EFFECT OF STALL-SIZES AND EQUIPMENT OF HERRINGBONE MILKING PARLOURS ON THE WORKING CONDITIONS OF THE MILKER

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INTRODUCTION

Many man-hours are being spent in the milking parlours on dairy farms. Bearing in mind the working conditions of the milker, it is very important to pay attention to this workplace.
In the Netherlands herringbone parlours are in use on most dairy farms with more than 50 cows.
The advantages of short walking lines, the relatively low building costs and the high capacity make the herringbone parlour very attractive. A disadvantage of the herringbone parlour is that the udder is not always easily accessible to the milker. The reason is that often reach distance to the udder is too great and the hind leg is placed too far forward, thus hindering the milker during milking activities.
Opinions differ how to improve accessibility and a large variety of stall sizes, kinds of rump rails and designs of pit edges have been recommended. The studies reported in this paper were devoted to the above parts of the herringbone parlour.
The effort to achieve standardization in the designing and construction of dairy farms provided an impetus to study the dimensions and layout of herringbone parlours.

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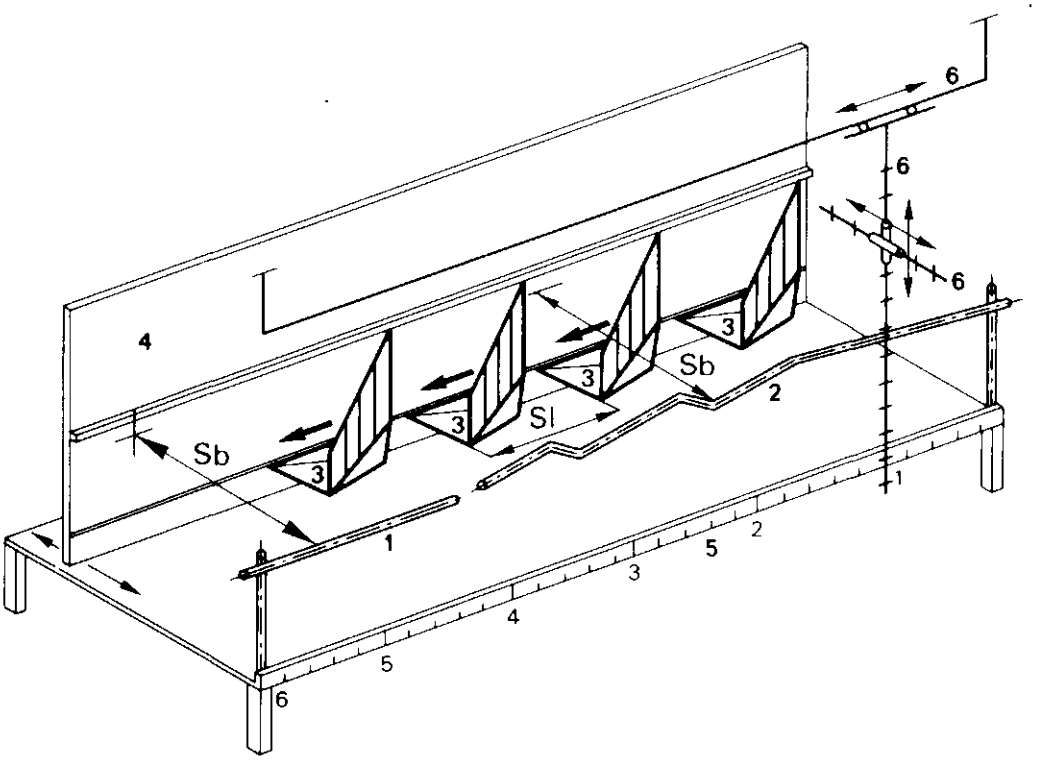


Fig. 1 Diagram of the experimental herringbone unit used for the experiments

1. straight rump rail
2. wavy-edged rump rail
3. adjustable mangers
4. adjustable wall
5. pit edge
6. measuring equipment

Sb = stall width
Sl = stall length

LITERATURE

In herringbone parlours the space available to the cows and the angle at which the cows are standing in the parlour depend on the length and the width of the stall. The stall length is the spacing of the mangers between centres. The width is the distance between the inside of the rump rail and the wall along which the mangers have been installed (Fig. 1).
If there is a metal screen behind the mangers, the stall width will be the distance between the inside of the rump rail and that part of the screen panel stopping the cows in front.
Different stall angles have been specified in the literature and by firms of milking equipment without indicating on which the data they are based. The report of the Studiecommissie Doorloopmelkstallen (1969) indicates a stall angle of 30-35°. Rüprich (1968) adopted a stall angle of 30° with a wavy rump rail.
According to Rogerson (1972) a variable height of the manger has little effect on the total length of the standing occupied by the cow. He indicates that a cow with a total length of 160 cm needs an extra 5 cm of stall length when the manger has been placed at a height of 40 cm instead of 20 cm.
Vos (1974) states that from the standpoint of ergonomics of milking in milking parlours the edge of the optimum working area should be at a distance of 45 cm from the pit edge.

PROCEDURE

To establish the effect of the various stall sizes and designs of herringbone parlours on the accessibility, an experimental herringbone unit with every part adjustable was set up, different versions being compared with each other using the same cows of known measurements.

Experimental set up

At the experimental farm "De Bunzing" at Zeist half a herringbone unit with four places was set up. Any desired stall width could be created by moving the side wall, on which the mangers were fixed, which was adjustable at right angles to the longitudinal axis of the herringbone unit. The stall length was adjustable by moving the mangers parallel to the side wall (Fig. 1). The rump rails were removable, so that they could be easily changed.

Measuring points

Fixed points were measured on the cow at various stall lengths and widths. Each measuring point has been laid down by three co-ordinates, three-dimensionally.
In this ways, two fixed points have been defined in each case, the distal end of the right front teat and the inside of the hock of the right hind leg, both measuring points being sited on the side of the milking pit.

Experimental animals

The experiments were carried out with 4 groups of cows, each of 4 animals. The groups were formed on the basis of the height of the cows. In groups I, II and III were tall, medium and small cows, respectively while group IV was composed of two tall and two small cows.
Table I presents a summary of the average sizes of the cows in the various groups. The measurements are shown diagrammatically in Fig. 2.

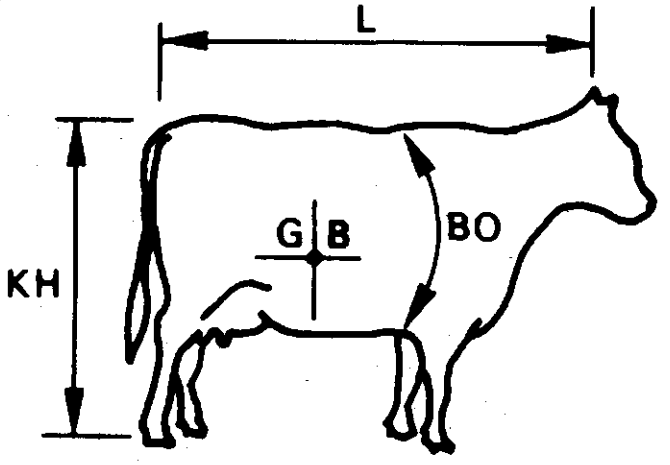


Fig. 2 Diagram of the measuring points for fixing the body sizes of the test animals
L = cow length
KH = height
GB = largest width
BO = chest girth

Table I Average body dimensions of the cows in the various groups

	Group	Height	Chest girth	Largest width	Total length
I	Tall cows	137	200	74	215
II	Cows of medium height	132	201	75	212
III	Small cows	120	180	68	196
IV	Tall + small cows	140-121	210-183	78-67	224-195

Scope of observations

The first series of observations was made with 11 variants of stall dimensions, a straight rump rail and a straight pit edge. Thereafter, various changes were made to the equipment of the parlour, e.g. two straight rump rails were used instead of one, a wavy rail, a wavy pit edge and some adaptations to the mangers with a view to the available space for the passage of the cows. In addition observations have been made with cows in a tandem parlour.

The cows were measured twice each time they were in the parlour, once when they were fed concentrate and once when they were not being fed.

The following data were collected for each adjustment of the herringbone unit:

- 4 groups of cows (tall, of medium height, small and small + tall)
- 4 cows per group
- 2 measurements per passage through the herringbone unit (with and without concentrate)
- 1 repetition of the whole measurement program with the given adjustment of the herringbone unit.

Four measurements were made on 16 cows for each adjustment of the herringbone unit.

The cows were always placed in the stalls in a random sequence.

Table II shows the different variants of stall dimensions and lay-outs of the herringbone parlour, in which the measurements were made.

Table II Summary of the measurements with different stall lengths and widths, cm.

	Herringbone parlour												Tandem parlour
Stall width	125				135				145				80
Stall length	95	105	115	125	95	105	115	85	95	100	105	115	235
Single straight rump rail	xx	x	xxx	x	x	x	x	x	x	x	x	x	x
Double straight rump rail			x										
Double wavy rump rail + straight pit edge			x							x			
Double wavy rump rail + wavy pit edge			x										
Single straight rump rail with adapted mangers			x										
Double wavy rump rail with adapted mangers			x										

x = 16 cows measured four times

RESULTS

Ability to reach the udder

In the first series of experiments 11 stalls were observed with variations in length and width, the stalls having a straight rump rail and a straight pit edge.
The choice of the range of dimensions of the stalls in which the observations were carried out was based on a theoretical model with fictitious cow sizes.
The evaluation of the stall sizes under examination was based on two relevant criteria for the ability to reach the udder. The first one is the distance from the pit edge to the udder, the measurement of the distance from the pit edge to the closest front teat being adopted. To calculate the reach distance the values obtained were corrected for the measuring equipment and 20 cm was added, this being the mean distance between the front teats. This value thus obtained is the maximum distance the milker has to reach to carry out the milking operations. Table III shows the percentage of cases in which the reach distance is less than 45 cm. The critical distance is 45 cm, this being within the optimum work area of the milker (Vos, 1974).
The second criterion for the objective evaluation of the experimental stall sizes is the distance between the front teat and the inside of the hock of the cow on the side where the milker is standing. Depending on the degree to which the hind leg has been placed forward, a larger part of the udder disappears from the milker's view and the accessibility of the udder deteriorates. Table III shows the percentages of cases in which the distance is greater than 10 cm.

Table III Summary of percentage of cases in which the reach distance is less than 45 cm and the accessibility of the udder is greater than 10 cm with a single straight rump rail.

Stall width Stall length in cm	reach distance of the udder % < 45 cm			accessibility of the udder % > 10 cm		
	concentrate uptake		total average	concentrate uptake		total average
	yes	no		yes	no	
125 - 95	97	94	96	31	28	30
125 - 105	97	97	97	34	41	38
125 - 115	84	87	86	59	44	52
125 - 125	50	78	64	53	50	52
135 - 95	69	69	69	37	19	28
135 - 105	47	69	58	38	41	39
135 - 115	28	56	42	47	31	39
145 - 85	40	53	47	31	28	30
145 - 95	28	47	38	31	50	41
145 - 105	6	47	27	47	56	52
145 - 115	12	37	25	41	59	50

Table III and Fig. 3 show that the position of the hind leg and hence the accessibility of the udder are particularly affected by the length of the stall.
Moreover, with increasing stall length the percentage of cases in which the distance from the front teat to the inside of the hock exceeds 10 cm also increases.

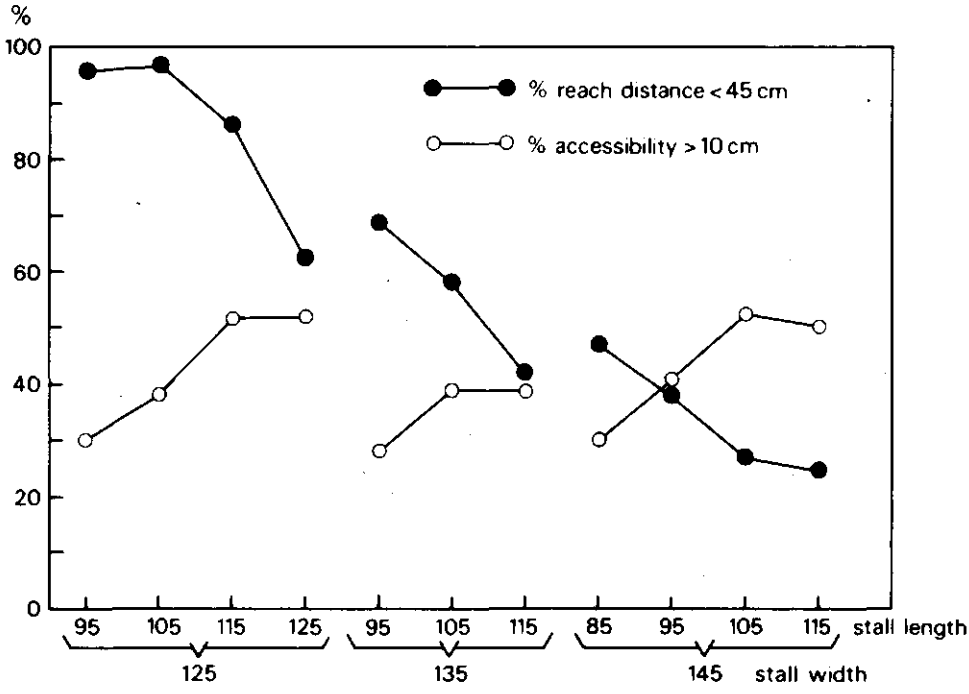
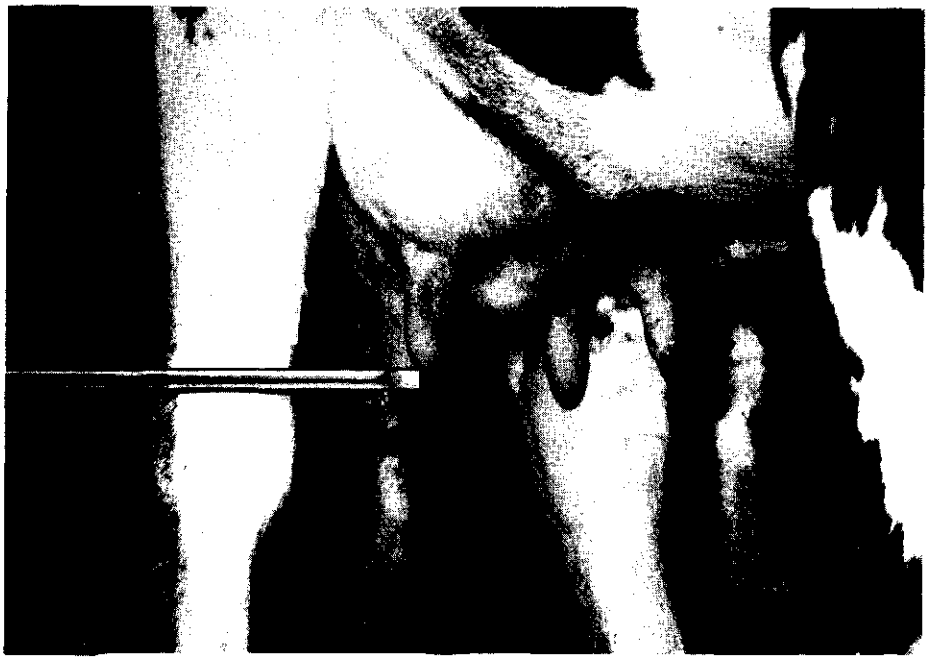


Fig. 3 Variation of the percentage reach distance < 45 cm and accessibility > 10 cm.

The distance from the pit edge to the udder also depends both on the length and width of the stall. Increasing the length and width of the stall reduces the percentage with a reach distance of less than 45 cm. In comparison with the values obtained with a herringbone disposition of the cows the percentages of reach distances < 45 cm and an accessibility > 10 cm (stall length 235 cm, width 80 cm) were respectively 18 and 69 in a tandem layout. In a herringbone parlour a stall with a length of 115 cm and a width of 125 cm gives on average the best accessibility to the udder.



Measuring the reach distance.

Feeding of concentrate

Table III shows separately the percentages for the evaluation criteria during concentrate uptake and when the cows are not eating. It appears from the percentages that the accessibility of the udder does not change systematically as a result of the cow eating concentrate. On the other hand, the required reach does change.
Especially with the combination of a great length and great width of the stall, the cows move away from the pit edge, thereby increasing the reach distance to the udder.

Height of the cows

Figs. 4 and 5 show respectively the variation of the average distance between the pit edge and udder and the average distance between the front teat and the hock for each group (tall, of medium height, small and small + tall).

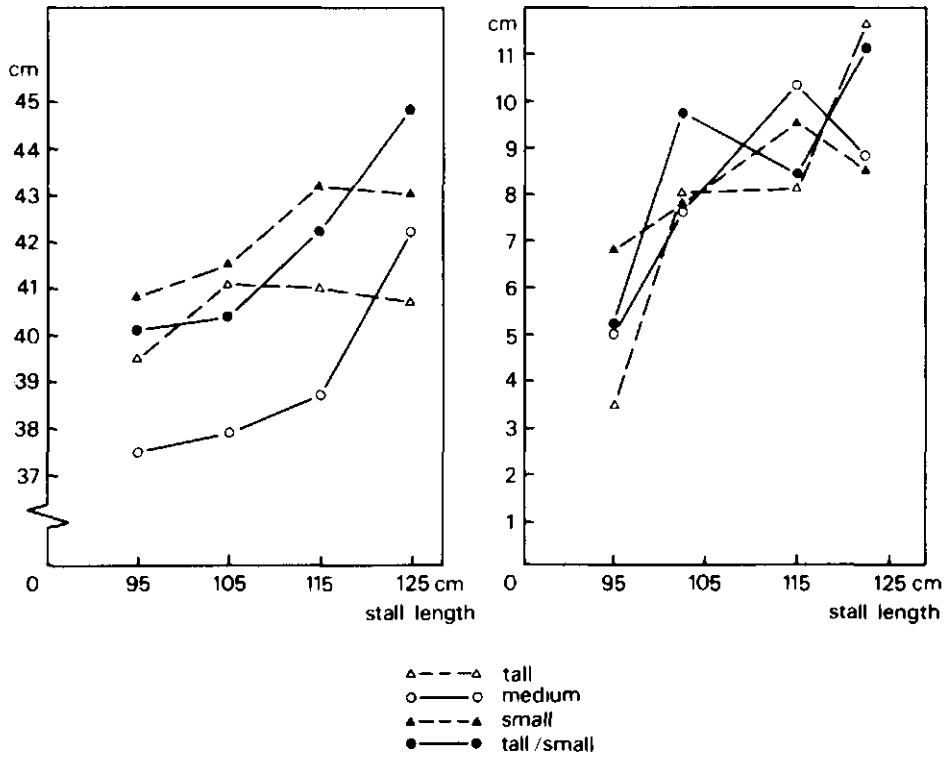


Fig. 4 Variation of the average distance between pit edge and udder for each group with a constant stall width of 125 cm and a variable length.

Fig. 5 Variation of the average distance between front teat and hock for each group with a constant stall width of 125 cm and a variable length.

It appears that at increasing stall length and a constant stall width of 125 cm, both the reach and the accessibility show a similar trend for 4 groups of cows.

Single and double straight rump rail

During the observations it appeared that the position of the hind leg is also determined by the pressure of the rump rail against the thigh of the cow.
The first measurements were always made with a single rump rail fixed at a height of 95 cm above the cow standing.
To assess the influence of a double rump rail - very common for reasons of safety - on the results obtained with a single rail, experiments were carried out with a double rump rail, fixed at a height of 115 cm and 70 cm above the cow standing.
Table IV shows the results of the comparison of the experimental set-up provided with a single and with a double rump rail at a constant stall width of 125 cm and a variable length of 95 and 115 cm respectively.

Table IV Influence on the accessibility and reach distance to the udder by a single and double straight rump rail.

stall width stall length in cm	single or double rump rail	reach distance % < 45 cm	accessibility % > 10 cm
125 - 95	single	100	41
125 - 95	double	100	28
125 - 115	single	91	50
125 - 115	double	81	44

The level and trend of the percentages of the reach distance of <45 cm and an accessibility of >10 cm were in good agreement with the results of the first experiments. The differences in the stance of the cow between a single and a double rump rail were the greatest at a stall length of 95 cm, i.e. in a situation in which the cows have little space available. With a stall length of 115 cm the difference is, however, smaller.

Wavy-edged rump rail

In order to be able to investigate the effect of a wavy-edge rump rail on the ability to reach the udder a commercially available wavy rail was installed into the experimental stall.
The stall sizes were adjusted according to the dimensions indicated by the manufacturer (stall width 145 cm and length 100 cm).
To enable comparison, the measurements were also carried out with a straight rump rail and the appropriate stall dimensions.

Table V Comparison between a wavy rump rail with straight pit edge and a straight rump rail.

stall width stall length in cm	type of rump rail	reach distance % < 45 cm	accessibility % > 10 cm
145 - 100	wavy	0 (70)	32
145 - 100	straight	25	47

( ) after correction for the wavy rump rail.

Table V shows that when the wavy rump rail is used instead of the straight one the accessibility is worse. The reach distance increases and the position of the hind leg is less favourable with respect to the ability to reach the udder.

With the combination of a wavy rump rail and a straight pit edge it is possible for the milker to get about 10 cm closer to the udder by bending forward, although this is not an optimum working posture.
After correcting the figures by 10 cm, the percentage for a reach distance of < 45 cm changes from 0 to 70%.
In a second experiment with a wavy rump rail, a stall width of 125 cm and a length of 115 cm were applied, these having been found to be the best in the first experiment with a straight rump rail.
Table VI shows that the wavy rail has a favourable effect on the position of the hind leg, as will be evident from the high percentage (65%) of cases in which the distance between the front teat and hock is greater than 10 cm. The number of cases with a reach of < 45 cm decreases slightly. When we correct the reach distance by 10 cm for the wavy rail this percentage will increase from 54 to 92%.

Table VI Wavy rump rail and straight pit edge in comparison with a straight rump rail with a stall width of 125 cm and a length of 115 cm.

stall width stall length in cm	type of rump rail	reach distance % < 45 cm	accessibility % > 10 cm
125 - 115	wavy	54 (92)	65
125 - 115	straight	87	51

( ) after correction for the wavy rump rail.

With the combination of wavy rump rail and a limited stall width the passage for the cows is narrow. Even with a straight rail and a stall width of 125 cm 70 cm is left for the passage when the manger partitions occupy 55 cm of the stall width.
In the next experiment another comparison was made between the wavy rump rail and the straight one, although in this case the passage was widened to at least 80 cm by changing the partitions. (Table VII).

Table VII Comparison of a wavy rump rail with straight pit edge, a wavy rump rail with wavy pit edge and a straight rump rail with a stall width of 125 cm and a stall length of 115 cm and a passage of 80 cm (Mangers modified).

stall width stall length in cm	type of rump rail	type of pit edge	reach distance % < 45 cm	accessibility % > 10 cm
125 - 115	straight	straight	87	50
125 - 115	wavy	straight	11 (94)	48
125 - 115	wavy	wavy	95	55

( ) after correction for the wavy rump rail.

With respect to the straight rump rail the percentages hardly change according to the results in Table VI. The wavy rump rail presents another picture. The position of the cow is nearly the same as with a straight rail. The percentage of reach distances of <45 cm decreased considerably. By correcting the reach by 10 cm, the percentages raise from 11 to 94%.
Finally, an experiment was carried out with a wavy rail and wavy pit edge and with the modified manger partitions.
Table VII shows that the wavy rail and pit edge offer no significant improvement over a straight rail and a straight pit edge. In the calculations of the percentages of the reach distances of <45 allowance has been made for the fact that the milker can get 10 cm closer to the cow (in an optimum work posture) with a wavy pit edge.

DISCUSSION

The research on stall sizes of herringbone parlours has been based almost entirely on the ability of the milker to reach the udder. With respect to the position of the hind leg of the cow it will be evident that the greater the distance between the front teat and hock, the better accessible is the udder for the required activities. If both criteria are ranked equally, a stall length of 115 cm in combination with a width of 125 cm seems to give on average the best accessibility of the udder.
These stand sizes are very critical, as shown by the fact that as either the stall length or width is increased by 10 cm according to the optimum stall sizes, one of the criteria becomes less favourable. The choice of a stall width of 125 cm is acceptable on

the basis of these data.
Bearing in mind the drop of the percentage of reach distances of <45 cm from 97 to 86% there could be some uncertainty of choice between a stall length of 105 and 115 cm. This drop has been caused exclusively by the group of small cows. On the other hand, by changing the stall length from 105 to 115 cm the percentage accessibility of >10 cm increases from 38 to 52%, this difference being significant ($P < 0,05$).
The objective data on the ability to reach the udder obtained from an analysis of the results of the measurement have been confirmed by visual observations.
With a stall length and width of 115 and 125 cm respectively the cows appeared to fit well "in each other", which means that the hind quarters of one cow came just before the belly girth of the next cow. The favourable effect on the ability to reach the udder was clearly evident. It will be noted that, in general, all four groups of cows showed the same trend with respect to the ability to reach the udder (Figs. 4 and 5). It may be concluded that cows of different sizes can be milked with an easy access in herringbone parlours with stall sizes of 115/125 cm.

Cows in the experimental set-up.

A double rump rail in combination with a shorter stall (95 cm) is inferior with respect to the ability to reach the udder. With a more appropriate stall length of 115 cm the difference between a single and a double rail is considerably reduced. The wavy-edged rump rail gave no improvement of the ability to reach the udder with a very wide stall of 145 cm compared with the straight rump rail. After correction for the wavy rail, the reach distance becomes more favourable. The question arises whether it is allowed to make corrections when the pit edge is not wavy. If the 10 cm are to be utilized by the milker to get closer to the cow, then he has to work in an unfavourable work posture with the body bending forward.
Initially the wavy rump rail seemed to have a favourable effect on the stance of the hind leg in combination with a stall of 115 cm and a stall width of 125 cm. If only the manger partitions are adapted in relation to the passage of the cows, the difference between a straight rump rail and a wavy one cases to be great once the reach distance has been corrected by 10 cm.
Since the wavy rump rail offers little advantage with respect to the ability to reach the udder and then only when a wavy pit edge is also used, the straight rail will be preferable in most cases, in view of the disadvantages of a wavy rail, like being more complicated, more expensive, narrower passage for the cows.

CONCLUSIONS

- Optimum ability to reach the udder by the milker in herringbone parlours was obtained with a stall length of 115 cm and a width of 125 cm.
- It was found that cows of different sizes (height varied from 120 to 140 cm) can be milked with a good ability to reach at these stall sizes.
- If the optimum stall sizes are used the height of the manger has no great effect on the stance of the cow.
- A wavy rump rail offers no improvement with respect to the ability to reach the udder compared with a straight rail in herringbone parlours with a very wide stall (145 cm).
- Even when the stall sizes 115/125 have been used a wavy rump rail has little advantage with respect to the ability to reach the udder and then only when the pit edge is also wavy. In most cases a straight rump rail with a straight pit edge will be preferable.
- Figs. 6 and 7 show the stall sizes and equipment of the herringbone parlour, which according to the study best enable the milker to reach the udder.

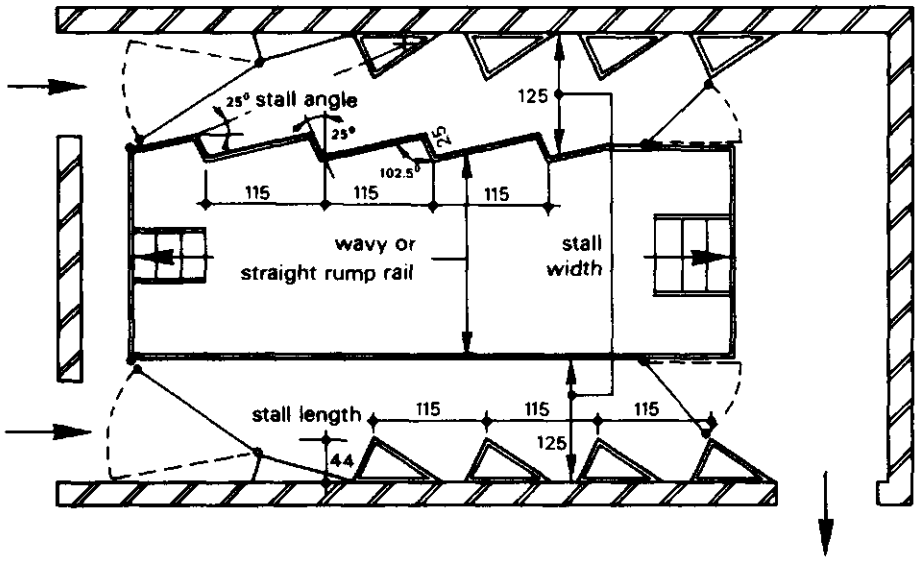


Fig. 6 Plan of a double four herringbone parlour with on one side a wavy rump rail with wavy pit edge and on the other side a straight rump rail with straight pit edge.

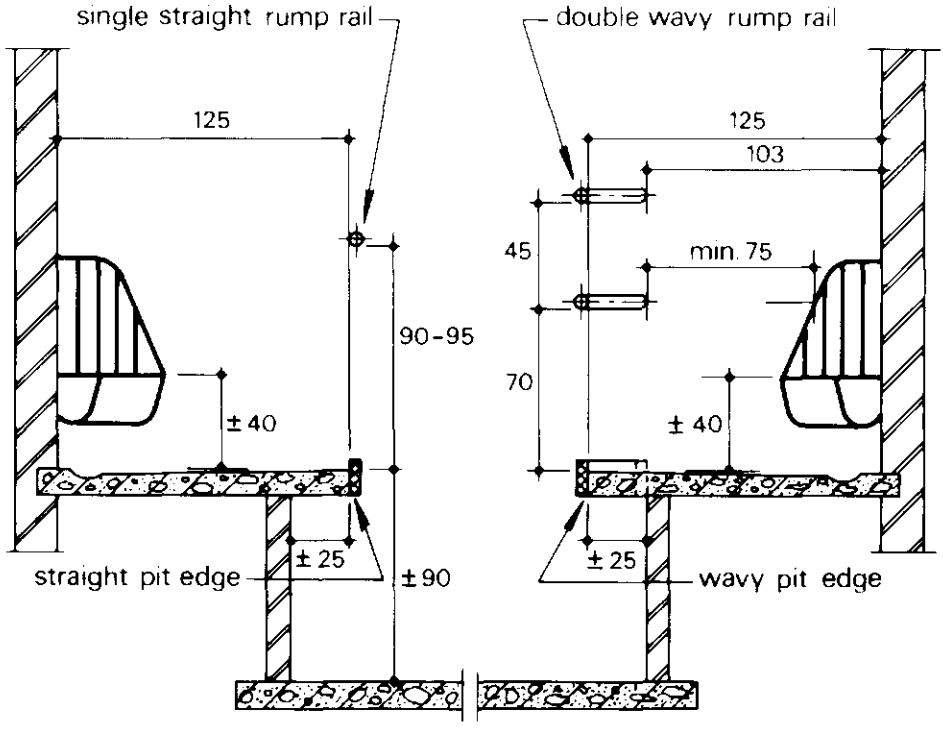


Fig. 7 Section of a herringbone parlour with on one side a single straight rump rail with straight pit edge and on the other side a double wavy rump rail and a wavy pit edge.

SUMMARY

The relationship between the stall sizes and the ability of the milker to reach the udder was investigated in one half of a four-stall herringbone parlour with adjustable stall width and length. The design of the milking parlour in terms of the shape of the rump rail and pit edge was part of the study. The research has been carried out with 4 groups of cows varying greatly in height (120-140 cm).
The distances to which the milker has to reach to carry out the milking activities have been obtained by measurements. The stance of the hind leg of the cow was also examined, which when placed too much forward can hinder the milker.
It appears that a stall width of 125 cm and a length of 115 cm are best with respect to the ability to reach the udder. A wavy rump rail offers no important improvement in the ability to reach the udder and then only if the pit edge is also wavy.

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