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I am submitting herewith a thesis written by Jimmy Paul Vaughn entitled "The Comparison of the Characteristics of the Rotary Milking System to Other Milking Systems." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

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THE COMPARISON OF THE CHARACTERISTICS OF THE ROTARY MILKING
SYSTEM TO OTHER MILKING SYSTEMS

A Thesis
Presented for the
Master of Science
Degree
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Jimmy Paul Vaughn

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ABSTRACT

Five milking systems were observed and evaluated for efficiency by various performance measurements. Milking routine in each system was divided into the following sub-components: cow movement, cow preparation activity, machine time, dismount activities, machine idle time and operator's idle time. These performance measurements were used to determine the level of efficiency for the various milking systems and to determine how the systems could be improved.

It was found that cow movement was a critical component for the milking routine. Milking systems that had short cow entrance times were usually efficient if all other components remained constant. The 14 stall herringbone rotary system was the most efficient milking system with regard to cow throughput per hour by theoretical measures when staffed with 2 operators. In terms of cow throughput per man hour, the efficiency of the various milking systems depend upon the number of operators in the milking parlor. Therefore, the double 8 herringbone system with automatic detachers and one operator was the most efficient in cows milked per man hour. If different levels of mechanization such as crowd gates, automatic preparatory stalls, automatic detacher units, and feedgates were applied to these systems, efficiency for cow throughput might increase. This would also allow a decrease in the number of operators which should increased the cow throughput per man hour.

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CHAPTER I

INTRODUCTION

Determination of which milking system best fits the needs of a dairy operation hinges on certain management decisions. These decisions are affected by cow throughput, labor requirements (quality and quantity), total investments and annual costs. Cow throughput for individual milking systems vary from a minimum value of 36 cows per hour to 167 cows per hour. Number of cows that can be milked per hour depends upon the levels of mechanization in the milking system and the quality of labor. The size of the labor crew required ranges from 1 to 4 operators depending on the type of milking systems. Labor is the most important component of a milking routine with 70 to 80 percent of the total chore time being spent in the milk barn. Labor accounts for 13 to 25 percent of the total cost of producing milk. Increased levels of mechanization and improvements in quality of operators can decrease labor requirements. Determining which milking system best applies to a dairy farmer's operation and resources is a very complex problem.

The objectives of this study were to determine the characteristics of some recently developed parlor designs engineered for large throughputs and to compare these with traditional parlor designs. This was accomplished by contrasting various characteristics of parlor operation, such as cow movement, cow preparation activity, machine time, dismount activities, machine idle time and operator's idle time.

CHAPTER II

REVIEW OF LITERATURE

I. COW THROUGHPUT

One of the major factors in evaluating modern parlors is the throughput or the total number of cows milked per hour. The decision by management as to how many hours are actually spent in the milking parlor performing the daily milking routine is very important. The number of cows that can be milked per man per day depends on the number of men milking, the number of milking units, the production level of the herd, efficiency of the milkers in performing various milking routines and degree of mechanization built into the system.

Claugh and Dodd (8) found that the number of cows that could be milked per hour in a given installation depended on the rate at which milk can be removed from the udders of the cows and the milk yield of the cows. Tomaszewski et al. (21) found that there was a strong correlation of .86 between milk yield and rate of milk flow. Therefore, herd milk production level will affect average milking time. Noorlander (16) stated that mastitis and other udder health problems can reduce milking rates and production levels. Therefore, the goal should be complete udder evacuation with sufficient operator time available to appropriately protect udder health.

The events of milking are a systematic process. These events are cow entrance, washing and drying of the udder, extracting foremilk from the teats, attaching milking unit, interval of active milk flow, detaching milking unit, teat dipping and cow exit. Variation in range of cow throughput is due to differences in performance by the operators and individual cow milking rates as stated by Micke (13). For example, the time required to attach a milking machine depends on the type of machine in use, the type of detacher used (some may require adjustment during the attachment process) and the operator's proficiency. Moreover, the rate and duration of malfunction depends on the operator's skill.

Hoglund (12) reported that crowd and power gates increased milking rate per hour by 4, 5, 7 cows in double 4, 6 and 8 herringbone type parlors, respectively. Armstrong and Bickert (2) reported that the addition of feedgates increased cow throughput per hour by 3 cows for double 6 and double 8 herringbone parlors. Micke and Appleman (14) reported that using crowd gates decreased cow movement from 18 seconds to 12 seconds per cow. Using crowd gates machine application intervals were shortened causing an increase in milk flow and yield (4, 9, 15) with a decrease in milking time (17, 20).

Armstrong and Bickert (3) reported that when the daily milk yield in the rotary 8 stall tandem parlor type system was 37 pounds per cow, 984 pounds of milk per manhour was harvested. Armstrong and Bickert (2) reported that the production of milk per manhour in different size herringbone parlors ranged from 870 pounds to 1440 pounds of milk without

mechanization and 1200 pounds to 2520 pounds with mechanization. In a comparison of an 8 stall tandem to a 17 stall turnstyle rotary system, Bickert and Armstrong (5) found that the daily milk yield per cow was 41 pounds with a producing level of 984 pounds of milk per manhour. Armstrong and Bickert (3) stated that the cow throughput for a 8 stall tandem parlor type system ranged from 35 to 57 cows per manhour depending on the level of mechanization.

Hoglund (11) stated that cow output per hour of the base system was 38, 60 and 74, respectively, for the double 4, 6 and 8 herringbone type parlors. With a high level of mechanization, the cow throughput per hour was 42, 68 and 84 cows, respectively. Appleman and Micke (1) reported that higher levels of mechanization increased the average cow throughput of 31 cows per manhour in herringbone type systems. Armstrong and Bickert (2) reported that different sizes of herringbone systems without mechanization had a cow throughput ranging from 37 to 86 cows per hour. When higher levels of mechanization were applied, the cow throughput ranged from 49 to 93 cows per hour. Bickert and Armstrong reported that 16, 20, 24, and 32 stall polygons had cow throughput of 87, 102, 117, and 145 cows per hour without mechanization and 100, 108, 115, 116, cows per hour with added mechanization.

II. LABOR REQUIREMENTS

Hoglund (11) stated that labor accounted for 13 to 25 percent of the total cost of producing milk. Furthermore, 70 to 80 percent of the

total chore time was spent in the milk barn. Next to tobacco farming, dairying has the largest requirement for labor, averaging 6,388 hours annually. The all farm average was 4,406 hours.

Brown et al. (7) estimated that the total man equivalent hours required by 1985 to produce the feed supply, and to feed, milk and care for 100 cows will be 9810 or 60 percent less than for 1970. The labor supplied by the operator and his family will be reduced by two-thirds but will still provide about 69 percent of the total labor force. However, the need for full-time hired men will increase one and one-fourth times (up to 21 percent of the total labor force). Therefore, labor requirements can be reduced by different levels of mechanization.

According to Sellers (19) dairy farms in United States average 34 hours of labor per \$100 of product sales. The large dairies with annual product sales greater than \$40,000 use only 14 hours of labor per \$100 of sales. Automation undoubtedly has contributed significantly to this improvement in labor efficiency.

Boyd et al. (6) stated that labor for milking cows was the major cost item ranging from 76 to 86 percent of total milking costs. Scarcity and high cost of quality labor emphasize the importance of investing in a complete milking system which uses labor efficiently.

Brown et al. (7) found on the basis of a 50 cow herd that a double 5 herringbone had a total milking time of 69 minutes compared to a double 3 walk-thru at 85 minutes total time. Therefore, labor requirements expressed in dollar values are less in higher levels of mechanized milking

systems than in base milking systems due to being more efficient in total time.

III. INVESTMENTS

Total investments required for various parlors are one of the major concerns that dairy farmers face. Investments required for different milking parlors consists of the costs of buildings, stalls and feeders, the milking and heating systems, water and sewage installations and other equipment for various types of parlors. Differences in investments for various types of parlors are the result of extra equipment needed for a specific system. Inflation of equipment cost is another concern in investing for milking systems. Hoglund (12) stated that 1976 investments for the same herringbone milking systems in 1966 increased in costs by an average of 57 percent and estimates claim an increase by 10 percent in 1977. The utilization of higher degrees of mechanization is another reason for a sharp increase in investment.

Armstrong and Bickert (2) in 1976 stated that double 3, 4, 5, 6 and 8 herringbone milking type systems had a base investment with moderate levels of mechanization of \$47,600, \$54,300, \$60,800, \$69,500 and \$84,400, respectively, as shown in Table I.

Armstrong and Bickert (3) found in 1976 that investments in 8 stall tandem, 14 stall herringbone, and 17 stall turnstyle were \$71,400, \$106,800 and \$109,400, respectively when these systems had high levels of mechanization (Table I).

TABLE I
INVESTMENTS IN MILKING SYSTEMS AND EQUIPMENT¹

Milking System	No. of stalls	Cost stalls	Construction	Base Equipment	Mechanization	Total Dollars
Herringbone ¹	3	7933	11,200	19,800	16,600	47,600
	4	6788	12,500	24,700	17,100	54,300
	5	6800	15,500	26,700	18,600	60,800
	6	5792	16,200	29,700	23,600	69,500
	8	5275	19,800	34,800	29,800	84,400
Rotary ²	10	4995	24,000	39,900	36,000	99,900
	8	8925	26,500	44,900		71,400
	14	7629	42,500	64,300		106,800
	17	6435	37,600	71,800		109,400
Polygon ³	16	6993	36,500	45,600	29,800	111,900
	20	6460	42,000	51,500	35,700	129,200
	24	7013	66,000	57,200	45,100	168,300
	32	6616	85,800	69,000	56,900	214,400

¹Reference. Armstrong, Dennis V. and William G. Bickert. 1976. Michigan St. Ext. Bulletin E-1034.

²Reference. Bickert, William G. and Dennis V. Armstrong. 1977. Michigan St. Ext. Bulletin E-1047.

³Reference. Bickert, William G. and Dennis V. Armstrong. 1976. Michigan St. Ext. Bulletin E-1035.

Brickert and Armstrong (5) reported in 1977 that investment for polygon parlors with high levels of mechanization was \$111,900, \$129,200, \$168,300 and \$211,700 for 16, 20, 24 and 32 stall systems, respectively, (Table I). Investment/milking per stall is a logical way of comparing investments in various milking systems.

Armstrong and Bickert (2) found that costs per stall for a double 4, 6, 8 and 10 herringbone type systems were \$6,788, \$5,792, \$5,275 and \$4,995, respectively. Armstrong and Bickert (3) found that cost per stall for rotary milking systems with high levels of mechanization for 8 stall tandem, 14 stall herringbone and 17 stall turnstyle were \$8,925, \$7,628 and \$6,435, respectively. Researchers found in 16, 20, 24 and 32 stall polygon milking systems that costs per stall were \$6,993, \$6,460, \$7,013 and \$6,616, respectively (Table I).

Hoglund (11) in 1973 found that total investments in a double 4 herringbone milking system with 4 milking units were \$30,700 or \$256 per cow. Installation of a milking unit for each stall in the system increased labor efficiency but also increased investments by \$1600 or \$13 per cow. Elimination of 2.4 hours of milking time per cow per year resulted from the installation of milking units to all stalls.

Total costs for a 120-cow herd were \$1,064 lower with installation of milking units for each stall for the double 4 herringbone milking system when labor was valued at \$3 per hour. Total costs were reduced by \$1,352 for the same system when labor was valued at \$4 per hour. Therefore, investments can be profitable depending on the dollar value placed on labor.

In milking large herds, 240 cows or more, management has many options as to the appropriate milking system to use in the operation. These options include small throughput systems used extended periods of time (two labor shifts) or larger throughput systems with split shifts. Boyd et al. (6) stated that total investments per cow were greatly reduced when two or three groups of cows utilized a single parlor. Investments per cow were reduced by 50 percent when a parlor was used 12 hours daily instead of 6 hours daily. An additional reduction of 17 percent was possible when parlor use totaled 18 hours daily for three groups of cows. Hoglund (11) stated that extra automated equipment would not yield returns unless labor cost \$3 or more per hour when the milking rate was 50 cows rather than 60 cows per hour.

Therefore, labor costs play an important role in deciding to invest. Due to this role, Boyd et al. (6) stated there were definite disadvantages in scheduling milking times when the parlor was used two or three times daily. One of the milking times must be accomplished either very early in the morning or late in the evening.

IV. ANNUAL COSTS

Annual costs consisted of expenses for depreciation, repairs, insurance, interest on equipment and buildings and charge on labor.

Hoglund (12) research with three herringbone parlor sizes and four levels of mechanization with split and straight shifts found that annual costs per cow for double 4, 6, 8 milking systems were \$137, \$152

and \$130, respectively. Costs were \$11, \$12 and \$15 less per cow milking twice as many cows with two split shifts.

Annual costs per cow for milking, for owning and operating the parlor and equipment averaged \$2 more or \$87 per cow for the double 4 compared to the double 8 herringbone parlors. Lower building and equipment costs per cow more than offset the reduced milking rate per man for the double 8 herringbone parlor. Lowest cost was for the double 5 herringbone for skilled operators. Annual costs of owning and operating side-opening parlors ranged from \$32 to \$39 more per cow than for the double 4 herringbone parlor stated Hoglund (10).

Hoglund (12) stated that a double 6 herringbone with two operators was a high annual cost system at \$112 per cow until automatic detaching units were installed to eliminate one operator. Annual costs per cow for a high level mechanized system using power gates, feed bowl covers and detaching units were \$10 to \$14 less than for the double 4 herringbone system.

Boyd et al. (6) found that a high level mechanized double 8 herringbone system was a low cost system with annual costs of \$85 per cow. Hoglund (12) stated that annual costs of \$130 for a base double 8 herringbone was reduced to a range of \$117-\$130 by installation of high levels of mechanization.

Hoglund (12) and Boyd et al. (6) stated that annual costs per cow was similar for the two sizes of herringbone parlors when they are operated the same total hours daily. Annual costs per cow were reduced for

both sizes of milking systems as hours utilized increased until the parlor was used for 12 hours a day with two groups of cows and operators. Milking an additional group resulted in a reduction of costs per cow by \$2 to \$3.

Boyd et al. stated that dairymen milking less than 180 cows were best adapted to the double 4 herringbone system. The double 8 herringbone system was best adapted to herds of greater than 240 cows.

Annual milking cost per cow for different size herringbone systems with different degrees of mechanization varied inversely with herd size. Armstrong and Bickert (2) reported that the comparison of the double 4 and 6 herringbone systems with no mechanization with herd sizes of 50, 100 and 200 cows had annual milking costs of \$223, \$145, \$107 and \$274, \$179, \$131, respectively (Table II). Double 6 herringbone system with moderate levels of mechanization decreased annual cost by 12 percent. The double 8 herringbone system with and without levels of mechanization compared to a 100-600 cow herd sizes consisted of annual costs at \$180, \$124, \$96, \$86 and \$208, \$120, \$76 and \$61, respectively (Table II).

Polygon milking systems with large herds, 400 to 1200 cows, varied considerably in annual costs. The 16 stall polygon system utilized in a 400 cow herd, without and with mechanization, had annual costs of \$99 and \$84 per cow. Thus mechanization decreased costs 16 percent. The 32 stall polygon system utilized with an 800 cow herd, without and with mechanization, had annual costs of \$89 and \$84 per cow. Thus the additional mechanization reduced costs 6 percent. The rotary parlor

TABLE II
ANNUAL MILKING COST PER COW IN DIFFERENT MILKING
PARLORS, 1976 PRICES¹

Parlor	Mechanization	No. of Operators	No. of milking cows Dollars/cow ²				
			50	100	200	400	600
Herringbone double 4	None	1	223	145	107		
Herringbone double 6	None	2	274	179	131	107	
Herringbone double 6	Partial	1		184	112	75	
Herringbone double 8	None	2		180	124	96	86
Herringbone double 8	Partial	1		208	120	76	61

¹Reference: Armstrong, Dennis V. and William G. Bickert. 1976. Herringbone and side-opening milking parlors. Michigan St. Ext. Bulletin E-1034.

²Annual cost was based upon: depreciation of 12 years for parlor and holding pen and 7 years on all equipment, interest at 8 percent on unpaid balance, insurance at \$4.65 per \$1000 of original investment, repairs at 2.5 percent for parlor and holding pen and 5 percent on equipment, labor charged at \$10,000 per man year.

follows the same pattern up to a 600 cow herd size. Therefore, the larger the herd size the lower the annual cost per cow and the greater the levels of investments that can be profitably utilized.



CHAPTER III

MATERIALS AND METHODS

The objectives of this study were to determine the characteristics of some recently developed parlor designs engineered for large throughput and with major emphasis to compare these with traditional parlor designs.

Operation characteristics and parameters were obtained for several types of milking systems (Table III). Data for the double 4 herringbone milking system were collected at Martin, Tennessee. The dairy operation at Martin consisted of a herd of 54 Holsteins and 39 Jerseys. There were two operators in the parlor using four milking units. The rolling herd average for milk production was 15,330 pounds of milk with 529 pounds of butterfat.

A double 5 herringbone milking system was observed at Spring Hill, Tennessee. The operation consisted of 112 Holstein cows and two operators were in the parlor operating five milking units. The rolling herd average for milk production was 18,460 pounds of milk with 651 pounds of butterfat.

Observations of a double 8 herringbone milking system were made on a farm located near Speedwell, Tennessee. The operation consisted of a milking herd of 220 Holstein cows. The rolling herd average for milk production was 15,710 pounds of milk and 576 pounds of butterfat. The

TABLE III

THE MILKING SYSTEMS OBSERVED

System	Location	Herd size and breed	No. of operators	No. of milking units	Herd avg. pounds of milk	Herd avg. pounds of butterfat
Herringbone double 4	Martin	54 Holsteins 39 Jerseys	2	4	15,330	529
Herringbone double 5	Spring Hill	112 Holsteins	2	5	18,460	651
Herringbone double	Speedwell	220 Holsteins	1	16 ¹	15,710	576
Rotary herringbone 14 stall	Greeneville	313 Holsteins	2.5	14	15,21 ²	---
Rotary herringbone 15 stall	Jackson	10 Holsteins 92 Jerseys	2.5	15	10,400 9,510	420 479

¹Automatic detachment units.²Pounds of milk per cow observed in visit.

system had one operator in the parlor. The system had 16 milking units and was equipped with automatic detachment units and automatic feed gates.

A 14 herringbone rotary milking system was observed on a farm near Greeneville, Tennessee. The herd for this operation consisted of 313 Holstein cows. There were two operators in the parlor with a third person responsible for changing groups of cows and controlling entrance of cows onto the rotary platform. The herd was not on DHIA milk test. Cows averaged 15.21 pounds of milk per milking. The rotation speed for the rotary platform was 7.5 minutes.

A 15 stall herringbone rotary milking system was observed at the West Tennessee Experiment Station (WTES) near Jackson, Tennessee. The herd consisted of 92 Jersey cows and 10 Holstein cows. Two operators were used in the parlor and a third man was responsible for cow entrance. The rolling herd averages for milk production were 10,400 pounds of milk with 420 pounds of butterfat for the Holsteins and 9,510 pounds of milk with 479 pounds of butterfat for the Jerseys. There were three observations made at WTES due to malfunctions of the rotary system and differences in the rotation speeds. In the first observation the rotation speed for the rotary parlor was 6.0 minutes. There was also a malfunction in the universal joint of the drive unit which caused excessive stopping of the rotating platform. The second observation of the rotary parlor had a rotation speed of 9 minutes. During the milking routine a cow was caught between the stall and the side of the rotary platform. This accident

caused excessive delay of milking time till the cow was freed. The third observation had a rotating speed of 9 minutes. There were no malfunctions during the milking routine therefore allowing an accurate measurement of the rotary system. The system was equipped with crowd gates and automatic spray stalls, but they were non-functional.

A Sony video tape camera was used to tape the milking process of each milking system. The tape for each milking was replayed through a television set and the time required to accomplish various routines were recorded from measurements from replays.

Total milking time was determined as being the total elapsed time from the entrance of the first cow into the milking parlor until the last cow exited. The time intervals between opening and closing of the entrance and exit gates were defined as the entrance and exit times. The time required for washing and drying udders was based on the operator's movements. Activity which appeared to be of a washing nature was defined as washing and if the activity seemed to be directed to drying it was recorded as drying time. Foremilking interval was determined by the operator's action of extracting milk. The operator's time from grasping the milking unit until the milking unit was attached determined the attachment interval. Machine time was measured from the completion of attachment to the initiation of detachment of the unit. This measurement was taken live on rotary systems. The detachment of the milking unit included the actual removal of the unit as well as the time which elapsed before the unit was placed on a rack. The interval of time spent recording the

milk weights for each individual cow was recorded. Teat dipping was measured from the time the operator grasped the iodine cup until it was replaced on the rack. Machine idle time was the interval that the milking units were not in use. The operator's time spent for non-operational functions was counted as man idle time.

Total milk produced per milking was derived by measuring the amount of milk received in the bulk tank after each milking. The number of cows milked were recorded from the daily milk records.

The video equipment malfunctioned during the recording the 14 stall rotary system. Measurements of the various characteristics were taken live during the remainder of the milking process. Therefore some measurements are based on a limited number of observations in this parlor system.

CHAPTER IV

RESULTS AND DISCUSSION

Data on the five milking systems that were observed and evaluated for efficiency were characterized by various performance measurements. The milking routine in each system was divided into the following sub-components: cow movement, cow preparation activity, machine time dismount activities, machine idle time, and operator's idle time.

Means for cow entrance and exit times are given in Table IV. Of the procedures leading up to the attachment of the milking units, cow entrance time was probably the most important, not only because of the length of time required for the movement but because of the interrelationships with the subsequent steps of the milking procedures.

It required an average of 20-23 seconds for the cows to enter the double 4 and 5 parlors and 40 seconds for the double 8 parlor. The rotary parlors used 7 to 12 seconds for entrance. Tolerances are rather confining in the rotary systems and if cows do not move freely on to the platform the system must be stopped or stalls skipped. The management of these herds had the option to add an extra man to ensure smooth cow flow on to the table. The use of crowd gates to encourage more rapid cow entrance onto the rotary platform would appear to be alternative correction for this problem. The WTES rotary parlor was equipped with crowd gates but it was not used. Cow throughput per hour

TABLE IV
TIME UTILIZED FOR COW MOVEMENT IN VARIOUS MILKING PARLORS

System	Location	No. cows milk	Entrance (sec)/ cow	Standard Deviation	Exit (sec)/ cow	Standard Deviation	Groups of cows	Entrance (sec)/ group	Standard Deviation	Exit (sec)/ group	Standard Deviation
Herringbone double 4	Martin	93	4.94	2.22	4.10	2.02	24	19.98	8.70	17.32	5.78
Herringbone double 5	MTES	112	4.77	2.18	4.86	2.20	23	23.26	7.40	23.71	7.97
Herringbone double 8	Speedwell	202	5.02	2.34	3.89	1.98	26	40.26	9.75	31.16	5.70
Rotary herringbone 14 stall	Greenville	313 ¹	6.50	2.41	4.00	1.78	--	-----	-----	-----	-----
Rotary herringbone 15 stall (April)	MTES	114	8.46	2.03	4.15	2.03	--	-----	-----	-----	-----
Rotary herringbone 15 stall (June)	MTES	75	10.76	2.48	3.84	1.95	--	-----	-----	-----	-----
Rotary herringbone 15 stall (Sept.)	MTES	92	11.98	3.46	3.53	1.88	--	-----	-----	-----	-----

¹Measurement was based on 20 random cows (video system malfunction).

could be increased 3 to 6 cows with use of crowd gates depending on the type of system. In comparison of exit time, the herringbone and rotary milking systems had an average of 4.2 and 3.9 seconds per cow, respectively. The small variation seemed to be dependent on the operator's attention to the exiting cows rather than to any factor inherent to the system.

The times required for washing, drying, and foremilking in each system are shown in Table V. In comparing washing times the herringbone and rotary milking systems had an average of 7.0 and 7.5 seconds per cow respectively. The two system both utilized 5 seconds per cow for drying time. The variation in the washing time averages was dependent on the amount of operator's time available for general concern of udder cleanliness and health. The drying time averages remained equal due to the lower degree of concern by the operators. Both rotary systems attached units immediately after drying and/or foremilking. Therefore the machines were normally attached before the let down reflex had time to occur. This approach is in violation of accepted good milking technique. The WTES rotary parlor was equipped with automatic preparatory stalls but these were not in use. Automatic preparatory stalls would obviously decrease the time that operators were involved in preparation activities and should permit a more proper sequencing of machine attachment. This level of mechanization would have accomplished stimulation of the udder before the cow entered the milking system and let down should be accomplished by time machines are attached.

TABLE V
TIME UTILIZED FOR WASHING, DRYING AND FOREMILKING IN VARIOUS PARLORS

System	Washing (sec)/cow	Standard Deviation	Drying (sec)/cow	Standard Deviation	Foremilk (sec)/cow	Standard Deviation
Herringbone double 4	6.25	2.50	4.40	2.09	.51	.71
Herringbone double 5	5.00	3.16	5.00	3.16	----	----
Herringbone double 8	9.78	3.28	5.69	3.01	----	----
Herringbone Rotary 14 stall	7.00	2.89	7.00	2.83	----	----
Herringbone Rotary 15 stall	4.32	3.10	4.32	3.10	6.90	2.62
Herringbone Rotary 15 stall	3.26	2.55	3.25	2.55	8.44	2.90
Herringbone Rotary 15 stall	7.99	2.83	5.50	2.35	8.86	2.98

The amounts of labor used for attachment and detachment of the milking units are presented in Table VI. In a comparison of attachment and detachment times, the herringbone and rotary milking systems had an average of 8.0, 11.5 and 1.0, 3.0 seconds per cow, respectively, for attaching and detaching milking units. The variation in the times for both actions were probably due to the time the operators had available to accomplish the necessary actions in all systems. In the herringbone systems the attachment time for the double 8 system of 8.4 seconds per cow was greater than the average for other systems due to the adjustments required for the automatic detacher units.

The milking intervals ranged from 6.14 to 3.69 minutes per cow and are presented in Table VII. There were many reasons for the variations of the machine time intervals for each milking system. One reason might be the production of the herds as found in Table VIII. The range of the average production was 10.5 to 20.1 pounds per cow. The higher the production of milk per cow, the greater was the milking interval. Another possible reason was the timing of machine attachment or removal. If the operator's were less skillful in determining when milking was completed or if machine was attached before let down reflex was accomplished. The efficiency machine time could be increased.

Machine and operator idle time are presented in Table IX. In the rotary systems each milking unit was idle from detachment until the stall on the rotating platform reached the attachment area. Therefore machine idle time is a function of rotation time. The machine idle times for the

TABLE VI
TIME UTILIZED FOR ATTACHING AND DETACHING MILKING UNITS
IN VARIOUS PARLORS

System	Attachment (sec)/cow	Standard Deviation	Detachment (sec)/cow	Standard Deviation
Herringbone double 4	7.86	2.80	1.72	1.31
Herringbone double 5	7.54	2.74	1.63	1.27
Herringbone double 8	8.40	2.91	Automatic	----
Herringbone Rotary 14 stall	5.00	2.11	1.50	1.19
Herringbone Rotary 15 stall (April)	16.04	4.00	3.43	2.47
Herringbone Rotary 15 stall (June)	12.18	3.48	3.80	1.85
Herringbone Rotary 15 stall (Sept.)	12.50	3.54	4.49	2.36



TABLE VII
MACHINE TIME FOR VARIOUS PARLORS

System	Machine Time (min)/cow	Standard Deviation
Herringbone double 4	4.66	2.15
Herringbone double 5	4.45	2.10
Herringbone double 8	5.27	2.21
Herringbone Rotary 14 stall	3.69	2.33
Herringbone Rotary 15 stall (April)	6.14	2.47
Herringbone Rotary 15 stall (June)	4.07	2.01
Herringbone Rotary 15 stall (Sept.)	5.80	2.40

TABLE VIII
MILK YIELD FOR THE VARIOUS PARLORS

System	No. of cows in herds	Total milk produced (pounds)	Avg. milk produced/cow (pounds)	Milk/ man hour
Herringbone double 4	93	1666	17.9	256
Herringbone double 5	112	2254	20.1	450
Herringbone double 8	202	3612	17.9	1095
Herringbone Rotary 14 stall	313	4762	15.2	635
Herringbone Rotary 15 stall (April)	114	1513	15.9	346
Herringbone Rotary 15 stall (June)	75	810	10.5	270
Herringbone Rotary 15 stall (Sept.)	102	1428	14.0	286

CRANES & CREST

TABLE IX
IDLE TIME FOR MACHINE AND OPERATORS IN THE VARIOUS PARLORS

System	Machine (sec)/cow	Standard Deviation	Operator (sec)/cow	Standard Deviation
Herringbone double 4	43.72	3.82	41.3	2.02
Herringbone double 5	39.50	3.67	6.6	2.86
Herringbone double 8	525.00	12.43	----	----
Herringbone Rotary 14 stall	19.50	3.13	----	----
Herringbone Rotary 15 stall	22.10	4.70	3.60	1.98
Herringbone Rotary 15 stall	34.40	4.95	6.40	2.54
Herringbone Rotary 15 stall	27.40	3.95	6.50	2.13

double 4 and 5 herringbone systems were 43.7 and 39.5 seconds per cow and were dependent on the preparation of the cows on the other side of the parlor. The double 8 system had automatic detachment units; therefore, each stall had an independent milking unit which increased machine idle time by tenfold. The movement time for larger groups of cows also extended the machine idle time for this system. Operator idle time was excessive for the double 4 herringbone system. This parlor was staffed with two operators but is normally considered to be a one man system.

The mean time utilized for teat dipping and milk recording is presented in Table X. The times utilized were similar for all systems and variation depended on the amount of time available for the operator to perform these actions.

Cow throughput is a composite of all the individual factors previously discussed. Throughputs are presented in Table XI. Armstrong and Bickert (3) reported that a 14 stall herringbone rotary parlor without any levels of mechanization had a cow theoretical throughput of 96 cows per hour. The addition of crowd gates, automatic washing stalls and automatic detachment units enabled cow throughput to be increased to over 100 cows per hour. In the herringbone systems it was shown that the double 4, 5, 6 and 8 milking parlors without extra mechanization had cow throughputs of 37, 49, 60 and 74, respectively, per hour. With additional levels of mechanization the cow throughputs for the double 4, 5, 6 and 8 herringbone milking systems were 49, 59, 70 and 85 cows per hour, respectively. Only the 14 stall rotary system met the expected levels of cow throughput per hour as outlined by Armstrong and Bickert's theoretical situations.

TABLE X
TIME UTILIZED FOR DIPPING TEATS AND RECORDING MILK
WEIGHTS IN VARIOUS PARLORS

System	Dipping teats (sec)/cow	Standard Deviation	Recording milk weights (sec)/cow	Standard Deviation
Herringbone double 4	2.60	1.61	2.75	1.65
Herringbone double 5	1.46	1.20	3.82	1.95
Herringbone double 8	3.87	2.04	---- ¹	----
Herringbone stall 14 stall	4.00	2.96	---- ¹	----
Herringbone stall 15 stall	4.27	2.06	9.19	3.03
Herringbone stall 15 stall	---- ¹	----	9.51	3.08
Herringbone stall 15 stall	---- ¹	----	8.24	2.87

¹ Action was not performed.

TABLE XI
COW THROUGHPUT FOR VARIOUS MILKING SYSTEMS

System	Levels of mechanization	No. of cows	No. of operators	Total time (hours)	Cows/hour	Cows/man hour
Herringbone double 4	None ¹	93	2	3.25	28.6	14.3
Herringbone double 5	None ¹	112	2	2.50	44.8	22.4
Herringbone double 8	Detachment units ²	202	1	3.30	61.2	61.2
Herringbone Rotary 14 stall	None ¹	313	2.5	3.00	104.3	41.7
Herringbone Rotary 15 stall (April)	None ¹	114	2.5	1.75	65.14	26.0
Herringbone Rotary 15 stall (June)	None ¹	75	2.5	1.20	62.5	25.0
Herringbone Rotary 15 stall (Sept.)	None ¹	102	2.5	1.60	63.75	25.5

¹Base system.

²The system contained automatic detaching units.

The throughput per man hour of the double 4 herringbone system could be made increased if the number of operators were decreased to one. This action would increase the number of cows per man hour considerably. With two operators in this system excessive operator idle time was allowed. Decreasing the number of operators to one would require a skilled operator to perform the actions but is possible in a parlor of this size. Grouping cows by production would also increase cow throughput. The above factors would also increase the efficiency of the double 5 herringbone system. Addition of automatic detachment units to this parlor size would be needed to decrease number of operator to one.

The double 8 herringbone system was the most efficient in cow throughput per man hour. The automatic detachment units made it possible for only one operator to perform the milking routine. An increase of cow throughput and a decrease in operation time would be possible if crowd gates were used. Also washing preparatory stalls would free time utilized by operator for preparation time and should decrease machine idle time. Machine idle time could also be decreased by grouping cows by production. This type of system depends on a highly skilled operator to perform the milking routine.

The 14 stall herringbone rotary parlor was efficient in cow throughput per hour but not in cows per man hour. The extra man needed at cow entrance could be eliminated by crowd gates. Also automatic washing preparatory stalls could decrease the operators preparation time and increase milk flow per man hour. Grouping cows by production would also be an advantage with this large herd.

The 15 stall rotary herringbone type system was less efficient in number of cows milked per man hour.

The utilization of more skillful operators and an improved program of maintenance would increase cow throughput. There was excessive machine idle due to malfunctions in equipment. Rotation time of the platform could be decreased if stimulents for let down, i.e. preparation stalls, functioned, was accomplished prior to and coordinated with cow entrance. Operator activities associated with preparation and attachment seemingly can be accomplished within 30 seconds as can dismount and recording activities. Therefore it would appear that a rotation time of 7.5 minutes and a throughput of 120 cows are theoretical maximums. Even utilizing 2.5 man per milking throughput should approach 45-48 cows per man hour. Even though these statements are true the interrelationship of labor and milking systems are confounding; therefore the effects cannot be separated.

CHAPTER V

SUMMARY AND CONCLUSIONS

Five milking systems were observed and evaluated for efficiency by various performance measurements. Milking routine in each system was divided into the following sub-components: cow movement, cow preparation activity, machine time, dismount activities, machine idle time and operator's idle time. These performance measurements were used to determine the level of efficiency for the various milking systems and to determine how the systems could be improved.

It was found that cow movement was a critical component for the milking routine. Milking systems that had short cow entrance times were usually efficient if all other components remained constant. The 14 stall herringbone rotary system was the most efficient milking system with regard to cow throughput per hour by theoretical measures when staffed with 2 operators. In terms of cow throughput per man hour, the efficiency of the various milking systems depend upon the number of operators in the milking parlor. Therefore, the double 8 herringbone system with automatic detachers and one operator was the most efficient in cows milked per man hour. If different levels of mechanization such as crowd gates, automatic preparatory stalls, automatic detacher units, and feedgates were applied to these systems, efficiency for cow throughput might increase. This would also allow a decrease in the number of operators which should increased the cow throughput per man hour.



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