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TB 1363 1966 USDA TECHNICAL BULLETINS UPDATA

EFFECT OF LAYOUT, EQUIPMENT, AND ROUTINE ON TIME AND TRAVEL REQUIRED

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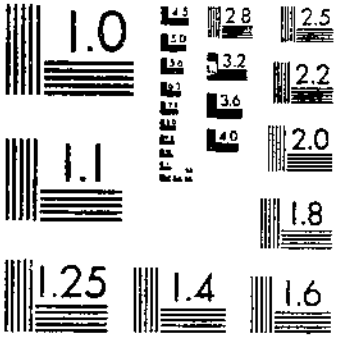

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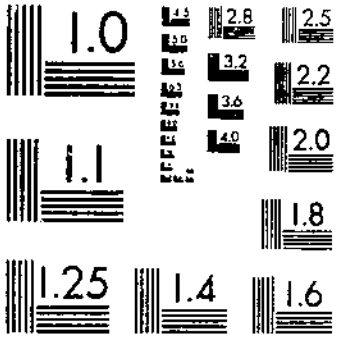

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EFFECT OF LAYOUT, EQUIPMENT, AND ROUTINE ON TIME AND TRAVEL REQUIRED FOR MILKING COWS

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EFFECT OF LAYOUT, EQUIPMENT, AND ROUTINE ON TIME AND TRAVEL REQUIRED FOR MILKING COWS

By THAYER CLEAVER, agricultural engineer,
Agricultural Engineering Research Division,
Agricultural Research Service

This study was made to determine the effects of buildings, equipment, and work routine on operator time and travel required for the milking of cows. The study began about the time Midwest dairy farmers were starting to use loose housing systems for cows and to install labor-saving equipment in existing stall barns. Field observations continued during the period in which some of the refinements of pipeline milking, bulk milk handling, and mechanized feed handling were developed.

Work started in Illinois and, as it developed, was extended to include Indiana, Wisconsin, California, and Massachusetts.[1] A related study was conducted by the Doane Agricultural Service under a research contract with the U.S. Department of Agriculture. A report of this study has been published.[2]

Improved farm dairy layouts and better methods and routines for doing the required dairy chores are the most important results of this study. Some of the improved plans for farm dairy layouts have been included in publications of the U.S. Department of Agriculture and State Universities and are incorporated into the Cooperative Farm Building Plan Exchange and the Midwest Plan Service. Other findings have been made available to cooperators and other investigators. The purpose of this report is to present the results of the basic research data obtained in the entire study.

DAIRYMEN'S ATTITUDES TOWARD REDUCING CHORE LABOR

Only 5 of the 90 Midwest farm dairies that furnished data for this report were operated entirely by hired labor. Many of the other dairies were small enough to be operated by a family even during the busiest season of the year. Most Midwest dairymen could appreciate the advantages of doing chores more quickly and easily with a new layout and equipment, but saving only a few minutes of chore time a day was not really important to them as long as the family could supply the necessary labor. However, the requirements of dairy sanitation codes were forcing many of

[1] Appreciation is expressed to the Agricultural Experiment Stations and Extension Services of the respective State Universities for their contributions to the work. These contributions included making facilities available, assisting in planning, and arranging access to farms for study and collection of data. Responsibility for interpreting the findings and reporting of results rests with U.S. Department of Agriculture, Agricultural Research Service.

[2] United States Department of Agriculture. MEETING DAIRY MARKET SANITATION REQUIREMENTS ECONOMICALLY. Market. Res. Rpt. No. 64. 1954.

these dairymen to make major changes in equipment, structures, and work methods. Many dairymen had reached the point that dairying was no longer profitable unless their operation could meet the requirements for producing quality milk that would bring top or Grade A prices. To accomplish this, dairymen were required to make major changes in dairy buildings and perhaps install new equipment. The lack of money handicapped many in making these changes.

Some of the dairymen wanted to increase the size of their herds but very few had any definite size limit in mind before making major changes. Most dairymen who had changed to a loose-housing arrangement with an elevated-stall milking parlor were able to do the dairy chores much easier and faster than they had thought possible. As a result, many dairymen enlarged their herds more than they intended.

The attitude of the dairymen in California who cooperated in the project differed from that of dairymen in the Midwest. Because herds were larger, most of the California milking operations were done by hired labor, which is unionized in some parts of the State. California dairymen were interested in reducing the labor force and in eliminating drudgery to attract and retain competent workers.

SCOPE OF STUDY

Time and travel data are reported for 116 dairy farmsteads located in 5 States. These farmsteads milked from 6 to 405 cows and used conventional types of milking facilities (table 1). Milking structures, equipment, and operations were observed on more than 125 farms. Data in table 1 are for farmsteads on which complete, satisfactory, and reliable information was obtained. The study covered a very wide range in layouts, equipment, management, and operator routine.

PROCEDURE

Selection of Farms

Initially, selection of cooperating farmers was on an "opportunity" basis. The selected farmsteads may or may not have been statistically representative samples of the types and numbers of milking facilities used in the areas covered by the study.

At first, the study was largely exploratory. We wanted to learn about the variations in buildings and practices in typical Midwest farm dairies and to develop techniques for conducting the research.

Later on, the study was extended to include other farms in order to provide additional information on specific types of milking facilities, equipment, methods, and routines. Final observations for this report were made in 1956.

Collection of Data and Related Information

Information on the farmstead was obtained in person by the research worker through interviewing, observing, measuring, sketching, photographing, and timing. The general procedure was as follows:

(1) Following an introduction to the farmer, the research worker described the study to the farmer and obtained his cooperation.

TABLE 1.—*Type, size, and distribution of milking facilities reported*

Type of milking facility	Location and year of study					Totals 1946–56
	Illinois 1946–56	Indiana 1946	Wisconsin 1946	California 1953	Massachusetts 1954	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Stall barns	29	13	9			51
Lactating cows, total	495	259	170			924
Range per farm, cows	6–38	8–37	8–27			6–38
Average per farm, cows	17.1	19.9	18.9			18.1
Floor-level milking barns	10	2	1	11		24
Lactating cows, total	163	58	17	2067		2305
Range per farm, cows	6–27	12–46	17–17	97–405		6–405
Average per farm, cows	16.3	29.0	17.0	187.9		96.0
Side-entering elevated-stall milking parlors	20			6	8	34
Lactating cows, total	301			563	227	1091
Range per farm, cows	8–38			53–151	13–63	8–151
Average per farm, cows	15.1			93.8	28.4	32.1
Walk-through elevated-stall milking parlors	4			1	2	7
Lactating cows, total	78			74	112	264
Range per farm, cows	11–33			74	42–70	11–70
Average per farm, cows	19.5			74	56.0	37.7

(2) The research worker then obtained general information on the enterprise, using information check lists as guides.

(3) All buildings, lots, lanes, gates, fences, payments, and other facilities and equipment involved in the dairy enterprise were measured and sketched in order to make a scale drawing of the entire dairy layout. Photographs were taken to supplement the sketches because some important details were too time-consuming and difficult to measure and record.

(4) Milking and related operations were timed with a stopwatch graduated in hundredths of a minute. Travel distances for milking were measured and recorded.

(5) Data taken at the farmstead were tabulated and analyzed; rough sketches were redrawn to scale. Some of the farmsteads were studied several times and at different seasons of the year; others only at one milking.

(6) Results were analyzed as case studies, but some generalizations were made from arithmetic averages.

Explanation of Items Measured and Tabulated

In this report the milking structures studied have been classified into three general groups: stall barns, milking barns, and elevated-stall milking parlors. These groupings have been further subdivided in order to recognize stall type and arrangement differences, which affect the milking operations. These subdivisions are face-out, face-in, and single-row arrangements of stall barns; one-row, two-row, back-out, and walk-through arrangements of milking barns; and side-entering and walk-through arrangements of elevated-stall milking parlors. Data are further divided for pipeline and bucket milking machines.

Tabulations of data on milking and related operations by type of layout show the size of herd, number of machine heads, and number of

operators; stopwatch time for selected operations—feeding concentrates admitting and releasing cows, milking, preparation and cleanup of milking utensils, and miscellaneous; milking rates in cows per hour—machine- and man-minutes per cow and per pound of milk; and operator travel for milking. These data are shown in tables 2, 4, 5, and 6. The rate data (items 10 to 24 in the tables) are particularly useful in comparing time requirements for milking and related operations in different types of buildings.

Milking rates (items 16 to 19) are based on overall milking time (OMT), which begins when the teat cups are placed on the first cow and ends when they are removed from the last cow. These are convenient and easily obtained measures of milking efficiency but must be used with the stopwatch data (items 10 to 15) for comparing milking rates in different types of buildings because the operations performed during OMT are not the same in all farm dairies. Stall barns and most milking barns generally do not include in the OMT such items as feeding concentrates, and admitting and releasing cows. In addition to these items, most large dairies common in California do not include the washing of udders in the OMT. However, elevated-stall milking parlors and some milking barns do include these items in their OMT. Time spent on feeding calves during the milking period occasionally was included in the OMT in the Midwest.

Machine-minutes per cow and per pound of milk (items 20 and 21) were obtained from a stopwatch record of the actual time that the teat cups were on each cow. These items are measures of efficiency in the use of machines and to some extent to whether cows are being overmilked. The average number of man-minutes per pound of milk—based on OMT—is an important measure of labor efficiency (item 23).

Machine-idle time (item 24) is the average number of minutes per machine during OMT that machines were not milking. It is expressed as a percentage of OMT. Machine-idle time has little or no relationship to layout unless the operator has trouble in keeping up with the machines. It is more of an indicator of the operator's milking practices than of efficiency of building layout. It may indicate either good or bad practices and therefore should be considered with related factors (items 21 to 23).

An unusually large time interval between removing the teat cups from one cow and placing them on the next may be the result of the machine operator following a poor routine, or it may be good practice when an alert operator breaks routine to remove the machine at the moment the cow is milked out.

THE STALL BARN

Description

On all but five of the Midwest farms on which stall barns were studied, members of the family did most or all of the milking chores, and the farm produced all roughages and part of the concentrate feeds.

Figure 1 shows typical layouts for face-out, face-in, and single-row stall barns that have long been used in cold climates. Age of stall barns included in this study ranged from new to over 50 years. Most stall barns had two stories in which cattle occupied the ground floor and hay and bedding the loft above. Concentrates were almost always stored in a feed room on the first floor of the main building, or in a feed room con-

necting the silo and the barn, or on the second floor of the barn and spouted down. Silage was usually fed from silos located either at one end or at the middle of one side of the barn.

Milk from all but the smallest barns or from some of those producing Grade B milk was handled in a milkroom or milkhouse in which it was cooled and kept until taken to market. In addition, the milkhouse was also used for cleaning the milk utensils.

With few exceptions, the barns had concrete floors, a gutter, and a manger, generally following the layouts shown in figure 1. A few "cross-gutter" or "transverse stallrow" barns were found. Some barns had cross alleys. Some barns had stalls that were too small to accommodate the cows comfortably. Inadequate space contributed to dirty udders

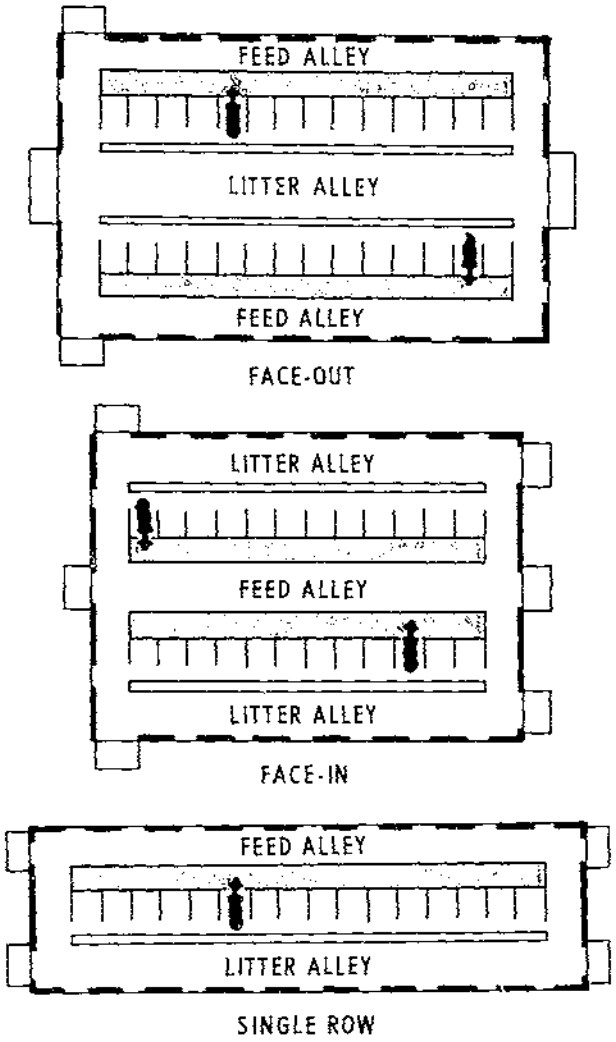


FIGURE 1.—Types of stall barns.

and increased the time needed for washing. All but a few of the smallest and oldest barns were equipped with steel stanchions and electric lights. Most barns had automatic waterers.

Bucket-type milking machines were used in all the Midwest barns reported in the stall-barn data summary. Milk was can-cooled and held until taken to market. Hand milking was done in a few small barns. Newly installed pipeline and bulk tank systems were observed in two Massachusetts barns.

Some of the barns had maternity and calf pens in the same part of the barn used by the lactating cows. On some farms calf pens were in a separate building. Bred heifers and dry stock were kept in the regular lactating cow stalls if space permitted.

Chore Routines

Chore routines followed in barns varied with the stall arrangement, management, equipment, season, and other factors.

It is common practice for most dairymen to prepare milking equipment first. The milking machines, udder wash, foremilking cup, and other milking equipment used in the milking area are usually moved to the barn after cows have been admitted and the stanchions are locked. If there are two or more operators, one operator immediately starts to feed the concentrate ration (bait feed is fed in some dairies before cows are admitted), while another starts to prepare cows for milking. Equipment is moved to a point in the litter alley near where milking starts. Udders of as many as four cows are washed, depending on the number of milking machines, but machines should be put on cows within about 3 minutes from the time udder washing starts. Suggested, efficient milking routines for face-out and face-in stall barns are discussed on page 12.

In the Midwest, most dairymen fed concentrates to all cows before milking began instead of during the milking. Hay and silage were fed after milking. In California, it was common practice to feed bait concentrate before milking; then feed the remainder of the ration when the milking machine was put on the cow.

The udders of all lactating cows in very large herds in mild climates may be washed in the barn before milking starts. In this procedure, udder washing may precede milking by as much as 30 minutes or more. Stimulation for milk ejection, therefore, must depend on some other operation, such as foremilking or feeding concentrates a minute or two before the teat cups are placed on the cow.

Discussion of Data

Herd, Equipment, and Operator

Table 2 summarizes the herd, facility, and milking chore data of the 51 small- to medium-size stall barns studied in the Midwest.

In stall barns studied, the number of cows in lactation (item 1) ranged from 6 to 38 and averaged 18. Of the 51 barns reported (item 3), 39 used 2 milking machine heads. The 12 other barns used 1, 3, or 4 heads and had an average of 2.2 milking heads per barn. The number of machine operators (item 4) was about half that of machine heads, and 47 of the 55 machine operators handled 2 machine heads each.

In 10 of the 22 face-out barns, the entire milking operation was performed by a single operator; in 5 barns, only 2 machine operators were used; in 1 barn, a second machine operator was used during part of the milking; in 4 barns, 1 machine operator and 1 other operator were used; and in the remaining 2 barns, 1 machine operator and part time of another operator were used. The average for the group is one and one-half operators.

Of the 17 face-in barns, the milking in 8 was done by a single machine operator; in 3, by 2 machine operators; in 2, by a machine operator and 1 additional operator; in 1, by a machine operator and 2 additional operators; and in the remaining 3, by a machine operator and another operator during part of the milking. Face-in stall barns averaged one and one-half operators per barn.

As could be expected, the herds in the 1-row stall barns were smaller than those in the face-out and face-in barns (table 2). One-row stall barns had an average of 1.3 operators to do the chores, but 3 barns had more than were needed to perform the chores efficiently. In a little more than half the barns, the machine operator worked alone. The majority of the operators handled two machine heads each.

Chore Time and Milking Rates

The time averages for the important work elements show a surprising uniformity for the three types of stall arrangements (table 2). The largest variations were in time for doing the miscellaneous, preparation, and cleanup chores. The average milking rate in cows per man hour in the face-out barns was a little faster than in the other arrangements (item 18). There was a slightly greater difference in milking rates among individual barns in each arrangement than among arrangements. A comparison of four individual barns in each group with four in the other groups shows a greater difference in milking rates. The averages of barn groups ABCD, EFGH, and IJKL for lines 16, 17, and 18 of table 2 are compared in the following tabulation, which applies only to operators who had no help:

Item	Cows milked per hour		
	Face-out (Group ABCD)	Face-in (Group EFGH)	One-row (Group IJKL)
16. Per machine operator	21.2	20.5	19.2
17. All machine operators	25.8	20.5	19.9
18. Per operator (machine and other)	21.2	17.7	16.3

Milking rates and herd size in the four best dairies in each barn type (table 2) where only one operator did all the milking operations are shown in the following tabulation:

Item	Face-out (Group ABCD)	Face-in (Group EFGH)	One-row (Group IJKL)
Milking rate, cows per hour	21.7	20.1	19.5
Herd size, number	21.0	22.5	8.5

The foregoing tabulation shows an even greater difference in milking rates between the face-out and face-in arrangements than between the face-in and one-row arrangements. The one-row arrangement also had a good milking rate, but because herd size was smaller, operator fatigue was

Table 2.—*Stall barns: Summary of time and travel*

Item	Face-out barns					
	Selected better barns				22 barns (10 in Ill., 7 in Wis., 5 in Ind.)	
	Barn A (Ill.)	Barn B (Ill.)	Barn C (Ill.)	Barn D (Ill.)	Average	Range
Herd, equipment, and operator:						
1. Cows in lactation ...Number	16	25	38	23	21.5	11-38
2. Cows milked by machine [1] do	16	22	38	23	20.5	7-38
3. Milking machine heads ..do	2	2	4	2	2.4	1-4
4. Milking machine operators [2] do	1	1	2	1	1.3	1-2
5. Other operators [2 3] ..do	0	0	0	0	0.2	0-1
6. All operators [3] ..do	1	1	2	1	1.5	1-2
7. Cows milked per machine operator ..do	16	25	19	23	17.1	7-37
8. Cows milked per machine head do	8	11	9	11	9.0	3.5-16
9. Machine heads per machine operator ..do	2	2	2	2	1.9	1-3
Chore time:						
10. Feeding concentrates [4] man-minutes/cow	.20	.24	.50	.34	.38	.15-.82
11. Admitting and releasing cows [5] do	.23	.35	.16	.54	.40	.16-.64
12. Milking operations [6] ..do	1.21	1.71	2.06	1.99	2.88	1.15-5.90
13. Miscellaneous operations [6] do	0.30	.29	.04	.13	.31	0-2.27
14. Preparation and cleanup [7] do	1.20	.93	1.02	.72	1.04	.60-1.70
15. All operations (items 10-14) do	3.14	3.46	3.78	3.72	5.04	2.06-11.42
Milking rate: [8]						
16. Per machine operator cows/hour	21.53	22.16	18.46	22.64	18.02	[9] 0.72-26.68
17. All machine operators ..do	21.53	22.16	36.92	22.64	21.96	9.72-36.92
18. Per operator (machine and other operators) [4] do	21.53	22.16	18.46	22.64	15.46	7.04-22.64
19. Per machine head ..do	10.77	11.06	9.23	11.32	9.53	5.55-15.78
20. Per cow [10] machine-minutes	4.83	4.62	5.04	4.47	5.50	3.40-10.29
21. Per pound of milk ..do	.27	.31	.28	.26	.39	.23-.84
22. Per cow [10] cows-minutes	2.70	2.73	3.30	2.66	4.15	2.60-8.43
23. Per pound of milk ..do	.16	.19	.18	.16	.30	.16-.49
24. Machine idle time ..percent	8	7	16	16	15.0	6-30
Operator travel: [11]						
25. Admitting and releasing cows and feeding concentrates [4] feet/cow	68	40	39	33	55	24-124
26. Milking and related operations (items 12-14) ..do	196	103	99	142	186	91-376
27. Total (items 25 and 26) ..do	264	143	138	175	221	116-380

[1] All herds milked with bucket-type machines.

[2] Includes all who helped with the milking or directly related operations during all or part of the overall milking time (OMT) which begins when the teat cups are placed on the first cow and ends when they are removed from the last cow. As a rule, helpers did not handle milking machines.

[3] Decimal figures indicate part time operator.

[4] Seldom done during OMT in stall barns.

[5] Wash udder, foremilk, dip teat cups, manipulate strcingle, position machine, machine strip, remove machine, hand strip, carry and pour milk. Not all these operations were performed in each case.

[6] If done during OMT, includes spraying cows, treating sore teats, hobbling cows, delays, getting fresh udder wash, washing manure to drain, etc.

[7] Only for milking equipment and milkroom.

data for the milking and related chores in 51 Midwest barns

Face-in barns						1-row barns					
Selected better barns				17 barns (10 in Ill., 2 in Wis., 5 in Ind.)		Selected better barns				12 barns (9 in Ill., 3 in Ind.)	
Barn E (Ill.)	Barn F (Ill.)	Barn G (Ill.)	Barn H (Ind.)	Average	Range	Barn I (Ill.)	Barn J (Ill.)	Barn K (Ind.)	Barn L (Ind.)	Average	Range
28	23	18	26	18.8	8–35	6	17	15	13	10.0	6–17
28	23	18	26	17.9	8–35	6	16	15	11	10.8	6–17
2	2	2	2	2.2	2–3	2	2	2	2	2.0	2–2
1	1	1	1	1.2	1–2	1	1	1	1	1.2	1–2
0	0	0.2	0.5	.30	0–2	0	0.5	0	0	.1	0–.5
1	1	1.2	1.5	1.5	1–3	1	2	1	1	1.3	1–2
28	23	18	26	16.7	5–35	6	16	15	11	9.0	4–15
14	11	9	13	8.2	4–14	3	8	8	3	6	3–9
2	2	2	2	1.0	1–3	2	2	2	4	1.5	1–2
.45	.31	.30	.25	.38	.15–.70	.32	.53	.41	.15	.34	.17–.53
.27	.60	.33	.25	.46	.27–.85	.50	.47	.54	.42	.51	.34–.71
1.36	2.84	3.98	2.34	2.09	1.36–4.03	2.40	4.17	1.95	2.65	3.07	1.95–5.90
.11	.33	.29	.06	.30	.06–1.23	.70	.39	.37	.54	.62	.10–1.72
.73	1.69	2.63	.90	1.96	.73–4.14	1.43	1.56	.88	1.71	2.12	.88–3.14
2.92	5.77	7.53	3.80	6.15	2.57–10.95	5.35	7.12	4.15	5.47	6.66	3.44–12.00
20.58	18.52	16.53	26.30	18.58[10]	11.40–27.36	19.00	22.07	16.0	18.08	16.20[11]	8.2–20.85
20.58	18.52	16.53	26.30	20.07	14.44–29.53	19.00	22.07	16.0	18.08	19.03	8.2–28.49
20.58	18.52	14.25	17.53	15.29	8.50–26.91	19.00	11.04	16.0	18.08	14.59	8.2–20.85
10.30	9.30	8.30	13.20	10.10	6.21–14.82	9.50	11.04	8.0	11.35	10.10	6.6–14.25
4.86	5.21	5.91	4.04	5.24	2.99–8.16	5.03	4.28	6.57	3.62	4.84	3.29–7.70
.36	.30	.26	.29	.40	.26–.79	.29	.27	.38	.37	.40	.27–.61
2.92	3.24	4.21	3.42	4.27	2.87–7.05		5.93	3.75	2.65	4.35	2.65–7.28
.21	.19	.18	.25	.34	.17–.70	.17	.37	.22	.27	.38	.17–.65
15	16	12	11	16	11–29	8	28	12	21	18	8–34
30	41	58	47	50	38–150	70	64	38	47	55	37–79
.....	150	70	.....	173	70–292	180	198	-----	-----	181	76–300
.....	191	137	.....	232	117–442	250	262	-----	-----	236	113–379

[9] Based on OMT.

[10] The higher figure is the highest rate for a machine operator with one full time helper. For a one man operation with no help, this figure was 22.64 cows per hour.

[11] The higher figure is the highest rate for a machine operator with one full time helper. For a one man operation with no help, this figure was 26.91 cows per hour.

[12] The higher figure is the highest rate for a machine operator with a helper. For a one man operation with no help, this figure was 26.85 cows per hour.

[13] Machine minutes for each cow begins when second teat cup is attached and ends when teat cups are removed.

[14] Per milking. Includes all workers in item 6.

not likely to be a factor in determining milking rates as it might be in the face-in and face-out barns, in which herds were 2.5 times the size of those in one-row barns. These milking rate differences are consistent with the general opinion that a good operator who follows a good routine in a good barn layout requires the least time for doing the milking chores. If he follows a good routine, an operator travels less in a face-out arrangement than in other stall barn arrangements.

Although the average differences for the barns reported in table 2 are not large, wide variations in unit time and operator travel are evident among barns with the same arrangement. For each arrangement the maximum value of almost every chore element is three to four times the minimum and one and one-half to two times the average. This suggests that the data differences are due to the work habits of operators more so than to the arrangement of barns, and that a tremendous amount of time and effort can be saved if individual operators made minor adjustments in their facilities, methods, and procedures. Simple time and travel records can show any dairy farmer how he compares with the average, and can suggest how he could save time and labor in his own operations.

As examples of the differences in time and travel between individual barns, consider face-out barns A and C (item 10, table 2). Note that in barn A concentrates were fed in 0.20 of a minute per cow compared with 0.50 in barn C. Barn A had only 12 stalls to the row, with a cross alley at each end of the stall rows. The operator used a feed cart large enough to feed all the cows in one round trip, and he worked a little faster than the two operators in barn C. Barn C had 26 stalls to the row, and the single cross alley was about 40 feet from the concentrate storage. It was necessary to make two round trips to feed concentrates. Milking operations time was 1.21 minutes per cow in barn A and 2.06 minutes per cow in barn C (item 12), partly because stall rows were shorter and the milkroom was in a more convenient location in barn A. On the other hand, the operator of barn A fed hay to three or four cows at a time during the milking period, and this lengthened his time for miscellaneous operations and increased his travel.

Face-in barn E was poorly arranged, and much time was needed to feed concentrates (item 10, table 2). Only a short time was needed for cleanup (item 14) because the operator used an equipment cart and steamed and sterilized his milking equipment as a separate operation later in the day. Milking operations (item 12, table 2) were less in barn E than in barns F, G, and H, mainly because milk was poured into cans in the barn, and the cans then were moved to the milkhouse on a cart. In the other three barns, milk was carried directly from the cows to the milkroom as soon as a machine can was filled.

Time for admitting and releasing cows (item 11) in face-in barn F was greater than in barns E, G, and H, mainly because the original barn had been enlarged enough to accommodate two-thirds of the herd, and the combination of old and new space required more time and travel than is needed in most face-in barns.

A further example of variation in milking rates caused by factors other than layout or equipment is shown in table 3 for two Massachusetts face-out stall barns using piped milking machines. Each barn had four new milking machines of the same make and type with the milk piped to new bulk milk tanks of the same make. The milking routine in each barn was back and forth across the litter alley. In barn 2 a single operator,

working alone, milked his herd at a rate of 41.6 cows per hour, which is just a little faster than the combined efforts of two operators in barn 1 who milked at the rate of 39.4 cows per hour in a herd of the same breed. All three operators did a good job of machine stripping and of performing other elements of their respective routines. In barn 1 the two operators hand stripped and used cords similar to surcingles to support the machine heads. In barn 2 the one operator did no hand stripping or concentrate feeding during the milking period.

The milking routine elements (items 1 to 6, table 3) were 1.73 man-minutes per cow less in barn 2 than in barn 1. However the shorter milking time in barn 2 was partly due to lower milk yield (item 15). The higher yield from cows in barn 1 is reflected in lower machine-minutes per pound of milk (item 12). The more efficient use of labor in barn 2 is reflected by the lower man-minutes per pound of milk (item 10).

TABLE 3.—*Rates of milking similar herds in similar face-out stall barns with similar milking equipment-Massachusetts*

[Both barns were equipped with the same number, type, and make of milking machines. Both had milk pipelines and the same make of bulk milk tank, but the tank and milking herd in barn No. 2 were larger than those in barn No. 1]

Item	Barn No. 1 (2 operators, hand stripping)	Barn No. 2 (1 operator, no hand stripping)
1. Surcingle ..... man-minute/cow	0.12	0
2. Wash udder and foremilk ..... do	0.82	0.38
3. Position machine ..... do	0.30	0.31
4. Check and aid machine ..... do	3.84	0.67
5. Hand strip ..... do	0.90	0
6. Delay of operators ..... do	0.11	0
7. Total of selected elements ..... do	3.09	1.36
8. OMT/cow [1] ..... minutes	1.54	1.44
9. OMT/cow [1] ..... man-minutes	3.08	1.44
10. Time/lb. of milk [1] ..... do	0.14	0.10
11. Machine time/cow ..... minutes	5.62	5.27
12. Machine time/lb. milk ..... do	0.26	0.34
13. Machine idle time ..... percent	5.51	5.15
14. Cows milked ..... number	39	60
15. Milk/cow/milking ..... pounds	21.4	15.2
16. Cows milked/hr ..... number	39.4	41.6
17. Cows milked/man-hr ..... do	19.7	41.6

[1] Based on overall milking time (OMT), which begins when the teat cups are placed on the first cow and ends when they are removed from the last. In these barns, cows were not admitted nor released during the milking period. Cows in Barn No. 2 were not fed concentrates during the milking period, but those in barn No. 1 were (0.4 min/cow).

Operator Chore Travel

Operator travel for milking operations, in feet per cow per milking (item 26, table 2) was less for the face-out barn arrangement than for the face-in and single-row arrangements. From the travel standpoint, the advantage of the face-out arrangement was not so pronounced as might be expected. Given equivalent good layouts, routines, and equipment, the face-in arrangement would be expected to require up to 60 percent more travel than would be needed in the face-out for doing only the milking operations.

Most operations that require excessive time also require excessive travel. For example, milkhouses of four barns in the face-out group, of two in the face-in group, and of most of those in the one-row group were

poorly located and were some distance from the barn. The extra travel to and from a milkhouse causes a far greater increase in total travel than does any other single milking operation. The milkhouse of barn A (table 2) in the face-out group was 64 feet from the barn and required an extra 900 feet of travel. Had it been located adjoining the barn, as were the milkhouses for barns B, C, and D, the total travel per cow would have been 140 feet instead of 196 feet.

Furthermore, eliminating the other three dairies having milkhouses separated from the barn in the face-out group but not changing barn A, would reduce the average operator travel in the remaining group to 141 feet per cow instead of the 166-foot average shown in item 26, table 2. Similarly, if the two milkhouses in the face-in group, which were separated from the barn (one a distance of 140 feet) are eliminated, the remaining group would average only 158 feet of operator travel per cow instead of the 173 feet shown in item 26.

Suggested Milking Arrangements

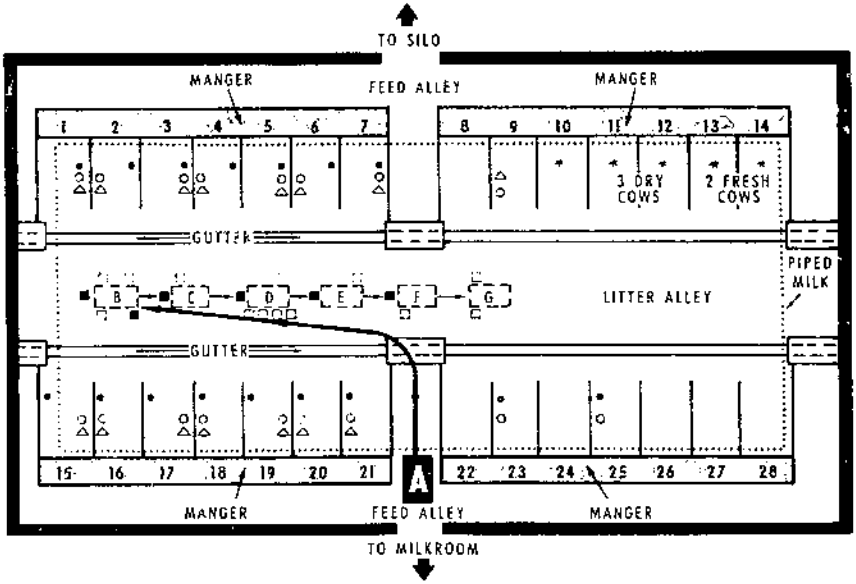
Figures 2 and 3 show suggested milking routines for milking part of the herd in face-out and face-in barns. The same routine is followed for all cows in each barn. Pipelines for the milk and a cart for carrying the milking machines and udder wash are assumed to be available in each case. The total minimum distance travelled by the operator in milking 23 cows in the face-out barn is 684 feet, or 30 feet per cow, and does not include carrying milk. The corresponding operator travel in the face-in barn is 1,092 feet, or 47 feet per cow. Both distances are considerably less than the minimums found in the barns studied. If bucket milkers had been used, the additional distance would depend on the location of the milkhouse and whether each cow's milk had to be carried separately or if cans on a small cart could be used.

Studies of conventional stall barns have shown that one, two, or possibly three operators may work together efficiently in a barn doing such chores as feeding, bedding, and removing manure, so long as their travel routes do not conflict. This is true because these chores can usually be started and completed without any delays.

Milking operations, however, are different. They usually require more time than do the other dairy chores. In addition, sanitary regulations impose certain restrictions, either directly or indirectly, which make the problem of labor a little more difficult. Assuming that the operator or operators thoroughly understand their jobs and have a good technique and routine for handling themselves, the equipment, and the animals, a good balance of operators and equipment is described in the following situations.

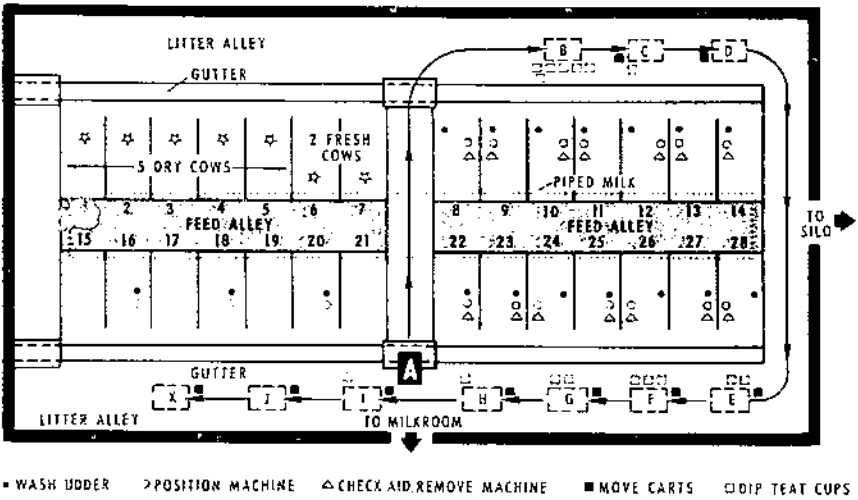
Case 1

The dairy has a 10- to 26-stall barn, 1 operator, 2 bucket-type machines, and good arrangements similar to those shown in figure 1. Milk is carried directly and immediately to the milkroom. For herds over 15 cows, an additional operator (helper) is usually advisable to lower the overall milking time, if the additional operator is a member of the farm family or is a farmhand who is hired primarily for other farm work. The additional operator would wash udders, foremilk, and carry milk.



1. Start with cart at A
2. Move cart to B
3. Wash udder, stall 1
4. Wash udder, stall 3
5. Wash udder, stall 16
6. Position machine, stall 1
7. Position machine, stall 3
8. Position machine, stall 16
9. Wash udder, stall 2
10. Check, aid, and remove machine, stall 1
11. Dip teat cups
12. Position machine, stall 2
13. Wash udder, stall 4
14. Dip teat cups
15. Dip teat cups
16. Position machine, stall 4
17. Wash udder, stall 15
18. Check, aid, and remove machine, stall 16
19. Dip teat cups
20. Position machine, stall 15
21. Wash udder, stall 18
22. Check, aid, and remove machine, stall 2
23. Move cart
24. Dip teat cups
25. Position machine, stall 18
26. Wash udder, stall 5
27. Check, aid, and remove machine, stall 4
28. Dip teat cups
29. Position machine, stall 5
30. Move cart
31. Wash udder, stall 20
32. Check, aid, and remove machine, stall 15
33. Dip teat cups
34. Position machine, stall 20
35. Wash udder, stall 17
36. Check, aid, and remove machine, stall 18
37. Dip teat cups
38. Position machine, stall 17
39. Wash udder, stall 6
40. Check, aid, and remove machine, stall 5
41. Dip teat cups
42. Position machine, stall 6
43. Wash udder, stall 19
44. Check, aid, and remove machine, stall 6
45. Dip teat cups
46. Position machine, stall 19
47. Wash udder, stall 21
48. Check, aid, and remove machine, stall 17
49. Dip teat cups
50. Position machine, stall 21
51. Move cart
52. Wash udder, stall 7
53. Check, aid, and remove machine, stall 6
56. Move cart
57. Wash udder, stall 23
58. Check, aid, and remove machine, stall 19
59. Dip teat cups
60. Position machine, stall 23
61. Move cart
62. Wash udder, stall 25
63. Check, aid, and remove machine, stall 21
64. Dip teat cups
65. Position machine, stall 25
66. Wash udder, stall 9
67. Check, aid, and position machine, stall 7
68. Dip teat cups
69. Position machine, stall 9

FIGURE 2.—Suggested milking routines for a face-out stall barn. The order in which work is done is shown by chores numbered consecutively and listed in vertical columns.



1. Start with cart at A
2. Wash udder, stall 9
3. Wash udder, stall 11
4. Wash udder, stall 13
5. Dip teat cups
6. Position machine, stall 9
7. Dip teat cups
8. Position machine, stall 11
9. Dip teat cups
10. Position machine, stall 13
11. Wash udder, stall 8
12. Check, aid, and remove machine, stall 9
13. Dip teat cups
14. Position machine, stall 8
15. Wash udder, stall 10
16. Check, aid, and remove machine, stall 11
17. Dip teat cups
18. Position machine, stall 10
19. Wash udder, stall 12
20. Check, aid, and remove machine, stall 13
21. Dip teat cups
22. Position machine, stall 12
23. Move cart
24. Wash udder, stall 14
25. Check, aid, and remove machine, stall 8
26. Dip teat cups
27. Position machine, stall 14
28. Move cart
29. Wash udder, stall 27
30. Check, aid, and remove machine, stall 10
31. Move cart
32. Dip teat cups
33. Position machine, stall 27
34. Wash udder, stall 25
35. Check, aid, and remove machine, stall 12
36. Dip teat cups
37. Position machine, stall 25
38. Move cart
39. Wash udder, stall 23
40. Check, aid, and remove machine, stall 14
41. Dip teat cups
42. Wash udder, stall 28
43. Position machine, stall 23
44. Check, aid, and remove machine, stall 27
45. Dip teat cups
46. Position machine, stall 28
47. Wash udder, stall 26
48. Check, aid, and remove machine, stall 25
49. Dip teat cups
50. Position machine, stall 26
51. Move cart
52. Wash udder, stall 24
53. Check, aid, and remove machine, stall 23
54. Dip teat cups
55. Position machine, stall 24
56. Wash udder, stall 22
57. Check, aid, and remove machine, stall 28
58. Dip teat cups
59. Position machine, stall 22
60. Move cart
61. Wash udder, stall 20
62. Check, aid, and remove machine, stall 26
63. Dip teat cups
64. Move cart
65. Position machine, stall 20
66. Wash udder, stall 18
67. Check, aid, and remove machine, stall 24
68. Wash teat cups
69. Move cart
70. Position machine, stall 18
71. Wash udder, stall 16
72. Check, aid, and remove machine, stall 22
73. Move cart
74. Position machine, stall 16

FIGURE 3. Suggested milking routine for a face-in stall barn. The order in which work is done is shown by chores numbered consecutively and listed in vertical columns.

Case 2

The dairy has a 20- to 40-stall barn, 2 operators, 3 bucket-type machines, and good arrangement. Milk is carried immediately and directly to the milkroom. One operator handles the machines while the other carries the milk to the milkroom and assists in washing udders, foremilking, and feeding concentrates.

If milk is piped from each stall to the milkroom, one operator in case 2 should be able to do the milking operations efficiently. However, if it is necessary to milk the herd faster, a second operator can be used to good advantage in washing udders, foremilking, and possibly some machine stripping.

Case 3

The dairy has a 50- to 100-stall barn, 3 operators, and 4 to 6 bucket-type machines. Milk is carried immediately and directly to the milkroom. Two of the operators each handle two or three machines. The third operator will be kept busy carrying milk most of the time but occasionally may help with washing udders and feeding concentrates. The third operator is especially needed in barns that are poorly arranged.

If milk is piped from each stall to the milkroom, two operators in case 3 should be enough to do the milking operations. Each operator should be able to use three machines effectively and do the additional necessary tasks of washing udders, foremilking, and machine stripping.

If milk is piped from all stalls to the milkroom, considerable time and travel are saved and, in cases 2 and 3, more machines are advisable. It is doubtful if a third machine is economically justifiable for most dairies with fewer than 20 cows. A third machine may be justified for herds of 20 to 26 cows and will be justified for more than 26 cows if they are well managed and have good production.

THE MILKING BARN

Description

The milking barn is a floor-level stall barn that is used solely or principally for milking. Most stall barns in the Northern States are used primarily as milking barns during the summer.

As with other types of facilities, the milking barn has both advantages and disadvantages. The main advantage is its adaptability to changing herd size and to the loose-housing system for cows. Because the number of stalls is usually one-eighth to one-half the number of cows to be milked, the milking barn is a smaller structure than most stall barns and has a shorter milk pipeline.

Because the milking barn is still a floor-level structure, it requires the stooping, squatting, and bending of the stall barn. Cows are not in the milking barn except during milking time. Consequently, supplemental heat is needed during cold northern winters to protect plumbing and to provide operator comfort.

The general arrangement of Midwest single-row or two-row milking barns is much like that of the stall barns shown in figure 1. The California string-type milking barn is also similar to a conventional stall barn but is usually larger. Small, single-row, back-out and walk-through types

of milking barns are shown in figure 4. Most cows in California are milked in string barns. A small floor-level, abreast, walk-through, stall arrangement may be referred to as a milking barn.

The small one-row and two-row milking barns studied in the Midwest were on farms where the work was done by family labor, and most of the feed was grown on the farm. The California string barns were used by dairies that hired most of their labor and purchased most of their feed.

The milking barns reported in this study include eight small single-row and five small two-row barns in the Midwest; five large single- and multi-row barns (commonly referred to as string barns) in California; and six abreast walk-through barns in California. The milking barns in California were floor-level structures arranged essentially as shown in

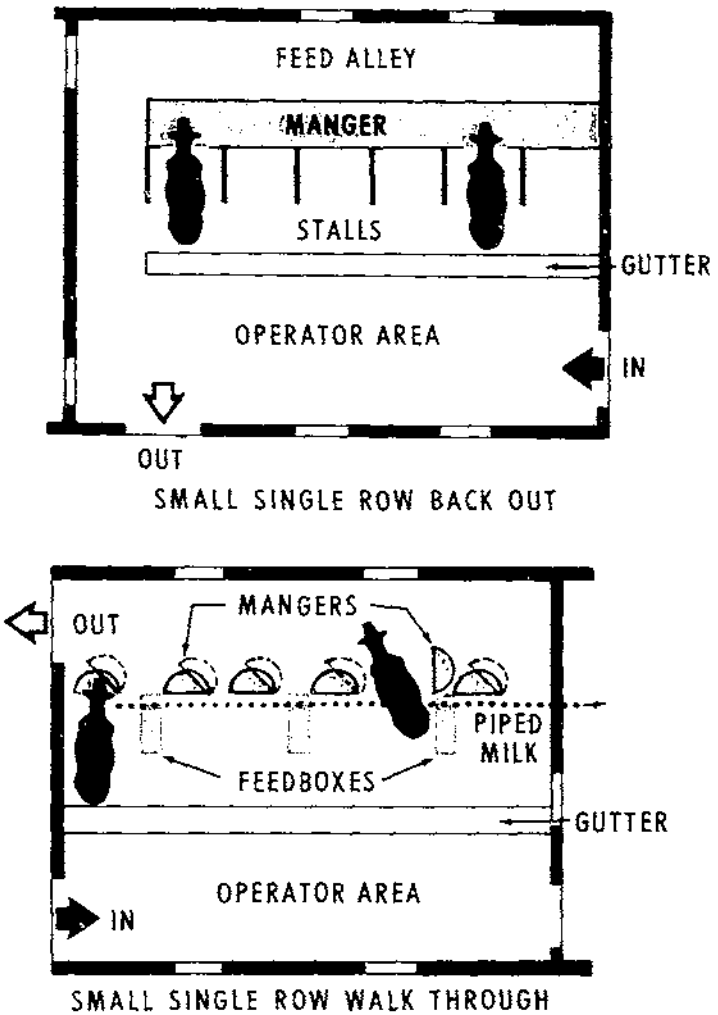


FIGURE 4.—Typical small floor-level single-row back-out and walk-through milking barns.

figure 1 or 4. The Midwest barns were used by herds that were very small to medium in size when judged by standards in the area. The California herds studied were average to above average in size by California standards. The barns ranged from new to possibly 15 years of age.

Amount and type of milking equipment varied considerably. All the small Midwest barns used bucket milking machines and cooled milk in cans. Three of the five California string barns and five of the six California walk-through barns had milk pipelines from stalls to bulk tanks for cooling and holding. Where milk was not piped from the stalls it was hand trucked or carried to the bulk tank or to a "dump" in the barn and then piped to the tank.

Water under pressure was used freely for cleaning floors in most of the California milking barns but was used to a limited extent in the Midwest and Massachusetts barns.

Roughage was fed at different places on the different farmsteads, all of it away from the milking barn. The location of the feed storage and milkhouse or milkroom was variable. The California milk code specified a 10-foot minimum separation between the milkhouse and the building in which the cows were milked. In the Midwest, most of the milkrooms and feed storages were attached to or were a part of the buildings in which the cows were milked.

In California, concentrate feed was sometimes stored in the milking building and sometimes in bins outside. Feed was distributed to the mangers in most barns by cart and hand scoop. In the walk-through barns, a feedbox was located between each pair of stalls (fig. 4). The operator merely had to scoop feed from the box into the manger as each cow came in.

Chore Routines

Chore routines varied with the stall arrangement, management, season, and other factors. Where the milking herd was separated into two or more corrals, the number of stalls in a milking barn was a multiple of the number of cows in a corral. For example, the milking barn might be of a size to accommodate one corral, two corrals, three corrals, or four corrals of cows in one filling, depending on the size of the herd and the maximum time available for milking the entire herd. The basic principle is that all cows in a corral must be moved to and from the milking barn in a single group to keep time and travel of the operators at a minimum and to simplify movement of the cows.

In the Midwest, most milking machine operators handled one or two machine heads; in California, two to four machine heads. Some Midwest machine operators had help from a part- or full-time operator who performed miscellaneous chores not involved with the use of the milking machines. Most machine operators in the California string barns had such help regularly.

Discussion of Data

Herd, Equipment, and Operator

Table 4 summarizes the herd, facility, and milking chore data of the 24 milking barns studied. Herds milked in the small barns averaged 19

Table 4.—*Milking barns: Summary of time and travel data for the milking and related chores in 18 Midwest and 11 California floor-level barns*

Item	Small, 1-row barns (with bucket milking machines)						Small, 2-row barns (with bucket milking machines)				
	Selected better barns				8 barns (7 in Ill., 1 in Ind.)		Selected better barns			5 barns (3 in Ill., 1 in Ind., 1 in Wis.)	
	Barn A (in Ill.)	Barn B (in Ill.)	Barn C (in Ill.)	Barn D (in. Ind.)	Average	Range	Barn E (in Ill.)	Barn F (in Wis.)	Barn G (in Ind.)	Average	Range
Herd, equipment, and operator:											
1. Cows in lactation—number	14	11	23	46	19.1	6–46	19	17	12	17.0	12–21
2. Cows milked by machine—do	14	11	23	46	19.1	6–46	19	17	12	17.0	12–21
2a. Number of stalls—do	4	5	7	15	6.9	4–15	16	8	20	14.8	8–20
3. Milking machine heads—do	2	2	3	3	2.3	1–4	2	4	2	2.4	2–4
4. Milking machine operators—do	1	1	2	2	1.3	1–2	1	2	1	1.4	1–2
5. Other operators [2]—do	0	0	0	1	.31	0–1	0	0	.5	.12	0–0.5
6. All operators—do	1	1	2	3	1.6	1–3	1	2	1.5	1.5	1–2
7. Cows milked per machine operator—do	14	11	12	23	14.9	6–27	19	8.5	12	13.7	8–21
8. Cows milked per machine head—do	7.0	5.5	7.7	15.3	8.4	5.5–15.3	9.5	4.3	6	7.7	4.3–10.5
9. Machine heads per machine operator—do	2	2	1.5	1.5	1.9	1–1.5	2	2	2	1.7	1–2
Chore time:											
10. Feeding concentrates—man-minute/cow	.11	.43	.32	.28	.27	0.09–0.43	.20	.15	.65	.32	.15–.65
11. Admitting and releasing cows—do	.46	.56	.51	.65	.51	0.40–0.65	.68	.33	.38	.64	.33–1.36
12. Milking operations [4]—do	3.62	2.66	2.03	2.91	2.42	1.04–3.62	2.91	3.80	3.54	2.93	2.10–3.80
13. Miscellaneous operations [5]—do	.27	.08	.04	.03	.15	0.03–0.55	.19	.01	.11	.33	.01–1.15
14. Preparation and cleanup [6]—do	1.53	2.17	.90	.86	1.30	0.85–2.17	1.35	1.13	1.82	1.73	1.13–3.18
15. All operations, (items 10–14)—do	5.99	5.90	3.80	4.73	4.65	2.03–7.42	5.33	5.42	6.50	5.95	3.72–10.14

Milking rates: [7]											
16. Per machine operator, cows/hour	13.9	21.6	15.8	17.6	19.1	13.1–32.4	18.7	12.0	23.7	16.7	12.0–23.7
17. All machine operators, do	13.9	21.6	31.5	35.2	23.3	13.1–35.2	18.7	23.9	23.7	21.5	16.4–25.0
18. Per operator (machine and other operators), do	13.9	21.6	15.0	11.7	15.4	11.7–21.6	18.7	12.0	15.8	15.1	12.0–18.7
19. Per machine head, do	6.9	10.8	10.8	11.7	11.1	6.9–15.4	9.4	6.0	11.9	9.6	6.0–12.5
20. Per cow, machine-minute	5.19	4.62	4.64	4.33	4.88	2.73–8.16	5.60	5.79	3.72	4.87	2.99–6.24
21. Per pound of milk, do	.43	.31	.36	.33	.41	0.25–0.79	.38	.29	.22	.32	.22–.39
22. Per cow, man-minute	4.33	2.91	3.82	5.16	4.04	2.91–5.16	3.21	5.04	3.94	4.14	3.21–5.04
23. Per pound of milk, do	.36	.19	.30	.40	.34	0.19–0.43	.22	.26	.23	.30	.22–.52
24. Machine idle time, percent	36	15	12	10	18	10–36	13	40	19	23	13–40
Operator travel: [8]											
25. Admitting and releasing cows and feeding concentrates (items 10 and 11), feet/cow	36	32	58	40	49	32–63	44	75	42	51	34–75
26. Milking and related operations (items 12–14), do	98	111	119	---	105	67–141	142	276	---	174	104–276
27. Total (items 25 and 26), do	118	143	157	---	149	92–202	186	351	---	225	138–351
28. Total travel for milking herd (items 25 and 26), feet/barn	1789	1568	4067	---	2404	1568–4067	3535	5972	---	4039	2611–5972

See footnotes at end of table.

Table 4.—*Milking barns: Summary of time and travel data for the milking and related chores in 18 Midwest and 11 California floor-level barns* —Continued

Item	Large 1-row and 2-row string barns (3 with piped milk, 2 with bucket milking machines and partly piped milk)				1-row floor-level abreast walk-through barns (5 with fully piped milk; 1 with a partly piped system)			
	Selected better barns		5 barns (all in Calif.)		Selected better barns		6 barns (all in Calif.)	
	Barn H (piped milk)	Barn I (piped milk)	Average	Range	Barn J (piped milk)	Barn K (piped milk)	Average	Range
Herd, equipment, and operator:								
1. Cows in lactation—number	218	149	228	149-405	102	193	155	97-228
2. Cows milked by machine—do	218	149	228	149-405	102	193	155	97-228
2a. Number of stalls—do	[1] 100	[1] 160	[1] 123	[1] 60-213	12	12	11	8-12
3. Milking machine heads—do	9	5	7.4	5-10	6	6	5.7	4-6
4. Milking machine operators—do	3.0	1.0	2.2	1-5	2.0	2.0	1.8	1-2
5. Other operators [2]—do	1.6	1.2	1.8	1-3	0	0	.1	0-.1
6. All operators—do	4.5	2.2	4.0	2-8	2.0	2.0	1.9	1.1-2.1
7. Cows milked per machine operator—do	73	149	134	73-189	51	97	84	49-128
8. Cows milked per machine head—do	24.2	29.8	31	24-41	17	32	27	17-38
9. Machine heads per machine operator—do	3	5	4.6	2-8	3	3	3	2-3
Chore time:								
10. Feeding concentrates—man-minutes/cow	.18	.24	.18	.13-.24	.21	.35	[3].15	0-.35
11. Admitting and releasing cows—do	.57	.36	.32	.16-.57	.44	.60	.43	.24-.60
12. Milking operations [4]—do	2.17	2.26	2.70	2.17-3.35	1.56	1.10	1.44	.95-2.46
13. Miscellaneous operations [5]—do	.07	.06	.14	0-.43	0	.39	.25	0-1.09
14. Preparation and cleanup [6]—do	.68	.26	.42	.26-.68	.57	.34	.40	.16-.68
15. All operations, (items 10-14)—do	3.67	3.18	3.76	2.72-5.27	2.78	2.78	2.67	1.45-5.18

Milking rates: [7]								
16. Per machine operator ..... cows/hour	25.7	46.4	39.1	25.7–55.8	29.2	26.1	29.6	19.1–47.3
17. All machine operators ..... do	76.5	46.4	68.4	43.8–119.6	58.3	56.7	52.1	38.3–62.8
18. Per operator (machine and other operators) ..... do	17.0	21.1	18.2	14.9–21.9	29.2	26.1	27.9	19.1–43.0
19. Per machine head ..... do	8.5	9.3	9.1	7.0–12.0	9.7	9.5	9.2	7.9–10.5
20. Per cow ..... machine-minutes	5.46	6.04	5.82	4.23–7.22	6.04	6.41	6.45	5.46–7.40
21. Per pound of milk ..... do	.29	.40	.38	.27–.55	.38	.48	.47	.33–.67
22. Per cow ..... man-minutes	3.51	2.84	3.37	2.74–4.00	2.06	2.12	2.26	1.40–3.14
23. Per pound of milk ..... do	.18	.19	.22	.16–.29	.13	.16	.19	.13–.31
24. Machine idle time ..... percent	5	4	8	4–13	5	3	3	2–5
Operator travel: [8]								
25. Admitting and releasing cows and feeding concentrates (items 10 and 11) ..... feet/cow	22	31	22	13–31	30	26	[3] 27	19–42
26. Milking and related operations (items 12–14) ..... do	86	88	88	83–102	40	29	41	27–54
27. Total (items 25 and 26) ..... do	108	119	109	94–126	70	55	68	55–73
28. Total travel for milking herd (items 25 and 26) ..... feet/barn	8393	17629	12664	7536–19586	7077	10610	9115	5472–15594

[1] These are total numbers of stalls in barns. Actually, barns H and I used only 32 and 20 stalls, respectively, from which milk was piped. Based on actual numbers by stalls used, the group average is 81, and the range is 20 to 213.

[2] Includes all (except machine operators) who helped during all or part of the overall milking time (OMT), which begins when the teat cups are placed on the first cow and ends when they are removed from the last cow. As a rule, helpers did not handle milking machines.

[3] One dairy fed no concentrates during milking operations; all concentrates and roughages were in a single, complete mixed ration and were fed in fence line feedbunks in the corrals.

[4] Wash cows, foremilk dip teat cups, operate surcingle, position machine, machine strip, remove machine, hand strip, carry and pour milk. Not all these operations were performed in each case.

[5] If done during OMT, includes spraying cows, treating sore teats, hobbling cows, getting fresh udder wash, delays, washing manure to drain.

[6] Only for milking equipment and milkroom.

[7] Based on OMT.

[8] Travel for operation in items 10 to 14 inclusive.

lactating cows (item 1). The California herds averaged 228 lactating cows in the string barns and 155 in the walk-through milking barns.

The number of milking stalls (item 2a) varied considerably but averaged 11 for both the Midwest barns and the California walk-through barns. The number of stalls in the California string barns averaged 123. In two of these barns less than half the stalls were used for milking.

Two milking machine heads (item 3) were used in 7 of the 13 Midwest barns; the others used from 1 to 4 heads and averaged a little over 2 heads per barn. The number of machine operators (item 4) in these barns was a little more than half the number of machine heads. Of the 13 barns, 9 used only 1 machine operator. The large California string barns used from 5 to 10 milking machine heads and had 1 to 5 machine operators each. The machine operators each handled from two to eight heads, averaging over four. All but 1 of the California walk-through barns used 6 machine heads and had 2 operators in a 12-stall barn. In this situation, each machine operator worked six stalls and handled three machine heads.

In 5 of the 13 Midwest barns, all milking operations were done by 1 machine operator working alone. The number of milking operators in the other eight barns ranged from one machine operator with another part-time operator to two machine operators with a full-time operator helping. The 13 Midwest barns averaged 1.5 operators per barn (item 6, table 4).

The three smaller California string barns, milking 150 to 190 cows each, used 1 machine operator and from 1 to 2.5 other operators per barn. The fourth string barn used 3 machine operators plus 1 full-time and 1 half-time operator to milk 218 cows. The fifth string barn used 5 machine operators and 3 other operators to milk 405 cows.

Five of the 6 California walk-through barns used 2 machine operators, without help, to milk 97 to 228 cows. In the sixth walk-through barn, 1 machine operator with 1 other operator 10 percent of the time milked 128 cows.

In some of the barns the number of operators was considered more than necessary to perform the dairy chores efficiently.

Chore Time and Milking Rate

The time used in doing chores shows a wide variation from barn to barn within barn types (items 10 to 15, table 4). The variations within the small one-row, small two-row and large one and two-row string barns are larger than the differences among the group averages for practically all the elements of the milking operation. The differences among the walk-through barns are also substantial, but operations in this barn type were at a higher level of efficiency than in any of the other types.

Milking rate in cows per man-hour (item 18) was 15.4 in the 1-row and 15.1 in the 2-row Midwest barns; 18.2 in the California string barns; and 27.9 for the California walk-through barns. In comparing these milking rates two points of interest are noted:

(1) It is surprising that the milking rates in the string barns were so little faster than the rates in the Midwest barns, even though the string barns had much larger herds, improved facilities for milk handling, and professional milkers. This is partly attributed to operator fatigue caused by the necessity of handling large herds and doing more and different operations required by the California milk code. String barns had a

major advantage over the smaller stall barns in that preparation and cleanup time were less per cow because operators milked more cows per machine. The use of unneeded workers in some dairies resulted in lower per-man-hour milking rates in the California barns.

(2) The milking rate in the California walk-through barns was more than 50 percent higher than in the string barns. Only a small part of this difference could be attributed to udders not being washed regularly in three of the walk-through barns or that five of the six walk-throughs had piped milk when only three of the five barns had it. The time saved must have been mainly due to the more compact and convenient arrangement of the walk-through barns, which resulted in less time during which machines were idle and less walking by the operators.

Table 4 shows that machine time is more dependent on the operator, cow, and equipment than on the layout or stall arrangement of the milking facility (items 20, 21). The walk-through barns, in which the milking rate was fastest, also showed the most machine-minutes per cow and per pound of milk. In these barns the machines averaged just under 6-½ minutes on the cow and just under ½ minute per pound of milk. The extremely low machine idle time in walk-through barns averaged only 3 percent (item 24) and partly accounts for the high machine time and the high overall milking rate. It appears that the low machine idle time is due to the operator's routine and to the walk-through arrangement, which enabled the operator to travel the minimum distance in removing the machine from one cow and placing it on the next.

Operator Chore Travel

Operator travel in feet per cow per milking (item 27) is far less for the California walk-through barns than in any of the other types of milking barns (item 27, table 4). The differences in travel per cow among barns in the walk-through groups were relatively minor. This was also true of differences among string barns, although the travel per cow was almost twice that of the walk-throughs. Travel per cow in the Midwest milking barns was much higher and showed much more variation from barn to barn. Differences in travel per cow among the small Midwest barns, the California string barns, and the walk-through barns were clear and distinct and without overlapping except among the one-row and two-row Midwest barns.

THE ELEVATED-STALL MILKING PARLOR

Description

Milking parlors with elevated stalls were developed primarily for use with loose-housing systems but are also used for milking cows that are housed in stall barns between milkings. Because the cows are in the milking parlor for only a small part of the day, supplemental heat is needed in cold climates during the winter months to prevent the freezing of water pipes and provide comfort for the operators.

Like the floor-level milking barn, the elevated-stall milking parlor is well adapted to expanding herds, is small in size, and is well-suited for use of pipeline milking machines. In addition, the elevated stalls eliminate the need for most of the bending and stooping for routine

milking operations. Elevated-stall milking parlors are usually equipped with hot and cold water under pressure, and this considerably reduces the work of washing udders, cleaning pipelines and utensils, and washing floors.

This report includes data on 41 elevated stall milking layouts located in the Midwest and in the States of California and Massachusetts. These layouts had 15 different stall arrangements and variations, which generally can be divided into side-entering and walk-through stalls (fig. 5). When studied, one parlor was 14 years old; all other were less than 4 years old. All of the larger milking parlors and most of the smaller ones used pipeline milkers or partially piped milking systems. Concentrates were usually fed entirely in the milking parlor, but in some cases only "bait" amounts of concentrate were fed in the milking parlor, and the rest was fed with the roughage, which was always fed elsewhere.

If concentrates are to be fed during milking, facilites should allow the cow to be fed in the shortest possible time and with the least travel. One of the best feeding systems provides overhead storage, a feed chute to each stall feedbox, and the equipment for measuring feed rapidly and accurately. A milking parlor in which 50.3 cows per hour were milked by 1 man (table 5, item 18) was so equipped, and the average time for feeding a cow was 0.04 of a man-minute. However, other California operators used 0.14 to 0.4 of a minute to feed a cow. In Massachusetts, where many dairymen fed citrus pulp, concentrate feeding required 0.05 to 0.6 of a minute per cow. Cows required more time for eating citrus pulp than they needed for most feeds.

A few operators fed concentrates in a separate building before milking. Cows that had been fed came in for milking as readily or more rapidly than cows that were going to be fed during milking. Milk letdown with these cows was just as rapid as with the other. When concentrates are fed elsewhere, the milking parlor construction, equipment, and operations are simplified.

Discussion of Data on Side-Entering Elevated-Stall Milking Parlors

Herd, Equipment, and Operator

Table 5 shows that herds milked in 3-stall tandem parlors averaged 15 lactating cows. Those in the double-2 tandem parlors, 31 cows; in double-3 tandem, 77; and those in the double-4 tandem parlors, 130 (item 1). Two milking machine heads were used in the 2-stall tandem; three heads in the 3-stall tandem; two to four heads in the double-2's; five or six in the double-3's; and eight in the double-4's. Two 2-stall tandem, one 3-stall tandem, and one double-4 tandem had two machine operators. All other layouts used only one machine operator and most had no other operators.

Chore Time and Milking Rate

Milking parlors of the types shown in table 5 had smaller within-type variations in time data than the stall barns and milking barns shown in tables 2 and 4. This indicates that milking parlor layouts favor good operating routines. However, there were distinct differences between milking rates for the different types of milking parlors shown in table 5.

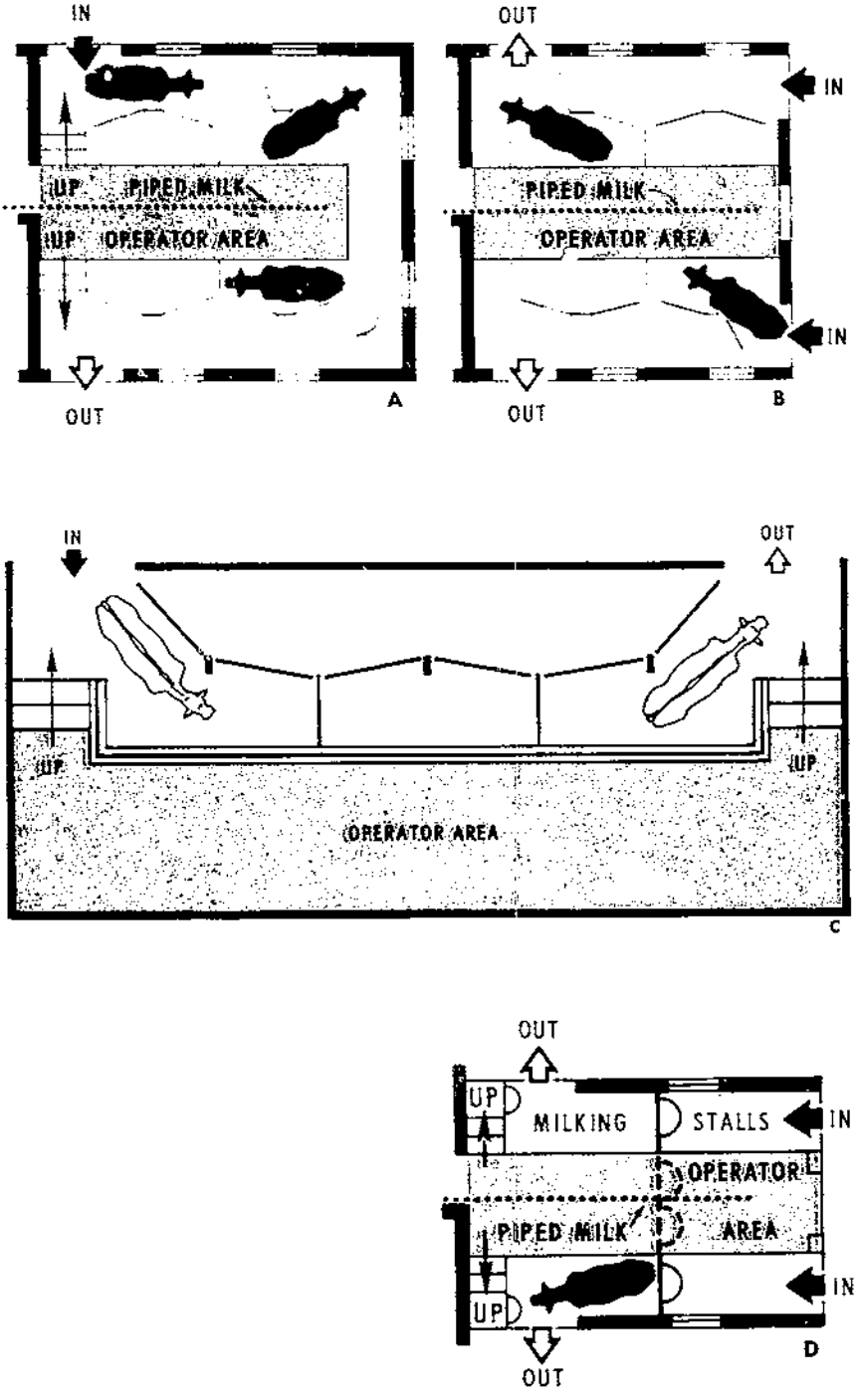


FIGURE 5.—Typical elevated-stall milking parlors. *A*, *B*, and *C* are the side-entering type; *D*, is a walk-through type.

Table 5.—*Side-entering, elevated-stall milking parlors: Summary of time and travel data for milking and related chores in 34 milking parlors in Illinois, Massachusetts, and California*

Item	2-stall tandem parlors (3 with a preparation stall; 4 with tail-to-tail arrangement; 11 with pipelines)				3-stall tandem parlors (4 with milk pipelines)					
	Selected better parlors with milk pipelines		12 parlors (all in Ill.)		Selected better parlors				6 parlors (5 in Ill., 1 in Mass.)	
	Parlor A (in Ill.)	Parlor B (in. Ill.)	Average	Range	Parlor C (in Ill.)	Parlor D (in Mass.	Parlor E (piped milk, in Ill.)	Parlor F (piped milk, in Ill.)	Average	Range
Herd, equipment, and operator:										
1. Cows in lactation—Number	22	22	14	8–22	10	20	20	24	15	8–24
2. Cows milked by machine—do	22	22	14	8–22	10	20	20	24	15	8–24
3. Milking machine heads—do	2	2	2	2–2	2	2	3	3	2.5	2–3
4. Milking machine operators—do	1	1	1.2	1–2	1	1	1	1	1.2	1–2
5. Other operators [1]—do	0	0	0	0	0	0	0	0	0	0
6. All operators—do	1	1	1.2	1–2	1	1	1	1	1.2	1–2
7. Cows milked per machine operator—do	22	22	12.4	7–22	10	20	20	24	14.7	4–24
8. Cows milked per machine head—do	11	11	6.8	4–11	5	10	6.7	8.0	6.2	3–10
9. Machine heads per machine operator—do	2	2	1.7	1–2	2	2	3	3	2.3	1.5–3
Chore time:										
10. Feeding concentrates—man-minutes/cow	.15	.12	.19	.06–.32	.25	.35	.19	.21	.22	.03–.35
11. Admitting and releasing cows—do	.34	.58	.63	.34–1.05	.55	.56	.42	.53	.47	.33–.56
12. Milking operations [2]—do	1.16	2.97	1.93	1.16–3.18	1.33	1.59	1.72	1.54	1.77	1.33–2.48
13. Miscellaneous [3]—do	1.06	.43	1.05	.04–2.86	.17	.36	.25	.08	.30	0–.91
14. Preparation and cleanup [4]—do	2.41	1.19	2.50	1.19–4.96	2.23	1.01	1.76	.96	1.92	0.96–2.96
15. All operations, items 10–14—do	5.12	5.29	6.30	2.79–12.37	4.53	3.87	4.34	3.32	4.67	3.32–6.11
Milking rate: [5]										
16. Per machine operator—cows/hour	21.9	15.5	17.0	8.3–26.6	25.8	20.8	23.1	25.3	21.6	16.5–25.8
17. All machine operators—do	21.9	15.5	18.6	13.2–26.6	25.8	20.8	23.1	25.3	24.6	16.5–36.0
18. Per operator (machine and other operators—do)	21.9	15.5	16.7	8.3–26.6	25.8	20.8	23.1	25.3	21.6	16.5–25.8
19. Per machine head—do	11	7.8	9.3	6.6–13.3	12.9	10.4	7.7	8.4	9.9	7.7–12.9
20. Per cow—machine-minutes	4.15	5.27	4.61	3.76–6.13	3.85	4.65	5.81	4.97	4.61	3.78–5.81
21. Per pound of milk—do	.28	.27	.31	.20–.42	.30	.31	.28	.29	.28	.20–.31
22. Per cow—man-minutes	2.74	3.88	3.95	2.26–7.21	2.34	2.89	2.61	2.37	2.86	2.34–3.63
23. Per pound of milk—do	.19	.20	.27	.16–.51	.18	.19	.13	.14	.18	.13–.24
24. Machine idle time—percent	21	28	27	13–42	11	16	27	32	24	11–36
Operator travel: [6]										
25. Per cow—(items 10 to 14)—feet	42	77	89	42–135	170	----------	80	159	131	80–170
26. Total travel for milking herd—do	916	1697	1140	534–1707	1695	----------	1604	3822	1861	1030–3822

See footnotes at end of table.

Table 5.—*Side-entering, elevated-stall milking parlors: Summary of time and travel data for milking and related chores in 34 milking parlors in Illinois, Massachusetts, and California*—Continued

Item	Double-2 tandem parlors (with bucket milking machine)				Double-2 tandem parlors (with milk pipelines)			
	Selected better parlors		5 parlors (3 in Ill., 2 in Mass.)		Selected better parlors		6 parlors (1 in Calif., 5 in Mass.)	
	Parlor G (in Ill.)	Parlor H (in Mass.)	Average	Range	Parlor I (in Mass.)	Parlor J (in Calif.)	Average	Range
Herd, equipment, and operator:								
1. Cows in lactation—Number	38	21	22.6	11–38	63	72	38.7	13–72
2. Cows milked by machine—do	38	21	22.6	11–38	63	72	38.7	13–72
3. Milking machine heads—do	4	2	2.8	2–4	4	4	3.7	2–4
4. Milking machine operators—do	1	1	1	1–1	1	1	1	1–1
5. Other operators [1]—do	.7	0	.24	0–.7	.8	0	.15	0–0.8
6. All operators—do	1.7	1	1.24	1–1.7	1.8	1	1.15	1–1.8
7. Cows milked per machine operator—do	38	21	22.6	11–38	63	72	38.7	13–72
8. Cows milked per machine head—do	9.5	10.5	8.1	6–11	15.8	18	10.2	6–18
9. Machine heads per machine operator—do	4	2	2.8	2–4	4	4	3.7	2–4
Chore time:								
10. Feeding concentrates—man-minutes/cow	.07	.40	.25	.07–.40	.03	.22	.18	.03–.40
11. Admitting and releasing cows—do	.43	.58	.53	.43–.60	.25	.59	.55	.25–.93
12. Milking operations [2]—do	1.73	2.05	1.92	1.48–2.72	1.24	1.59	1.61	1.24–2.11
13. Miscellaneous [3]—do	.09	.10	.09	.04–.12	.08	.09	.11	0–.27
14. Preparation and cleanup [4]—do	1.73	.73	1.30	.65–1.85	.48	1.08	1.06	.48–1.97
15. All operations, items 10–14—do	4.05	3.86	4.09	3.13–5.42	2.08	3.57	3.52	2.08–4.55
Milking rate: [5]								
16. Per machine operator—cows/hour	32.8	21.3	25.5	21.3–32.8	58.5	26.4	31.4	23.6–58.5
17. All machine operators—do	32.8	21.3	25.5	21.3–32.8	58.5	26.4	31.4	23.6–58.5
18. Per operator (machine and other operators)—do	19.3	21.3	20.9	18.1–25.7	32.5	26.4	26.7	23.6–32.5
19. Per machine head—do	8.2	10.6	9.8	6.5–12.8	14.6	6.6	8.9	6.0–14.6
20. Per cow—machine-minutes	5.55	4.90	5.05	3.89–6.18	3.50	7.67	5.69	3.50–7.67
21. Per pound of milk—do	.33	.25	.37	.25–.53	.37	.35	.43	.26–.64
22. Per cow—man-minutes	3.11	2.82	2.88	2.34–3.36	2.03	2.46	2.31	2.03–2.54
23. Per pound of milk—do	.19	.14	.21	.14–.24	.21	.11	.17	.11–.22
24. Machine idle time—percent	26	9	17	9–32	8	13	22	8–42
Operator travel: [6]								
25. Per cow (items 10–14)—feet	58	----------	67	58–95	----------	[7] 56	[7] 56	----------
26. Total travel for milking herd—do	2210	----------	1775	1493–2210	----------	4017	4017	----------

See footnotes at end of table.

Table 5.—*Side-entering, elevated-stall milking parlors: Summary of time and travel data for milking and related chores in 34 milking parlors in Illinois, Massachusetts, and California*—Continued

Item	Double-3 tandem parlors (1 with a fully piped system; 2 partly piped)				Double-4 tandem parlors (with milk pipelines)		
	Selected better parlors		3 parlors (all in Calif.)		Selected better parlors		2 parlors (in Calif.)
	Parlor K (partly piped milk; in Calif.)	Parlor L (in Calif.)	Average	Range	Parlor M (in Calif.)	Parlor N (in Calif.)	Average
Herd, equipment, and operator:							
1. Cows in lactation—Number	109	70	77	53-109	151	108	130
2. Cows milked by machine—do	109	70	77	53-109	151	108	130
3. Milking machine heads—do	5	6	5.7	5-6	8	8	8
4. Milking machine operators—do	1	1	1	1-1	2	1	1.5
5. Other operators [1]—do	0	0	0	0-0	0	1	.5
6. All operators—do	1	1	1	1-1	2	2	2
7. Cows milked per machine operator—do	109	70	77	53-109	75	108	92
8. Cows milked per machine head—do	21.8	11.7	14.1	8.8-21.8	18.9	13.5	16.2
9. Machine heads per machine operator—do	5	6	5.7	5-6	4	8	6
Chore time:							
10. Feeding concentrates—man-minutes/cow	.04	.40	.19	.04-.40	.24	.14	.19
11. Admitting and releasing cows—do	.20	.26	.31	.26-.39	.61	.38	.50
12. Milking operations [2]—do	.85	1.61	1.19	.85-1.61	1.71	1.97	1.84
13. Miscellaneous [3]—do	.01	0	.04	0-.11	.13	.05	.09
14. Preparation and cleanup [4]—do	.55	.70	.69	.55-.81	.57	.72	.65
15. All operations, items 10-14—do	1.74	2.07	2.42	1.74-2.07	3.26	3.26	3.26
Milking rate: [5]							
16. Per machine operator—cows/hour	50.3	28.8	37.7	28.8-50.3	24.9	47.4	36.1
17. All machine operators—do	50.3	28.8	37.7	28.8-50.3	49.7	47.4	48.5
18. Per operator (machine and other operators)—do	50.3	28.8	37.7	28.8-50.3	24.9	23.7	24.3
19. Per machine head—do	10.1	4.8	6.8	4.8-10.1	6.2	5.9	6.1
20. Per cow—machine-minutes	5.58	5.70	6.49	5.58-8.20	7.14	6.81	6.98
21. Per pound of milk—do	.41	.35	.51	.35-.77	.57	.41	.49
22. Per cow—man-minutes	1.19	2.29	1.75	1.19-2.29	2.41	2.54	2.48
23. Per pound of milk—do	.09	.14	.13	.09-.17	.19	.15	.17
24. Machine idle time—percent	5	52	26	5-52	25	35	30
Operator travel: [6]							
25. Per cow (items 10-14)—feet	70	75	76	70-83	92	59	76
26. Total travel for milking herd—do	7640	5234	5757	4397-7640	13861	6392	10127

[1] Includes all (except machine operators) who helped during all or part of the overall milking time (OMT), which begins when the teat cups are placed on the first cow and ends when they are removed from the last cow.

[2] Wash cows, foremilk, dip teat cups, operate surcingle, position machine, machine strip, remove machine, hand strip, carry and pour milk. Not all of these operations were performed in each case.

[3] If done during OMT, includes spraying cows, treating sore teats, hobbling cows, delays, getting fresh udder wash, washing manure to drain.

[4] Only for milking equipment and milkroom.

[5] Based on OMT.

[6] Travel for operations in items 10 to 14 inclusive.

[7] Travel for only one dairy.

For example, the average number of cows milked per man-hour (item 18) was 16.7 in the 2-stall tandem, 21.6 in the 3-stall tandem, 23.8 in the double-2 tandem, 37.7 in the double-3 tandem, and 24.3 in the double-4 tandem (about the same as in the double-2).

The operator of one California double-3 tandem layout (Parlor K) milked 109 cows at the exceptionally fast rate of 50.3 cows per hour with no help. In addition, after milking each cow he carried the milk to a milk dump at the end of the operator alley. In some respects this milking parlor was one of the best parlors studied, but the operator was more skilled than others in the way he handled the equipment, the cows, and himself. His OMT of 1.19 man-minutes per cow did not include regular washing of udders (item 22). Even if this operator's total time were increased to 1.37 man-minutes per cow by adding 0.18 man-minute per cow for washing udders (the average time for washing udders) minus his time carrying milk, the resulting rate of 43.8 cows per man-hour would still be exceptionally fast. This operator also rated the best performer in all milking layouts studied in "man-minutes per pound of milk". His machine-minutes per pound of milk was only 0.06 higher than the minimum of 0.35 for a dairy that was at peak production for the year.

The eight-stall milking parlor with the stalls arranged in a double-4 tandem and having two operators was about equivalent in arrangement, use, and operation to two double-2 tandem milking parlors end to end, except that the machine-minutes per cow were higher. This does not mean that the larger elevated-stall layouts were inherently bad, but rather that too often the operators did not use a good milking routine. There is a tendency for some operators to use too many stalls and too many machines. Six stalls and six machines are too many for most operators even if the best barn layouts are used and best routines are followed. The best operators, however, can manage six machines with very little overmilking of the cows.

It should be noted that, as the number of stalls per operator increases, the number of machine-minutes per cow also increases. Some of the best operators are exceptions to this rule, but most operators cannot keep up with six machines. Consequently, machines are left on some cows too long, and these cows are overmilked. The only reason an operator has for using one or two more machines than he can properly handle is to milk the herd faster. If an operator uses only one machine more than he can properly handle, he may milk the herd faster, but the use of more than one machine beyond his capacity to handle generally results in a slower herd milking rate and too much overmilking.

Operator Chore Travel

Operator travel in the 3-stall tandem parlors was 131 feet per cow per milking and was more than in the other types of parlors reported in item 25, table 5. Operator travel per cow was least in the milking parlors with two rows of two stalls each (double-2 tandem parlors) equipped with pipeline milkers.

Figure 6 illustrates the travel cycle of operators for milking six cows under two types of conditions. In *A*, the actual measured travel of an operator in a dairy that used five machines to milk six cows and where the operator moved the heads from stall to stall and carried milk from each stall to the milk dump is shown by solid and dashed lines. The dashed

lines represent the travel for carrying milk—a distance of 126 feet or 21 feet per cow; the solid lines, operator travel for all other milking chores—a distance of 168 feet or 28 feet per cow. Total travel for an operator is 294 feet or 49 feet per cow.

Figure 6*B* is a theoretical situation intended to show how operator travel can be reduced in milking six cows by using six machine heads and piping milk from each stall to the milkroom. If this situation had existed in the dairy described in 6*A*, operator travel for doing all the milking chores could have been reduced to a total of 150 feet or 25 feet per cow.

Milking Rates and Chore Travel in Parlors Having Pipeline Milking Machines Compared with Those Having Bucket Milking Machines

This series of studies was not planned to compare milking rates of pipeline milking machines with those of bucket milking machines in the same type of milking parlor. Time and travel variations due to other causes are so large that no conclusions can be drawn. The double-2 milking parlor was the only type in the study that had more than two examples each of bucket and pipeline milking machines. Five dairies used bucket milkers and six used pipeline machines. In the double-2 parlor, the milking rate of dairies equipped with the pipeline milkers was 27.8 percent faster, the machine-time per cow was 12.8 percent higher, and the machine idle time was 29 percent greater than in dairies equipped with bucket machines. Operator travel recorded for only one double-2 parlor using pipeline milkers and for three using bucket machines indicated that travel was 20 percent less in the double-2 parlors equipped with the pipeline machines. This travel difference of 20 percent is not significant, because travel for only 1 layout when compared with that for 3 layouts is subject to considerable error. Furthermore, travel in one of the bucket-machine layouts was only 3.6 percent more than that in the one pipeline layout, and 10 percent of the travel in one of the other bucket-machine layouts was for carrying milk to a milkhouse, which was 40 feet from the milking parlor. No other dairy in those two groups had a detached milkhouse. All other milkhouses adjoined the milking parlor.

Suggested Arrangement, Operator Routine, and Machine Combinations for Side-Entering Elevated-Stall Milking Parlors

The number of cows that can be milked satisfactorily in a given milking parlor depends on the rate of milking and the overall time limitation for milking the herd. The rate of milking depends on the (1) layout and number of stalls, (2) amount and type, condition, and adjustment of equipment, (3) number, ability, method, and routine of the operators.

A milking parlor with a loose-housing system will require a different combination of operators and machines than will a stall barn. In general, the requirements of the milking parlor are more flexible, and fewer operators are needed because with good arrangement and management, the work can be done faster and easier than in conventional stall barns. Good combinations of operators and machines for milking parlors and loose-housing systems are described as follows.

Combination 1: One operator, 2 elevated milking stalls, and 1 bucket machine for 10 cows or less, such as the first two or last two stalls in

figure 5C. Two bucket machines would permit greater operator efficiency and allow the herd to be milked faster, but even with only one machine, the overall time will be small. There are also economic limitations to the use of two machines. It is doubtful whether more than 1 machine is economically justifiable for herds of fewer than 10 cows, unless they are exceptionally good producers.

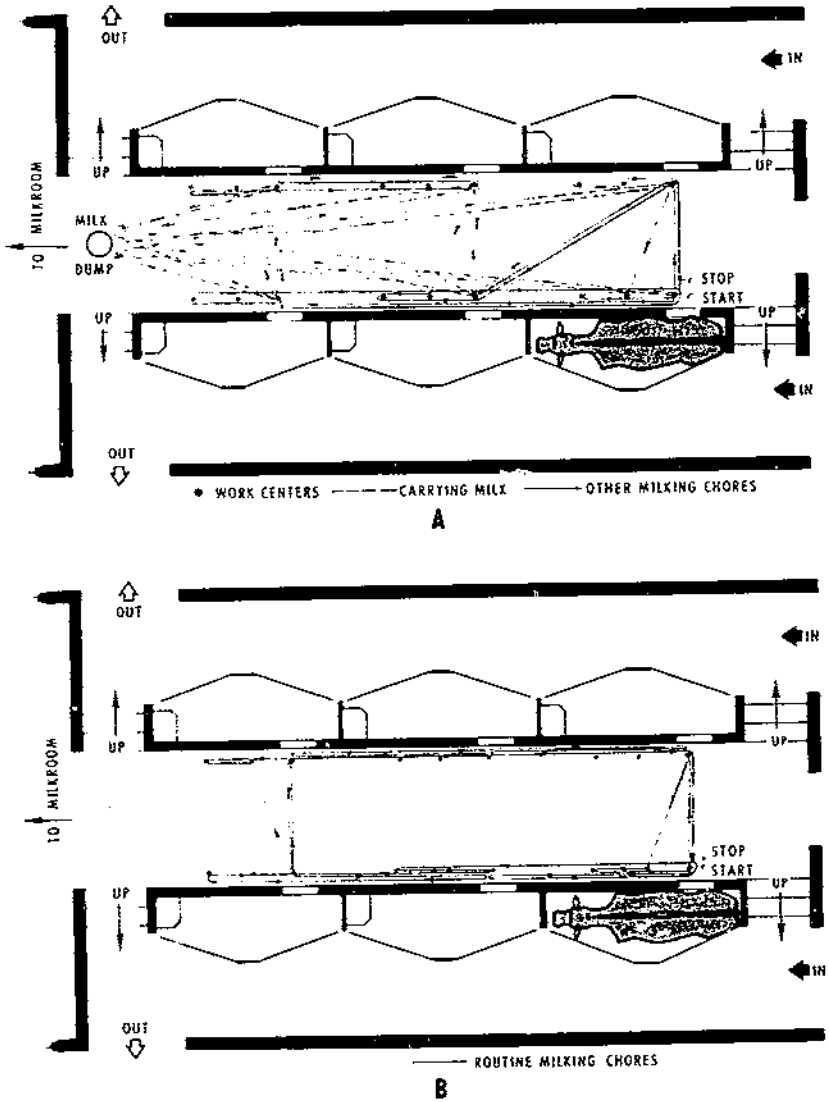


FIGURE 6.—Travel of operators for milking cows under two types of conditions. *A*, when milking six cows with five machine heads and carrying milk to the milk dump; *B*, when milking six cows with six machine heads and piping milk to a milkhouse.

Combination 2: One operator, 2 elevated stalls, and 2 machines for 10 to 20 cows, such as the first 2 or last 2 stalls in figure 5*C*.

Combination 3: One operator, 3 to 4 elevated stalls, and 2 bucket machines for 15 to 30 cows. If the milk is piped from each stall, one operator with two or three machines (fig. 5*A* or 5*C*) is adequate.

Combination 4: One or 2 operators, 4 or 5 elevated stalls, and 3 or 4 bucket machines for 30 to 50 cows (fig. 5*A*). If the milk is piped and the parlor has only four stalls, a machine head at each stall and only one operator are adequate for the herd.

Combination 5: Two operators, 6 or 8 elevated stalls similar to those shown in figure 5*B*, and 4 to 6 machines for a herd of more than 50 cows. If milk is piped, two operators are needed in a parlor that has six or eight elevated stalls and a machine head at each stall. In an eight-stall layout each operator serves the four stalls at one end of the operator area, that is, two stalls on each side, and has a machine head at each stall.

In most of the combinations discussed in the foregoing paragraphs, operations probably could be speeded up if the milk is piped from each stall to the milkroom. In combination 4 where two operators are recommended, only one operator should handle the machine heads. The second operator should be kept busy carrying milk or checking equipment in the milkroom, feeding, washing udders, perhaps doing some machine stripping and admitting and releasing cows. To prevent confusion and duplication of effort, operators must always have a definite understanding of the operations for which they are responsible.

The previously described combinations are flexible, and there is no definite dividing line between number of machines and stalls to be served by a given operator in milking a herd of definite size. Sometimes an additional stall or machine will help to milk the herd a little faster, but they may not be economically justifiable except for use with larger sized herds.

Two elevated stalls tandem but facing apart gave about the same milking rate as a two in-line tandem arrangement. The face-apart arrangement requires a slightly larger building, complicates entrance and exit lane arrangements, and usually is not as satisfactory as a two tandem layout.

A preparation stall, when used, precedes the milking stalls in a milking layout. A preparation stall is similar to a milking stall but is a place where cows' udders are washed and they may be fed part of their concentrates. Cows then go directly to a milking stall.

Two to four stalls in tandem (figs. 5*A*, 5*B*, and 5*C*) plus a preparation stall, showed no significant advantage over those without the preparation stall. Other things being equal, a preparation stall will help only if the operator's routine results in enough idle time for him to wash and foremilk a cow during the time he would otherwise be waiting for something to do. If the operator has no idle time, cows can be milked faster by washing them in milking stalls because the operator can move from stall to stall much faster than a cow can move from a preparation stall to a milking stall. Regardless of where the preparation stall is located, its use requires more travel by the operator, and the extra travel requires extra time.

Dairy studies have shown that the average milking rate in a group of 2-stall tandem parlors with preparation stalls was about 2.6 cows per hour faster than in a group of parlors without preparation stalls, because there was ample idle time to use them. However, cows in the parlors with

preparation stalls had an average of 0.6 of a minute less time to eat their concentrates. This means that cows should be fed in both the preparation and milking stalls, and more time is required for feeding.

The convenience of a milking parlor with three elevated stalls in a U-shape can be equal to or greater than that of a three in-line layout. But in some cases the U-shaped parlor is not so easily attached to an existing building as is the three in-line arrangement.

Four in-line elevated stalls are unsatisfactory for a single operator because too much time and too may steps are required for walking from stall to stall. From 10 to 23 percent more travel per cow will be required if an operator uses four in-line stalls instead of three. Many operators who have no help have learned by experience that they can milk the herd faster, more easily, and with fewer steps when stalls are three in-line than when four in-line. Four in-line stalls can be satisfactory and will require much less time if two operators are employed and if milk is piped from each stall to the milk cooler. One of the operators should handle the two stalls on the right; the other operator, the two stalls on the left. Each operator should stay in his own area, except in emergencies when either may help the other to their mutual advantage.

Cow alleys in elevated-stall milking parlors should not be less than approximately 42 inches wide, although most cows can pass through a 26- to 28-inch alley. If the alley is too narrow, the walls get dirty faster where cows rub against them. In addition, cows are likely to walk more slowly in the narrower alleys.

Operator areas in milking parlors can be as narrow as 40 inches and still be wide enough to obtain maximum efficiency in the milking operations. This assumes there are no obstructions on the floor such as pails, cans, and brooms, and it assumes milk is piped and that concentrates are fed from overhead bins or automatic equipment that is not in the operator area.

Discussion of Data on Walk-Through Elevated-Stall Milking Parlors

Table 6 shows data on milking operations in seven walk-through elevated-stall milking parlors of the type shown in figure 5*D*. The data are for four milking parlors in Illinois, each with four stalls in two rows, and for three parlors, two in Massachusetts and one in California, each with eight stalls. Of the eight-stall parlors, the one in California and one in Massachusetts have two rows of four stalls each. The other one in Massachusetts has four rows of two stalls each. Data on these parlors are placed together in table 6 because the methods used in them are almost identical, and they are more nearly alike than parlors in other elevated-stall types.

The walk-through milking parlor in Massachusetts, with eight stalls in four rows (parlor D, table 6) was in effect, two milking rooms side-by-side. It used two operators and eight machines. The machine idle time was unusually high because neither operator could handle four machines properly and keep them busy in this type of milking parlor, partly because slow-milking cows delayed the operation.

Another Massachusetts milking parlor with eight stalls in two rows (parlor C) used only four machines, which were moved back and forth

Table 6.—*Milking parlors with elevated walk-through stalls: Summary of time and travel data for the milking and related chores in 7 milking parlors*

Item	4-stall milking parlors (2 rows, each row has 2 stalls)				8-stall milking parlors (2 parlors have 2 rows of 4 stalls; 1 parlor has 4 rows of 2 stalls)			
	Selected better milking parlors with piped milk		4 milking parlors of which 2 have piped milk (all in Ill.)		Selected better milking parlors with piped milk		3 milking parlors all with piped milk (2 parlors in Mass., 1 in Calif.)	
	Parlor A (in Ill.)	Parlor B (in Ill.)	Average	Range	Parlor C (in Mass.)	Parlor D (in Mass.)	Average	Range
Herd, equipment, and operator:								
1. Cows in lactation—number	23	33	20	11-33	42	70	62	42-74
2. Cows milked by machine—do	23	33	20	11-33	42	70	62	42-74
3. Milking machine heads—do	2	2	2	2-2	4	8	5	4-8
4. Milking machine operators—do	1	1	1.25	1-2	2	2	1.67	1-2
5. Other operators [1]—do	0	0	0	0	0	.1	.03	0-.10
6. All operators—do	1	1	1.25	1-2	2.0	2.1	1.7	1-2.1
7. Cows milked per machine operator—do	23	3	18	6-33	21	35	43.3	21-74
8. Cows milked per machine head—do	11.5	16.5	9.8	6-17	10.5	8.8	12.6	8.8-18.5
9. Machine heads per machine operator—do	2	2	1.75	1-2	2	4	3.33	2-4
Chore time:								
10. Feeding concentrates—man-minutes/cow	.36	.07	.28	.07-.37	.58	.21	.33	.21-.58
11. Admitting and releasing cows—do	.46	.28	.42	.28-.54	.35	.39	.44	.35-.57
12. Milking operations [2]—do	1.04	2.32	2.18	1.04-3.06	1.57	1.51	1.25	.67-1.57
13. Miscellaneous operations [3]—do	.78	.19	.50	.19-.78	.21	.08	.11	.04-.21
14. Preparation and cleanup [4]—do	1.65	1.70	1.97	1.65-2.75	.62	.71	.64	.58-.71
15. All operations, (items 10-14)—do	4.29	4.56	5.34	4.29-7.01	3.33	2.90	2.77	2.07-3.33
Milking rate: [5]								
16. Per machine operator—cows/hour	24.4	23.5	19.4	13.4-24.4	26.3	20.9	33.9	26.3-45.5
17. All machine operators—do	24.4	23.5	22.7	16.2-26.8	52.5	59.8	52.6	45.5-59.8
18. Per operator (machine and other operators)—do	24.4	23.5	19.4	13.4-24.4	26.3	28.5	33.4	26.3-45.5
19. Per machine head—do	12.2	11.8	11.4	8.1-13.4	13.1	7.5	10.7	7.5-13.1
20. Per cow—machine-minutes	3.95	4.71	4.61	3.66-6.12	4.02	4.19	4.14	4.02-4.20
21. Per pound of milk—do	.36	.44	.39	.35-.44	.23	.26	.29	.23-.37
22. Per cow—man-minutes	2.46	2.60	3.32	2.46-4.48	2.29	2.01	1.87	1.32-2.29
23. Per pound of milk—do	.22	.24	.29	.22-.43	.13	.13	.13	.12-.13
24. Machine idle time—percent	15	53	24	14-53	8	51	25	8-51
Operator travel: [6]								
25. Per cow (items 10-14)—feet	114	91	101	71-129	----------	----------	[7] 101	----------
26. Total travel for milking herd—do	2611	2997	1952	782-2997	----------	----------	[7] 7475	----------

[1] Includes all except machine operators who helped during all or part of the overall milking time (OMT), which begins when the teat cups are placed on the first cow and ends when they are removed from the last cow. Decimal figures indicate part time operators.

[2] Wash cows, foremilk, dip teat cups, apply surcingle, position machine, machine strip, remove machine, hand strip, carry and pour milk. Not all of these operations were performed in each case.

[3] If done during OMT, includes spray cows, treat sore teats, hobble cows, delays, get fresh udder wash, and wash manure to drain.

[4] Only for milking equipment and milkroom.

[5] Based on OMT.

[6] Travel for operations in items 10 to 14 inclusive.

[7] Travel for only 1 dairy.

across the operator area. With only 4 machines, the 2 operators milked 53 cows per hour compared with the milking of 60 cows per hour with 8 machines in parlor D. In California, 1 operator in a parlor of 8 stalls in 2 rows and equipped with 4 machine heads, milked 74 cows at a rate of 45 cows per hour.

Cows should enter and leave an elevated-stall milking parlor quickly and voluntarily, particularly in a parlor of the walk-through type. If a cow is slow to enter a side-entering stall, even though she may enter voluntarily, a good operator usually will leave that stall entrance gate open and work on another cow while the slow one is entering the open stall. Furthermore, with side-entering stalls, a slow-milking cow will not delay other cows as she will in a walk-through layout. Good work routines, methods, and management can keep the cow delay in elevated walk-through layouts to a minimum.

SIZE OF OPERATION, MILKING RATE, AND OPERATOR TRAVEL IN STALL BARNS AND MILKING BARNS

Table 7 is a comparison of average data for floor-level types of milking barns shown in items 1, 4, 6, 16, 18, and 27 of tables 2 and 4 and items 14, 16, and 17 of table 3. The size of the sample was too small to explain the variation that existed within and among types of buildings. Nevertheless, because much of the variation is due to differences in the skill and energy of the operators in different buildings, the averages provide a reasonably satisfactory way to compare the types of buildings.

The number of cows milked per building type should not be regarded as the optimum capacity of that building type. It more nearly reflects the size of farm units in the area at the time the study was made.

Table 7 shows that all floor-level barns using bucket milking machines, except the string barns and abreast walk-throughs, had average milking rates below 15.5 cows per man-hour. However, 29 barns averaged a little more than 15.5 cows per man-hour, and 5 of this group averaged a little above 20 cows per man-hour. The floor-level abreast walk-through type averaged 28 cows per man-hour, mainly because the layout and method of milking required far less travel than did other types of floor-level layouts.

Milking parlors with 3 or more elevated stalls had milking rates of 13.4 to 50.3 cows per man-hour (item 18, tables 5 and 6). Only 5 of the 32 in this group had rates less than 19 cows per man-hour, and 23 had rates above 20 cows per man-hour. Milking parlors with 6 or more elevated stalls had rates of 24 to 50 cows per man-hour.

In 4 types of elevated-stall milking parlors (2-, 3-, 4-, and 6-stall types) and in the California abreast walk-through milking barns, the total time averages required to perform the 5 selected operations (items 10–14 of tables 4 and 5) ranged from 2.4 to 6.3 man-minutes per cow, and the operator travel averages ranged 56 to 131 feet per cow. In the small milking barns (table 4, items 10–14), the average total man-minutes per cow ranged from 4.7 to 6.0, and the average operator travel ranged from 149 to 225 feet per cow.

Notice should be taken that the fewest man-minutes per cow and the least travel per cow usually are required when one skilled operator works alone. Adding operators increases the number of cows milked per hour, but it also increases the man-minutes per cow and per pound of milk and

TABLE 7.—*Average size of operation, milking rate, and operator travel by stated types of floor-level milking facilities*

Type of milking facility [1]	Size of operation			Milking rate man-hour		Travel of total, all operators
	Cows in lactation	Machine operators	Total operators	Machine operators	Total, all operators	
	Number	*Number*	*Number*	*Cows*	*Cows*	*Feet per cow*
Stall barns:						
2-row, face-out, bucket (22 in Midwest)	21.5	1.3	1.5	18.0	15.5	221
2-row, face-in, bucket (17 in Midwest)	18.8	1.2	1.5	18.6	15.3	232
1-row, bucket (12 in Midwest)	10.9	1.3	1.4	16.2	14.6	236
2-row, piped (2 in Mass.) [2]	52.5	1.5	1.5	27.0	40.5	
Milking barns:						
1-row, bucket (8 in Midwest)	19.1	1.3	1.6	19.1	15.4	149
2-row, bucket (5 in Midwest)	17.0	1.4	1.5	16.7	15.1	225
String type; 2 with bucket milkers, 3 with piped milk [3] (all in Calif.)	228	2.2	4.0	39.1	18.2	109
Abreast walk through; 1 with bucket milker, 5 with piped milk (all in Calif.)	155	2.0	2.1	29.6	27.9	68

[1] Milking equipment: Bucket means bucket milking machines; milk is carried and poured by hand. Piped means milk is piped from stall to milkroom.
[2] These barns are reported in table 3.
[3] Milk carried to and poured in dump in breezeway from which it was piped through milkroom wall to a bulk tank.

decreases the cows milked per man hour. The large California string barns with several operators per barn had high combined milking rates and moderate travel, and the man-minutes per cow were 3.8 with an average travel of only 109 feet. This can be compared with the performance in the Midwest stall barns. The floor-level walk-through barns had very satisfactory rates for milking and operator travel, but considerable bending and stooping were necessary.

COW TIME AVAILABLE FOR EATING CONCENTRATES

Many dairymen who are planning their first milking parlor want to know how many stalls are needed and if a given number of stalls will allow ample time for the cows to eat concentrates, yet permit the maximum milking rate. Cows in stall barns may take from 10 to 15 minutes to eat concentrates, but cows in milking parlors learn to eat much faster. Observations and time studies of the milking parlors listed in table 8 plus those of 43 other parlors indicate that 6 minutes is ample time for most cows to eat concentrates. Except cows in Massachusetts that were fed citrus pulp, 90 percent of all cows observed actually required less than 5 minutes to eat their concentrates. Citrus pulp fed with other concentrates is difficult to eat rapidly. Consequently, many cows were milked out before they had finished eating.

Some exceptionally high-producing cows may require more concentrates and therefore more time to eat, but 7.5 minutes seem to be ample for such cows.

HAND STRIPPING COMPARED WITH MACHINE STRIPPING

Very little additional time was required for hand stripping in 22 California dairies (11 used hand stripping) and in 22 Massachusetts dairies

Table 8.—*Elevated-stall milking parlors: Time available for cows to eat concentrates and related milking data*

Side entering stalls

Milking parlors		Stall arrangement			Cow time available for eating concentrates [1]		Cows milked		Number of operators [2]		Operator area width		Milking machine heads	Milking rate per man hour		Machine time per cow		Machine idle time	
In sample	With piped milk	Stalls	Stall rows	Stalls per row	Average	Range	Average	Range	Average	Range	Average	Range		Average	Range	Average	Range	Average	Range
Number	*Number*	*Number*	*Number*	*Number*	*Minutes*	*Minutes*	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*	*Number*	*Cows*	*Cows*	*Minutes*	*Minutes*	*Percent*	*Percent*
4	4	[3] 2	1	2	6.63	5.62-7.84	13	9-18	1.4	1.0-2.0	37	27-42	2	16.5	8.3-20.6	4.58	4.10-5.08	28.1	23.7-33.7
5	4	[4] 2	1	2	6.52	4.95-8.65	16	9-22	1.2	1.0-2.0	47	36-54	2	15.4	11.0-21.9	4.60	3.86-5.43	30.1	18.4-41.9
3	3	[5] 2	1	2	6.28	5.00-7.01	12	10-14	1.2	1.0-2.0	59	45-69	2	17.2	15.9-26.6	4.73	3.43-6.13	21.4	12.9-35.9
6	4	3	1	3	6.99	5.25-8.82	15	8-24	1.2	1.0-2.0	54	51-57	2-3	21.1	16.5-25.8	4.77	3.78-5.95	23.7	10.9-36.0
3	3	4	1	4	7.70	5.78-8.72	47	26-73	1.8	1.5-2.0	66	46-96	3-4	16.0	14.3-20.4	5.94	4.98-6.52	16.4	11.0-23.0
11	6	4	2	2	8.17	3.80-10.90	31	11-72	1.2	1.0-1.8	60	43-88	2-4	24.0	18.1-32.5	5.35	3.50-7.67	20.1	7.9-42.2
3	2	6	2	3	7.86	5.98-10.57	77	53-109	1.0	1.0-1.1	80	66-96	5-6	36.8	26.2-50.3	6.49	5.58-8.20	25.5	4.5-52.1
2	2	8	2	4	8.16	7.44-8.87	130	108-151	2.0	2.0-2.0	96	96-96	8	24.3	23.7-25.0	6.97	6.81-7.13	29.8	24.9-34.6
Walk-through stalls																			
5	4	4	2	2	9.91	7.48-13.13	17	6-33	1.2	1.0-2.0	61	56-74	2-4	18.7	13.4-24.5	4.52	3.66-6.12	27.4	13.0-53.4
3	3	8	2 or 4	4 or 2	8.92	7.86-11.01	62	42-74	1.7	1.0-2.1	67	40-96	4-8	33.4	26.3-45.4	4.14	4.02-4.20	25.0	8.1-50.8

[1] Number of minutes cow is in milking stall.
[2] Only operators who helped with milking operations.
[3] Face-apart stalls.
[4] In-line stalls.
[5] In-line stalls plus a preparation stall.

(10 used hand stripping). Hand stripping in both states required 0.24 man-minutes per pound of milk. Without hand stripping, 0.16 man-minutes per pound of milk were required in California and 0.23 in Massachusetts.

RECOMMENDATIONS FOR DESIGN AND OPERATION OF BUILDINGS USED FOR MILKING COWS

The following recommendations for design and operation of buildings for milking cows were developed:

1. Good layouts should require the minimum movement of men, animals, and materials. In most dairies, chore time is closely associated to the distance operators travel while doing chores.
   (a) Equipment and interior arrangements of buildings should permit and encourage cows to move into and away from the milking stalls as rapidly as possible. Loitering cows not only waste the operator's time but interfere with the movement of other cows. Holding pens, entrance and exit lanes, cow alleys, and stalls should be located and arranged so that cows have a direct approach to and from the milking facility with a minimum of turns, gates, or doors to slow their movements.
   (b) Operators should have easy and direct access to all work areas and a minimum of travel between cows and other work centers.
   (c) Feed, bedding, milk, and other materials should be moved as little as possible, particularly if these items must be moved by hand.
2. Mechanization saves labor. Milking facility equipment that usually pays for itself includes:
   (a) Warm water washing systems for udders.
   (b) High volume, high pressure water systems for flushing floors.
   (c) Modern milking machines with as many machine heads as an operator can use effectively in a specific layout. Place a machine head at each elevated side-entering stall, or between each pair of cows in a walk-through layout.
   (d) In most cases a piped milk system.
   (e) In many cases a bulk milk tank.
   (f) In many cases a system for conveying and metering concentrates to milking stalls. Piped milk systems, bulk milk tanks, and automatic feed conveyors become more important as size of herd increases.
3. Keep cows out of mud and manure, mainly to avoid excessive washing of udders.
   (a) Holding, feeding, and cow movement areas should be paved. Pavement in open barnyard should be a minimum of 100 square feet per cow and should be located where cow traffic is heaviest—to, from, and within feeding areas.
   (b) In the loose-housing system, feeding and resting areas must be kept separated. Cross traffic should not be permitted in resting areas.
   (c) In stall barns, stall platforms must be long enough so that cows will not have to stand or lie in the gutters.

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END