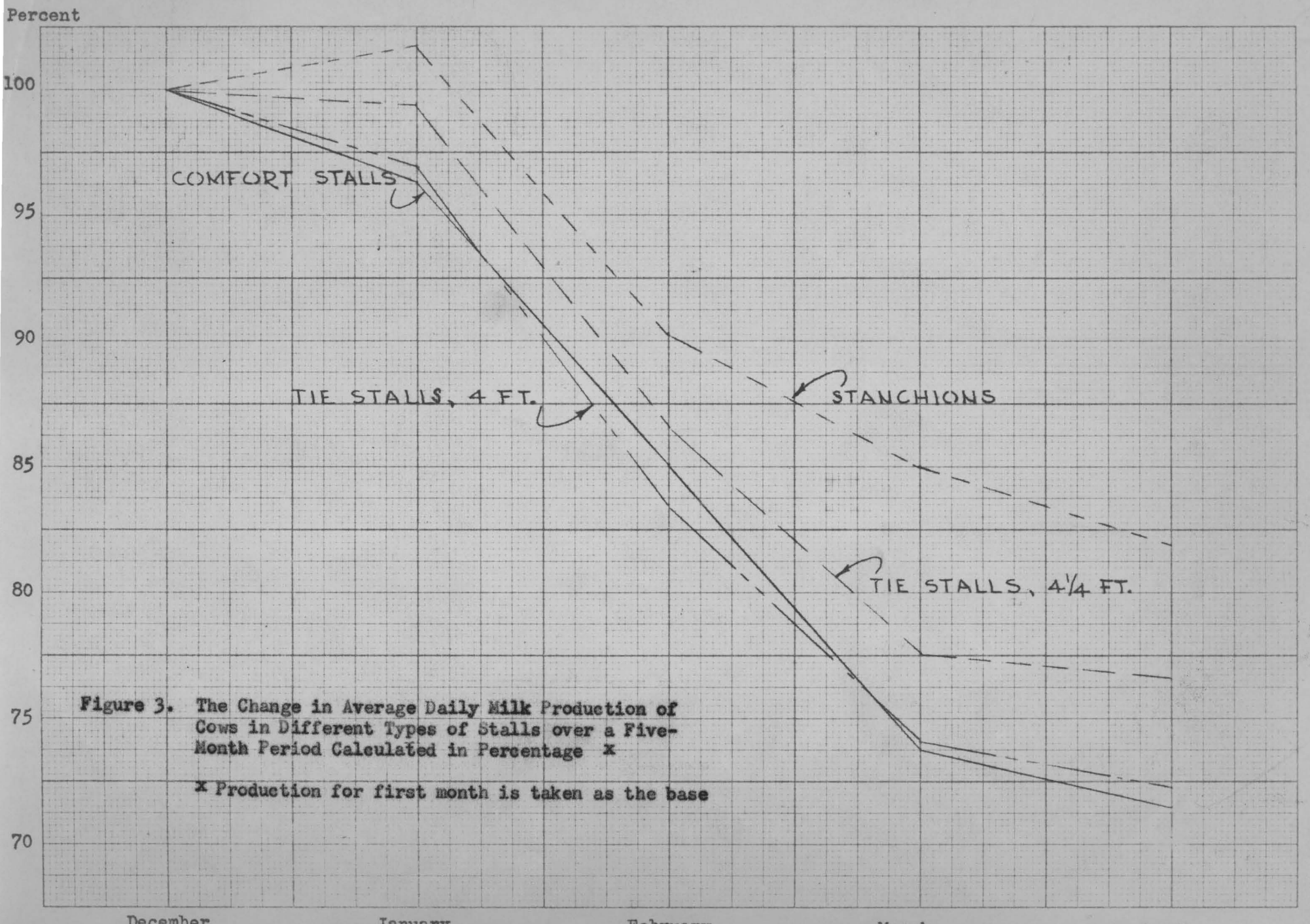

Figure 3. The Change in Average Daily Milk Production of Cows in Different Types of Stalls over a Five-Month Period Calculated in Percentage x

x Production for first month is taken as the base

IV. DISCUSSION

The time required to clean and brush cows appears not to be influenced by the type of stall studied. The small variation indicated in Table 1 was not statistically significant. It would appear that it was equally as easy to work in and around the cows in either of the different types of stalls. Any variation can, in all probability, be correlated with the effect of the stall on the cleanliness of the cow.

The average stall cleaning time of 1.47 minutes per day for the comfort stalls was 39.0 seconds longer than for the tie stalls and 43.8 seconds longer than for the stanchions. This was the time required to remove manure and soiled bedding from the stall platform into the gutter. The difference between the comfort stall and the tie stall was considerably greater than 6.8 seconds which was reported by Porterfield[8] at the University of West Virginia. The comfort stalls that were used in this study were eight inches longer than those used by Porterfield. The additional length may account for a longer time to clean them. The greater time required by the comfort stall was highly significant compared to the other two types of stalls. The difference between the stanchion and tie stall was not significant. There are several factors that could contribute to certain stalls getting dirtier

than others. The fact that cows have greater freedom of movement in the comfort stall compared with the other stalls would possibly cause the stall to become dirtier. The stanchion used has adjustments which facilitate holding the cow more nearly in a position that will assure the majority of the droppings falling into the gutter. It is possible, too, that height of manger will affect cleanliness. The act of reaching out into the feed alley in the low manger to reach feed that has been thrown out could account for dirtier stall platforms.

Removing manure from the barn by the conventional litter carrier method required considerably more time than did the truck or the mechanical gutter cleaner. These differences in the time required when analyzed statistically, were found to be highly significant. Analysis of variance indicated that the difference between the truck and the litter carrier was highly significant in favor of the truck. The greater time for the litter carrier was due to the handling of the manure in small quantities for all operations and therefore requiring more trips from the barn to the collection point. When the truck was used it was driven through the barn and the manure loaded directly on from both sides. Generally, these results are in agreement with those of Carter[3] who reported that the use of improved methods and improved barn

arrangement resulted in a reduction of time required to remove the manure.

Comparison of the mechanical gutter cleaner with the litter carrier and the truck revealed that the least time was required with the mechanical gutter cleaner. The differences were highly significant. There was a significant difference between the mechanical gutter cleaner and the litter carrier, however between the mechanical gutter cleaner and the truck there was no statistical difference. From the standpoint that the mechanical gutter cleaner does not require any expenditure of man hours in the time required to clean the manure from the gutter, this is not a true presentation with regard to labor efficiency. In order to get a valid comparison of the mechanical gutter cleaner and the other two methods it is necessary to determine the labor involved in the combined operations of cleaning the stalls in the entire barn plus the actual man hours of labor required by each method to remove the manure from the gutter out of the barn. The total stall cleaning time of the entire barn was 52.43 minutes for 56 stalls. Add to this figure the average daily requirements in man hours of labor by each of the methods of removing manure. The totals of these two figures should be a valid comparison between the methods. If this procedure is followed the mechanical gutter cleaner with no man hours of labor involved would require the least total time. In order to make such

a comparison it must be assumed that other jobs can be done in and around the barn while the gutter cleaner is in operation. The stalls can be cleaned while the cleaner is operating.

Moving silage by cart and by basket into both high and low feed mangers showed highly significant differences between each method with the exception of high and low mangers for the basket. This showed a significant difference. It can be seen from Table 4 that with the cart method, a greater difference in time was required between the high and low manger than with the basket. This is probably due to the height at which the fork of silage is elevated to place the silage over the high front of the manger. In the basket method considerable time is involved in the travel to and from the silo which in turn overshadows the effect of high and low mangers.

The results obtained in a comparison of the time required to feed baled and loose hay showed that considerable time was saved in feeding the baled hay. As noted in Table 5, less than half the time was required to feed baled hay. Loose hay is quite bulky and hard to move as compared with baled hay, hence the greater time required to handle it. If these figures are generally true it would seem worthwhile to consider all baled hay for barn feeding.

The comparison of central hay chutes with sectional hay chutes for feeding baled hay from an overhead mow indicated slightly less

time was required for feeding from the sectional chutes. The difference was not statistically significant, however it approached very close to the five per cent level of significance. It would seem that additional studies should be made before any conclusions can be made of the relative merits of these two facilities.

The differences in the time required for feeding grain from a cart and from a stationary feed bin in high and low mangers proved highly significant. Various combinations of methods and mangers varied with regard to significant differences. It was found that the cart with high and low mangers showed a highly significant difference in favor of the low manger. A factor is the obstruction presented by the high front of the high manger. A comparison of the time required to place grain into the high mangers showed no significant difference between the methods used, however when placing grain in the low manger a significant saving of time was noted with the cart method compared to the stationary bin method.

The differences in the time involved in fastening and unfastening cows in the different types of stalls was highly significant. Highly significant differences were observed between the comfort stall and the stanchion, and between the tie stall and the stanchion for the fastening operation. The unfastening operation involved slightly less time in all types of stalls than did the fastening. The differences in time required in unfastening

cows in the comfort stalls and the tie stalls was highly significant. No significant difference was indicated for the tie stalls compared with the stanchions.

The various locations of the milker vacuum lines studied seemed to have very little effect on the efficiency with which the air hose could be attached and detached. It was indicated that either of the locations served equally well when the operator became accustomed to the location of the vacuum line. A particular location did require less time in attaching, however when the detaching time was considered, the total time was about the same for all locations. This study was made in the same barn and each of the operators used all of the locations. This necessitated switching from one position to the other during each milking period and may have caused some inefficiency.

A study of the bedding requirements of the different types of stalls was made for both straw and sawdust. As shown in Tables 12 and 13, the comfort stalls required the greatest amount of bedding regardless of type of bedding. These are larger stalls and the larger cows were placed in them. The wider tie stalls required the least amount of bedding. There was not, however, a great variation between the stanchions and either of the tie stall sections. Comparison of the requirements for the stanchions and narrower tie stalls, when straw was used as bedding, showed the stanchions used

slightly more bedding. This might be accounted for by the fact that these were the shortest stalls in the barn. The cows were longer in proportion to this stall than the tie stalls. The shorter stall and the longer cow combination caused more straw to appear in the gutter. Statistical analysis of these data were not attempted. The technique is not readily apparent. It would seem that the initial amount and the amount taken out at the end of the trial complicated the analysis for this single trial. If the study were made over a longer period and several replications made for comparison, a more comprehensive analysis could be made.

Results obtained in the two cleanliness trials conducted showed that cows stayed cleaner in the comfort stalls than in either of the tie stalls. This difference was found to be highly significant. The design of the comfort stall no doubt accounts for this. The crossbar in the rear of the stall and the system of pipes in the front of the cow help to keep the bedding cleaner and consequently the cow remains cleaner. While the average cleanliness scores in Table 14 for straw and sawdust indicate that the cows in the comfort stalls remained cleaner than the cows in the stanchions, these differences were not significant. It appears that the shorter stall and the longer cow combination in the stanchion section helped to keep these cows clean. The restricted movement of the cows in

the stanchions compared to that of the cows in the tie stall sections, probably accounted for the lower score for the former. This difference was not found to be significant. The wider tie stalls showed slightly higher cleanliness scores than the narrower tie stalls. These stalls were longer as well as wider. In addition, the cows had more freedom of movement in that the arches of the stall were about three inches wider apart than in the narrower tie stalls.

Observations were made on the relative amounts of grain wasted by the cows for high and low stall curbs. Indications were that not as much grain was thrown back behind the stall curb when the higher curb was used. This was true to a greater extent in the comfort stall section, since the cow could move her head around with more freedom. It was true to a lesser extent in the stanchion section where the cow's head was confined.

Results of observations on feed thrown out into the feed alley when using high-front mangers and sweep-in mangers revealed that more feed was thrown out when the sweep-in manger was used. This would be the expected result. It was further found that in comparing the sweep-in manger between the stanchion section and the tie stall section slightly more feed was thrown out in the tie section where the cows had more freedom of movement.

Observations on the time cows spent lying down in the different types of stalls were used as an indication of comfort to the cow. Results of observations covering one 24-hour period indicated that the cows in the stanchions spent slightly more time lying down than did the cows in the other types of stalls. The cows in the comfort stalls spent approximately as much time lying down as the cows in the stanchions. As shown in Table 18, the average time the cows spent lying down in the comfort stalls was 13 hours and 33 minutes while the cows in the stanchion stalls spent 14 hours and one minute lying down. Porterfield[8] found that cows spent more time lying down in the comfort stalls. His study included only comfort stalls and tie stalls, however he indicates that if stanchions were used a greater difference in performance should be expected. In his study observations were made in such a way as to observe the same cow's performance in different stalls. This was not the case in this study as the observations were made on different cows. It did not seem practical to move the larger cows over into the smaller stanchion stalls. It is believed that the age of the cow may have some effect on this. It was noted that the younger cows spent more time lying down than did the older cows with the exception of those in the comfort stalls. These results compare favorably with the average time of

13 hours reported by Atkeson[1] for time spent lying down by dry cows and heifers on pasture.

A study made of the production records of cows in different type stalls revealed that there was very little difference in the shape of the lactation curve for any of the stalls. It was noted that in the stanchion section the younger cows seemed to be more persistent in their production than did the cows in the other stalls. Espe[4] stated that heifers are inclined to be more persistent because they are developing in size, body weight and in mammary development. If persistency of production were studied on complete lactations with the same cows in different stalls different results may have been obtained.

Porterfield[8] reported that a greater amount of milk was produced in the comfort stalls than in the tie stalls. He also indicated that greater differences in performance can be expected in favor of the comfort stall if stanchions were also used in the study. His observations were made over a period of several years comparing the production of the same cow in different stalls on an entire lactation basis.

V. SUMMARY AND CONCLUSIONS

1. A nine-day study of the time required to clean and brush cows in the different types of stalls was conducted. Results showed cows in comfort stalls required 1.56 minutes, cows in stanchions required 1.66 minutes, and cows in the tie stalls required 1.67 minutes per cow daily. The differences in time required were not statistically significant.

2. Observations were made over a nine-day period on the time required to clean three types of stalls. A daily average of 1.47 minutes required for the comfort stall was highly significant compared to 0.82 minute for the tie stall, and 0.74 minute for the stanchion. The difference of 0.08 minute between the stanchion and tie stall was not significant.

3. Results of observations on removing manure from the barn by different methods showed that the litter carrier required 43.66 minutes per ton compared with 24.44 minutes per ton for the truck driven through the barn and 18.55 minutes for the mechanical gutter cleaner. The difference is highly significant between the litter carrier and the truck but not significant between the truck and the gutter cleaner. Although this amount of time is required by the mechanical gutter cleaner, it does not represent man hours of labor and consequently is not a true presentation of labor efficiency with regard to the mechanical gutter cleaner.

4. Time required to feed silage by cart and by basket was compared in high and low mangers. Results showed that it required 1.02 minutes per stall to feed by cart and 1.44 minutes by basket in high mangers. When feeding into low mangers it required 0.79 minute per stall for the cart and 1.36 minutes for the basket. These differences were both highly significant. A highly significant difference was noted between high and low mangers when feeding with the cart while a significant difference was indicated for the basket in high and low mangers.

5. Studies were made on the time required to feed loose and baled hay from an adjacent storage barn. Results showed that it required 62.66 minutes per day to feed the loose hay compared to 28.66 minutes to feed baled hay to 51 cows. This difference is highly significant.

6. A study on the time required to feed baled hay from an overhead mow using central and sectional hay chutes was made. Results were: 23.20 minutes per day for the central chute and 20.75 minutes per day for the sectional chutes to feed 28 cows. This difference is hardly significant.

7. Studies were made comparing the time required to feed grain from a stationary bin and from a cart into high and low mangers. Results showed that when feeding into a high manger it required 0.561 minute per stall to feed from a stationary bin and 0.527 minute when

the cart was used. This difference was not significant. When feeding into the low manger the stationary bin required 0.543 minute compared to 0.436 minute for the cart. This difference was highly significant. The difference between high and low mangers for the cart was highly significant while that for the stationary bin was not.

8. A study to compare the time required to fasten and unfasten cows in the different type stalls was made. The time required to fasten cows in comfort stalls was 0.167 minute per stall, 0.119 minute per tie stall and 0.096 minute per stanchion stall. Time required to unfasten cows in the comfort stall was 0.120 minute per stall, 0.101 minute per tie stall and 0.079 minute per stanchion stall. All differences were highly significant with the exception of the difference in the unfastening time between the stanchions and tie stalls.

9. Time required to attach and detach milker vacuum hose with the vacuum line in various locations was studied. Results showed no significant differences in time required for the combined operations of attaching and detaching for any of the locations. When the vacuum line was placed along the top of the comfort stall it required 4.87 seconds per cow to attach and 4.00 seconds per cow to detach the milker hose. When it was placed along the top of the stanchions 5.30 seconds were required to attach and 3.33 seconds were required to detach the milker hose for each cow. When

overhead towards the rear of the tie stalls with stall cock pointing forward 4.90 seconds to attach and 3.50 seconds to detach the milker hose were required. When placed overhead toward the rear of the tie stall with stall cock pointing backward 5.87 seconds to attach and 3.10 seconds to detach the milker hose were required.

10. Trials comparing the amounts of bedding required for the different types of stalls for straw and sawdust were conducted. Results showed that the comfort stalls required 8.08 pounds of straw or 35.52 pounds of sawdust. Stanchions required 5.99 pounds of straw or 31.73 pounds of sawdust. Tie stalls four feet wide required 5.70 pounds of straw or 31.76 pounds of sawdust. Tie stalls four feet, three inches wide required 5.67 pounds of straw or 30.00 pounds of sawdust. The amounts were of bedding computed on a daily basis.

11. Trials in which cows in different types of stalls were scored for cleanliness were conducted. Comparisons were made of both straw and sawdust as the bedding material. Results showed that cows in comfort stalls received an average daily score of 2.00 when straw was used or 0.78 when sawdust was used. Cows in stanchions received a score of 2.99 bedded with straw or 1.47 when sawdust was used. Cows in tie stalls four feet wide received a score of 3.51 bedded with straw or 2.03 when sawdust was used. Cows in tie stalls four feet, three inches wide received a

score of 3.66 bedded with straw or 2.08 when sawdust was used. The difference between the scores for the comfort stalls and the tie stalls was highly significant regardless of the type of bedding used. The differences between the scores for the comfort stalls and the stanchions, and the stanchion and the tie stalls showed no statistical significance. Highly significant differences were found between the scores for straw and sawdust in favor of the sawdust for each type of stall.

12. Observations on grain wasted with high and low stall curbs indicated that less grain was wasted with the high stall curbs. Observations on grain thrown out of the feed manger into the feed alley in different types of stalls with different types of mangers indicated that the high front manger with the tie stalls resulted in less grain thrown into the feed alley by the cows. The stanchions with sweep-in manger resulted in 0.037 pound of grain per stall thrown into the feed alley. The tie stall and sweep-in type manger resulted in 0.041 pound and the tie stalls with the high front manger resulted in 0.002 pound of grain thrown into the feed alley. No grain was observed to have been thrown out of the high front mangers in the comfort stalls by the cows.

13. Observations were made of the amount of time cows spent lying down during a 24-hour period in the different types of stalls. This was used as an indication of comfort. Results showed that cows in stanchions spent 14 hours, one minute out of the 24-hour period

lying down. Cows in comfort stalls spent 13 hours, 33 minutes lying down. Cows in the tie stalls four feet wide spent 12 hours, 58 minutes lying down and cows in the tie stalls four feet, three inches wide spent 12 hours, 56 minutes lying down.

14. An analysis of the production records of the cows in this study was made to determine the effect of the type of stall on the milk production. The ages of the cows in the different types of stalls were not comparable. It did not seem advisable to rotate the cows in the different stalls for this short period nor was it practical to place the larger cows in the smaller stanchions and tie stalls. The comparisons were made on the percentage change in production for the five-month period using the first month's production of each group as 100 per cent. Results showed that cows in the comfort stalls dropped to 71.5 per cent the fifth month, the cows in the stanchions declined to 81.9 per cent, those in the tie stalls, four feet wide dropped to 72.2 per cent and those in the tie stalls, four feet, three inches wide produced 76.6 per cent of the first month's production in the fifth month. It should be noted that the first calf heifers in the stanchions were more persistent than the older cows. This might have been influenced by the fact that these heifers were growing and increasing in size during this period. This persistency of the heifers may have overshowed any difference in production due to the different types of stalls.

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Appendix A

Tables of Basic Data

Table 20

Length of Stall Compared to Length of Cow in the Stall for Stanchions and Tie Stalls

Type of Stall	Average Length of Stall	Average Length of Cow in Stall	Difference in Stall Length Over Cow Length
	inches	inches	inches
Stanchion	60	61.3	- 1.3
Tie, 4 feet wide	64	63.0	+ 1.0
Tie, 4 feet, 3 inches wide	66	64.0	+ 2.0

Table 21

Time Required to Clean and Brush Cows in Different Types of Stalls

Type of Stall	No of Stalls	Observations									Total Time	Daily Average	Average per Stall
		1	2	3	4	5	6	7	8	9	minutes	minutes	minutes
Comfort	12	22.5	25.0	22.0	9.5	16.0	16.0	22.5	17.0	18.5	169.0	18.78	1.56
Stanchion	15	14.5	41.0	26.0	11.5	24.5	21.5	35.0	26.5	23.5	224.0	24.89	1.66
Tie	29	52.0	76.0	56.0	25.5	37.5	50.0	50.0	48.0	40.5	435.5	48.39	1.67

Table 22

Time Required to Clean Different Types of Stalls

Type of Stall	No of Stalls	Observations									Total Time	Daily Average	Average per Stall
		1	2	3	4	5	6	7	8	9	minutes	minutes	minutes
Comfort	12	13.5	16.0	14.5	15.0	14.0	19.5	22.0	19.5	25.0	159.0	17.66	1.47
Stanchion	15	6.5	10.5	10.0	8.0	8.5	9.5	15.0	14.5	17.5	100.0	11.11	0.74
Tie	29	13.0	18.5	19.0	17.0	16.5	25.5	36.5	33.5	34.0	213.0	23.66	0.82

Table 23

Time Required to Remove Manure from the Barn by Different Methods

Method	Observations			Total Time	Daily Average	Approximate Amount Removed	Average Time Per Ton
	1	2	3	minutes	minutes	tons	minutes
Litter Carrier	85	79	98	262	87.33	2	43.66
Truck	62	66	92	220	73.33	3	24.44
Mechanical Gutter Cleaner	59	57	51	167	55.66	3	18.55

Table 24

Time Required to Feed Silage by Cart and by Basket in High and Low Mangers

Method	Type of Manger	No of Stalls	Observations											Total Time	Daily Average	Average Per Stall
			1	2	3	4	5	6	7	8	9	10	11	minutes	minutes	minutes
Cart	High	12	13.5	18.0	11.0	11.0	10.5	10.5	11.0	12.5	11.0	13.5	13.5	135.5	12.31	1.02
Cart	Low	15	11.0	15.0	10.0	10.0	10.0	10.5	12.0	13.5	11.5	12.0	13.0	128.5	11.68	.79
Basket	Low	15	23.0	23.0	20.5	17.5	17.5	18.0	21.0	22.0	20.0	20.5	21.5	224.5	20.41	1.36
Basket	High	14	20.5	24.0	18.5	19.5	18.5	17.5	21.0	21.0	20.5	20.0	21.0	222.0	20.19	1.44

Table 25

Time Required to Feed Loose and Baled Hay from an Adjacent Barn

Form in Which Hay was Fed	Observations			Total Time	Daily Average
	1	2	3	minutes	minutes
Loose	68	61	59	188	62.66
Baled	31	26	29	86	28.66

Table 26

Time Required to Feed Baled Hay from a Central Hay Chute and Sectional Hay Chutes

Type of Chute	Observations										Total Time	Daily Average
	1	2	3	4	5	6	7	8	9	10	minutes	minutes
Central	26.0	26.0	20.0	23.0	21.5	21.0	19.0	22.0	25.0	28.5	232.0	23.20
Sectional	19.0	23.0	23.0	18.5	23.5	16.0	18.5	20.0	26.0	20.0	207.5	20.75

Table 27

Time Required to Feed Grain from a Cart and from a Stationary Feed Bin in High and Low Feed Mangers

Method	Type of Manger	No of Stalls	Observations											Total Time	Daily Average	Average Per Stall
			1	2	3	4	5	6	7	8	9	10	11	minutes	minutes	minutes
Cart	High	12	8.0	8.0	5.5	5.5	4.5	6.0	5.5	6.5	6.0	7.0	7.0	69.5	6.33	0.527
Cart	Low	15	8.0	8.0	4.5	5.0	4.0	5.5	5.5	7.5	7.5	8.0	8.5	72.0	6.54	0.436
Stationary Feed Bin	High	14	11.5	11.0	7.0	5.0	5.0	6.5	6.5	7.5	7.5	9.5	9.5	86.5	7.86	0.562
Stationary Feed Bin	Low	15	8.5	11.5	8.5	7.5	6.0	6.5	7.0	8.0	8.0	8.5	9.5	89.5	8.14	0.543

Table 28

Time Required to Fasten Cows in Different Types of Stalls

Type of Stall	No of Stalls	Observations				Total Time	Average for Section	Average per Stall
		1	2	3	4	minutes	minutes	minutes
Comfort	12	2.00	2.00	1.75	2.25	8.00	2.00	0.167
Stanchion	15	1.50	1.50	1.25	1.50	5.75	1.44	0.096
Tie	29	3.50	3.75	3.00	3.50	13.75	3.44	0.119

Table 29

Time Required to Unfasten Cows from Different Types of Stalls

Type of Stall	No of Stalls	Observations				Total Time	Average for Section	Average per Stall
		1	2	3	4	minutes	minutes	minutes
Comfort	12	1.50	1.50	1.50	1.25	5.75	1.44	0.120
Stanchion	15	1.50	1.50	1.00	0.75	4.75	1.19	0.079
Tie	29	3.00	3.00	3.25	2.50	11.75	2.94	0.101

Table 30

Time Required to Attach the Vacuum Hose with the Vacuum Line in Different Locations

Location	Observations															Total Time	Average Per Operation
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	seconds	seconds
About 4 feet high, along front of comfort stalls	7.0	5.0	6.0	4.5	5.5	3.5	3.5	5.0	5.0	5.0	4.5	4.5	4.5	5.0	4.5	73.0	4.87
About 5 feet high, along front of stanchions	5.5	4.0	5.5	5.0	5.0	5.0	7.0	6.0	5.5	5.5	5.5	5.0	5.0	5.5	4.5	79.5	5.30
About 6 feet, 7 inches high, toward rear of tie stalls, stall cocks pointing toward feed manger	6.0	5.0	7.0	6.5	5.0	5.5	6.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.5	73.5	4.90
About 6 feet, 7 inches high, toward rear of tie stalls, stall cocks pointing toward litter alley	5.5	5.0	5.5	6.0	6.0	5.5	5.5	5.5	5.5	5.0	8.0	7.0	8.0	5.5	4.5	88.0	5.87

Table 31

Time Required to Detach the Vacuum Hose with the Vacuum Line in Different Locations

Location	Observations															Total Time	Average Per Operation
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	seconds	seconds
About 4 feet high, along front of comfort stalls	3.0	4.5	3.5	5.0	3.5	5.0	4.5	3.5	3.5	3.5	5.0	4.5	3.5	4.0	3.5	60.0	4.00
About 5 feet high, along front of stanchions	2.5	2.5	2.5	4.0	3.0	2.5	3.5	4.5	3.0	3.5	4.0	3.5	4.5	4.0	3.5	50.0	3.33
About 6 feet, 7 inches high, toward rear of tie stalls, stall cocks pointing toward feed manger	3.5	2.5	3.5	2.5	3.5	3.5	3.0	5.5	3.5	3.5	4.0	4.0	3.5	3.5	3.0	52.5	3.50
About 6 feet, 7 inches high, toward rear of tie stalls, stall cocks pointing toward litter alley	2.5	3.0	3.0	2.5	2.5	3.0	2.5	2.5	4.0	4.0	3.5	4.0	3.0	3.5	3.0	46.5	3.10

Table 32

Amount of Bedding Required for Different Types of Stalls when Straw Was Used

Type of Stall	No of Stalls	Initial Amount	Amounts Added Per Day										Total Amount	Amount Removed	Amount Used	Daily Amount	Average Per Stall
			1	2	3	4	5	6	7	8	9	10					
		pounds											pounds	pounds	pounds	pounds	pounds
Comfort	6	102	69	104	58	40	87	70	55	56	67	67	775	290	485	48.50	8.08
Stanchion	8	78	38	59	63	40	73	57	32	58	60	56	614	135	479	47.90	5.99
Tie, 4 feet wide	8	86	38	66	58	40	58	57	33	66	59	65	626	170	456	45.60	5.70
Tie, 4 feet, 3 inches wide	7	78	41	76	38	30	61	52	37	48	57	49	567	170	397	39.70	5.67

Table 33

Amount of Bedding Required for Different

Types of Stalls When Sawdust Was Used

Type of Stall	No of Stalls	Initial Amount	Amount Added Per Day										Total Amount	Amount Removed	Amount Used	Daily Amount	Average Per Stall
			1	2	3	4	5	6	7	8	9	10					
		pounds											pounds	pounds	pounds	pounds	pounds
Comfort	6	1400	510	480	0	56	127	127	85	112	170	112	3179	1048	2131	213.1	35.52
Stanchion	7	700	225	212	170	85	170	170	170	234	255	255	2646	425	2221	222.1	31.73
Tie, 4 feet wide	7	850	85	212	85	85	212	127	170	340	340	255	2761	538	2223	222.3	31.76
Tie, 4 feet 3 inches wide	7	985	0	212	0	113	111	170	170	311	311	255	2638	538	2100	210.0	30.00

Table 34

Daily Cleanliness Scores of Cows in Different Types of Stalls when Straw was Used as Bedding (First Trial)

Type of Stall	No of Stalls	Daily Scores					Total of Scores	Daily Average	Average Per Day Per Cow
		1	2	3	4	5			
Comfort	6	8	8	12	7	9	44	8.80	1.47
Stanchion	8	16	18	21	17	22	94	18.80	2.35
Tie, 4 feet wide	8	9	12	13	22	11	67	13.40	1.68
Tie, 4 feet, 3 inches wide	7	25	26	23	13	19	106	21.20	3.03

Table 35

Daily Cleanliness Scores of Cows in Different Types of Stalls when Straw was Used as Bedding (Second Trial)

Type of Stall	No of Stalls	Daily Scores					Total of Scores	Daily Average	Average Per Day Per Cow
		1	2	3	4	5			
Comfort	6	23	10	13	15	16	76	15.20	2.53
Stanchion	7	23	34	17	23	33	130	26.00	3.71
Tie, 4 feet wide	7	40	41	32	40	43	196	39.20	5.60
Tie, 4 feet, 3 inches wide	7	25	21	35	35	34	150	30.00	4.29

Table 36

Daily Cleanliness Scores of Cows in Different Types of Stalls when Sawdust was Used as Bedding (First Trial)

Type of Stall	No of Stalls	Daily Scores					Total of Scores	Daily Average	Average Per Day Per Cow
		1	2	3	4	5			
Comfort	6	9	10	5	2	2	28	5.60	0.93
Stanchion	7	11	3	6	13	15	48	9.60	1.37
Tie, 4 feet wide	7	19	21	23	27	13	103	20.60	2.94
Tie, 4 feet 3 inches wide	7	6	21	22	13	11	73	14.60	2.08

Table 37

Daily Cleanliness Scores of Cows in Different Types of Stalls when Sawdust was Used as Bedding (Second Trial)

Type of Stall	No of Stalls	Daily Scores					Total of Scores	Daily Average	Average Per Day Per Cow
		1	2	3	4	5			
Comfort	6	2	3	7	3	4	19	3.80	0.63
Stanchion	8	11	6	11	16	18	62	12.40	1.55
Tie, 4 feet wide	8	4	10	11	11	13	49	9.80	1.22
Tie, 4 feet, 3 inches wide	7	16	17	10	17	13	73	14.60	2.09

Table 38

Amount of Grain Thrown Out of Feed Manger into Feed Alley by the Cows with Different Types of Mangers and Different Types of Stalls

Type of Stall	Type of Manger	No of Stalls	Amount of Grain Thrown Out			Total Amount Thrown Out	Average Per Stall Per Day
			1	2	3	pounds	pounds
Comfort	High	12	0.00	0.00	0.00	0.00	0.000
Stanchion	Low	15	0.80	0.40	0.50	1.70	0.037
Tie, 4 feet wide	Low	15	0.75	0.60	0.50	1.85	0.041
Tie, 4 feet, 3 inches wide	High	14	0.10	0.00	0.00	0.10	0.002

Table 39

Amount of Time Cows Spent Lying Down in

Different Types of Stalls

Type of Stalls	No. of Cows	Time Spent Lying Down															Average Per Cow
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Hours - Minutes															Hrs-Mins.
Comfort	12	11-38	14-48	16-30	13-00	8-54	13-01	10-56	15-17	14-40	18-01	12-34	13-12				13-33
Stanchion	15	13-47	13-30	13-25	13-11	12-24	15-16	13-26	13-14	15-27	13-04	14-42	12-59	13-43	17-41	14-24	14-01
Tie, 4 feet wide	15	13-35	10-09	9-14	13-25	13-46	12-59	11-57	14-00	14-15	13-33	14-34	13-33	15-47	14-47	8-49	12-58
Tie, 4 feet 3 inches wide	14	9-31	14-00	12-51	7-34	8-51	11-47	8-09	15-20	14-00	15-26	14-35	12-01	11-21	14-39		12-09

Table 40

Daily Milk Production of Five Cows in Comfort Stalls for a Five-Month Period

Month	Average Daily Milk Production					Total Milk Produced	Daily Average	Milk[x] Production
	1	2	3	4	5	pounds	pounds	per cent
December	72.1	57.0	66.3	63.4	53.3	312.1	62.4	100.0
January	69.9	54.3	64.6	55.9	55.8	300.5	60.1	96.3
February	61.2	53.8	56.2	44.6	49.5	265.3	53.1	85.1
March	49.8	48.6	49.7	39.1	43.0	230.2	46.0	73.7
April	47.8	46.7	48.1	38.7	42.1	223.4	44.6	71.5

[x] Milk production in December used as base to determine change in milk production in succeeding months.

Table 41

Daily Milk Production of Nine Cows in Stanchions for a Five-Month Period

Month	Average Daily Milk Production									Total Milk Produced	Daily Average	Milk[x] Production
	1	2	3	4	5	6	7	8	9	pounds	pounds	per cent
December	43.3	53.4	43.3	44.7	46.6	45.0	42.3	50.4	44.0	413.0	45.9	100.0
January	47.6	50.4	43.2	45.6	47.4	44.4	44.0	51.8	45.6	420.0	46.7	101.7
February	42.7	44.6	37.2	40.8	40.9	39.4	40.8	46.5	39.9	372.8	41.4	90.2
March	39.1	39.0	35.5	38.3	38.8	39.4	38.8	43.4	38.8	351.1	39.0	85.0
April	37.6	32.6	35.7	38.1	39.1	35.8	38.9	41.5	39.5	338.4	37.6	81.9

[x] Milk production in December used as base to determine change in milk production in succeeding months.

Table 42

Daily Milk Production of Eight Cows in Tie Stalls Four Feet Wide for a Five-Month Period

Month	Average Daily Milk Production								Total Milk Produced	Daily Average	Milk[x] Production
	1	2	3	4	5	6	7	8	pounds	pounds	per cent
December	36.7	45.0	28.9	58.4	50.6	42.8	68.8	60.8	392.0	49.0	100.0
January	34.7	44.0	23.7	57.5	52.2	44.6	63.4	60.2	380.3	47.5	96.9
February	29.4	38.9	19.6	51.6	48.3	38.1	50.6	50.7	327.2	40.9	83.5
March	27.4	33.9	17.2	46.7	44.8	33.8	44.1	42.6	290.5	36.3	74.1
April	29.8	32.9	14.1	46.2	45.8	32.4	41.2	40.9	283.3	35.4	72.2

[x] Milk production in December used as base to determine change in milk production in succeeding months.

Table 43

Daily Milk Production of Seven Cows in Tie Stalls Four Feet, Three Inches Wide for a Five-Month Period

Month	Average Daily Milk Production							Total Milk Produced	Daily Average	Milk Production[x]
	1	2	3	4	5	6	7	pounds	pounds	per cent
December	58.2	56.9	43.1	55.1	58.5	59.1	46.6	377.5	53.9	100.0
January	59.0	63.5	46.1	45.6	55.2	58.1	48.1	375.6	53.6	99.4
February	48.5	58.4	41.5	40.2	45.0	51.5	41.7	326.8	46.7	86.6
March	43.3	54.5	36.7	36.1	40.4	46.8	34.9	292.7	41.8	77.6
April	43.8	54.1	35.9	34.1	40.4	46.5	34.3	289.1	41.3	76.6

[x] Milk production in December used as base to determine change in milk production in succeeding months.

Appendix B

Tables of Statistical Analysis

Table 44

Analysis of Variance of Differences in Time Required to Clean and Brush Cows in Comfort Stalls, Stanchions and Tie Stalls

Source of variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Stalls	2	0.06	0.03	0.375
Between Days	8	4.91	0.64	8.000^{xx}
Error	16	1.23	0.08	
Total	26	6.20	0.24	

^{xx} Highly significant

Table 45

Analysis of Variance of Differences in Time Required to Clean Comfort Stalls, Stanchions and Tie Stalls

Source of variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Stalls	2	2.85	1.43	28.40^{xx}
Between Days	8	1.81	0.23	4.60^{xx}
Error	16	0.77	0.05	
Total	26	5.43		

^{xx} Highly significant

Table 46

Analysis of Variance of the Difference in Time Required to Clean Stanchions and Tie Stalls

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Stalls	1	0.025	0.025	3.57
Between Days	8	1.171	0.146	20.85^{xx}
Error	8	0.058	0.007	
Total	17	1.254		

^{xx} Highly significant

Table 47

Analysis of Variance of the Differences in Time Required to Clean Manure from the Barn by Litter Carrier, Truck and Mechanical Gutter Cleaner

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Methods	2	1033.46	516.73	34.86^{xx}
Between Days	2	50.96	25.48	1.72
Error	4	59.26	14.82	
Total	8	1143.68		

^{xx} Highly significant

Table 48

Analysis of Variance of the Difference in Time Required to Clean Manure from the Barn by Litter Carrier and Truck

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Methods	1	552.96	552.96	211.05^{xx}
Between Days	2	101.07	50.54	19.29^{x}
Error	2	5.23	2.62	
Total	5	659.26		

^{x} Significant
^{xx} Highly significant

Table 49

Analysis of Variance of the Difference in Time Required to Clean Manure from the Barn by Truck and Mechanical Gutter Cleaner

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Methods	1	52.21	52.21	2.24
Between Days	2	16.42	8.21	0.35
Error	2	46.64	23.32	
Total	5	115.27		

Table 50

Analysis of Variance of the Differences in Time Required to Feed Silage by Cart and by Basket in High and Low Mangers

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Methods	3	3.05	1.017	169.50^{xx}
Between Days	10	0.64	0.064	10.60^{xx}
Error	30	0.18	0.006	
Total	43	3.87		

^{xx} Highly significant

Table 51

Analysis of Variance of the Difference in Time Required to Feed Silage by Cart and by Basket in Low Mangers

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Methods	1	185.60	185.60	431.62^{xx}
Between Days	10	24.93	2.49	5.79^{xx}
Error	10	4.30	0.43	
Total	21	214.83		

^{xx} Highly significant

Table 52

Analysis of Variance of the Difference in Time Required to Feed Silage by Cart and by Basket in High Mangers

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Methods	1	0.90	0.900	128.57^{xx}
Between Days	10	0.45	0.045	6.43^{xx}
Error	10	0.07	0.007	
Total	21	1.42		

^{xx} Highly significant

Table 53

Analysis of Variance of the Difference in Time Required to Feed Silage by Basket in High and Low Mangers

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Mangers	1	3.44	3.44	8.60^{xx}
Between Days	10	28.69	2.87	7.18^{xx}
Error	10	4.04	0.40	
Total	21	36.17		

^{xx} Highly significant

Table 54

Analysis of Variance of the Difference in Time Required to Feed Silage by Cart in High and Low Mangers

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Mangers	1	33.38	33.38	47.01^{xx}
Between Days	10	40.22	4.02	5.66^{xx}
Error	10	7.09	0.71	
Total	21	80.69		

^{xx} Highly significant

Table 55

Analysis of Variance of the Difference in Time Required to Feed Baled Hay from a Central and Sectional Hay Chutes

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Methods	1	30.01	30.01	4.06
Between Days	9	99.74	11.08	1.50
Error	9	66.49	7.39	
Total	19	196.24		

Table 56

Analysis of Variance of the Differences in Time Required to Feed Grain from a Cart and Stationary Feed Bin in High and Low Mangers

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Stalls	3	0.1013	0.0338	10.56^{XX}
Between Days	10	0.4626	0.0463	14.47^{XX}
Error	30	0.0945	0.0032	
Total	43	0.6584		

^{XX} Highly significant

Table 57

Analysis of Variance of the Difference in Time Required to Feed Grain from a Cart and Stationary Feed Bin in Low Mangers

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Methods	1	0.061692	0.061692	17.48^{XX}
Between Days	10	0.185539	0.018554	5.26^{XX}
Error	10	0.035288	0.003529	
Total	21	0.282519		

^{XX} Highly significant

Table 58

Analysis of Variance of the Difference in Time Required to Feed Grain from a Cart and Stationary Feed Bin in High Mangers

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Methods	1	0.006737	0.006737	2.34
Between Days	10	0.307426	0.030743	10.66^{xx}
Error	10	0.028829	0.002883	
Total	21	0.342992		

^{xx} Highly significant

Table 59

Analysis of Variance of the Difference in Time Required to Feed Grain from a Cart in High and Low Mangers

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Mangers	1	0.044640	0.044640	30.68^{xx}
Between Days	10	0.190278	0.019028	13.08^{xx}
Error	10	0.014546	0.001455	
Total	21	0.249464		

^{xx} Highly significant

Table 60

Analysis of Variance of the Difference in Time Required to Feed Grain from a Stationary Feed Bin into High and Low Mangers

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Mangers	1	0.002023	0.002023	0.393
Between Days	10	0.300744	0.030074	5.84^{xx}
Error	10	0.051514	0.005151	
Total	21	0.354281		

^{xx} Highly significant

Table 61

Analysis of Variance of the Differences in Time Required to Fasten Cows in Comfort Stalls, Stanchions, and Tie Stalls

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	2	0.0104	0.00520	86.66^{xx}
Between Days	3	0.0011	0.00036	6.00^{xx}
Error	6	0.0004	0.00006	
Total	11	0.0119		

^{xx} Highly significant

Table 62

Analysis of Variance of the Difference in Time Required to Fasten Cows in Stanchions and Tie Stalls

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	1	0.001058	0.001058	132.25^{xx}
Between Days	3	0.000526	0.000175	21.88^{xx}
Error	3	0.000024	0.000008	
Total	7	0.001608		

^{xx} Highly significant

Table 63

Analysis of Variance of the Difference in Time Required to Fasten Cows in Comfort and Tie Stalls

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	1	0.004657	0.004657	55.44^{xx}
Between Days	3	0.000964	0.000321	3.87
Error	3	0.000250	0.000083	
Total	7	0.005871		

^{xx} Highly significant

Table 64

Analysis of Variance of the Differences in Time Required to Unfasten Cows from Comfort Stalls, Stanchions and Tie Stalls

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	2	0.0036	0.0018	18.00[xx]
Between Days	3	0.0017	0.0006	6.00[xx]
Error	6	0.0010	0.0001	
Total	11	0.0063		

[xx] Highly significant

Table 65

Analysis of Variance of the Difference in Time Required to Unfasten Cows from Stanchions and Tie Stalls

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	1	0.000990	0.000990	4.32
Between Days	3	0.001543	0.000514	2.24
Error	3	0.000687	0.000229	
Total	7	0.003220		

Table 66

Analysis of Variance of the Difference in Time Required to Unfasten Cows from Comfort and Tie Stalls

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	1	0.000666	0.000666	95.14^{xx}
Between Days	3	0.000672	0.000224	32.00^{xx}
Error	3	0.000022	0.000007	
Total	7	0.001360		

^{xx} Highly significant

Table 67

Analysis of Variance of the Differences in Time Required to Attach and Detach the Milker Vacuum Hose from the Vacuum Line with the Line in Different Locations

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Locations	3	1.82	0.607	0.546
Between Operations	14	12.12	0.866	0.779
Error	42	46.68	1.111	
Total	59	60.62		

Table 68

Analysis of Variance of the Differences in Cleanliness Scores of Cows in Comfort Stalls, Stanchions and Tie Stalls when Straw was Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	3	8.41	2.803	12.86^{xx}
Between Days	4	0.27	0.068	0.31
Error	12	2.61	0.218	
Total	19	11.29		

^{xx} Highly significant

Table 69

Analysis of Variance of the Difference in Cleanliness Scores of Cows in Comfort Stalls and Stanchions when Straw was Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	1	2.4305	2.4305	7.290*
Between Days	4	0.4398	0.1100	0.329
Error	4	1.3336	0.3334	
Total	9	4.2039		

* Approaches significances at five per cent level

Table 70

Analysis of Variance of the Difference in Cleanliness Scores of Cows in Stanchions and Tie Stalls When Straw was Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	1	0.6812	0.6812	5.09
Between Days	4	1.1245	0.2811	2.09
Error	4	0.5378	0.1344	
Total	9	2.3435		

Table 71

Analysis of Variance of the Difference in Cleanliness Scores of Cows in Comfort and Tie Stalls When Straw was Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	1	5.6852	5.6852	23.66^{xx}
Between Days	4	0.3707	0.0927	0.38
Error	4	0.9615	0.2403	
Total	9	7.0174		

^{xx} Highly significant

Table 72

Analysis of Variance of the Differences in Cleanliness Scores of Cows in Comfort Stalls, Stanchions, and Tie Stalls when Sawdust was Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	3	5.4685	1.8228	7.31^{xx}
Between Days	4	0.3823	0.0956	0.38
Error	12	2.9899	0.2492	
Total	19	8.8407		

^{xx} Highly significant

Table 73

Analysis of Variance of the Difference in Cleanliness Scores of Cows in Comfort Stalls and Stanchions when Sawdust was Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	1	1.3032	1.3032	3.25
Between Days	4	0.2777	0.0694	0.17
Error	4	1.6028	0.4007	
Total	9	3.1837		

Table 74

Analysis of Variance of the Difference in Cleanliness Scores of Cows in Stanchion and Tie Stalls when Sawdust was Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	1	0.6761	0.6761	1.26
Between Days	4	0.0252	0.0063	0.01
Error	4	2.1384	0.5346	
Total	9	2.8397		

Table 75

Analysis of Variance of the Difference in Cleanliness Scores of Cows in Comfort and Tie Stalls when Sawdust was Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Stalls	1	3.8564	3.8564	25.34^{xx}
Between Days	4	0.4064	0.1016	0.67
Error	4	0.6087	0.1522	
Total	9	4.8715		

^{xx} Highly significant

Table 76

Analysis of Variance of the Difference in Cleanliness Scores of Cows in Comfort Stalls when Straw and Sawdust were Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Materials	1	3.6845	3.6845	30.45^{xx}
Between Days	4	0.5038	0.1260	0.04
Error	4	0.4838	0.1210	
Total	9	4.6721		

^{xx} Highly significant

Table 77

Analysis of Variance of the Difference in Cleanliness Scores of Cows in Stanchions when Straw and Sawdust were Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Materials	1	5.4612	5.4612	16.20^{x}
Between Days	4	1.3183	0.3296	0.98
Error	4	1.3480	0.3370	
Total	9	8.1275		

^{x} Significant

Table 78

Analysis of Variance of the Difference in Cleanliness Scores of Cows in Tie Stalls Four Feet Wide when Straw and Sawdust were Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Materials	1	5.4760	5.4760	54.98^{xx}
Between Days	4	0.9611	0.2403	2.41
Error	4	0.3985	0.0996	
Total	9	6.8356		

^{xx} Highly significant

Table 79

Analysis of Variance of the Difference in Cleanliness Scores of Cows in Tie Stalls Four Feet, Three Inches Wide when Straw and Sawdust were Used as Bedding

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Between Materials	1	6.1780	6.1780	34.36^{xx}
Between Days	4	0.5182	0.1296	0.72
Error	4	0.7190	0.1798	
Total	9	7.4152		

^{xx} Highly significant

Figure 4. Photograph of Comfort Stall.

Figure 5. Photograph of Tie Stall.

Figure 6. Photograph of Interior of Barn, showing mechanical gutter cleaner at lower left.

Figure 7. Photograph of Exterior of Barn showing hay chute attached to side of barn.