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AUTOMATED FLAT PARLORS: A COST-EFFECTIVE METHOD TO IMPROVE LABOR EFFICIENY FOR SMALL DAIRY HERDS

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Summary:
The major types of flat parlors that are being used in Minnesota and Wisconsin are described. Performance and cost data were obtained for 13 flat parlors and compared to new moderately priced herringbone parlors. Measured milking time throughput rates for flat parlors ranged from 38 to 57 cows per person per hour. The cost analysis indicated that using a flat parlor allows an 87 cow herd to have the same annual milking center cost as a 350 cow herd milked with a double-8 herringbone parlor.

Keywords:

Milking Systems, Milking Efficiency, Dairy Housing, Low-Input System

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INTRODUCTION

The average Upper Midwest dairy producer milks about 50 cows in a traditional stall barn. Changes in life style expectations, financial pressures related to transfer of the farm to the next generation, and the inefficient use of labor in stall barns has caused many producers to consider converting to free stall and parlor systems. However, even the most profitable dairy producers (greater than 20,000 lb/cow/year, 80 to 90% equity) in the region are finding it difficult to expand the herd, build a new free stall barn and milking center, and add a modern waste handling system all at once.

In many cases converting the existing stall barn into a flat parlor milking center can be an effective cost reduction strategy to allow the dairy farm family to make the transition to a free stall and parlor system. Flat parlors also provide an effective, low-cost milking system for dairy farm families that are either not interested or unable to make a large scale expansion to 200 cows or more. Common factors that can limit dairy herd size are: insufficient cropland for manure application, lack of labor, or close proximity to urban areas.

The objectives of this paper are to: (1) describe the components of back-out and walk-through flat parlor milking centers, (2) provide performance and cost data for 13 flat parlors, and (3) compare the investment and annual costs of flat and herringbone parlors for small herds.

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[1] John P. Chastain, Assistant Professor, Department of Biosystems and Agricultural Engineering, University of Minnesota, and Douglas J. Reinemann, Department of Agricultural Engineering, University of Wisconsin. ASAE Paper No. 953497.

BACKGROUND

Milking System - A Key To Increasing Cows Per Worker

The number of cows that can be managed well per full-time worker (or full-time equivalent, FTE) is one of the key measures of overall labor efficiency on a dairy farm. Most stall barn herds in the Midwest require 30 to 40 cows per worker. In free stall and parlor systems the number of cows per FTE can range from 35 to 75 with 50 being about average. In well-designed free stall and parlor systems 60 cows per worker is an attainable goal. Increasing the number of cows that can be managed well per FTE requires labor efficient methods for: (1) milking, (2) feeding, (3) treatment, (4) manure handling and land application, and (5) heifer raising. Milking is one of the most time consuming tasks, and becomes one of the primary concerns for dairy producers who are planning the transition from stall barn to free stall housing.

During the transition from a stall barn to a free stall housing system the milking rate must be increased. In the typical stall barn, one worker uses three unautomated milking machines and milks 20 to 25 cows per hour. The primary goal is to double the milking rate. That is increase the milking rate to 40 to 50 cows per person per hour. If the milking rate is not improved profitability will suffer since labor must be added at about the same rate as cows.

Setting a goal of increasing the cows per worker rules out the possibility of using a simple switch system. I a switch system one group of cows is housed in the stall barn, and the other groups are kept in a free stall or loose housing barn. In most switch systems the milking rate falls to 12 to 17 cows per person per hour. Switch systems significantly increase the labor requirements for milking as well as feeding. Typically cow management suffers in a switch system, the dairy producer becomes discouraged, profitability suffers, and burnout is inevitable.

Cost and Performance of Herringbone Parlors

Automated herringbone or parallel parlors can provide milking rates from 32 to 97 cows per hour (c/hr) as indicated in Table 1. Obviously pit parlors satisfy the need to double the milking rate as compared to stall barn milking systems, and greatly reduce the physical labor requirements. However, many dairy producers find the expense of a parlor prohibitive during the beginning of a transition from a stall barn to free stall system. Price estimates of moderately priced herringbone and parallel milking centers are listed in Table 2. These values will be used for comparison with the performance data for flat parlors. Throughput and costs of small parallel and herringbone parlors are very similar and were pooled together for simplicity

Table 1. Estimates of steady-state throughput rates (c/hr) for automated herringbone and parallel parlors assuming one operator with average skill.

Automatic Detachers, crowd gate, power entry, rapid exit on herringbone parlors with more than 9 stalls per side. Actual throughput rates can be 10% higher or lower than the values shown in this table depending on operator skill. If a major portion of the udder preparation is either automated or neglected throughput rates can be 20-25% higher than indicated.

Stalls Per Side	Milk Weight per Milking, lb/cow/milking (kg/cow/milking)							
	20 (9.1)	25 (11.3)	27 (12.2)	30 (13.6)	33 (15.0)	35 (15.9)	37 (16.8)	40 (18.1)
4	44	40	39	37	35	34	33	32
6	66	60	58	55	53	51	50	48
8	80	73	71	68	65	63	62	59
9	84	78	76	73	70	68	66	64
10	92	85	83	79	76	74	72	70
12	97	90	88	85	82	80	78	76

Steady-state throughput values found in the literature were varied based on production using the following relationship for milk-out time:

Milk-Out (min/cow) = 2.54 + 0.1026 x (lb/cow/milking).

The above interpolation equation was developed from values given by Appleman (1988), and Bridges, et al (1992). The udder preparation time was assumed to be 24 sec. Information on throughput values and trends were taken from Armstrong (et al., 1990), Armstrong (1988), Bickert (1980), Bridges, et al. (1992), and Steevens (1992).

Milking-Time Throughput, Set-Up and Clean-Up Time

The values shown in Table 1 are estimates of the steady-state throughput (SST) and is a measure of parlor performance at full capacity. Total milking throughput or milking-time throughput (as defined by Barry et al., 1992) includes all of the delays associated with group changes, cows milked with a bucket, time when the milking area is not full of cows at the end of groups, unit fall-offs, and other delays. Milking-time throughput (MTT) is typically less than steady-state, and is a better measure of what the operator actually experiences. Milking-time throughput includes all delays but not the time for parlor set-up and clean-up. Barry et al. (1992) developed the following regression equation that relates steady-state throughput to milking-time throughput for 30 herringbone parlors ranging from double-6 to double-12 :

$$MTT = 0.92\ SST, \quad (r^2 = 0.96) \tag{1}$$

Barry also determined that the average set-up and clean-up time for the 30 parlors in the study was 0.5 hours.

Table 2. Price estimates of moderately priced new herringbone and parallel milking centers.[1]

Herd Size	Stalls Per Side					
	4	6	8	9	10	12
50	78,000					
100	88,000	123,000	157,000			
150	98,000	133,000	167,000	184,000		
200	108,000	146,000	180,000	197,000	258,000	301,000
250		157,000	191,000	208,000	269,000	312,000
300		167,000	202,000	219,000	279,000	322,000
350		178,000	212,000	229,000	290,000	333,000
400		189,000	223,000	240,000	301,000	344,000
450		200,000	234,000	251,000	312,000	355,000
500		210,000	245,000	262,000	323,000	366,000
550			255,000	273,000	333,000	376,000
600			266,000	283,000	344,000	387,000
650				294,000	355,000	398,000
700					366,000	409,000
800						430,000

[1] Includes: Milking equipment, automatic detachers, power entry gates, crowd gate, bulk tank, and other milk room equipment. Milk meters cost an additional $700 to $1,000 per stall. Consult an equipment dealer for cost of computer equipment, automatic cow identification, sorting gates, and other options. Parlors with many of these options, or more expensive buildings or stalls, can cost 1.1 to 1.25 as much as the values shown. Low-cost automated parlors with the most basic equipment can cost 10 to 15% less than the values shown.

Description of Automated Flat Parlors

An automated flat parlor is simply a stanchion or tie-stall barn that has been remodeled to operate like a herringbone or side-opening parlor. Most often the flat parlor is constructed by renovating the existing stall barn into a milking area, a holding area, return lanes, and possibly maternity or treatment areas. The elements of a flat parlor are: (1) a well defined milking area with 6 to 8 milking machines with automatic detachers; (2) a holding area sized to provide about 15 ft^2 per cow; (3) simple but effective entrance and exit gates; (4) individual lever, dual lever, or walk-through stanchions to allow cows to be handled in groups or individually; (5) a return lane; (6) an all-weather lane that leads to the cow housing area; (7) heat; and (8) ventilation. Throughput rates of 35 to 50 cows per person per hour are possible in automated flat parlors. The two basic flat parlor stall configurations are the back-out and the walk-through, and are illustrated in Figures 1 and 2.

Back-Out Flat Parlor

The milking area of a back-out flat parlor looks almost identical to a stanchion barn, and is the most easily adapted to a traditional stall barn. In most cases, a milking machine and automatic detacher is mounted between a pair of stalls. Either individual or dual lever stanchions are used for stall fronts. Individual lever stanchions have a lever per stall and allow individual cow flow like a side-opening parlor. The number of cows that are brought into the milking area will depend on the number of cows that have milked out if individual lever stanchions are used.

Dual lever stanchions are gang stanchions that have two levers, and facilitate handling cows in groups corresponding to half the number of stalls on one side of the flat parlor. A back-out flat parlor with dual lever stanchions, and a raised platform is shown in Figure 3a. Each lever opens or closes every other stanchion. For example, the left lever may operate the stanchions to the left of the milking machine, and the right lever can operate the stanchions to the right of the milking machines. Dual lever stanchions can be purchased new (Humane Manufacturing®, and others[2]) or the second lever can be added to single lever stanchions. Locate the levers on the entrance side of the parlor (Figure 1).

The optimum dual lever stanchions will allow: (1) every other cow to be released or restrained as a group, and (2) an individual cow to be released or restrained independently. These features allow the operator to isolate a cow for transfer to a treatment pen, or continue milking round a slow cow.

Walk-Through Flat Parlors

Walk-through stalls, Figure 2, are typically more expensive to adapt to an existing barn than the back-out stall. The number of cows that can be milked per person per hour is similar to back-out stalls (Reinemann et al., 1992). Cows can be handled individually or in groups. Walk-through flat parlors can easily accommodate a unit per pair of stalls or a unit per stall. Walk-through stalls can be home-built, but most are purchased new. Stall fronts of walk-through flat parlors are either operated with mechanical release mechanisms or pneumatic cylinders.

A walk-through flat parlor with a raised platform and a unit per stall is shown in Figure 3b. The stalls shown are marketed by Agromatic® and Universal® Dairy Equipment[2]. Merrill Equipment Company®[2], and other companies also sell walk-through stalls.

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[2] Name brands mentioned in the text or shown in photographs are for the benefit of the reader, and do not imply an endorsement by the authors or the organizations that they represent.

Automatic Detachers

Automatic detachers are an essential part of the flat parlor concept. Cord or chain-type detachers are typically used. Both parlor and portable stall barn type detachers can be used in flat parlors. The disadvantage of stall barn detachers is that the entire detacher, and milking machine must be carried into the milk room to be cleaned. A third pipe is added to serve as the wash line to clean the detacher sensor in place if parlor-type detachers are used. Milking machines should not be cleaned in the flat parlor unless the milking area walls, ceiling, and doors are upgraded to meet the grade-A specifications associated with pit parlors. Contact the local milk inspector for requirements for clean-in-place systems. It is typically most economical to wash and store machines in the milk room.

Automatic detachers function best if they are mounted as close to the udder as possible. If the detacher is too far from the udder then the machine is more likely to hit the floor when removed. A three-sided bracket can be built to hold the detacher 2-3 ft away from the stall front towards the udder. The bracket will also provide protection for the milking equipment. Mount a single service paper towel dispenser at each detacher. A hanger for a teat dip cup or a teat dip spray hose can also be located at each milking station for convenience.

Automatic detachers increase the rate of milking by allowing one person to effectively use 6 to 8 machines. They also reduce labor requirements for the milking system. In a typical stall barn the operator performs 3 to 4 deep knee bends per cow. The automatic detacher eliminates 1 deep knee bend per cow.

Remove Gutters

Dairy cows have poor depth perception and are fearful of open gutters and holes. Consequently, the gutter behind the stalls interferes with cow flow in a flat parlor. Cows tend to jump across the gutter as they enter the stall, and back out of the stall at an angle striking the next cow. If a holding pond or some other type of waste storage is available the gutters can be converted to floor drains. The floor and platforms can be cleaned with a hose or high-pressure washer. The floor waste water and manure can be transferred to an existing reception pit by gravity. If needed, a small reception pit can be installed between the milking area and holding area to receive the floor wash water and milk room wastewater. A small pump is all that is needed to transfer the waste to storage using a top loading pipe.

If a slurry or liquid manure storage is unavailable then fill in the gutters with concrete. Spread chopped bedding on the parlor floor, and clean the area daily with a skid-steer loader. Bedding can also be used in the holding area to facilitate cleaning. Wash the stall platform with a hose and use the bedding in the center alley to absorb the moisture.

Raised Stall Platform and Stationary Stool

A raised platform can be used with back-out or walk-through stalls to reduce physical effort. If the barn will have a flat floor after the gutters are filled in then adding a 6 to 10 inch high platform to the milking stalls is recommended for back-out stalls. The raised platform will allow the operator to perform pre and post-milking hygiene tasks by placing one foot on the

platform, and bending at the knees and waist. This helps to reduce the strain on the operator's back. The combined effect of the raised platform and the automatic detacher is to reduce the average number of deep knee bends per cow from 3 or 4 to 1. As a result, one person can milk 100 cows in a back-out flat parlor with about the same number of deep knee bends as required to milk 33 cows in a conventional stall barn. The platform in Figure 3a is raised 6 inches above the milking alley floor.

Walk-through stalls allow the use of a stall platform that is 10 to 14.5 inches above the floor, and an operator's cubicle as shown in Figure 3b. The cubicle is typically 30 to 32 inches wide and 24 inches deep. An operator's cubicle is not recommended for back-out stalls since the platform is not as high and is used differently. A platform height of 10 to 12 inches is sufficient if a stationary, height adjustable, stool is used between each pair of stalls. Good cow flow has been obtained with platform heights up to 14.5 inches without a stool. The higher platform and/or the use of the stationary stool eliminates all deep knee bends associated with stall barn milking. If a stool is used (marketed by Agromatic® and Universal ® [2]) the operator does not need to bend over to milk cows. The ability to use higher platform heights and stationary stools without impeding cow flow is the primary advantage of the walk-through stall.

Milk Line Slope

A 2 inch diameter milk line is used In most stall barns, and is sloped about 1 inch per ten feet of length (0.8%). In a flat parlor, the slope of the milk line should be increased to about 2 inches per 10 ft (1.7%) to allow 4 machines to be used per slope on two inch line (Mein et al., 1993). This will allow a producer to construct a flat parlor with up to 8 units without investing in a 3 inch receiver. Also, the amount of wastewater that is generated from pipeline washing will be greatly reduced. Double-12 and 16 flat parlors will require either 4 slopes with 2 inch pipe (and two receivers) or 2 slopes of 2.5-3 inch pipe. Mount the pipeline as low as practical to improve vacuum stability.

Crowd Gates

Crowd gates can be used with flat parlors, but the cost may not be justified by additional throughput. A pair of gates that can be closed to reduce the holding area by half is recommended to encourage cow entry.

Feeding in The Flat Parlor is Not Recommended

Providing feed and water in the flat parlor is not recommended. Feed may entice the cows to enter, but it may cause them to be slow to exit. Feeding in any parlor will also induce defecation and will require more labor for clean-up. It is not uncommon to provide a small amount of grain in the flat parlor during the initial training process. However, once the majority of the cows understand what is expected of them remove all feed. Cows will soon learn that fresh feed will be available in the housing area after milking, and is enticement enough.

FLAT PARLOR PERFORMANCE AND PRICE

Description of Flat Parlors and Initial Cost

Performance and cost data were taken on 7 back-out and 6 walk-through flat parlors. A description of the flat parlors, total investment, number of cows milked, and production per cow are shown in Tables 3 and 4. All of the back-out flat parlors used one milking machine per pair of stalls. The two 6 unit back-outs and one 8 unit back-out used individual lever stanchions and had individual cow flow capability. The other 8 unit back-out flat parlors had dual lever stalls, and were limited to group cow flow. The two, 6 unit walk-through flat parlors used a unit per pair of stalls. The 8 and 16 unit walk-through parlors used a unit per stall. The number of cows milked per day in the study ranged from 37 to 200. The average production was 69 lb/cow/day.

The total investment ranged from $1,500 to $4,517 per milking machine for back-out flat parlors. The most expensive back-out included the cost of a new bulk tank. For walk-through flat parlors the investment per unit ranged from $2,388 to $7,315. The most expensive walk-through included stalls controlled by pneumatic cylinders, construction of a new office, extensive remodeling of the milking and holding areas, milk meters, and a computer. The total cost of converting a stall barn to a flat parlor and holding area depends on: the number of milking machines purchased, upgrades required in the milking system and milk cooling equipment, and building renovation needs. The costs of remodeling the milking area, stalls, and milking equipment ranged from $1,350 to $3,750 per unit for back-out stalls, and $2,088 to $5,326 per unit for walk-through stalls.

Flat Parlor Measurements

Data were taken to calculate the throughput of the total milking, throughput of individual groups (if possible), number of operators, set-up time, clean-up time, time for udder preparation, lag time and attachment, and post dip time.

Time for Udder Preparation, Lag Time, Unit Attachment, and Post dip

Udder preparation can account for as much as 25% of the work routine in parlor milking systems (Barry et al., 1992). In this study, the quantity measured was the combined udder preparation, lag, and attachment time. The time required for post dipping was also included. Measurements were taken for 3 to 6 cows at each site without the operator's knowledge. A summary of the results is indicated in Table 5.

One producer did not prepare the udder in any way, and simply released the cows after milking. Excluding the operator who did not post-dip cows the average time spent on post-milking hygiene was 3.1 sec/cow.

The time spent on pre-milking hygiene and attachment varied from 35.4 to 334.2 sec/cow. Therefore, the overall average has little meaning.

Table 3. Description and initial costs of back-out flat parlors.

Description	Stall Costs	Milking Equip.	Total Remodeling Costs	Bulk Tank	Other Expenses	Total Investment	No. of Cows Milked	Prod. (lb/cow/ day)
6 Units, 12 Stalls								
12 new individual lever stanchions, 6 new machines, portable automatic detachers, and pulsators, shed converted to holding area	$2,000	$5,400	$8,100	$19,000	-- *	$27,100	120	82
6 new machines, portable detachers, pulsators, pipeline and vacuum upgrade, used existing stanchions, holding area is free stall alley	$0	$12,000	$12,000	$1,800 used	--	$13,800	85	60
8 Units, 16 Stalls								
8 new machines, portable detachers, pulsaters, used single lever stanchions, used existing, new holding area	$0	$12,000	$12,000	--	--	$12,000	91	80
Converted used stanchions to dual lever stanchions, new milking equipment, 2 inch pipeline	--	$10,000	$12,000	--	$8,000 Holding Area	$20,000	76	55
New dual lever stanchions, 3 in line, 2 new units and detachers	? **	?	$30,000	--	--	$30,000	113	56
Added dual lever capability to used stanchions, new milking equipment, raised milking stall platform 6 in	?	?	$15,000	--	--	$15,000	68	76
Controls dual lever stanchions with air cylinders, raised stall platform 8 in, electric crowd gate in holding area.	?	?	$13,000	--	$6,700 Crowd Gate	$19,700	120	69

* Item indicated was not needed.

** Itemized cost unknown, but price is included in total.

Table 4. Description and initial costs of walk-through flat parlors.

Description	Stall Costs	Milking Equip.	Remodeling, and Equip. Costs	Bulk Tank	Other Expenses	Total Investment	No. of Cows Milked	Prod. (lb/cow /day)
6 Units, 12 Stalls								
Had 6 units and portable detachers, added floor drains in place of gutters, raised stall platform 10 in, pumped waste water to holding pond, used stationay stool	$8,500	$0	$12,530	-- *	$1,000 Pump $800, Heater	$14,330	66	80
All new equipment with milk meters and computer, raised stall platform 14.5 in, remodeled part of barn into office	$9,300	$12,910	$31,957	--	$11,930 milk meters & computer	$43,887	121	74
8 Units, 8 Stalls								
All new milking equipment, 3 in line, and extensive remodeling of milk room, detacher sensors cleaned in place, stall platform raised 10 in.	$7,000	$12,000	$29,000	--	?	$29,000	37	68
New units, 4 new pulsators, 8 new detachers, stall platform raised 10 in, used stationary stool	$7,000	$15,500	$24,500	--	--	$24,500	55	70
All new milking equipment, raised stall platform 11.5 in	? **	?	$30,000	--	--	$30,000	74	71
16 Units, 16 Stalls								
Home-built stalls, raised stall platform 13 in, extensive remodeling to barn, electric crowd gate, units cleaned in place	?	?	$32,000	$30,000	$6000 plate cooler	$68,000	200	55

* Item indicated was not needed.

** Itemized cost unknown, but price is included in total.

Table 5. Summary of time spent on pre and post-milking hygiene in flat parlors.

	Back-Out			Walk-Through		
	Ave.	Max.	Min.	Ave.	Max.	Min
Total Time for Udder Prep, Lag Time, and Unit Attachment, sec/cow	126.9	334.2	35.4	64.4	129.8	7.8 *
Time for Post-dip, sec/cow	3.6	5.1	2.6	2.2	3.3	0**

* No udder preparation, unit attachment only.

** No post-dip.

Milking-Time Throughput Data

Performance data for back-out and walk-through flat parlors are shown in Tables 6 and 7 respectively. All of the dairies included in the study were family farms. Only three of the farms hired a part-time worker to milk. As a result, the number of operators in the flat parlor varied during the milking shift in some cases. That is, it was not uncommon for one person to feed cows, scrape manure alleys, and change groups, and then help the other person milk the second or low group. When this occurred the time when the second operator entered the milking pit was recorded. If the number of operators changed during a milking shift the weighted average was calculated based on the amount of time the parlor was operated in the two different modes. These weighted averages are the decimal values indicated in the tables. The average number of operators was used in the cost analysis that will follow in the next section.

Influence of Bucket Cows on Throughput

In two cases, the fresh and treated cows (bucket cows) were milked last in a separate group. In Table 6 a single asterisk denotes throughput data for separate fresh and treated cow groups. For the 6 unit walk-through the throughput rate dropped from 41 cows per hour (c/hr) to 22 when cows were milked with a bucket. The 16 unit flat parlor fell from 69 to 11 c/hr. In both cases the effect of the of the bucket cow group was to drop the total milking-time throughput rate by 7%.

Throughput Rates for Six Unit Flat Parlors

All throughput data for flat parlors with 6 milking machines are shown in Table 8. The data in the table indicate that the throughput rates did not depend on the number of operators or the type of stall used. Furthermore, the most efficient 6 unit flat parlor had a milking-time throughput of 47 c/hr and spent a relatively large amount of time on pre-milking hygiene. This operator was the most efficient at changing groups, and used a pair of gates to reduce the size of the holding area when the group was half milked.

Table 6. Performance data for back-out flat parlors.

Description	Average Production lb/cow/day	Average Time for Udder Prep. and Attachment sec/cow	High Group		Other Group (s)		All Cows	
			No. of Oper.	Throughput c/hr (c/u/hr)	No. of Oper.	Throughput c/hr (c/u/hr)	Wt. Ave. No. of Oper.	Throughput c/hr (c/u/hr)
6 Units, 12 Stalls, Single Lever Stanchions With Individual Cow Flow								
	82	113.8	1	41 (6.8)	2	43 (7.1)	1.7	42 (7.0)
	60	191.3					2	44 (7.3)
8 Units, 16 Stalls								
Single lever, individual flow	80	35.4	1	37 (4.6)	2	48 (6.0)	1.5	42 (5.3)
Dual lever, group flow	55	39.0					1	38 (4.8)
Dual lever, group flow, platform raised 2 in *	56	334.2	2	34 (4.3)	2	36 (4.5)	2	35 (4.4)
Dual lever, group flow, 3X milking, stall platform raised 6 in	76	107.9	1	44 (5.5)	1	38 (4.8) **	1	43 (5.4)
Dual lever activated by air cylinders, group flow, crowd gate, stall platform raised 8 in	69	66.5	1.7	46 (5.8) +	2	65 (8.1) ++	1.8	55 (6.9)

* Two operators in milking area but only one milked cows. The other pre-dipped teats and moved cows.
** Heifer group. Operator waited till older cow group was completed before starting heifer group.
\+ Production = 78 lb/cow/day
++ Production = 51 lb/cow/day

Table 7. Performance data for walk-through flat parlors.

Description	Average Production lb/cow/day	Average Time for Udder Prep. and Attachment sec	High Group		Other Group (s)		All Cows	
			No. of Oper.	Throughput c/hr (c/u/hr)	No. of Oper.	Throughput c/hr (c/u/hr)	Wt. Ave. No. of Oper.	Throughput c/hr (c/u/hr)
6 Units, 12 Stalls								
Height adjustable stool, stall platform raised 10 in	80	52.5	1	41 (6.8)	1	22 (3.7) *	1	38 (6.3)
Walk-Through with stall platform raised 14.5 in, manual crowd gate.	74	129.8					1	47 (7.8) **
8 Units, 8 Stalls								
Stall platform raised 10 in,	68	69.2					2	53 (6.6)
Stall platform raised 10 in, height adjustable stool	70	81.4					1	41 (5.1)
Stall platform raised 11.5 in	71	7.8 +	1	59 (7.4)	1	54 (6.8)	1	57 (7.1)
16 Units, 16 Stalls								
Home-built stall fronts, cows are gang released and loaded in groups of 4, platform raised 13 in.	55	45.6	2	69 (4.3) ++	2	11 (3.7) *	2	64 (4.0)

* Denotes a fresh and treated cow group.

** Operator began milking next group while cows in previous group were still being milked.

+ No udder preparation or post-dip. Time shown corresponds to attachment time.

++ Data for 3 groups of cows without any fresh or treated cows.

The results indicate that the throughput rate of a 6 unit flat parlor depends primarily on operator skill, and good cow flow. Adding a second person did not increase throughput.

The average throughput rate for 6 unit flat parlors was 43 c/hr. From Table 1 the steady-state throughput of an automated double-6 herringbone for cows producing 74 lb/day is 50 c/hr. The milking-time throughput based on equation 1 would be 46 c/hr ± 10%. The average value of 43 c/hr is only 3 c/hr (6.5%) lower than that expected for a double-6 herringbone. Therefore, the average throughput of the 6 unit flat parlors in this study performed in a similar manner as a fully equipped double-6 herringbone parlor.

The reasons these flat parlors performed so well are related to cow flow and unit on-time. All of the 6 unit flat parlors provided two stalls per machine, and were operated in a manner similar to an individual stall or side-opening parlor. As a result, all machines were typically on cows whenever cows exited or entered the parlor, and the operator could easily work around a slow milking cow. These features allowed unit on-time to be maximized, and the delays associated with cow entry and exit to be minimized. This is reflected in the fact that the 6 unit flat parlors provided 7.2 cows per unit per hour (c/u/hr) as compared to 3.8 for the herringbone.

Table 8. Summary of milking-time throughput data for flat parlors with 6 machines.

	Production (lb/cow/day)	Udder Prep. and Attachment (sec/cow)	1 Operator (c/hr)	2 Operators (c/hr)
Back-Out				
	60	194.9		44
	82	113.8	41	43
Walk-Through				
	74	129.8	47	
	80	52.5	38	
Average	74	122.8	43 c/hr (7.2 c/u/hr)	

Throughput Rates for 8 Unit Flat Parlors

The throughput data for 8 unit flat parlors shown in Tables 6 and 7 are summarized in Table 9. Throughput values for one operator did not tend to vary with production or time spent on pre-milking hygiene for operators that prepared udders. The average value of MTT was 40 c/hr or 5.0 c/u/hr. That is, the 8 unit flat parlors were on the average 3 c/hr slower than the 6 unit flat parlors. The difference in throughput was a result of how the majority of the 8 unit back-out flat parlors were operated. Unlike the 6 unit flat parlors, all of the 8 unit back-out flat parlors moved cows in and out of the milking area in groups of 4 or 8. As a result, the unit on-time decreased. The 8 unit flat parlor that had a preparation time of 81.4 sec/cow and an MTT of 41 c/hr did not consistently operate as an individual stall parlor.

Table 9. Summary of milking-time throughput data for flat parlors with 8 machines (B = Back-Out; W = Walk-Through).

Production (lb/cow/day)	Udder Prep. and Attachment (sec/cow)	1 Operator (c/hr)	2 Operators (c/hr)
55	39.0	38 (B)	
70	81.4	41 (W)	
76	107.9	43 (B)	
80	35.4	37 (B)	
	Average =	40 c/hr (5.0 c/u/hr)	
No Udder Preparation or Post Dip			
71	7.8	57 (W)	
51	66.5		65 (B)
68	69.2		53 (W)
69	66.5		55 (B)
80	35.4		48 (B)
		Average =	55 c/hr (6.9 c/u/hr)
Udder preparation and attachment time 430% greater than the mean of other data			
56	334.2		35 (B)

At a production level of 70 lb/cow/day a double-4 and double-6 herringbone would be expected to have milking-time throughput rates of 31 c/hr and 47 c/hr respectively. Both of these parlors provide 3.9 c/u/hr. Therefore, the average 8 unit flat parlors provided a throughput rate that was 29% higher than a herringbone parlor with the same number of units.

The only 8 unit flat parlor that had the same per unit performance as the 6 unit flat parlor was for the case of no udder preparation with 57 c/hr or 7.1 c/u/hr. The pre-milking delay was 745% lower than the other cases, and this flat parlor was operated as an individual stall parlor. Furthermore, the delay for group changes was minimal. This operator had another person changing groups, and began milking the next group while cows from the previous group were still being milked. If this producer spent a similar amount of time on pre-milking hygiene the throughput would still be expected to be greater than the others.

The data for flat parlors with 8 units and 2 operators appeared to have some dependency on production. In all cases the cows were moved in groups of 4 or 8. However, the addition of the extra person increased the amount of time the units were on cows. This resulted in a per unit throughput of 6.9 c/u/hr or 55 c/hr. Addition of a second person increased throughput by 37.5%. The economics of using two people in an eight unit flat parlor will be discussed in a following section.

The slowest flat parlor of the data set had 2 operators, a throughput rate of 35 c/hr (4.4 c/u/hr), and appears to have spent 334.2 sec/cow on pre-milking hygiene. In this case, the operators moved the cows in groups of 4 or 8. One operator then pre-dipped all 4 or 8 cows. The other operator then dipped the teats again, wiped dirt from the teats on 4 or 8 cows, and then attached the milking machines. After the units were detached the other operator post-dipped the cows, and released them with the dual lever stanchions. After releasing the cows the operator would individually coax many of the cows out of the milking area. It was also not uncommon for cows to exit or enter the milking area with milking machines hanging by cows. The basic layout of the milking area, and holding was very well organized. However, the operators simply did not work so as to maximize the unit on-time of the flat parlor.

Throughput Rate for a 16 Unit, 16 Stall Flat Parlors

The data for the 16 unit walk-through flat parlor is at the bottom of Table 7. This flat parlor had 8 stalls per side and the walk-through head gates were designed so as to allow 4 cows to be gang released at once. Therefore, cows were moved in groups of 4. The milking-time throughput rate of this parlor with 2 operators, three groups of cows, but no bucket cows was 69 c/hr (4.3c/u/hr). Including the bucket cows decreased the throughput rate to 64 c/hr. The question of weather or not the second operator is cost effective will be addressed in the economics section.

Time for Set-Up and Clean-Up

The set-up times ranged from 5 to 17 min/milking with the average being 9.5 min/milking. Clean-up took 10 to 20 min/milking with the average being 14.1 min/milking. On the average, 24 min was spent on set-up and clean-up per milking. The maximum set-up and clean-up time was 37 min/milking.

Defecation and Urination Rates

Armstrong et al. (1990) observed that the percentage of cows that defecated or urinated in the milking area ranged from 1.5 to 3.5% for herringbone parlors, and 0.5 to 1.7% for parallel parlors. In the flat parlors studied, 9.1% of the cows defecated or urinated in the milking area on the average. The minimum elimination rate was 2.7% and the maximum was 14.2%. Most of the cows in the study were docile and did not show any signs of excess excitement while being milked. The higher defecation rate is believed to be related to the fact that 9 out of the 13 flat parlors had a single unit per pair of stalls. As a result, individual cows were in the flat parlor milking area longer than in a herringbone or parallel parlor.

COST COMPARISONS BETWEEN AUTOMATED FLAT PARLORS AND HERRINGBONE PARLORS

One of the most important questions to ask when considering flat parlors is does investment in a flat parlor make economic sense? In order to answer this question the investment costs, and annual fixed and labor costs were estimated for new double 4, 6, and 8 herringbone parlors and compared to the flat parlors in this study.

Calculation of Labor Costs

Labor costs are determined by the length of the milking shift, number of operators, and the labor rate. The milking shift for the herringbone parlors was calculated using the steady-state throughput rates indicated in Table 1, equation 1, and a set-up and clean-up time of 0.5 hr/milking. The milking shift for any parlor on farms that milk twice-a-day (2X) can be estimated by the following equation.

$$\text{Milking Shift} = 0.5 + (\text{No. of Cows Milked} / \text{MTT}) \quad (2)$$

The milking shift for the flat parlors was calculated using the measured MTT values for the total herd given in Tables 6 and 7 with equation 2.

The labor rate was assumed to be $8/hr plus 25% to cover social security tax, workman's compensation insurance, and unemployment tax. The resulting total hourly rate was $10/hr.

Annual labor cost per hundred weight of milk sold (cwt) was calculated as follows.

$$\text{Annual Labor Cost/cwt} = \frac{(\text{Milking Shift} \times \text{No. of Milkings} \times \text{No. of Operators} \times 365 \times \$10)}{(\text{Total Herd Size} \times \text{cwt/cow})} \quad (3)$$

The total herd size defined in equation 3 includes both lactating and dry cows. It was assumed that 88% of the herd was lactating in all cases. The total herd size for the flat parlors was the number of cows milked per day divided by 0.88. The annual production per cow was calculated as the average daily production times 300 days. The mean production of all 13 dairies included in the study was 69 lb/cow/day. Therefore, the production value used for the herringbone calculations was set at 70 lb/cow/day to agree with the throughput values in Table 1.

All of the herds were assumed to be milked twice each day. All herringbone parlors were assumed to have 1 operator. The number of operators used in the flat parlor cost calculations corresponded to the weighted averages indicated for the entire milking shift (all cows) in Tables 6 and 7.

Calculation of Fixed Costs

Annual fixed costs were calculated using a cash-based partial budget (principle was included instead of depreciation). The annual fixed cost per cwt was calculated as the sum of annual costs for principle, interest, taxes, insurance and repairs divided by the total milk sold per year. The loan value was assumed to be equal to the total milking center price indicated in Table 2 for herringbone parlors, and Tables 3 and 4 for flat parlors. Principle and interest were calculated assuming an interest rate of 9.5% for a 10-year loan period. A 10-year loan

period was selected because most banks depreciate milking parlors over 10 years. The annual costs for taxes, insurance, and repairs were estimated as 7% of the purchase price of the new milking center or flat parlor (adapted from Bennett et al, 1991).

Total annual cost is the sum of the fixed and labor costs.

Economic Results

Investment costs of the flat and herringbone parlors are compared in Figure 4. Except for the 42 cow herd (37 cows milked) the investment per cwt for the flat parlors were lower than all new herringbone milking centers. The average investment for back-out flat parlors was $0.92/cwt. The price of the average walk-through flat parlor was twice as much as the average back-out at $1.82/cwt.

Annual Fixed Costs

The fixed costs associated with these investment levels are shown in Figure 5. All of the flat parlors with a herd size of 63 cows or more had annual fixed costs lower than $0.50/cwt. That is, the fixed milking center cost for these small herds was lower than the fixed costs for a 550 cow herd milked with a double-8.

The average fixed cost of the walk-through flat parlors was $0.20/cwt more than for the back-out. For a 100 cow herd producing 69 lb/milk/day a cost saving of $0.20 is equivalent to $4,140 per year. This is not to say that walk-through flat parlors are not cost effective. The walk-through flat parlor with the least cost had 6 units, and 12 stalls. The investment was $0.80/cwt and the annual fixed costs were $0.18/cwt. However, these results do indicate that smaller herds need to closely consider the impact of their remodeling costs to maximize profitability. Fixed costs should receive the greatest attention for small herds that predominately use family labor to milk cows.

Annual Labor Costs

As was stated previously, only three of the dairy producers represented in this study hired part-time employees for at least one milking. Therefore, it was common for a second person to help with the low group. As long as family labor is used to milk cows there is nothing wrong with such a practice. The purpose of this portion of the cost analysis is to examine the impact of using more than one operator if workers are hired for all milkings at $8/hr plus 25% fringe ($10/hr). The number of operators used for each flat parlor corresponds to the weighted averages for the total milking shift (Tables 6 and 7). The comparisons of labor costs are shown in Figure 6.

The labor costs per cwt for the 1 operator flat parlors ranged from slightly below that of a double-6 herringbone to slightly more than a double-4. The average labor cost for one operator in 6 or 8 unit flat parlors was $0.91/cwt. Using 1.5 to 2 operators over the milking shift increases labor cost by 84% on the average. Therefore, it is not economical to hire more than one operator for 6 or 8 unit flat parlors.

Two points are indicated in Figure 6 for the 16 unit walk-through parlor. The labor cost for 2 operators is based on the data, and is $1.41/cwt. Assuming that 1 operator could provide a throughput rate of 55 c/hr the labor cost would drop to $0.81/cwt. Therefore, accepting a lower throughput rate may save as much as $0.60/cwt.

Total Annual Costs

Total annual costs of flat parlors and herringbones are compared in Figure 7. The results shown indicate that if the labor rate was $8/hr plus 25% fringe the average 1 operator flat parlor in the study would have a total annual cost of $1.22/cwt. That is, an 87 cow herd producing 71 lb/cow/day milked in a flat parlor would have the same total milking center cost as a double-8 herringbone used to milk a 350 cow herd producing 70 lb/cow/day. In addition, lowering labor costs by hiring one person to milk will significantly reduce the total annual cost in all cases.

Other Uses for Flat Parlors

Some dairy producers are not able to renovate their stall barn to construct a flat parlor, and equity is not available to make the large scale expansion that is typically needed to afford a new pit parlor. Dairy producers in this situation may want to consider a new building, or an extensive remodel of another building for the flat parlor. Common reasons that a producer may consider a new building for a flat parlor are: (1) the stall barn is too old to be used for anything; (2) the stall barn is in an unusable location; or (3) the stall barn has been destroyed by fire, flood, or tornado. The total cost of the building and milking equipment should be considered closely in context of the quantity of milk sold per year. Using the pipeline, milk room equipment, and some of the existing units may allow this option to be cost effective in some cases.

An automated flat parlor can also be used to milk all treated and fresh cows for large herds (400 to 1000 cows). In this study, cows that were milked with a bucket reduced the milking-time throughput rate by about 7%. Providing a separate milking system for bucket cows would have the following advantages: (1) accidental contamination of the bulk tank by milk from cows treated with antibiotics can be avoided, (2) the efficiency of the main parlor will be improved, (3) treated and fresh cows will be milked more efficiently, and (4) the level of vacuum used in the flat parlor can be adjusted to be similar to that used in the pit parlor.

SUMMARY AND CONCLUSIONS

Flat parlors provide a powerful risk reduction strategy for dairy producers that are in transition from stall barn to free stall housing. It allows the producer to obtain the same annual costs as large dairies in the beginning of the transition. If herd sizes are limited to 120 cows or less the flat parlor may become the long-term option allowing the small dairy to be competitive with 350 to 500 cow dairies. Flat parlors address one of the most critical factors regarding the goal of increasing the number of cows that can be managed per worker by increasing the rate at which cows are milked by a factor of two.

Some of the specific conclusions from the study of 13 flat parlors are listed below.

1.) The type of flat parlor stall (back-out vs. walk-through) did not significantly influence the milking-time throughput rate.
2.) Flat parlors that allowed cows to be moved individually were the most efficient, and provided 7.2 cows per unit per person per hour (c/u/p/hr).
3.) Flat parlors that required cows to be moved in groups of 4 or 8 provided 5.0 c/u/p/hr with one operator.
4.) A cost analysis of annual fixed and labor costs indicated that only one operator should be hired to milk cows in flat parlors.
5.) Flat parlors allow dairy producers with herd sizes ranging from 63 to 227 cows to have lower fixed costs than a 550 cow herd milked with a moderately priced double-8 herringbone.
6.) If 1 operator is hired at $8/hr plus 25% fringe ($10/hr) a flat parlor will allow an 87 cow herd to have the same total annual costs as a 350 cow herd milked in a double-8 herringbone.

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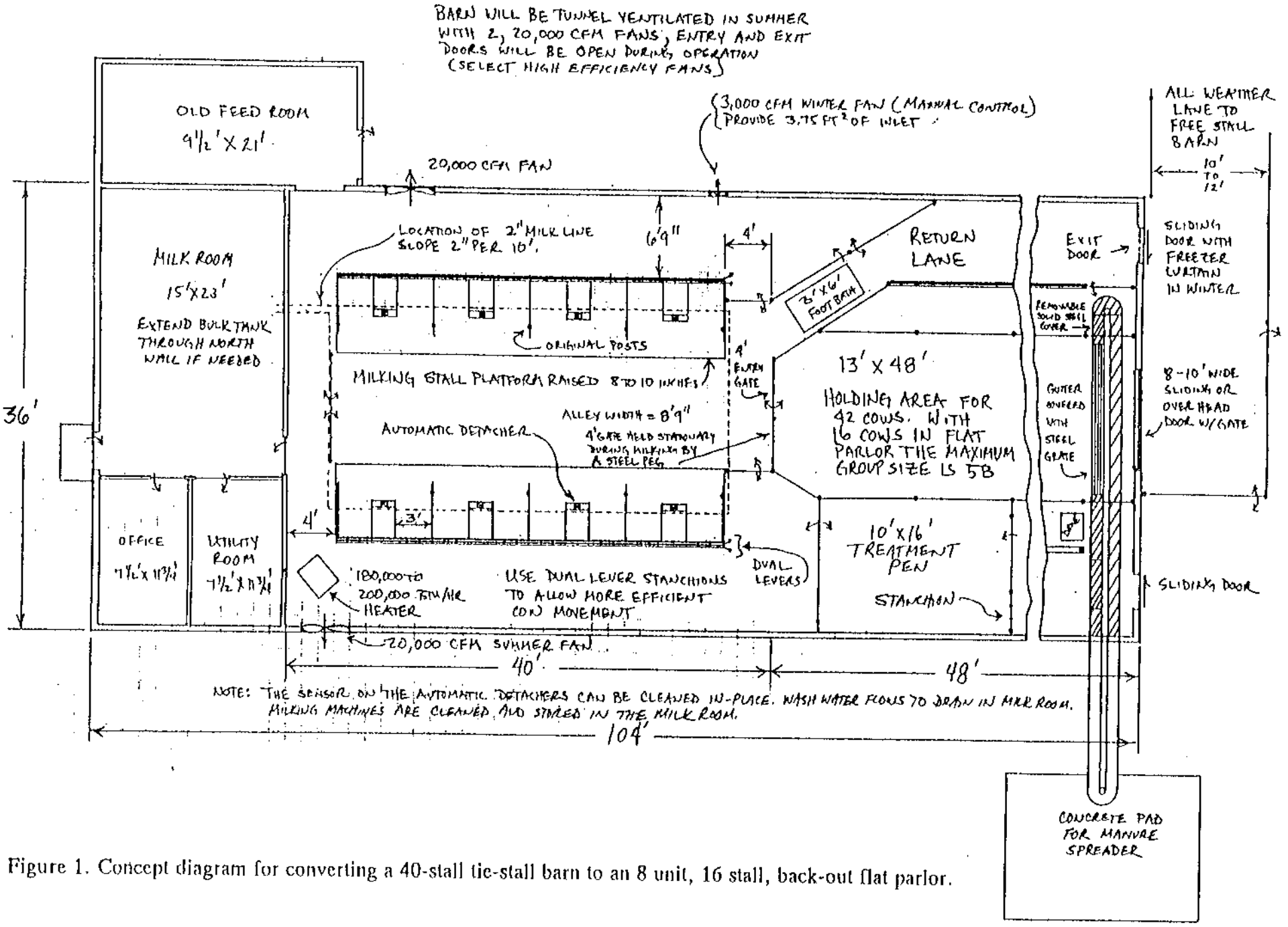

Figure 1. Concept diagram for converting a 40-stall tie-stall barn to an 8 unit, 16 stall, back-out flat parlor.

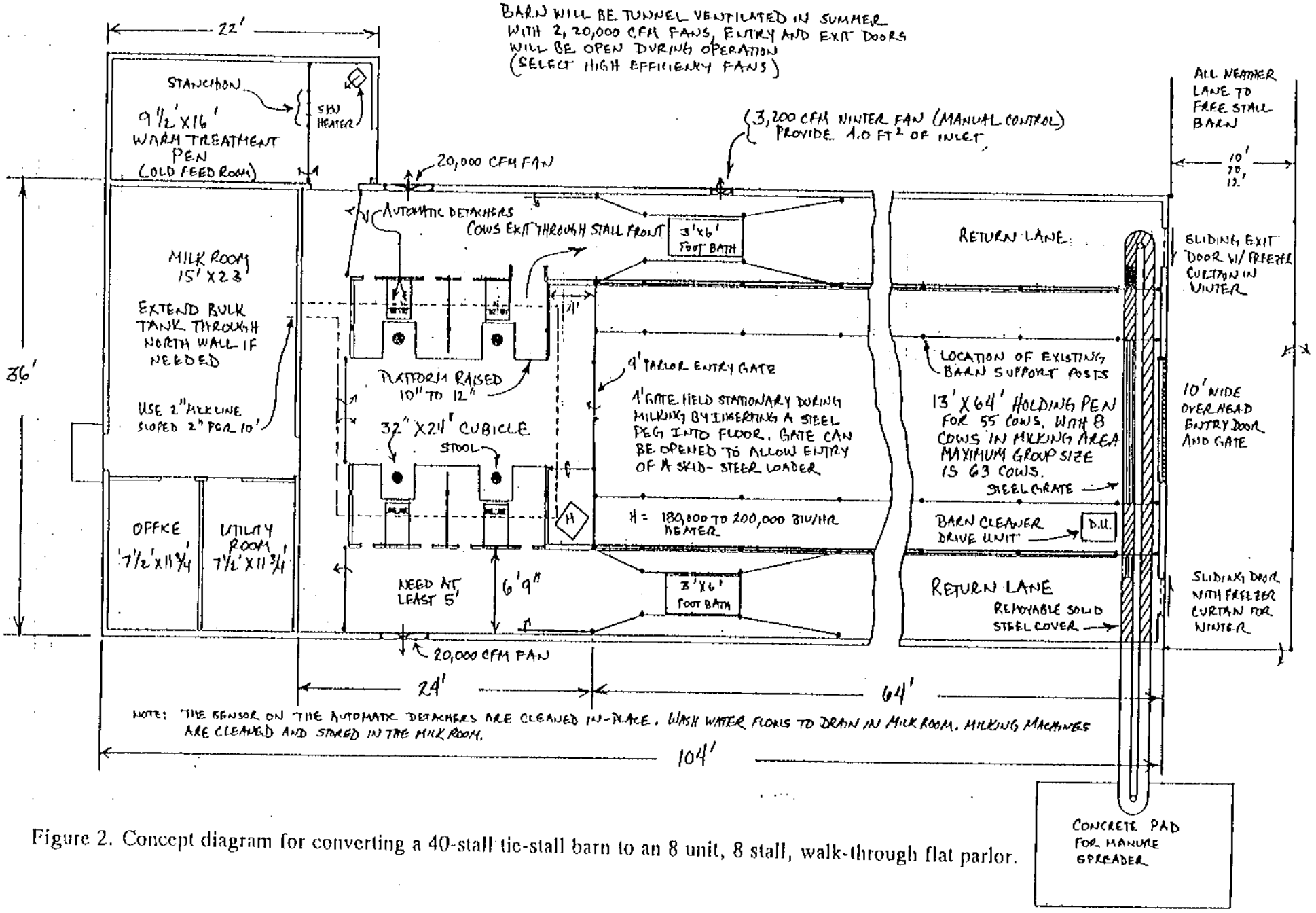

Figure 2. Concept diagram for converting a 40-stall tie-stall barn to an 8 unit, 8 stall, walk-through flat parlor.

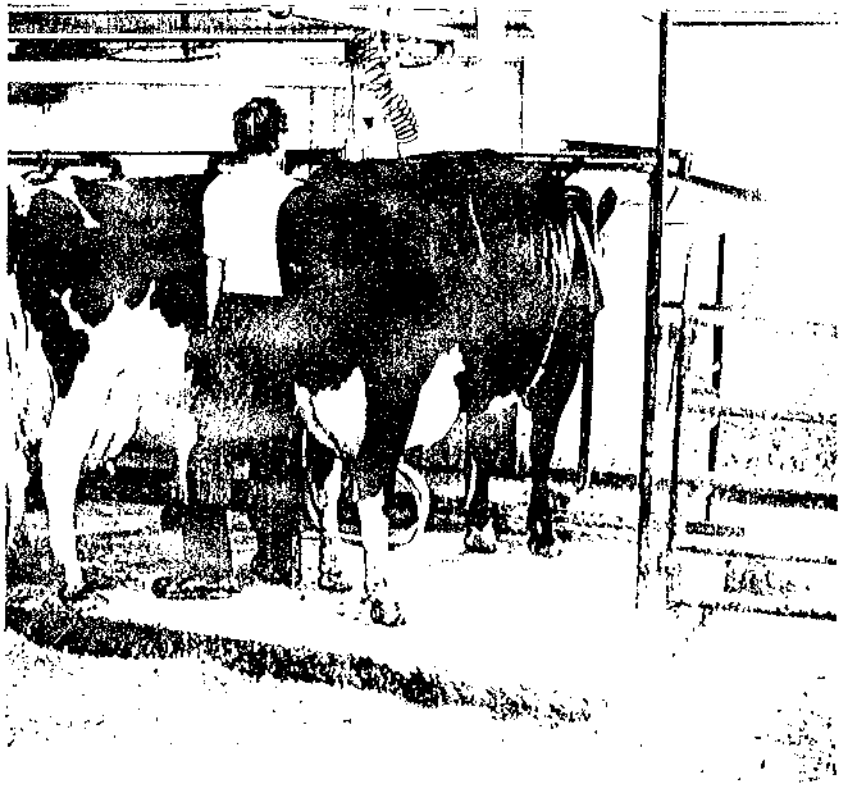

Figure 3a

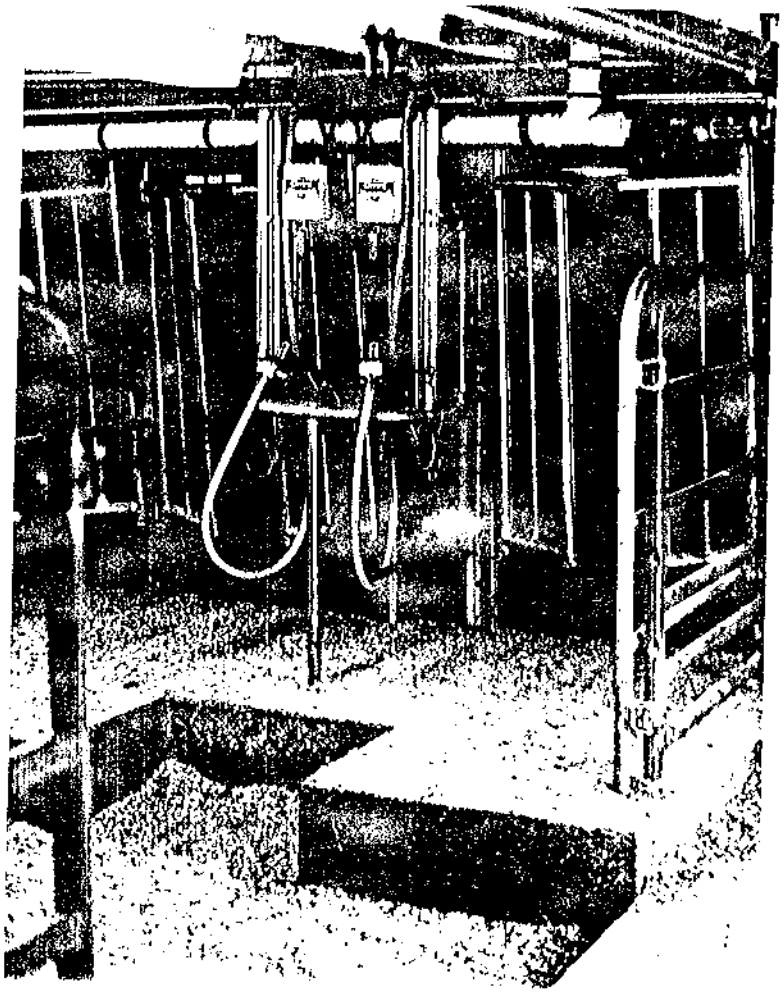

Figure 3b

Figure 3. Examples of dual lever back-out (Figure 3a), and walk-through stalls (Figure 3b).

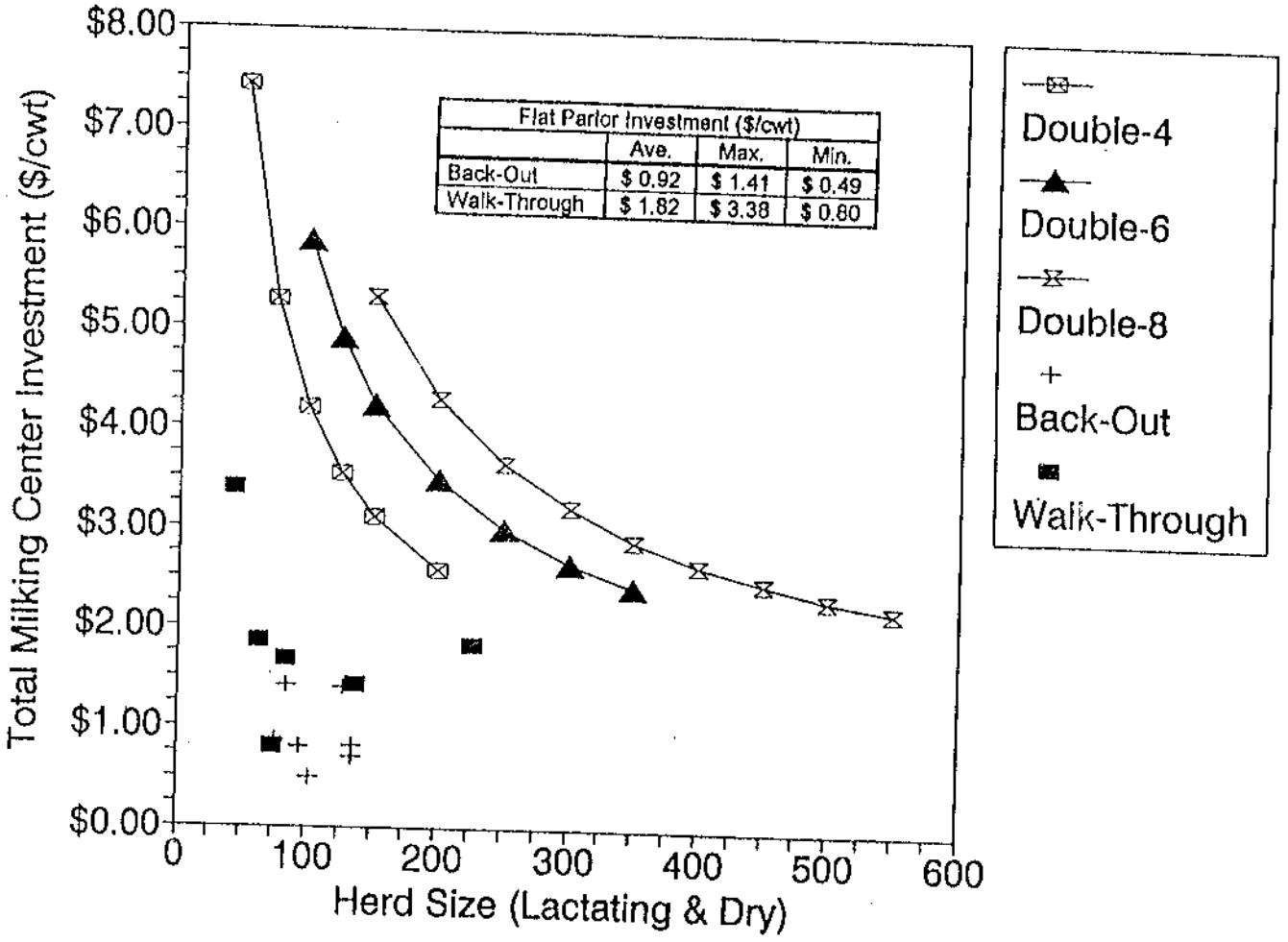

Figure 4. Milking center prices of herringbone and flat parlors.

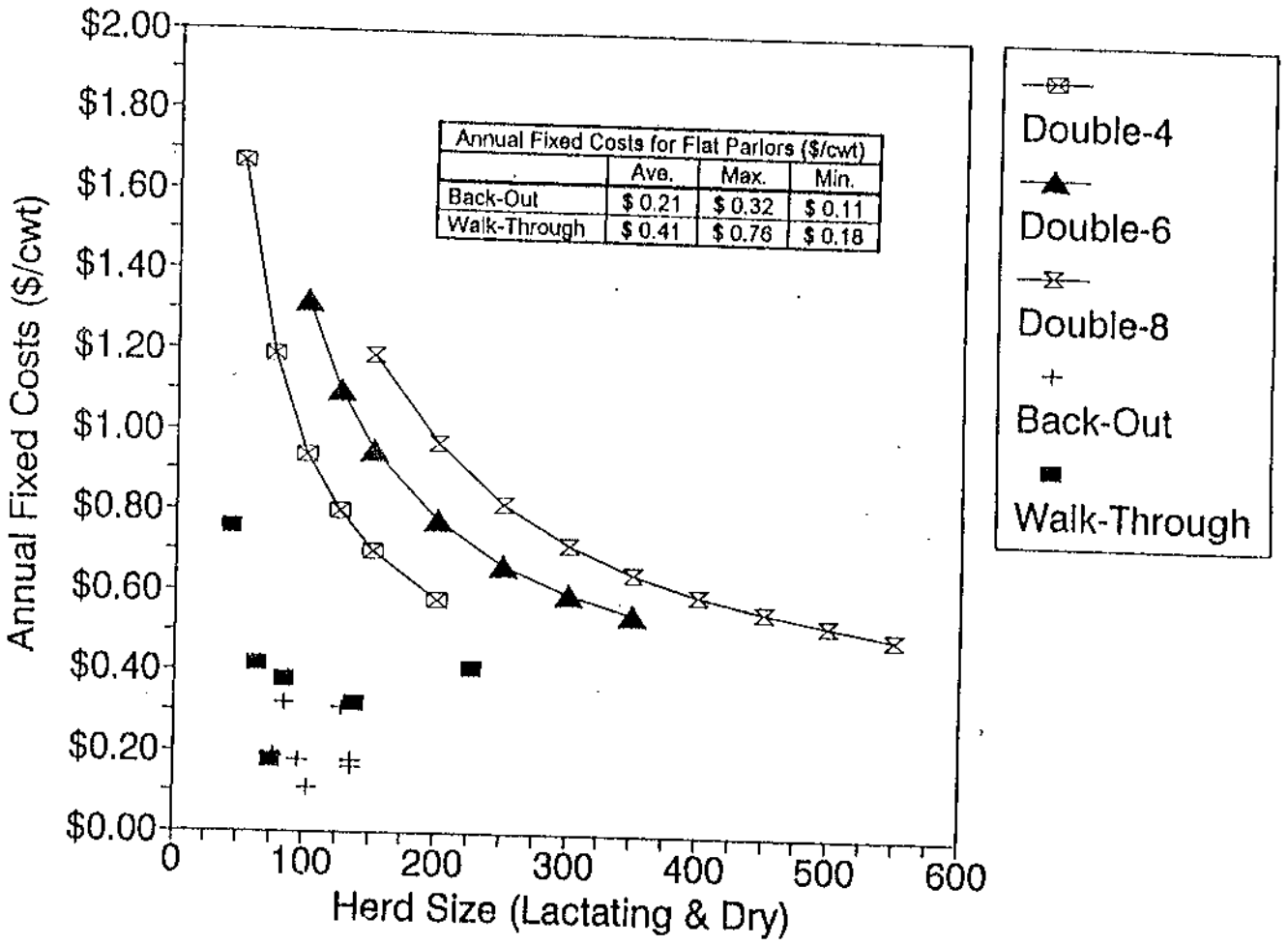

Figure 5. Annual fixed costs of herringbone and flat parlors.

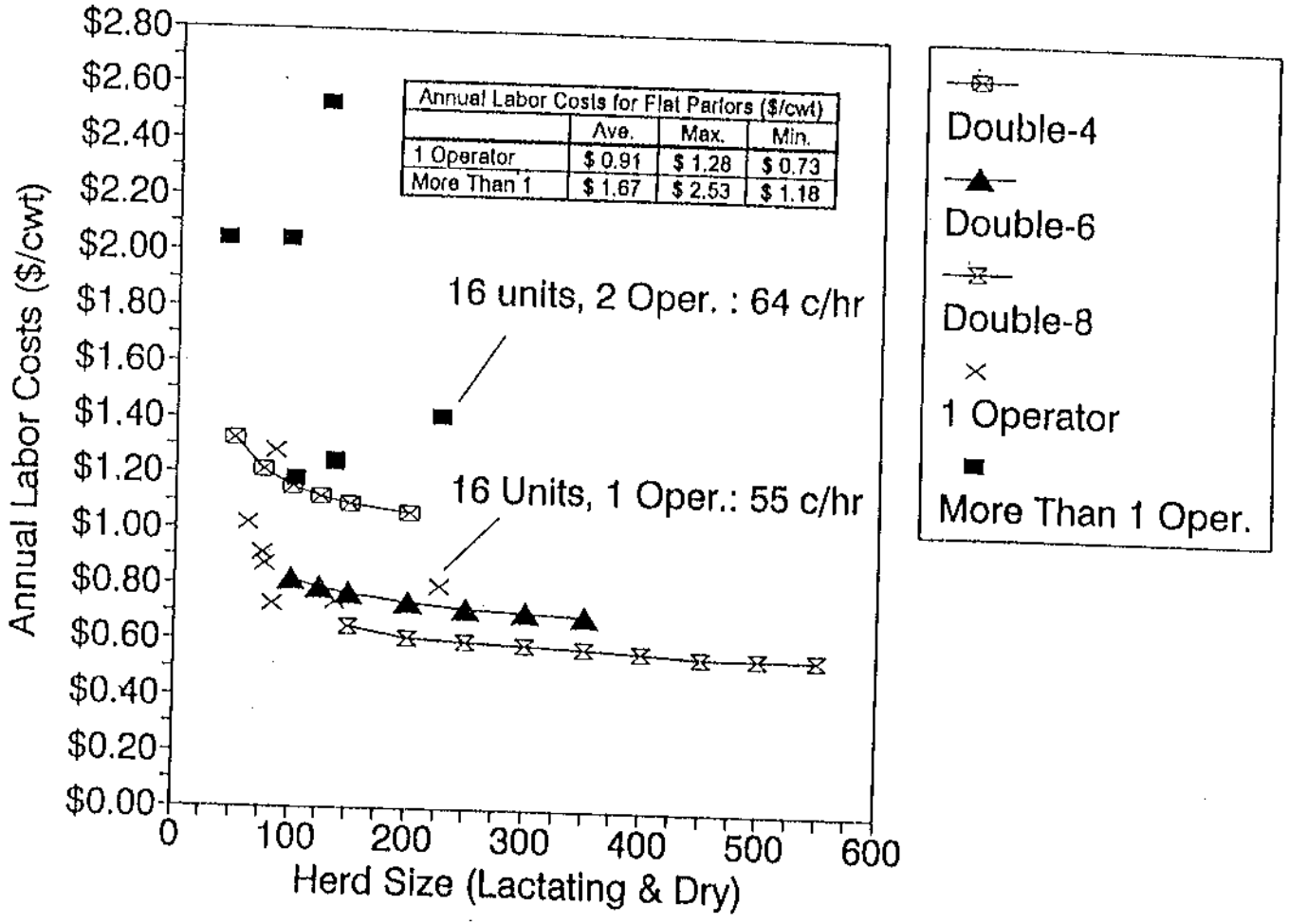

Figure 6. Annual labor costs of herringbone and flat parlors.

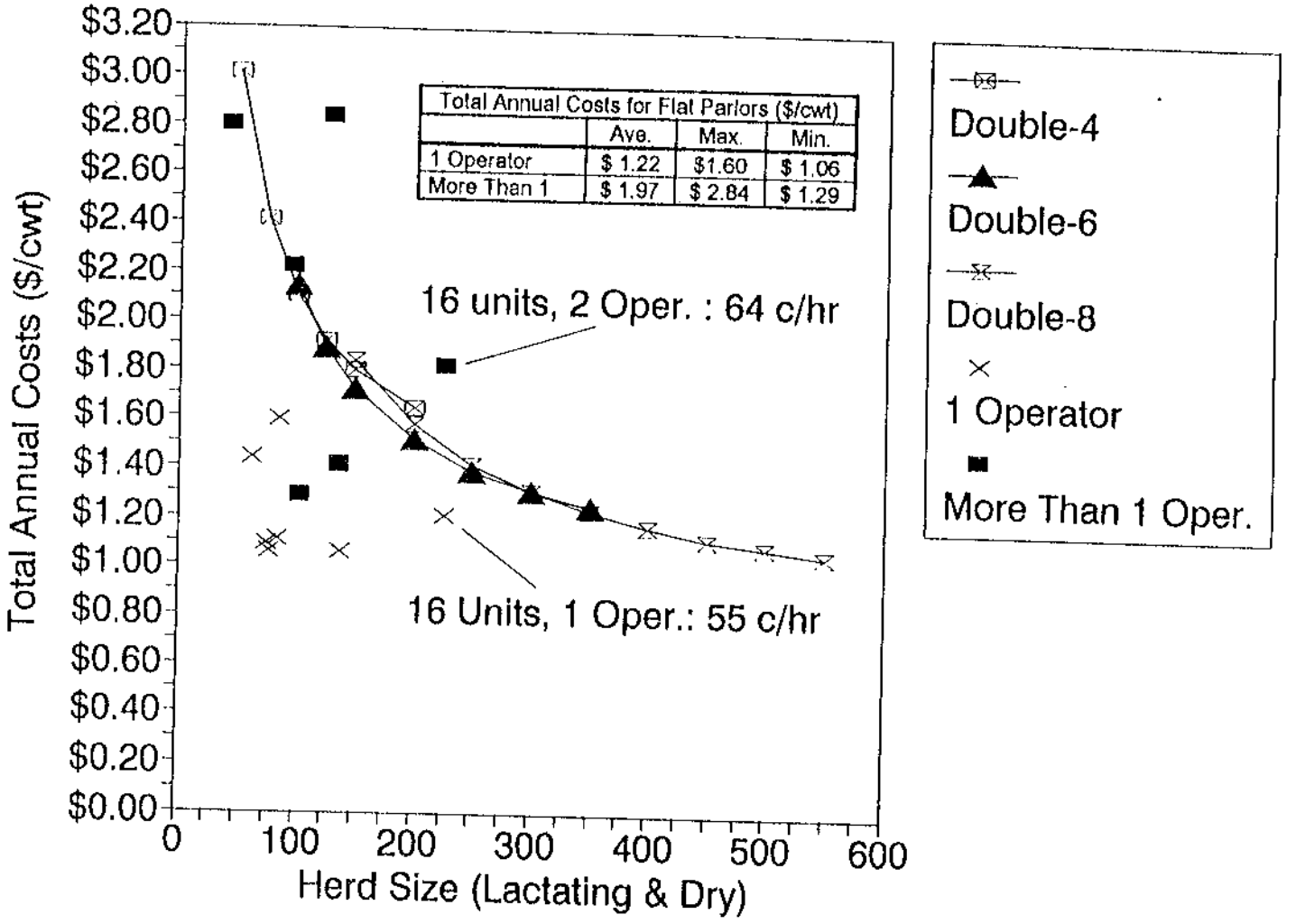

Figure7. Total annual costs of herringbone and flat parlors.

Figure 3a

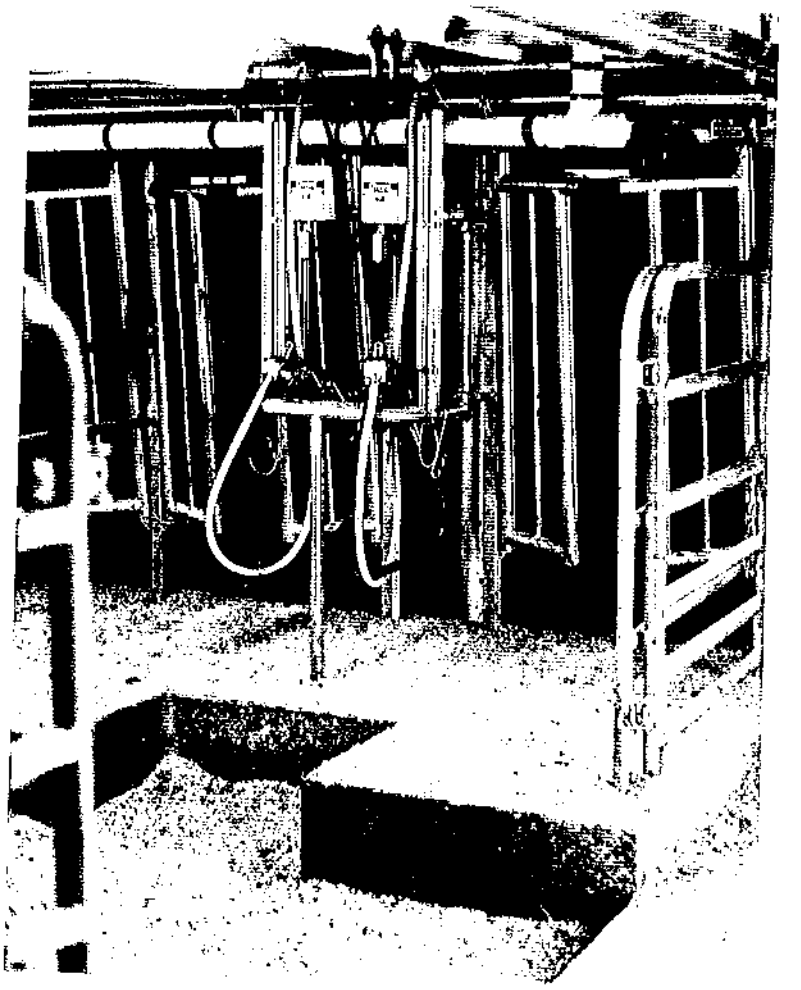

Figure 3b

Figure 3. Examples of dual lever back-out (Figure 3a), and walk-through stalls (Figure 3b).