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Technical Report (Work Study) No. 3.

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A WORK STUDY EXERCISE IN MILKING PARLOUR PERFORMANCES

by

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E R R A T A

- P.7 Footnote ~~xx~~ Amend "lb/min" to read "min/lb" in all cases.
- P.14 Line 23. After "directed" insert missing line, "to work at the point opposite the cow that he thinks is the next to milk out, can induce ....."
- P.48 List No. 24, Random selection No. 2. Amend "1" to read "41".

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## PREFACE

Two reports have been prepared recently by the Farm Economics Branch, one dealing with the economic aspects of loose-housing\* and the other with parlour milking systems of dairying\*\*. The preparation of each report demanded some basic work study analysis. Naturally it was not possible to include all such detailed material evidence in either publication.

The latter report called for an investigation into what happens rather than what is thought to happen, in the parlour at milking time, and into the complexity of the problems which face the cowman in various types of layout. This paper describes some of the more salient points which emerged from this line of research. Although specifically intended for those with a particular interest in agricultural work study, nevertheless it is hoped that others concerned with the business of milking cows will derive some information of use and interest from the contents.

Acknowledgement is due to the National Institute of Research in Dairying for providing the basic data on individual milking times and particularly to P.A. Clough and F.H. Dodd of that Institute for the knowledge gained from their previous work in a similar field. Thanks are also due to A.J. Quick, Milk Production Officer of the N.A.A.S. for his advice and encouragement at various times during the research period, and also to J.S. Nix and D.G.R. Belshaw who directed the main part of the investigation. The author, however, accepts responsibility for any conclusions drawn and recommendations made in the report.

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\* The Yard and Parlour - Capital Costs and Work Requirements, Report 58, Farm Economics Branch, University of Cambridge.  
\*\* The Milking Parlour - Economic and Technical Aspects, Report , (still to be published).

### OBJECTIVES

The intention was to determine what effects parlour type and variations in milking-out times within the herd can have, in practice, upon:

- (a) overall milking time
- (b) 'let-down' stimulus time
- (c) overmilking time
- (d) machine idle time
- (e) man idle time
- (f) feeding time available
- (g) standard work routines.

It is hoped that the results of the exercise will confirm or reveal shortcomings in current thought of the theoretical performances of various milking parlours, when these are operated by a standard work method and deal with cows whose 'milking-out' times fluctuate about the average time for the herd.

## CHAPTER 1

### REQUIREMENTS OF A WORK METHOD IN MILKING

Consideration must first be given to what constitutes a satisfactory parlour-milking routine: unless the routine established\* can fulfil the following conditions it will fall short of doing a good job.

- (a) It must incorporate quickness with effectiveness.
- (b) Udder washing is generally regarded as the action which stimulates milk let-down. To be an effective stimulus, the time from commencing washing to applying the milking cluster must be reasonably constant from milking to milking, and from cow to cow. A time of about  $\frac{1}{2}$  to  $1\frac{1}{2}$  mins. is considered to be about right.
- (c) Assuming concentrate feeding is practiced and that the best time and place for issue are at milking time and in the parlour, then all cows must have sufficient time to consume their ration\*\*.
- (d) There must be no excessive over-milking. Although experimental data is incomplete as to the long term effect of over-milking, it is agreed that a maximum of three minutes should not be exceeded. Neither should all cows be over-milked habitually.
- (e) It should be possible to let out the cow quickly after milking or feeding have finished (which is the later), to avoid unnecessary fouling of the parlour.
- (f) The established routine must permit smooth operation under all herd conditions, i.e. irrespective of the milking times or stage in lactation of the individual cow passing through. Alternatively, it may be said that the work routine must be such as to allow the cowman to deal with cows entering the parlour in random order.
- (g) The operator must not be expected to possess super-human powers; he should be kept busy but not overworked.
- (h) The method employed must satisfy published regulations concerning clean milk production, e.g. udder washing, foremilk extraction, etc.

Provided that the herd is large enough to justify the purchase of the necessary equipment, the best routine is the one that enables the cowman to milk the herd in the shortest time, and meets all the conditions specified above.

In addition to the obvious advantages of finishing milking in the shortest possible time, a quick throughput, based on a good work method, is desirable for other reasons:-

- (a) If milking takes too long (extends much beyond about  $1\frac{1}{2}$  hours) the operator is unduly fatigued and this in turn increases the risk of expensive errors.
- (b) The cows themselves react favourably. To get the best from a cow she must be allowed as much rest as possible; long waits in the collecting yard are not conducive to top performance.
- (c) The operator kept busy with a good work routine, that he can see is quick and effective, is happier than if he is continuously dodging about aimlessly.
- (d) Proficiency, like the lack of it, can be infectious and is likely to spread to other activities on the farm.

### EXPERIMENTAL DATA

Factors affecting the job of milking in a parlour are divided under two main headings:

1. The time the cow needs to be in the parlour i.e. time to milk out, (or milk flow time), time to be prepared for milking and machine stripped, and the time required to consume her feed.
2. The layout of the parlour, its equipment, and the time the man requires to handle that equipment and attend to the needs of each cow.

Dealing with the more important of these items in turn:-

- (1) Time in Parlour: Whilst the milking unit is extracting milk from the cow, the operator will be available to do other work - attend to other cows or machine units. It follows that the period during which the machine unit is working unattended determines how much, or how little the man can do before he is obliged to return to remove the cluster from the milked-out cow. Furthermore, as in most herds no two cows are certain to have the same milking-out time, the time available to the cowman for other jobs will fluctuate significantly between cows. To estimate the extent of the variation which is likely to be experienced, use has been made of data collected by N.I.R.D., Shinfield and referring to twenty commercial herds.\*\*\* A statistical summary is shown at Appendix 1. The figures show an average a.m. milk flow time of some  $4\frac{1}{2}$  minutes.

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\* Of course, no routine will operate satisfactorily unless the equipment is in good order.

\*\* Meal 1.8 lb./min.; Cubes 1.3 lb./min.; Mixture of both estimated at 1.5 lb./min. - Roberts, W.P., Department of Agriculture, Reading University. 'Selecting a Milking Parlour for the Individual Farm.' - Agricultural Review, Vol. 3, No. 2, April 1959.

\*\*\* The data was collected specifically to establish the association between milk flow time and yield at milking, but provides excellent information on the range of individual milking times which can be encountered with herds. Vide: Clough, P.A. and Dodd, F.H. - 'Measurement and Performance in Machine Milking', N.A.A.S. Quarterly Review No.43, 1959.



but only two-thirds of all cows milked out in times varying from 3 to 6 minutes. The range of a.m. milk flow times to cover 95 per cent of the herd is from  $1\frac{1}{2}$  to  $7\frac{1}{2}$  minutes. A range of these proportions was apparent in nearly every herd irrespective of the herd average milk flow time. It is anticipated therefore, that most milking installations and routines will frequently be dealing with animals where there is a difference of at least 6 minutes between the times required for the shortest and longest milkers to milk out. The effect these fluctuations can have upon the work routine has therefore been studied. Adequate time to feed is also considered.

- (2) Parlour type and work routine: To simplify the problem of assessing the efficiency of a routine, only parlours of the double-sided, two-level type are considered here, with the assumption that pipeline milking is installed. (It is recognised that parlours of another type may involve different problems, but these are mainly additional to any which this study reveals).

Standard times for the completion of the elements of work comprising the routine, with various set-ups, are recorded at Appendix 2\*, together with the order in which they are generally performed to maintain a standard routine.

Although the order of doing jobs can differ between layouts and equipment installed, it will be noted that the man's time attending to each cow is very similar in all cases. Thus a measure of the efficiency with which man and machines are matched will be indicated by the time in which a herd would be milked.

### SELECTING A HERD FOR CASE STUDY

In order to illustrate more clearly the intricacies encountered with different methods, and using different numbers of machine units, it was necessary that the herd selected for study should include the properties which would enable it, (theoretically at any rate) to be milked in various set-ups. For example, it would be fatuous to try to compare milking a small herd of some 15 cows with parlour layouts employing from two to six units. The same applies to a herd of 80 cows or more. In the first case, because of the incomplete work routine operated when the first and last batches are being milked, a relatively large number of units could not be used effectively, and in the second case, if only two or three units were in use, and it was physically possible to keep them pumping continuously, the whole routine would still be prolonged beyond the stage where undue fatigue would affect the operator.

Examination of the sample of twenty herds timed indicated that the records for herd No. 1 divulged most information and would therefore be the best for closer study. This was for various reasons.

- (a) Any method installed must be able to deal with the herd during the period when a fair proportion is at peak production. Thus, although average a.m. milking time of 5.64 minutes is the highest recorded, it is still considered to be representative of many herds at around the peak period.
- (b) The distribution of milk flow times about the mean - standard deviation 1.48 minutes - is similar to the figure for the whole sample.
- (c) Milk flow time associated with yield is also similar to that found overall, e.g. a.m. milking:-

Where yield in lb.	=	10	25	35
Milk flow time - sample	=	4.22	6.29	7.66 mins
- selected herd	=	3.54	6.03	7.67 mins

- (d) The herd is of reasonable size - 41 cows in milk - to be managed by one man.
- (e) Being a prime number the herd total (41) does not give an advantage to any combination of units and standings by providing an equal number of cows to be milked at each.

### METHODOLOGY

Using standard tables of random numbers, the order in which cows might enter the parlour was established. (Random order No. 1 - Appendix 3.)

It was assumed that the cowman handled the animals in the random order now selected, and maintained, as far as possible, the standard routine for the particular parlour as outlined at Appendix 2.

Details of the complete milking were then recorded on Multiple Activity Charts for scrutiny, analysis and comparison with the results obtained from an 'optimum' solution and with estimates of theoretical performance. The optimum solution was derived from the multiple activity chart completed on the assumption that all cows had identical milk flow times.

To corroborate the information available, of the effect of random entry, the experiment was repeated for two further random orders.\*\* (Random orders 2 and 3).

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\* Except for very slight modification these figures are a reproduction of standard times as published in I. C. I. Report E 26 - 'A Work Study Guide to Machine Milking' - Walker, J. K. (1959).

\*\*It can be stated that results of the second and third replications were not significantly different from those of the first experiment and divulged no extra information of importance.



To gain a better idea of the effect of the spread of individual milk flow times, two modifications were made to the data and tested:-

- (a) Milk flow times were adjusted to provide a distribution with standard deviation of only 1.0 minutes.
- (b) A further distribution was synthesised in which deviation about the mean was identical to that of the original experiment but proportionally lower yields were assumed to give an average milk flow time of 4.04 minutes.\*

In both instances cows were being milked in the random order specified for experiment 1. The routines for the latter were compared with theoretical throughput and an 'optimum' solution as previously, except that all cows were assumed to have identical milk flow times of only 4.04 minutes.

The order of entry according to random selection is noted in Appendix 3 alongside the number of the cow in the original list.

A further experiment was based on the assumption that cows in the original order could have been divided into two groups, according to yield, with high yielders entering the parlour first at morning milking (Random order No. 1a).

Where the operation was practicably feasible the 41 cow herd was considered to have been milked in the various parlour types listed below, with one man in attendance, i.e.

1. 41 cows	(a) Milk flow time	5.64 mins. (standard deviation 1.48)			
		5.64	(	"	1.00)
	(b)	5.64	(	"	nil) (optimum)
		4.04	(	"	1.48)
2. Parlour types	(a) Tandem	4.04	(	"	nil) (optimum)
		4.04	(	"	nil) (optimum)
	(b) Chute	2 units : 2 and 4 standings			
		3 units : 3 and 6 standings			
		4 units : 4 and 8 standings			
		5 units : 5 standings			
	(c) Herringbone	6 units : 6 standings			
		2 units : 4 standings			
		3 units : 3 and 6 standings			
		4 units : 4 and 8 standings			
	(d) Herringbone	6 units : 6 standings			
		4 units : 8 standings			
		5 units : 10 standings			
		6 units : 6 and 12 standings			
		8 units : 8 standings			

Overall, this meant that nearly 100 multiple activity charts were produced for scrutiny and analysis. Information was readily available from the charts for tabulation under the following headings:

1. Parlour type.
2. Total time to complete the milking.
3. Man idle time
  - (a) enforced during first work cycle because of less work to do.
  - (b) during general routine because 'work routine time' and 'available work time' can seldom be identical, also due in part to the fact that all cows do not require the same time to milk out.
  - (c) enforced during the last cycle when time normally spent preparing further cows for milking is no longer required. (Usually some of this can be utilised on the removal of surplus units and preparing for the ensuing dairy work.)
4. Milking Machine utilisation:-
  - (a) number of cows milked by each unit.
  - (b) actual time the unit spends extracting milk unattended.
  - (c) actual time that the unit spends extracting milk during machine stripping.
  - (d) the time that each unit is idle (or ineffective).
    - (i) At the start of the first work cycle.
    - (ii) Whilst hanging waiting for the man to complete washing etc.
    - (iii) Whilst the man is picking up, arranging and applying the cluster.
    - (iv) During overmilking.
    - (v) Whilst hanging (Chutes or 1 : 1 type tandems) after milking has been completed, either because the cow cannot be released as she has not finished feeding, or slower milkers in her batch are still being milked despite the fact that the cow opposite has also been milked.
    - (vi) During the last cycle, awaiting the last cow to finish milking.
5. Handling and Experience of the Cow:-
  - (a) Average and range in let-down 'stimulus' time, where the standard published routine is rigidly operated.
  - (b) Amount of over-milking, average, maximum and number over-milked beyond any fixed maximum.
  - (c) Number of cows which appeared to have insufficient time to eat their concentrates at any particular feeding level, if the standard routine is strictly adhered to.

\* For the purposes of this publication timing data has generally been recorded in centiminutes as a matter of expediency, and not as a demonstration of fine mathematical accuracy.

## CHAPTER 2

### EXAMINING THE ADEQUACY OF STANDARD WORK ROUTINES

#### Parlours with 2 stalls/1 unit

The study completed on the lines above revealed several shortcomings when dealing with animals having varying milk flow time. These points, (especially applicable to the 2 stall/1 unit parlour type) are obscured if routines based only on herd average milk flow time are considered, and indicated essential adjustment before a satisfactory work routine could be operated. Included in the unsatisfactory features of the standard work routines were:-

1. Let-down stimulus time too erratic - applicable to both tandem and chute.  
In fact this will apply to any system in which one unit serves two stalls or more.
2. Overmilking in excess of 3 minutes can be prevalent.
3. There is no guarantee that all cows have time to eat their concentrates.
4. Attempts to modify the basic routine can quite easily destroy it entirely.

These features are explained in more detail below.

#### The 2 stall/1 unit Tandem parlour

The basic principle behind any 2 stall/1 unit layout is to permit maximum utilisation of the machine units, simultaneously allowing the cow more time to feed, because she is theoretically in the parlour while another animal is being milked. She is thus usually in the stall some minutes being prepared before receiving the milking cluster.

The recognised standard work routine is as follows:-

1. At stall 2, wash cow and use the strip cup.
2. Move across pit to stall 1 and let in another cow to behind that being milked.
3. Machine strip the cow in stall 1.
4. Remove the cluster and transfer it to the cow previously washed in stall 2.
5. Return then to stall 1 and release the finished cow, allowing the next cow into the stall while feed is being placed in the bowl, and the front parlour gate shut.
6. After shutting the gate behind the new cow in, the man then moves across to stall 4 where he washes, etc. the cow in the stall and repeats the process as before.

Applying standard work times, the following extract from a chart shows that the routine is straightforward, and reasonably smooth where cows have similar milking-out times.

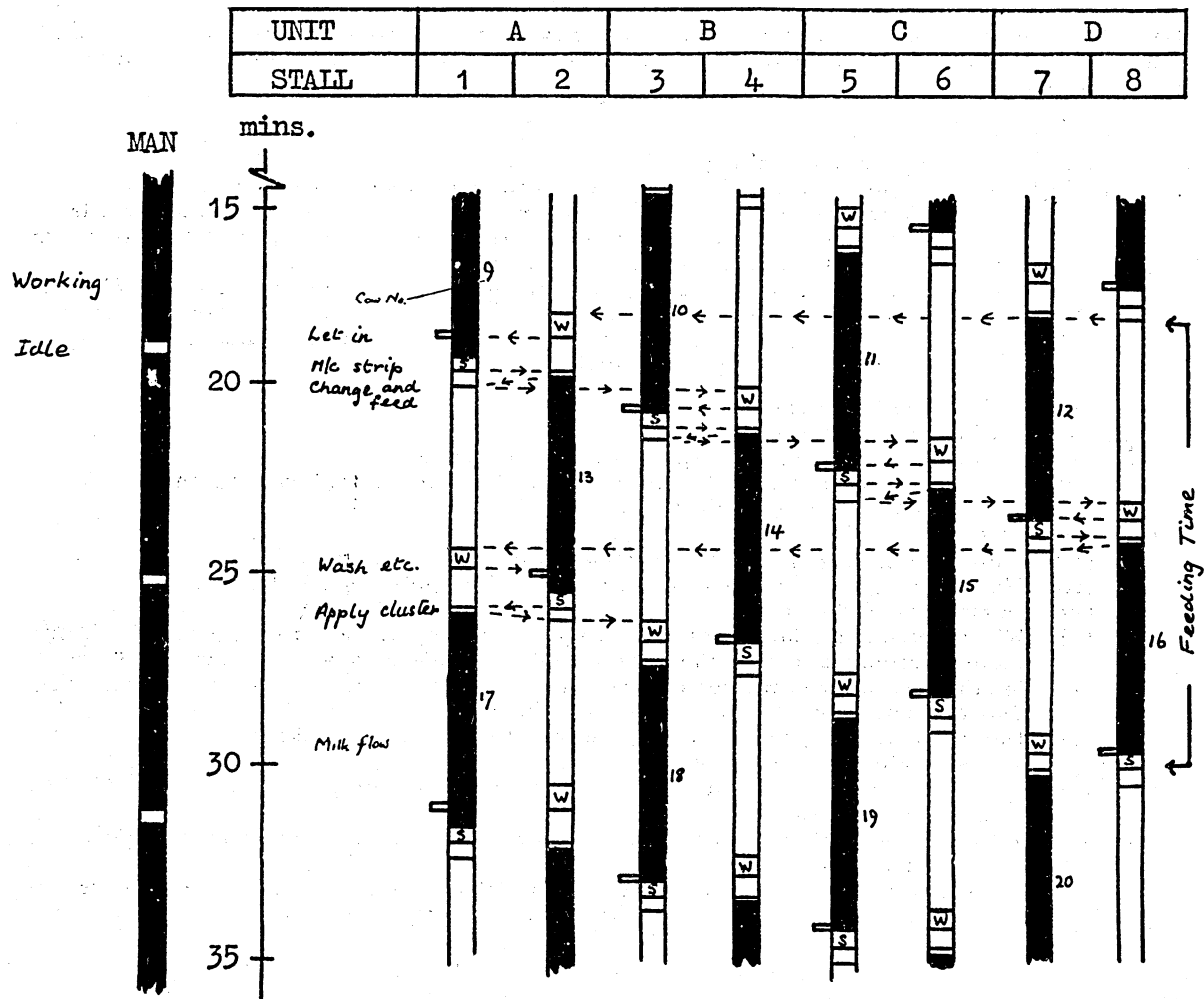


Figure 1 - Extract of Multiple Activity Chart - Milking in 8 stall/4 unit Tandem parlour. Milk flow time = 5.64 mins. (standard deviation NIL). Pipeline milking.

Inspection of the chart reveals:

- that the man is fully occupied but not overworked.
- stimulus time is reasonably constant, varying from about 1½ mins. in stalls 1 and 2 down to a little over 1 minute in the remainder.
- all cows have about 12 minutes in which to feed.
- there is a maximum machine utilisation.

However, it can be shown that difficulties arise which can prevent or discourage the cowman from adhering to this routine in practice. These difficulties appear:

- during the first work cycle in all cases.
- when cows of varying milk flow qualities have to be accommodated.

Figure 2 charts the start of the routine in the 8 stall/4 unit parlour.

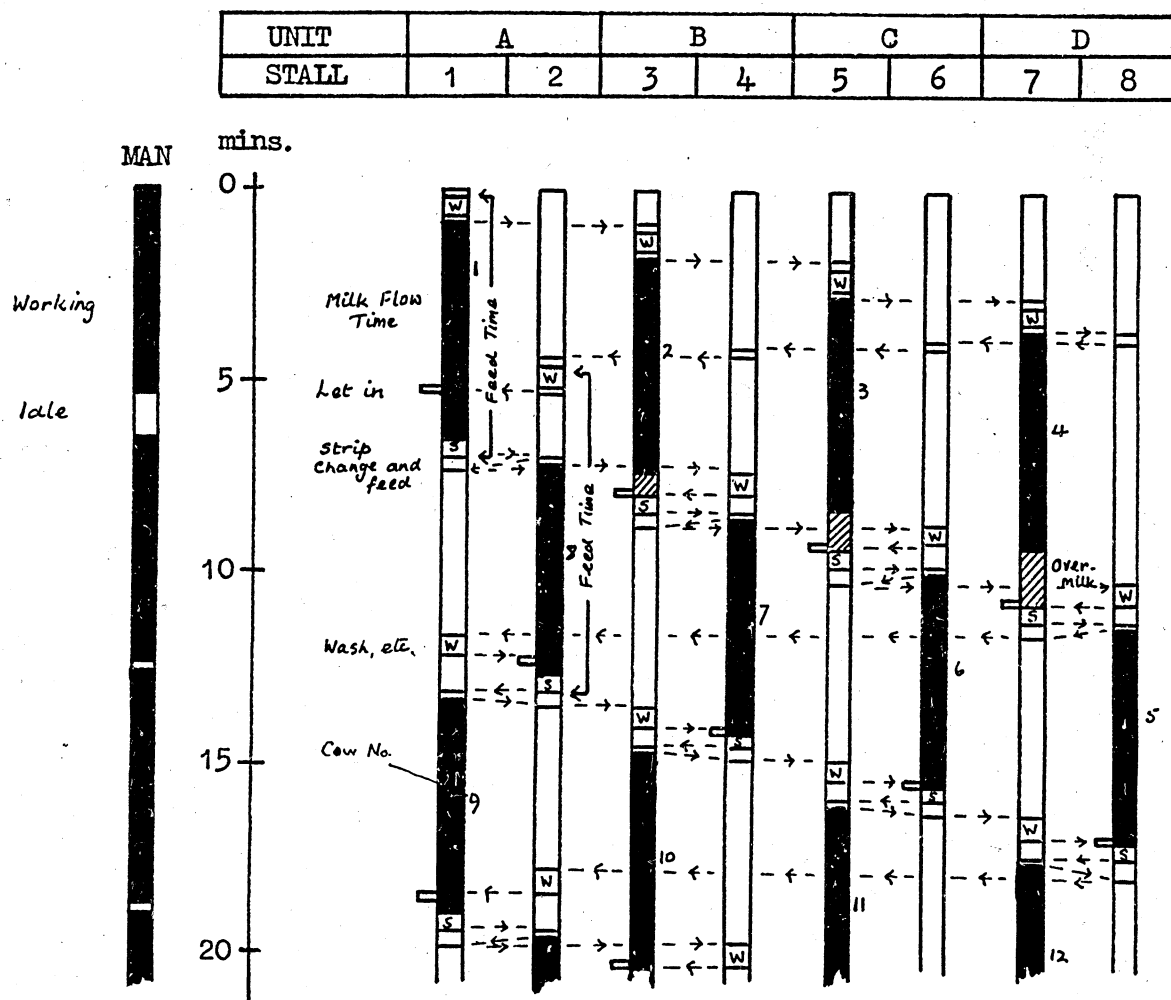


Figure 2 - Specimen Multiple Activity Chart of first work cycles in 8 stall/4 unit Tandem Parlour. Milk flow time = 5.64 mins. (Standard deviation = NIL). Pipeline milking.

It will be seen that:-

- although the man has idle time after letting in, feeding and washing cow No. 8 in stall 2, cow Nos. 2, 3 and 4 are still overmilked.
- stimulus time for cow No. 8 has been extended to about 2½ mins.
- the first five cows to be milked (Nos. 1, 2, 3, 4 and 8) have only 7-8 minutes in which to eat concentrates compared with about 12 for the remainder.

In order to avoid overmilking, which the cowman will realise is a possibility, there will be a tendency for him to 'keep working' while there are jobs to do. Thus, having washed cow 8 (opposite cow 1) before cow 1 is ready for stripping, he is likely to deviate from the standard routine by attempting to wash cows in stalls 4, 6 and 8 to prepare them to receive the cluster.

In this example he will have had time to wash and draw foremilk from two more cows before cow 1 reaches the point for machine stripping to commence. Figure 3 shows the results of this deviation.

It can be seen that only cow 4 is now slightly overmilked, but stimulus time for other cows has been extended by a full minute. Furthermore, having started milking the eighth cow and prepared the ninth, the cowman is in the same predicament as at the commencement of the previous work cycle, i.e. he is faced with idle time which he might be tempted to spend preparing further cows. A similar situation will also arise with subsequent cycles. The man will not be working the near-perfect routine described in Figure 1.

UNIT	A		B		C		D	
STALL	1	2	3	4	5	6	7	8

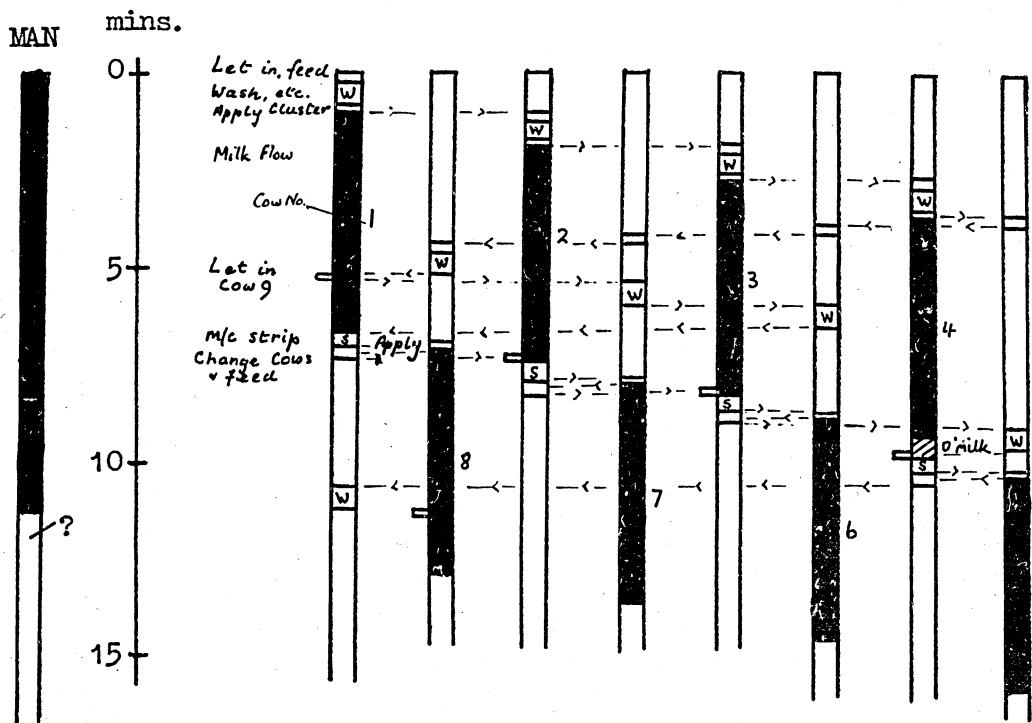


Figure 3 - First Work Cycles in 8 stall/4 unit Tandem Parlour - Cowman deviates from standard routine, after cow 8 have been prepared for milking, to avoid overmilking cows No. 2, 3 and 4.

A routine which encourages such deviation may not appear to be vital with this 'optimum' programme, but where individual milk flow times are dispersed about the mean as in the sample investigated, (i.e. a range of some 6 mins.) and the man is dealing with cows entering in random order, the unsatisfactory features outlined are accentuated.

Extracts from charts synthesised to apply to the herd case-studied, (i.e. 41 cows, average milk flow 5.64 mins., standard deviation 1.48 mins.) illustrate the cowman's dilemma. Thus Figure 4 indicates that the first four cows to enter the parlour have milk flow times of 6.0, 5.6, 3.4 and 4.1 minutes respectively. Having applied the clusters to each of these cows and let in and fed four more to fill the stalls on the opposite side (the elapsed time to this stage = 4.70 mins.) the alternatives facing the cowman are to adhere rigidly to the basic work method or fill in time washing extra cows. The effects of these are as follows:-

- (a) Adhering rigidly to the set routine of working stalls, 2, 4, 6 and 8 in that order, i.e. wash etc., cow 8 and let in cow 9 behind cow 1 and then wait for cow 1 to reach the point where she is ready for machine stripping.

In this case, cow 3 will have finished milking before machine stripping cow 1 commences, and both cow 3 and cow 4 would be over-milked by some  $3\frac{1}{2}$  mins. Stimulus time for cow 8 will also be extended to  $2\frac{1}{2}$  mins.

Figure 4 (see page 13) is continued to the point where the 24th cow would have entered the parlour and cow 21 in stall 2 prepared for milking. At this stage the cowman's problems of doing a satisfactory job are readily shown. Whatever the next move, the stimulus time for cow 21 will be  $4\frac{1}{2}$  minutes. Furthermore, because all cows being milked will milk out within approximately one minute of each other, adhering strictly to the standard routine will involve over-milking in excess of 3 minutes. Alternatively if the man tries to avoid this by filling in time, washing and using the strip cup, the four latest cows in the parlour will be subjected to a 'stimulus time' of 5 to 6 minutes.

It might be argued that the man will notice that cow 19 has milked out first and therefore he would naturally have to deviate from the set routine by attending to this and cow 23 in the opposite stall, instead of waiting at stalls 1 and 2. Several snags arise, however:- Firstly, although he may be aware that cow 19 is a quicker milker than cows 17 or 18, it would be asking too much to expect him to know that the time which elapsed between applying the clusters to the two other cows in question would not offset the difference in milking out times. Secondly, having followed the routine laid down, cow No. 25 is held up, waiting to enter stall 1. Adjusting the routine to bring this cow into stall 5 would create a precedent which would be followed by a complete disruption of the standard work method. And thirdly, to make this deviation would not reduce the amount of overmilking and would prolong the stimulus time on cow 21 to 7 or 8 minutes. In the absence of an effective milk flow meter a principle of

UNIT	A		B		C		D	
STALL	1	2	3	4	5	6	7	8

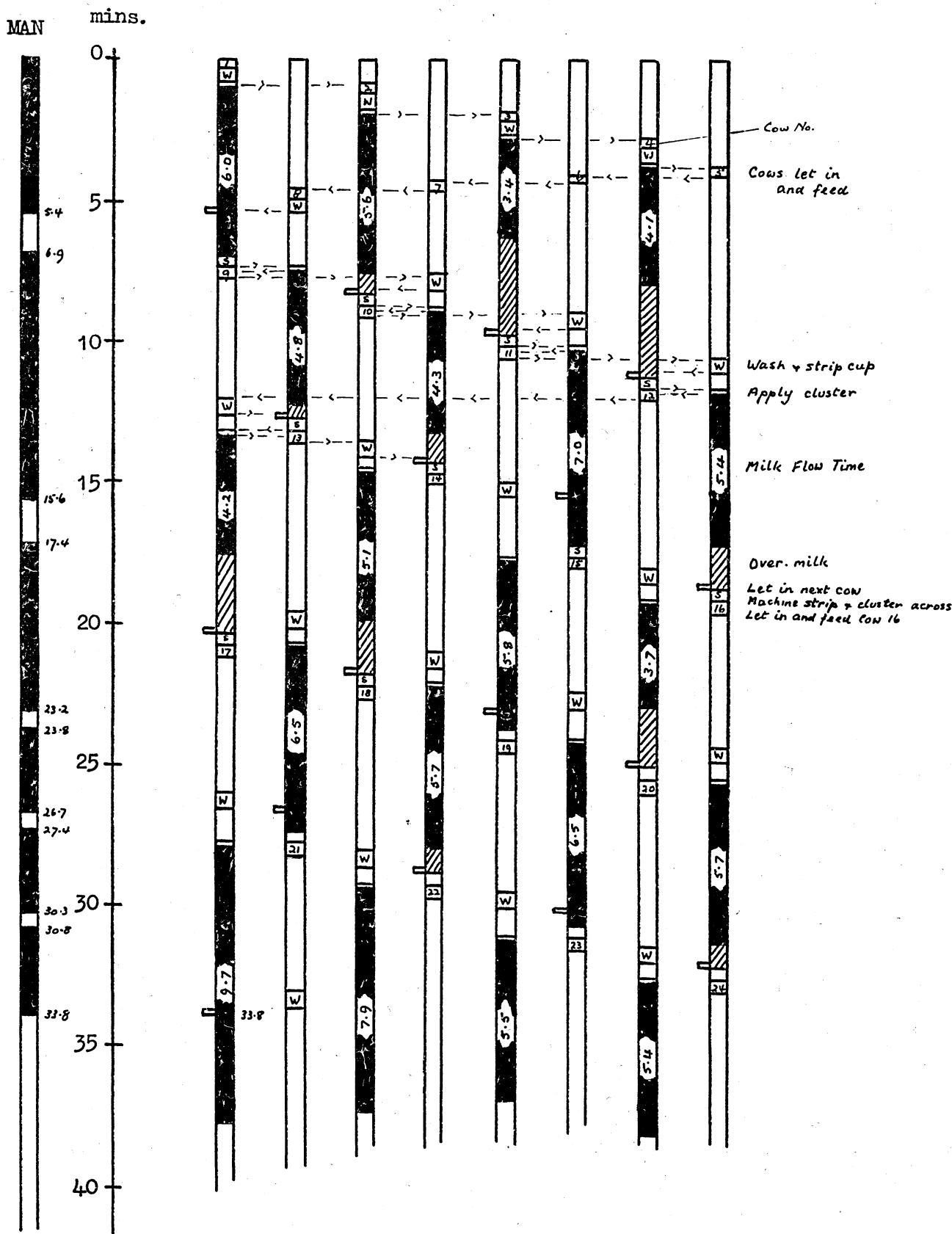


Figure 4 - Multiple Activity Chart - Specimen Extract  
Random entry (order No. 1) into 8 stall/4 unit Tandem Parlour - (Milk flow - Average = 5.64, standard deviation = 1.48 mins.). Man adheres rigidly to routine of working stalls, 1 - 3 - 5 - 7 and 2 - 4 - 6 - 8 in turn.

always attending to the cow opposite that which is next to milk out, (irrespective of its position along the parlour), infers that washing and use of strip cup could not start until the cow to leave had practically milked out. Thus, there would be over-milking continuously by an amount at least equivalent to the time it took to prepare one cow and be ready to start stripping the one milked out.

- (b) Filling in time by washing extra cows. No chart extract need be reproduced to record the effect of the cowman always filling in time by preparing additional cows, for it is patently obvious that, if udder washing is to be treated as the let-down stimulus, then times will fluctuate so widely as to make the practice ineffective.

Summarising the possible effects of operating this recognised standard work routine it has been shown:-

- (a) Theoretically, where all cows have similar milking out times, the routine meets the requirements of a satisfactory work method, except during the first work cycles. Cows in the first cycle are not assured time to eat concentrates if they happen to be high yielders. Moreover the cowman, in order to avoid the over-milking which would otherwise occur, is tempted to fill in time by washing extra cows, disrupting the basic routine to the detriment of stimulus time.
- (b) When the assumption of equal milking out times is dropped and the individual milk flow times in the herd follow the pattern common to the 20 herds investigated - (a range of some 6 minutes between the quickest and the slowest milkers) - all drawbacks listed above at (a) will apply. In addition, rigid adherence to the work method throughout the milking is likely to incur the excessive over-milking of a high proportion of the cows. Attempting to eliminate this by adjusting the routine so that the man is directed a haphazard work method without any guarantee of success.

#### Suggested modification to standard work routine in a 2 stall/1 unit\* type Tandem Parlour.

In order that no unfair comparison between a 2 stall/1 unit and 1 stall/1 unit set-up should be made and, at the same time to minimise the unfavourable points disclosed earlier, it has been assumed that\*\*:-

- (a) a flow indicator is installed from which the cowman can tell when any particular animal is within half a minute of milking out.
- (b) washing the opposite cow will not commence until the milk flow indicator shows that stripping can commence within half a minute.
- (c) the cowman will prepare the cow opposite that shown to be the next to milk out, irrespective of position along the parlour.

These modifications will demand less concentration, and incur less risk of errors than any adjustments possible in the absence of a flow indicator. However, although 'stimulus time' can now be held constant there is still no guarantee that overmilking will be substantially reduced from that indicated in the previous programme.

The results that these modifications would have in practice are outlined in chart form in Figure 5. From this it is evident that although only straightforward adjustments have been made to the basic routine, nevertheless overmilking is unavoidable. This is despite the fact that average milk flow time is exactly the same as that used in Figure 1, which demonstrated that the work routine could be performed comfortably within the time available.

It may appear unnecessarily academic to have adjusted the routine so that a satisfactory constant stimulus time can be maintained, whilst there is no evidence that overmilking is substantially reduced. However, it is argued that where cows must be accepted in some random order, there is always a fair probability that two or three will milk out at approximately the same instant. This makes overmilking unavoidable, unless the parlour is equipped so that the man is greatly under-occupied.

#### The 2 stall/1 unit Chute Parlour

The main difference in the operation of the chute compared with the tandem is that cows enter and leave the parlour in batches, according to parlour size, instead of individually. Utilising a much narrower building and more simplified stall equipment the initial cost of a chute can be appreciably lower\*\*\* However, this initial saving could be offset by extra difficulties arising from batch-handling.

The following paragraphs illustrate the achievements of this type of parlour as compared with the tandem. As in the previous example it is assumed that an 8 stall/4 unit parlour is being operated with the 41 cows having average milk flow time of 5.64 mins. The recognised standard work routine is as follows (cluster having just been applied to cow in stall 7):-

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\* An 8 stall/4 unit tandem parlour has been used as an illustration but exactly the same features are apparent if quicker milking out makes a smaller parlour adequate. Only standard times for the performance of work elements have been utilised. If allowances were made for variation probabilities, complications would be added to the completion of the charts with no amelioration of the difficulties outlined.

\*\* Results tabulated and used in subsequent analysis for comparative purposes are based on the standard routine modified as above.

\*\*\* Vide. Belshaw and Scott: The Milking Parlour: Economic and Technical Aspects. University of Cambridge, Farm Economics Branch. (To be published).

UNIT	A		B		C		D	
STALL	1	2	3	4	5	6	7	8

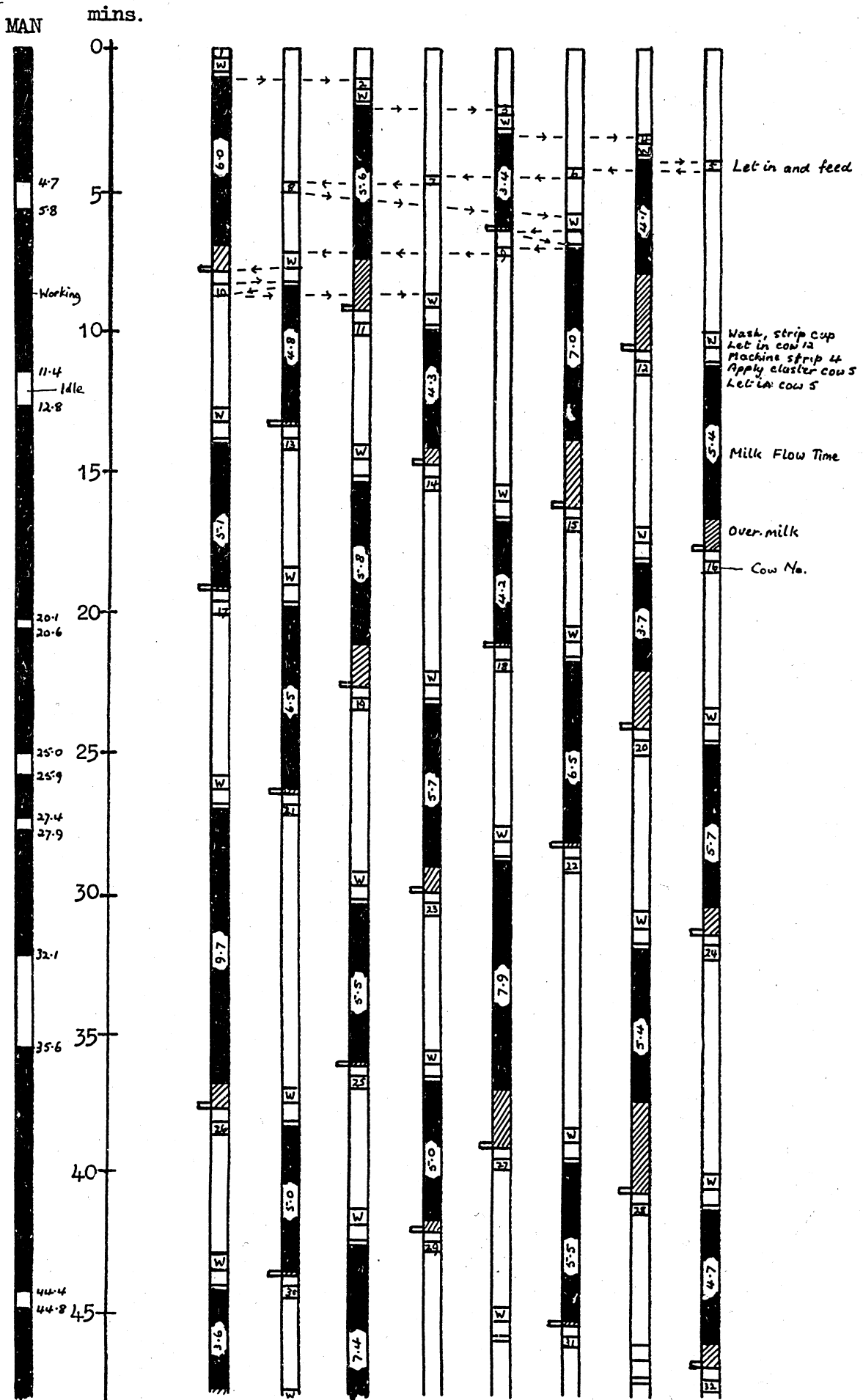


Figure 5 - Multiple Activity Chart - Specimen Extract  
Random entry (order No.1) into 8 stall/4 unit Tandem parlour - (Milk Flow time - Average 5.64 - standard deviation = 1.48 mins.) Washing commences  $\frac{1}{2}$  minute before opposite cow milks out.



Moves to opposite work place (i.e. stall 8)  
 With rope opens all gates and parlour door simultaneously, allowing 4 cows to walk out and 4 more to follow them into the parlour.  
 As the fourth cow leaves, the man:  
 Shuts front gate to stall 8  
 Puts feed in bowl at stall 8  
 Shuts front gate to stall 6  
 Puts feed in bowl at stall 6  
 etc. to stall 2  
 Washes cow in stall 2 and uses strip cup  
 Moves to opposite work place (stall 1)  
 Machine strips cow in stall 1, removes cluster and transfers it across work pit  
 Applies cluster to cow in stall 2  
 Moves to stall 4  
 Washes cow in stall 4 and uses strip cup  
 etc.

The operation of the work method is illustrated in Figure 6, which shows that if all cows had equal milking out times:-

- (a) The man is well occupied but not overworked.
- (b) Stimulus time is reasonably constant, ranging from 1 to 1.3 mins.
- (c) Only 1 cow is overmilked by more than 1 minute.
- (d) There is maximum machine utilisation.

Compared with the similar capacity 'tandem' parlour, the following features can be noted:-

- (a) batch changeover of cows makes for a simpler work routine; the man is no longer confused by the extra work of changing over cows each time he handles a cluster - the changeover in the tandem also involved another crossing of the work area.
- (b) cows in the first batch to enter the parlour are in for about the same period as subsequent batches. Thus the difficulty of allowing these cows time to feed, should they be high yielders, is partly alleviated.
- (c) should the man deviate from the basic routine by 'filling-in time' washing extra cows - (at a point where the chart shows him to be idle) - the drawbacks associated with this practice would be identical to those described for the tandem.

The effect that rigidly adhering to the basic routine would have with cows (average milk flow time 5.64 minutes, standard deviation = 1.48 mins.) entering in random order is illustrated below in Figure 7.

With all cows having identical milking out times it was shown at Figure 6 that when the basic 'work routine time' was only slightly less than 'available work time', the prescribed work method performed a most satisfactory job. There was no demand for excessive concentration on the cowman's part. However, where individual milk flow times vary about the average various weaknesses become apparent, indicating that some modifications are needed.

Dealing with possible drawbacks, as they occur on the chart:

- (a) Cow No. 4 (stall 1) is not ready for machine stripping before Cow 3 (stall 3) has milked out. Adhering to the routine leads to overmilking which ought to be avoided. The possible effects, in practice, could perhaps be more readily understood if the first 4 cows had entered the parlour in the reverse order. In this case, stimulus time on the cow in stall 2 would be extended to  $3\frac{1}{2}$  minutes whilst those in stalls 5 and 7 would be overmilked by more than 3 minutes. These undesirable features could also occur during any work cycle throughout the milking. The trouble would not be overcome if the operator endeavoured to avoid overmilking by utilising his enforced idle time in washing extra cows. In this event 'stimulus time' would fluctuate so widely as to be ineffective.\*

If a regular routine is to be followed, it is, therefore, essential for the cowman, having let in and fed a new batch of cows, to work first on that cow which is opposite the next to milk out. Owing to the time lag between placing the cluster on the cows in any batch, and the irregular order of application which this modification will entail, the man could not be expected to know which cow should receive his attention next. As with the 2 stall/1 unit tandem, the satisfactory operation of this modification is only possible where an accurate milk flow indicator is installed.

In order to compare the efficiency, and ease of work methods in the various set-ups, it will be assumed, therefore, that the 2 stall/1 unit Chute (like the similar tandem) is equipped with an indicator from which the operator can tell that any particular cow will be ready for stripping in half a minute, and that when applicable he works first on the cow opposite that which is next to milk out.

- (b) Some flexibility is lost with batch entry; the time an individual cow is likely to spend in the parlour is largely dependent upon the milk flow time of the slowest milker in the batch; and to some extent, the longest milker of the preceeding batch.
- (c) A result, extending from this restricted flexibility, is shown at the end of the chart at Figure 7. The batch containing cows 21-24 has entered, and cluster has been applied to cow 22, stall 6 (37.7 mins.). Theoretically, at this point, the man should prepare cow 21 to receive cluster from cow 17. However, it will be noted that cow 17 will not be milked out for another  $2\frac{1}{2}$  minutes whilst cow 23 on the opposite side has already

\* An exercise showed that the practice of 'filling-in time' by washing would give stimulus times, with this herd, ranging from about  $\frac{3}{4}$  to 9 minutes.

milked out and cow 24 will be ready for stripping before this period has elapsed. Cow 17 prevents the entry of further animals to replace cows 19 and 20 to receive the units from 23 and 24. If the man works on cows 21 and 17 first there will be serious over-milking of cows 23 and 24.

It is suggested that with batch entry these circumstances are likely to develop with any herd. The cowman should machine strip and hang the cluster when such conditions arise. Thus, if the modification at (a) above was in operation, and the routine position was at 37.7 minutes on the chart, the man would machine strip cow 21 and hang up the cluster. As it would still be too early to prepare cow 21 when cow 23 had milked out he would machine strip cow 23 also and hang up the cluster.

Although this modification avoids what might otherwise be serious overmilking, it does, nevertheless, imply that batch entry may also reduce effective machine utilisation.

The chart at Figure 8 illustrates the results when the above modifications have been introduced.

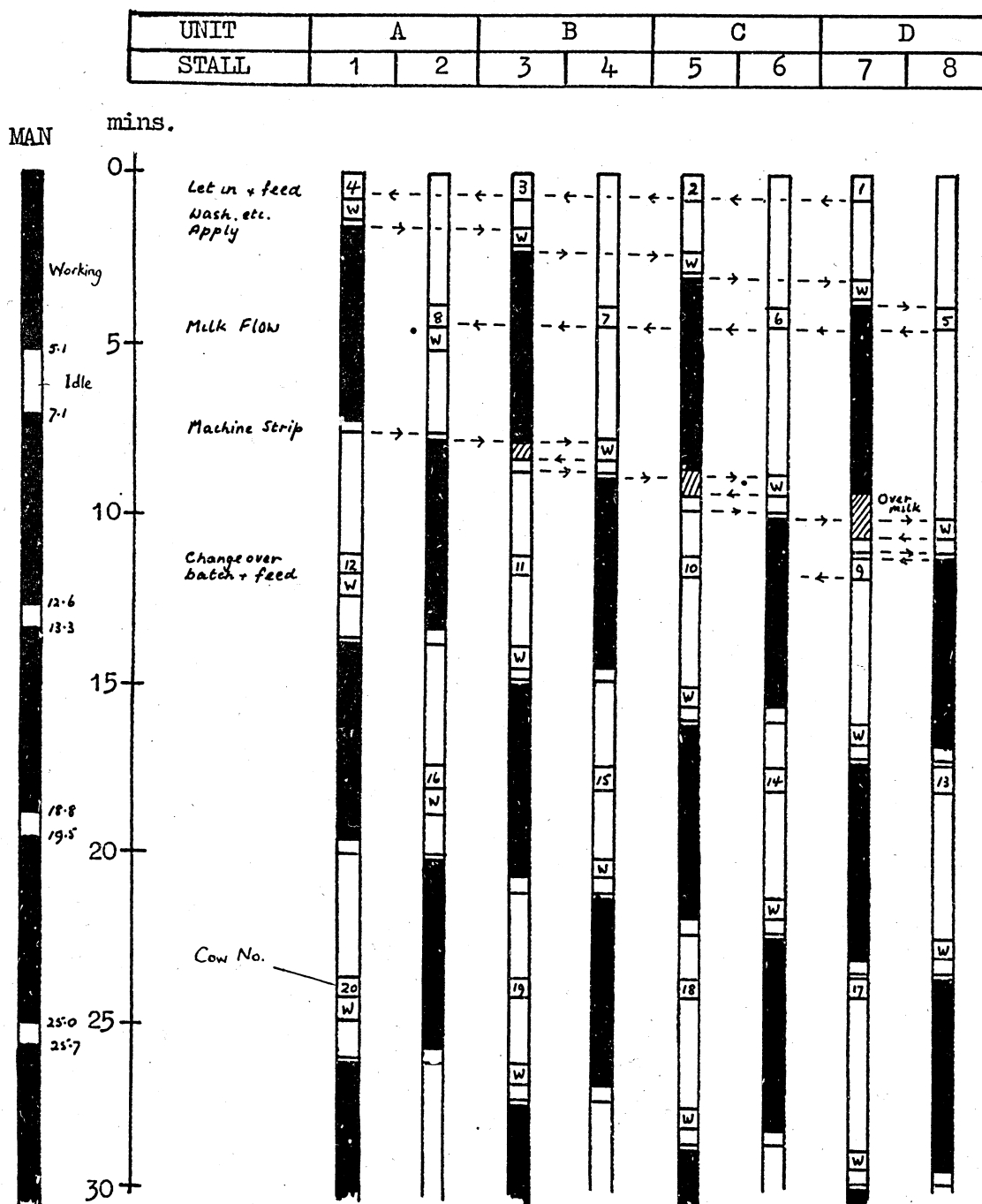


Figure 6 - Multiple Activity Chart - Specimen Extract  
Milking in 8 stall/4 unit CHUTE Parlour (Milk Flow Time = 5.64 mins. - standard deviation - nil). Pipeline milking. One operator.



Comparison of Work Methods between Tandem (single entry) and Chute (batch entry) Parlours, operated with 1 unit/2 stalls.

Examination of Figures 5 and 8 enables some comparisons to be made between Tandem and Chute Parlours in operation, bearing in mind the following points:

- (a) The same herd is considered to pass through each parlour in the same random order.

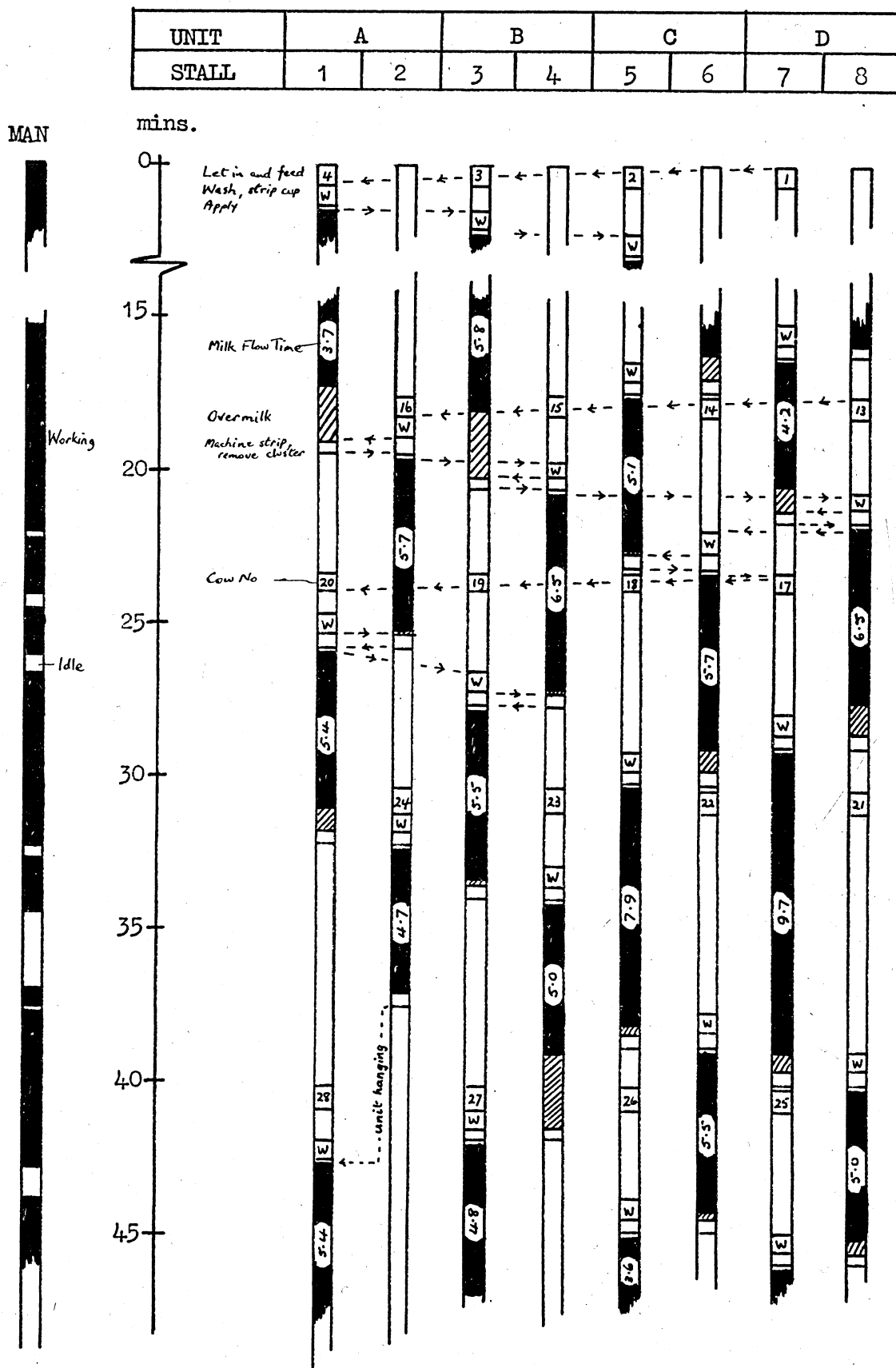


Figure 8 - Multiple Activity Chart - Specimen Extract  
Random entry (order No. 1) into 8 stall/4 unit CHUTE Parlour (Milk flow 5.64 mins. Standard deviation = 1.48 mins.) Constant 'stimulus' time maintained.

- (b) The effective work performed by the man will be identical in each case.
- (c) Let-down stimulus time has been held reasonably constant ( $\frac{3}{4}$  to  $1\frac{1}{4}$  mins.) by using a milk flow indicator to mark when udder washing can commence.
- (d) The initial cost of the building of the Tandem is estimated to be some 30 per cent higher than that for the Chute.

The Man's Routine. Batch entry simplifies the task of changing over cows. In turn this eliminates the need for twice breaking into the routine of machine stripping one cow and preparing and applying the cluster to that opposite. Of less importance, the parlour door has only to be opened once per machine cycle as opposed to once per work cycle on each cow.

Herd Throughput. The difference in rate of throughput is negligible, e.g. the cluster was placed on the 28th animal (cow 25) after 46 minutes had elapsed in the Chute and at  $47\frac{1}{2}$  minutes (cow 28) in the tandem.

Machine Utilisation. It is possible that the uneven milking-out times of cows in two consecutive batches may necessitate the hanging up of a unit in the Chute, suggesting that machine utilisation is lower. However, as noted above, overall throughput is similar for both parlour types and it can therefore be inferred that the time the unit is hanging in the chute is offset by extra overmilking in the tandem.

Feeding Time. The probability that all cows have time to eat concentrates is higher with the Chute, because unlike the Tandem, cows in the first batch may stay in the parlour almost as long as those of subsequent batches.

Parlour Cleaning. The floor area of the Chute being much less than that of the Tandem means there is less to wash down. However, this is likely to be nullified because only a proportion of the cows in the Chute are turned out immediately milking has finished. There may be a tendency for those prevented from leaving at this point to foul the parlour.

#### Parlours equipped with 1 Stall/Unit

##### The 1 Stall/1 Unit Tandem

Parlours fitted with 1 unit per stall are frequently not recommended for two main reasons.

1. The normal practice is to turn out the cow immediately milking and machine stripping have finished. Consequently the time available to the cow for eating concentrates is restricted to her milking-out time plus the time taken to wash and machine strip. With a herd of fairly heavy yielders, this period would be insufficient for a high proportion of cows. To make alternative arrangements for the individual rationing of concentrates is expensive and unnecessarily time-consuming in most cases.
2. The milking unit is idle for the whole time it takes to changeover animals in the stall, issue feed and prepare the next cow for milking. Machine utilisation is therefore of a lower order than in parlours where 1 unit serves 2 stalls.

It follows that with 1 stall/unit more units will be required to extract a given quantity of milk in a fixed time - even ignoring the drawbacks at (1) above. An example, using previously recorded data, will illustrate the position.

	<u>2 stall/unit</u> <u>mins.</u>	<u>1 stall/unit</u> <u>mins.</u>
Average milk flow time per cow	5.64	5.64
Machine strip	<u>.40</u>	<u>.40</u>
Machine on time	6.04	6.04
Machine off time:		
Wash and use strip cup	x	.57
Pick up and arrange cluster	x	.06
Apply cluster	.11	.11
Remove cluster and across/hang	.05	.06
Changeover cows in stall and feed	<u>x</u> <u>.16</u>	<u>x</u> <u>1.04</u>
Machine cycle time	<u>6.24</u>	<u>7.08</u>

In each case the man's Routine Time is similar (1.46 mins.). Theoretically, therefore, five units would be required in the 1 stall/unit parlour to do the job which four would do in the 2 stall/unit. In addition, cows in the 2 stall/unit layout would have some 12 minutes in which to consume their feed, whilst less than seven minutes would be available in the 1 stall/unit.

The chart at Figure 9 describes the operation of the recognised standard routine in the tandem parlour using 5 units and 5 standings.\* Times for completing elements of work and the standard work routine are shown in Appendix 2.

Because the optimum moment to start washing the cow in the 1 stall/unit parlour is not governed by the qualities of the cow opposite, and there are no complications in choosing the next work point, the entry into the parlour of animals with unequal milking times does not present difficulties as encountered where one unit must serve two stalls. It is therefore considered unnecessary to illustrate the effect of random entry into the 5 stall/5 unit (i.e. the good work fit) tandem.

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\* It is realised that a 5 standing parlour is unusual but the assumption is that 5 stalls of a 6 stall parlour are in use, each equipped with a milking unit.

For comparison with results achieved in the 8 stall/4 unit tandem, however, Figure 10 details the operation of the 6 stall/6 unit, where cows of the studied herd enter in random order and are allowed time to finish their feed.

Examination of the extract chart at Figure 10 reveals that, although 5 units would normally be regarded as the maximum which the man could operate where the average milk flow time was 5.64 minutes, nevertheless with 6 stalls and 6 units when feeding time\* is allowed there is less overmilking than in the 8 stall/4 unit tandem (Figure 5). The man's enforced idle time, due to the random entry of cows having varied milking times, is also slightly reduced. One reason for this is that the ability to allow the cow to remain in the stall, after machine stripping, increases the flexibility of the routine.

Final charts, referring to the completed milking of the whole herd, have made possible some comparisons between operating the modified routines in a 1 stall/unit and 2 stall/unit tandem parlours. Summarised results are given later at Table 1. However, it can be stated that the advantages of the 6 stall/6 unit, (where there is a relatively long milk flow time) compared with the 8 stall/4 unit, are repeated where shorter milking times indicate that proportionately smaller parlours are adequate.

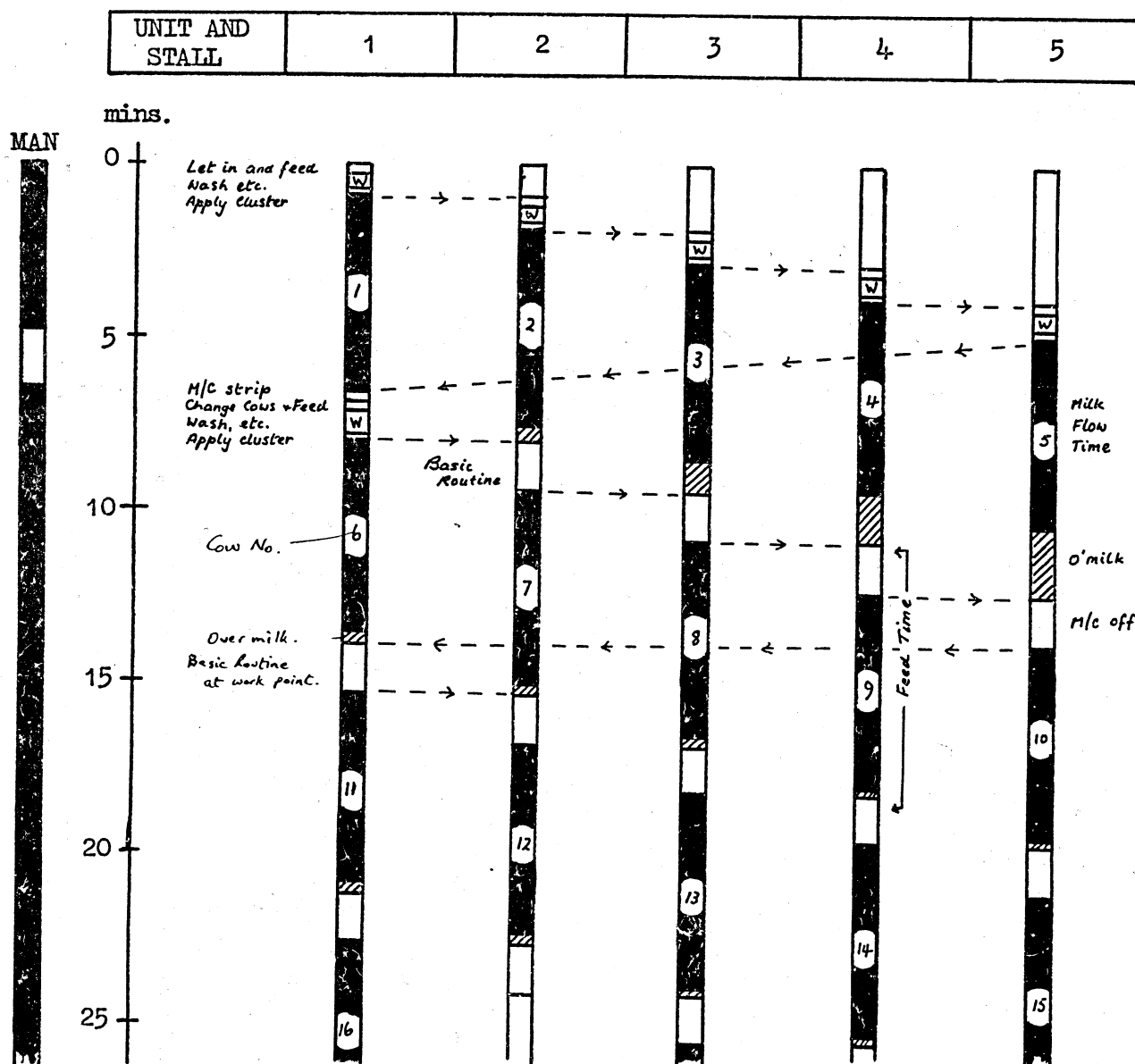


Figure 9 - Multiple Activity Chart - Extract  
Milking in 5 stall/5 unit Tandem Parlour. Milk Flow Time 5.64 mins. (Standard Deviation - nil). Pipeline Milking. (No extra feeding time allowed).

The advantages and disadvantages of the 1 stall/unit tandem parlour. These can be summarised as follows:-

- Man's work method.** The 1 stall/unit routine is much simpler, demanding less skill and concentration on the cowman's part, and therefore less risk of mistakes. This factor is especially important on those occasions when the relief milker takes over.
- Stimulus Time** is constant throughout the herd. There is no need for the installation of any special flow indicator.

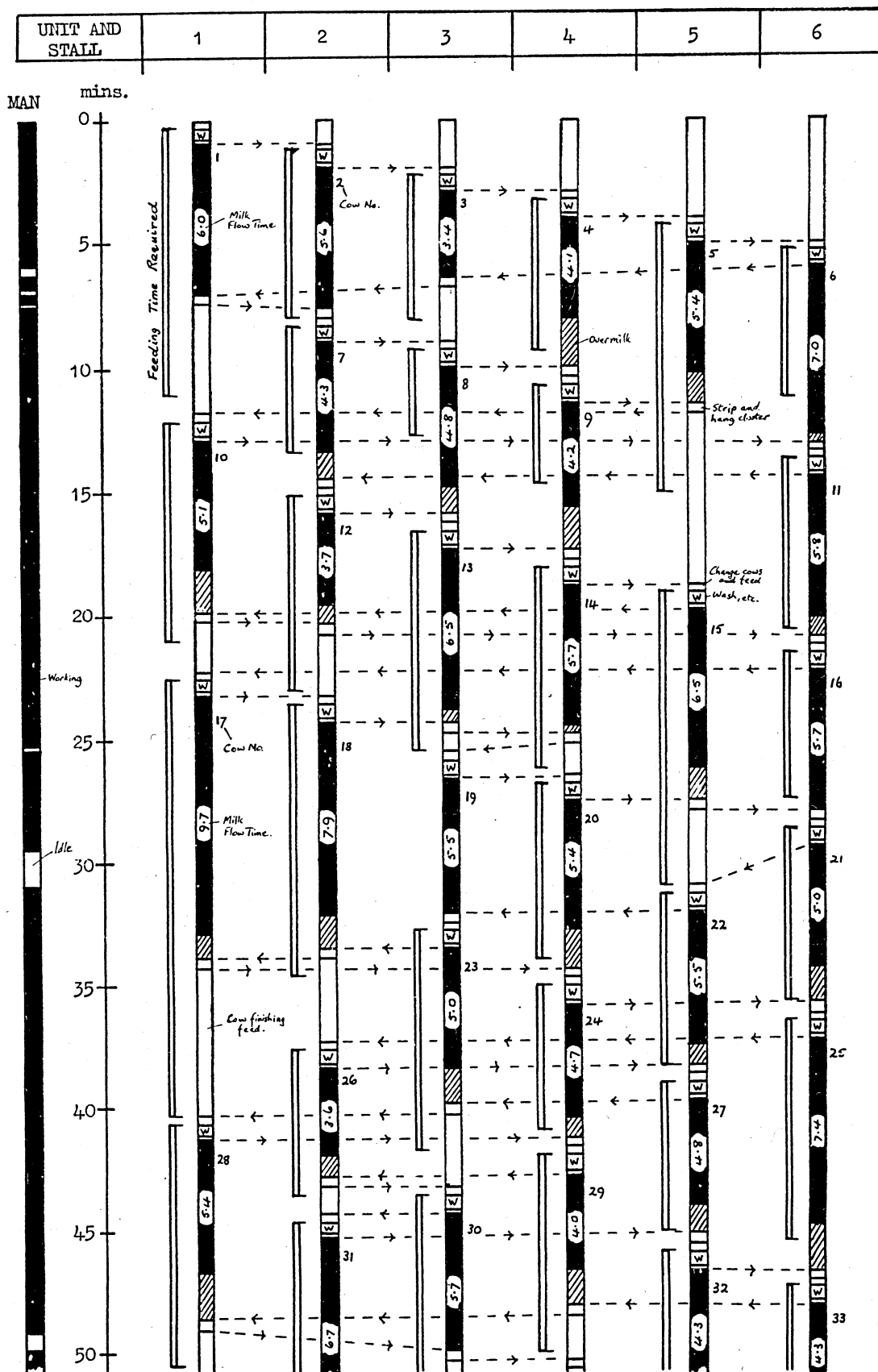


Figure 10 - Multiple Activity Chart - Extract  
 Milking in 6 stall/6 unit Parlour. Milk flow time = 5.64 mins. (Standard Deviation 1.48 mins.). Pipeline Milking. Feeding: Concentrates issued at 4 lb./gallon after "M + 1" on daily yield - and consumed at rate of 1.5 mins./lb.



- (c) Feeding Time\*. All cows can be allowed time to feed irrespective of the relationship between yield and milk flow time. This is not certain to be the case in the 2 stall/unit, unless there is some complicated sorting of cows which would inevitably prolong the herd milking. In the 2 stall/unit it is possible that the restless cow may have eaten all her concentrates before milking starts, encouraging the cowman to make an extra, wasteful issue to keep her quiet.
- (d) Parlour Size. A smaller parlour can be used. Thus, in the examples shown, a six-stall parlour completed the job better than an 8 stall/4 unit. This means the man is always nearer his next work point and is not faced with quite so many cows at one time. Similarly it could be shown that where the herd consists of cows with quicker milking out times, the 4 stall/4 unit might replace the 6 stall/3 unit, and the 3 stall/3 unit replace the 4 stall/2 unit, with advantage.  
Admittedly the 1 stall/unit will involve extra expenditure on machine units but this will be more than offset by savings in capital cost of buildings and fixed equipment. With modern recirculation and immersion cleaning methods the cleaning of any extra unit will be no more onerous than cleaning extra standings.
- (e) Machine Utilisation. Machine idle time is inevitably higher in the 1 stall/unit and this idle time is extended when cows have to be left to finish their feed. However, this disadvantage can be over-emphasised. In any case, milking machine units are out of commission 20 hours of every day. Compared with arable implements, or the capital cost of buildings and fixed equipment which the extra unit can replace, it is cheap equipment. Moreover, if an extra unit can simplify the work routine, reducing mental as well as physical fatigue, the cowman's job becomes easier - an essential factor if productivity is to be improved.

Details emanating from multiple activity charts completed during the study are recorded at Table 1 below. The effect that various sizes of tandem would have on milking a herd of 41 cows, at two levels of milking-out times, is shown. There are several points to be taken into consideration when interpreting the results.

- (a) More attention should be paid to comparisons between times rather than to the absolute times themselves.
- (b) In the example studied, the random order places the 1 stall/unit type at some disadvantage in that one of the last cows in (No. 39) requires an estimated 18 minutes to feed, where average milk flow time is 5.64 minutes, or 11 minutes with the shorter milking time.
- (c) More concentration and greater skill is demanded to operate the 2 stall/unit with success.
- (d) With the current trend to higher vacuum/pulsation ratios, etc., - to induce faster extraction rates - there is less likelihood that all cows in the 2 stall/unit will have time to feed. For example, if a 4:1 pulsation ratio meant that milking-out time could have been reduced from 5.64 to 4.04 minutes, with no loss in yield, then nine animals would have been unable to consume their food in the 6 stall/3 unit, and 13 in the 4 stall/2 unit parlour - unless they were allowed to remain in the parlour after the cluster had been removed. Such action, however, in any 2 stall/unit system, must result in the complete disruption of the standard work routine.

Bearing in mind that the cowman performs the same amount of 'effective' work in each parlour (about 60 minutes) the synthesised time for milking the herd must reflect the efficiency with which man and machines are matched. Overall, the results indicate that whenever the "optimum" number of units are employed, a quicker, and more satisfactory job in all other respects, can be performed where a unit is located at each stall. Generally speaking this better job will be at the expense of extra machine idle time but the cost of a smaller parlour will mean, on balance, that there is an initial saving in capital expenditure. This is so whether or not concentrate feeding in the parlour is a main consideration. Thus, where Milk Flow Time averaged about four minutes (a time which many herds hope to achieve) a 4 stall/4 unit tandem gave a more satisfactory throughput than the 6 stall/3 unit. Again, if the cowman's standard of proficiency were lower, and his work routine time therefore correspondingly longer, throughput with the 3 stall/3 unit tandem would be superior to that in the 4 stall/2 unit.

#### The 1 Stall/Unit Chute Parlour

As in the comparison of parlours with 2 stall/unit systems, the batch changeover of animals in the 1 stall/unit chute is the prime factor which determines a slightly different work method from that operated in the tandem. Assuming a 6 stall/6 unit chute parlour the basic work routine would be as detailed in Appendix 4.

Thus the man's time in attending to the needs of each cow is approximately the same as that in the tandem set-up.

In the discussion of the 1 stall/unit tandem parlour, with average milking-out time 5.64 minutes, it was shown that 5 stalls and 5 units were theoretically the optimum equipment, if feeding in the parlour did not have to be considered. However, if the same herd of cows passed through a 1 stall/unit chute parlour, machine cycle time would be extended. More unavoidable,

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\* Feeding time has been calculated as directly proportional to yield and estimated food issued based on that yield but, just as some cows milk faster than others in relation to their yield, likewise feeding time required and quantity of food consumed are not perfectly correlated. Furthermore, in practice, food may not be issued strictly according to yield, because of the cows' varying conversion potential. However, if full account were taken of the variability in feeding time due to causes other than yield the arguments put forward would still be valid. It is realised also that levels of concentrate feeding, other than that used for illustration, might be applicable, e.g. 4 lb. gal. after M+2, etc.

TABLE 1. Relative Performance of 2 stall/Unit and 1 Stall/Unit TANDEM Parlours. (All times in minutes at standard performance.)

(41 Cow Herd. Milked by one man. Average Milk Flow Times: (A) 5.64 mins. (B) 4.04 mins. (Std. Deviation = 1.48 mins. in each case). (a)

Milk Flow Times				(A) Average 5.64 mins. (Std. Dev. = 1.48 mins.)							(B) Average 4.04 mins. (Std. Dev. = 1.48 mins.)							
PARLOUR SIZE		Stalls Units	No. No.	8 4	6 6	6(b) 6	5 5	5(b) 5	6 3	4 4	4(b) 4	6 3	4 4	4(b) 4	4 2	3 3	3(b) 3	
HERD MILKING TIME (mins.)	"Optimum" Possible (d)			71.0	64.1	64.1	65.5	65.5	91.7	77.9	77.9	69.4	63.6	63.6	101.5	78.2	78.2	
	Total (actual)			76.7	66.1	75.0	70.8	84.6	97.7	82.1	98.5	78.3	68.5	73.0	106.4	82.9	87.5	
	Effective Work Time			60.6	60.3	60.8	60.4	60.7	60.6	60.2	60.6	60.7	60.2	60.1	59.7	60.1	60.4	
	Man Idle Time (total)			16.1	5.8	14.2	10.4	23.9	37.1	21.9	37.9	17.6	8.3	12.9	46.7	22.8	27.1	
	" " " (last work cycle)			6.8	4.2	9.5	5.7	10.9	10.6	6.5	10.2	6.3	4.6	5.4	8.1	6.1	6.8	
COWS NOT FINISHED THEIR FEED (b)			No.	5	14	-	18	-	4	17	-	-	5	-	-	7	-	
MACHINE UTILISATION	Total Unit Time (c)			306.8	396.6	450.0	354.0	423.0	293.1	328.4	394.0	234.7	274.0	292.0	212.8	248.7	262.5	
	Milk Flow Time			← 231.4 →								← 165.6 →						
	Machine Stripping			← 16.4 →								← 16.4 →						
	Total Effective Use			← 247.8 →								← 182.0 →						
	Per cent. Effective Use %			82.1	62.5	55.1	70.0	58.6	84.5	75.5	62.9	77.5	66.4	62.3	85.5	73.2	69.3	
	UNIT IDLE TIME	Total Unit Idle Time			59.0	148.8	202.2	106.2	175.2	45.3	80.6	146.2	52.7	92.0	110.0	30.8	66.7	80.5
		Change cows, wash, strip cup			-	33.0	33.0	33.0	33.0	-	33.0	33.0	-	33.0	33.0	-	33.0	33.0
		Arrange, apply and remove cluster			6.7	9.4	9.4	9.4	9.4	6.7	9.4	9.4	6.7	9.4	9.4	6.7	9.4	9.4
		Prep. work at (1st work cycle (c)			8.5	14.4	14.4	9.6	9.6	5.2	5.8	5.8	5.2	5.8	5.8	2.5	2.9	2.9
		other stalls (to last cycle			-	-	16.1	-	11.2	-	-	5.9	-	-	8.9	-	-	4.9
		Over Milking			34.2	68.0	26.6	35.1	17.2	17.7	21.0	10.7	30.6	33.3	26.5	16.1	12.8	8.2
		Finishing Feed			-	-	56.5	-	63.0	-	-	60.3	-	-	13.3	-	-	14.8
		Others Finishing Feed, etc.			-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Last Work Cycle (c)			9.6	24.0	46.2	19.1	31.8	15.7	11.4	21.1	10.2	10.5	13.1	5.5	8.6	7.2	
OVER-MILKING	Average per cow			.8	1.7	.6	.9	.4	.4	.5	.3	.8	.8	.6	.4	.3	.2	
	Maximum Reading			3.2	3.4	2.9	3.5	2.0	1.9	3.0	1.5	2.7	3.0	2.7	1.3	2.6	1.7	
	Number (> 3 mins.			2	6	-	2	-	-	1	-	-	1	-	-	-	-	
	over-milked (> 2 mins.			5	17	2	4	1	-	3	-	3	2	2	-	1	-	
(> 1 min.				14	28	12	13	8	5	6	5	14	12	11	5	3	1	

(a) Cows enter parlour in Random Order No. 1.

(b) When cows allowed time to finish their feed - Concentrates issued at 4 lb./gallon after "Maintenance + 1 gal." and consumed at 1.5 mins./lb.

(c) Assuming all units hanging alongside standing as first cow enters and until last cow leaves.

(d) If all cows had identical Milk Flow Time.

machine-idle time is involved because units must also be out of action during the time that preparation work and machine stripping of other cows in the batch are being carried out. Moreover it is not possible to operate a standard work routine satisfactorily if batches of different sizes are admitted to opposite sides of the parlour. In this respect the 1 stall/unit chute is less flexible than the tandem and only parlours of 6 stall/6 unit and 4 stall/4 unit have been considered.\*

A further complication arises in any attempt to assess the theoretical performance of the 1 stall/unit chute, due to the fact that work on the cow before milking commences takes longer than machine stripping after milk flow ceases. Thus, in the 'ideal' situation where all cows had the same milk flow time, when no cow was overmilked and all were given the same 'stimulus' time, there must be an enforced delay for the man between completing stripping of the first and second, and second and third cows on each side of the pit of a 6 stall/6 unit parlour. Each delay is equivalent to the difference between preparation and stripping times, (standard times  $(0.57 + 0.17)$  less  $(0.40 + 0.06) = .28$  minutes).

Using standard times for performance of elements of work, the chart at Figure 11 shows that a 'best fit' could be provided in the 4/4 chute where milk flow time was 3.92 minutes, whilst in the 6/6 chute the corresponding figure would be 6.40 minutes - a difference of  $2\frac{1}{2}$  minutes. This difference implies that there is a relatively wide spread of average milking-out times which cannot be dealt with satisfactorily in the 1 stall/unit chute. Thus, if milk flow time averaged about  $5\frac{1}{4}$  minutes, to use the 4 stall/4 unit chute would mean the man was under-occupied and milking would therefore take considerably longer than desirable. Alternatively, operating a 6 stall/6 unit would appear to incur too high a figure for regular over-milking.

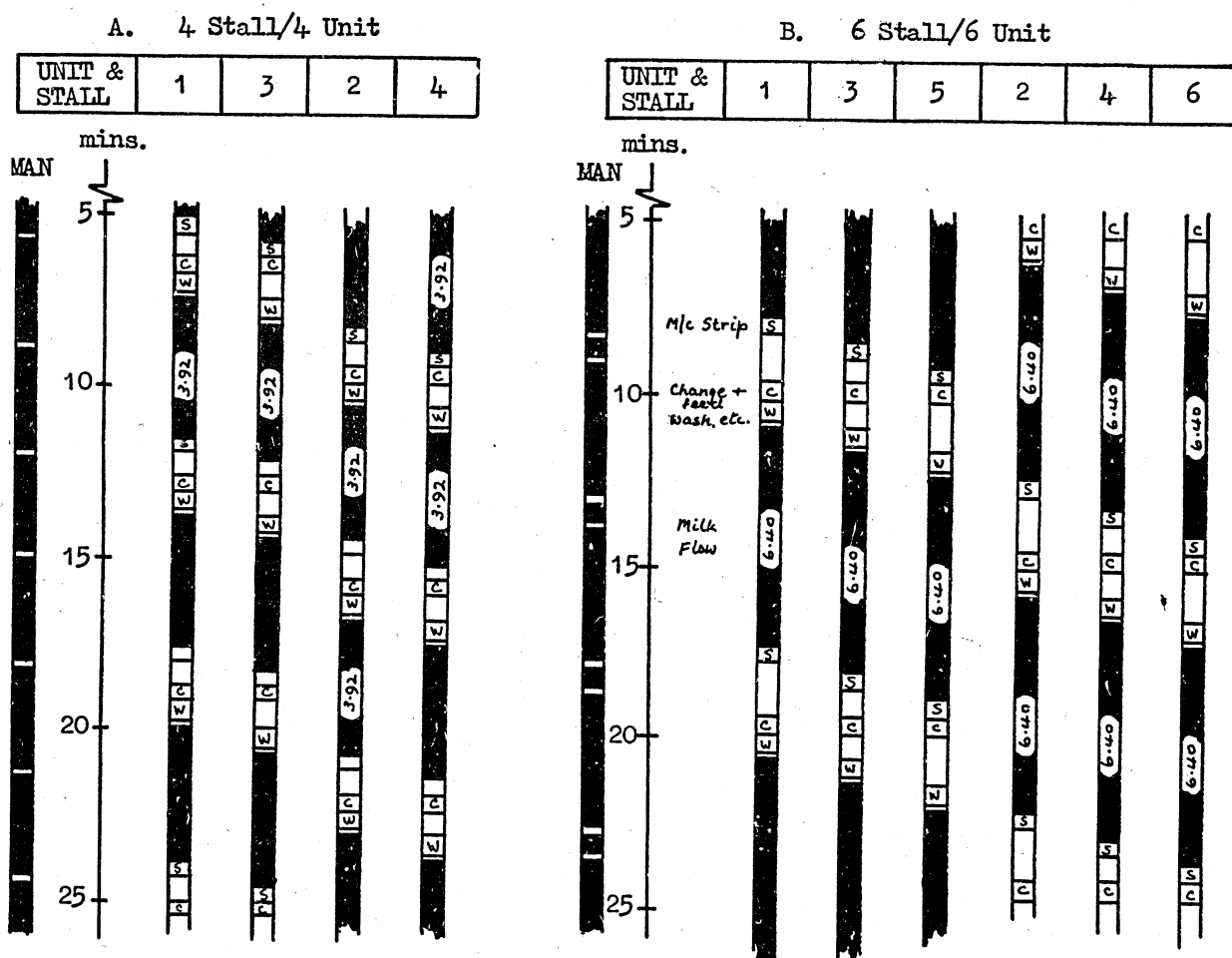


Figure 11 - Multiple Activity Chart - Extracts  
One stall/unit Chute Parlours. Estimated average Milk Flow Times providing the 'Best Fit' for operating 4 stall/4 unit and 6 stall/6 unit Parlour.

\* The circumstances can be envisaged when 3 stalls and units could be operated on one side of the pit and only 2 on the other, e.g. where the assembly yard was divided and 40 per cent of the herd - the high yielders, longest milkers - were channelled through the side using only two stalls and units.

A further difficulty arises in assessing the effectiveness of employing the 1 stall/unit chute. This is not apparent from Figure 11. A combination of batch entry, and the fact that attention to the cow before milking takes longer than after milking, means that overmilking during the first work cycles can have repercussions during subsequent cycles, if milk flow time differs at all from the average figure giving the 'best fit'.\* This is illustrated in the chart at Figure 12, based on the 6 stall/6 unit chute and a longer milk flow time of 7 minutes - compared with 6.4 minutes which gave a satisfactory result above. The chart shows that despite the lengthening of milk flow time, two cows in the even numbered stalls are overmilked in all cycles after the first batch. Although the overmilking (.56 and .28 minutes) appears negligible, nevertheless this feature can be accentuated when cows of unequal milking times enter the parlour in some random order.

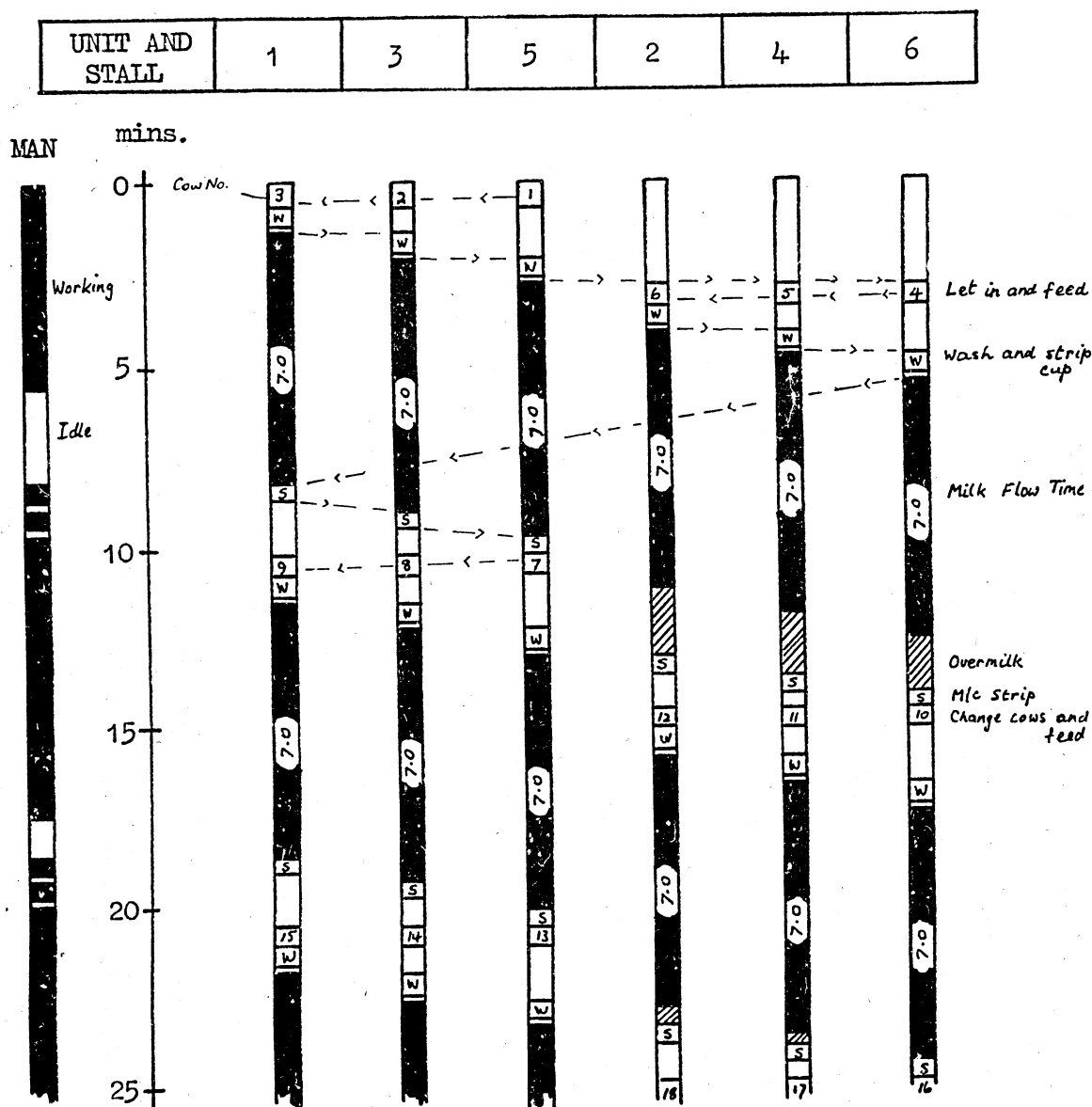


Figure 12 - Multiple Activity Chart - Extract  
Milking in 6 Stall/6 Unit Chute. (1 Operator) Milk Flow Time 7.00 minutes.  
Standard deviation = Nil.

However, it is more probable that, in practice, a similar "chute" will be expected to deal with the milking of a herd of a lower average milkingout time. The effect that attempting this has upon overmilking can be seen from Figure 13, in which all cows are assumed to have milk flow time of 5.64 minutes - i.e. the same as in previous examples and also the average for the sample herd.

With 6 stalls and 6 units it has been shown that a 6.40 minutes milk flow time provided an "exact" fit (Figure 11). Theoretically, therefore, if this time is reduced to 5.64 minutes all cows will be overmilked by .76 minutes. However, Figure 13 indicates that in these circumstances only one cow in six is slightly overmilked by about half a minute and two by about  $\frac{1}{4}$

\* In all the parlour types, an increase in milk flow time would have the effect of decreasing overmilking and increasing free time for the man.

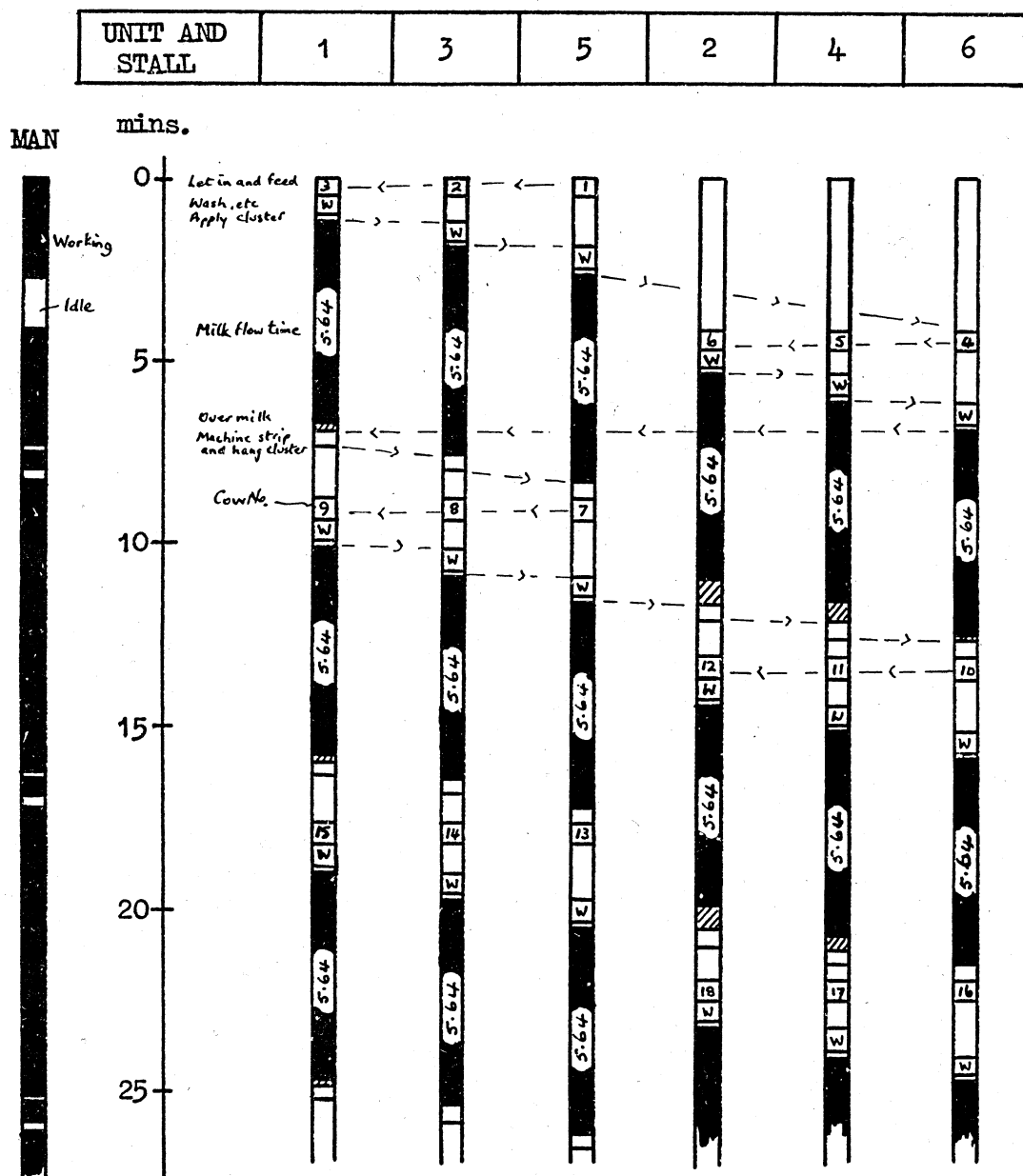


Figure 13 - Multiple Activity Chart - Extract  
Milking in 6 stall/6 unit Chute Parlour. Milk Flow Time for all cows - 5.64 minutes (cf. "exact" fit 6.40 minutes).

minute. This could not be termed unsatisfactory. Nevertheless it must be added that "taking up the slack" caused by differences in preparation and stripping times would have proportionately less effect with a shorter herd average milk flow time. It was fortuitous that a time of 5.64 minutes was chosen because below this point overmilking per cow virtually increases directly by any difference noted. For example, a diagram prepared to chart the milking of cows with 4.04 minutes milking time would show that in each batch of three cows, one was overmilked by 1.80 minutes, one by 1.52 minutes and the third by 1.24 minutes.

From the foregoing it can be seen that with cows entering the parlour in random order, the synthesised results achieved in operating the 6 stall/6 unit chute when milk flow time was 5.64 minutes, or the 4 stall/4 unit chute with the corresponding figure of 4.04 minutes, will provide a fair comparison of the 1 stall/unit chute, with other parlour types discussed.

#### Modifications to work routine with random entry

Where all cows have similar milking-out times there is no problem for the man to work at stalls 1-3-5 and 2-4-6 in order. In practice, however, every batch is likely to be comprised of cows of varying milking-out times. As none of the batch can be replaced in the parlour until the last cow has milked out, it follows that the time any batch remains in the parlour will depend largely upon the time taken to milk out the longest milker. For example, assuming the batch filling stalls 1,3 and 5 consists of cows requiring 4 minutes, 4 minutes and 7 minutes respectively, strictly adhering to the standard routine would mean that the cow at stall 5 would be kept waiting some  $1\frac{1}{2}$  minutes at the start while preparation work was in progress on the animals in stalls 1 and 3, and the unit at stall 1 would be idle an additional  $4\frac{1}{2}$  minutes as the cow there waited for the longest milker to be ready for machine stripping.

In some circumstances, where time to feed is a factor to be considered, strict adherence to the standard routine may be less important. Where concentrate feeding in the parlour does not extend beyond milking time, it is apparent that the cowman should prepare the cows of each batch according to estimated milk flow time - longest first. However, no cowman can possibly be expected to differentiate between cows where milking-out times are similar to within a minute. For the purposes of this exercise it has therefore been assumed that he will operate the standard routine of first preparing cows in stalls 1 (or 2) unless a cow (or cows) in the other stall(s) has a milk flow time of at least two minutes longer. In such a case he will attend first to the stall holding the longest milker. Except for this simple modification, which requires no excessive extra concentration, the basic routine can be completed.

Figures 14A and B record the results at the start of routine in the 6 stall/6 unit and 4 stall/4 unit chutes when milk flow times average 5.64 and 4.04 minutes respectively and with standard deviation 1.48 minutes, and cows enter the parlour in random order. No extra feeding time has been allowed.

Figures 14A and 14B are also comparable with Figures 11 and 13 respectively and as average figures are identical, any differences noted are due to working with cows having varying milking-out times.

The most obvious feature is that with random entry a slightly increased amount of over-milking is unavoidable, but that this increase is not serious. Again, if the one modification stated above is incorporated in the standard basic routine, throughput appears to differ very little from the optimum. Thus, in both figures 13 and 14B, the cluster is shown to be applied to cow 21 after about 28 minutes have elapsed.

Compared with the 1 stall/unit tandem more cows should have the opportunity to finish their feed where no special arrangements are made in the system for this. Moreover, as the unit must be hung up after machine stripping has been completed, there is no special difficulty if the routine is broken and cows left to finish their concentrates. However, this practice means that shorter milkers and low yielders may be delayed in the parlour much longer than is desirable with the result that, there may be extra fouling of the parlour.

The effect upon the routine of allowing every cow time to feed is shown in the chart extract at Figure 15.

The most obvious feature of this chart is that machines are ineffective for a high proportion of the time. This is in no way due to excessive over-milking. As can be seen with batches containing cows 13-15 and 16-18, the animal with the longest feeding time determines the period which others in the batch must remain in the stall. In these two instances the entry of the next batch of cows is delayed by 3 minutes and 7 minutes respectively because one cow in the batch happened to need extra feeding time. However, despite poor machine utilisation, the rate of throughput is little different from that in other parlours where the man is kept well-occupied. Furthermore, except for the fact that some cows have to be held back in the parlour when both feeding and milking have finished, all other requirements of a satisfactory method have been fulfilled, viz.

A constant stimulus time has been maintained; all cows have had time to feed; there has been no excessive overmilking; the simple straightforward routine has been able to accommodate cows entering in random order.

Table 2 below, compares the throughput of 1 stall/unit chutes with the 2 stall/unit at two levels of milking-out time. It can be seen from this that where the feeding of concentrates in the parlour is not a major factor to be considered the performance of 1 stall/unit parlours with 3, 4 or 6 units is comparable to that for 2 stall/unit having 4, 6 and 8 standings respectively. This also applies where the parlour feeding of concentrates is practiced, as long as the man is equipped with the optimum number of milking units. Where he is under-equipped, productivity of the 1 stall/unit set-up falls away. All the advantages of the one stall/unit tandem parlour are, therefore, not applicable when the batch entry of cows is operated.

#### Tandem v. Chute

Examining the details of Table 2 alongside those of Table 1, it may be said that if a 2 stall/unit system is to be operated, the less expensive chute (batch entry) parlour can match the performance of the tandem and, at the same time, requires a simpler work routine. However, if the feeding of concentrates in the parlour is a main factor to be considered, the advantages that the smaller 1 stall/unit tandem can have over a larger 2 stall/unit are not necessarily reproduced with the chute layout. This is largely due to the loss of flexibility in changing over cows as a result of which the longest milker, or longest feeder in a batch determines the moment when the batch can be released.

#### Pre-selection of heavier yielders

When milking cannot be arranged at approximately 12 hour intervals, it is often recommended that the effect of this on the highest yielders can be minimised by putting them through the parlour first at morning milking and last in the afternoon. Because it is probable that these cows are the longest milkers, and require longest to feed, a deliberate policy which includes them in the first or last groups has an adverse effect upon overall milking time. This is readily understandable, for in addition to the time required to sort or segregate cows, the following points apply, depending on the parlour type:

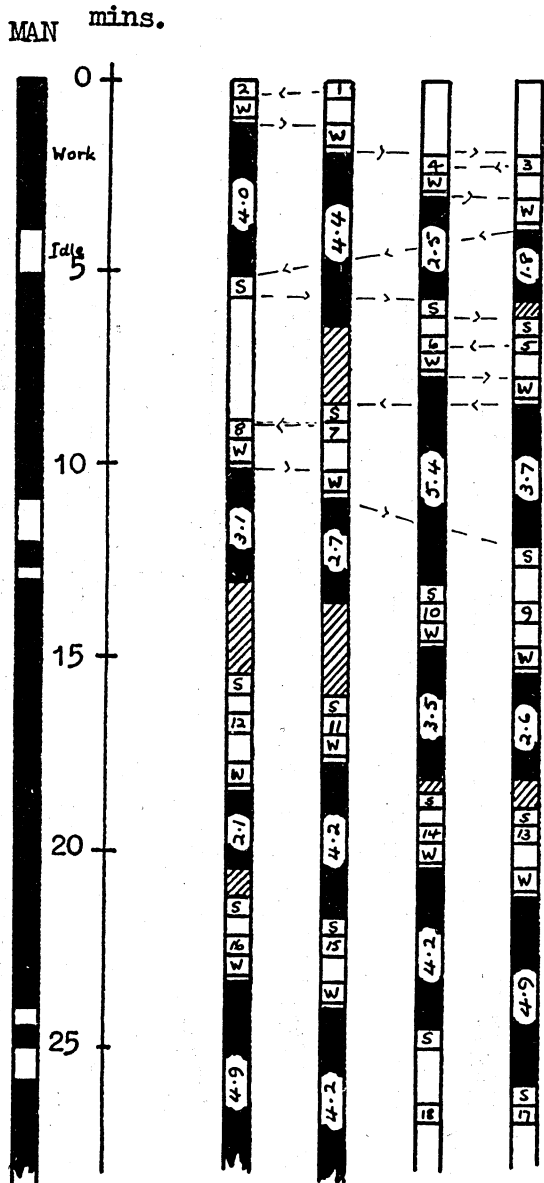
- (a) As only part of the work cycle can be operated when first or last batches are in the parlour there will be longer idle periods for the operator at these times.

If the man deviates from the basic routine by preparing additional cows when he would otherwise be idle, the stimulus time of these will be prolonged so as to become ineffective.

- (b) There is less time available in the 2 stall/unit parlours for the first group entering to consume their feed, than for subsequent groups.

- Average Milk Flow Time = 4.04 mins.  
(Std. Deviation of 1.48 mins.)

UNIT & STALL	1	3	2	4
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- (B) 6 Stall/6 Unit - one operator.  
Average Milk Flow Time = 5.64 mins.  
(Std. Deviation of 1.48 mins.)

UNIT & STALL	1	3	5	2	4	6
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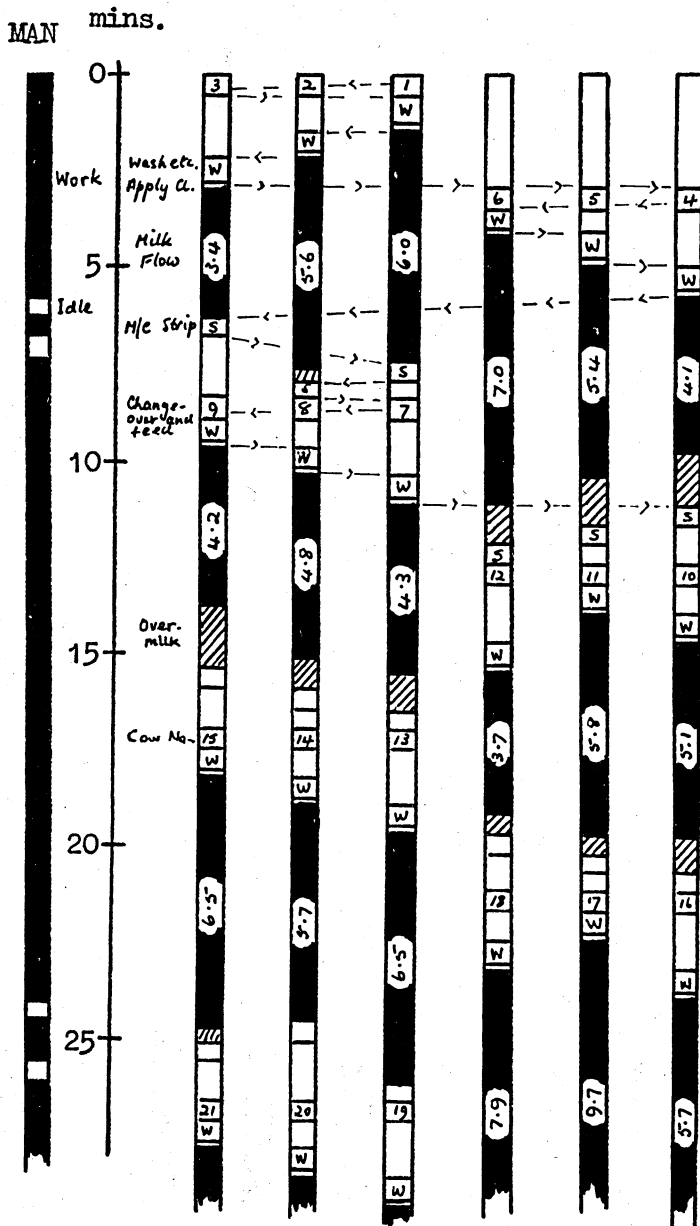


Figure 14 - Multiple Activity Chart - Extract  
JOB: Milking in 1 stall/unit Chute Parlour.

- (c) It is probable that there will be more overmilking of the lower yielders/quicker milkers.

It is estimated that the additional work involved in pre-selecting high yielders as outlined above increases overall milking time by quite 10 per cent. The advantages accruing would, therefore, have to be substantial to justify such a practice. In view of the obvious disadvantages the system cannot be recommended. No attempt has been made to fully illustrate all the implications.

## Cluster dipping between cows

The dipping of the machine cluster in a disinfectant solution between cows, as practiced in a number of herds, is not included in the standard work methods. This is because experience



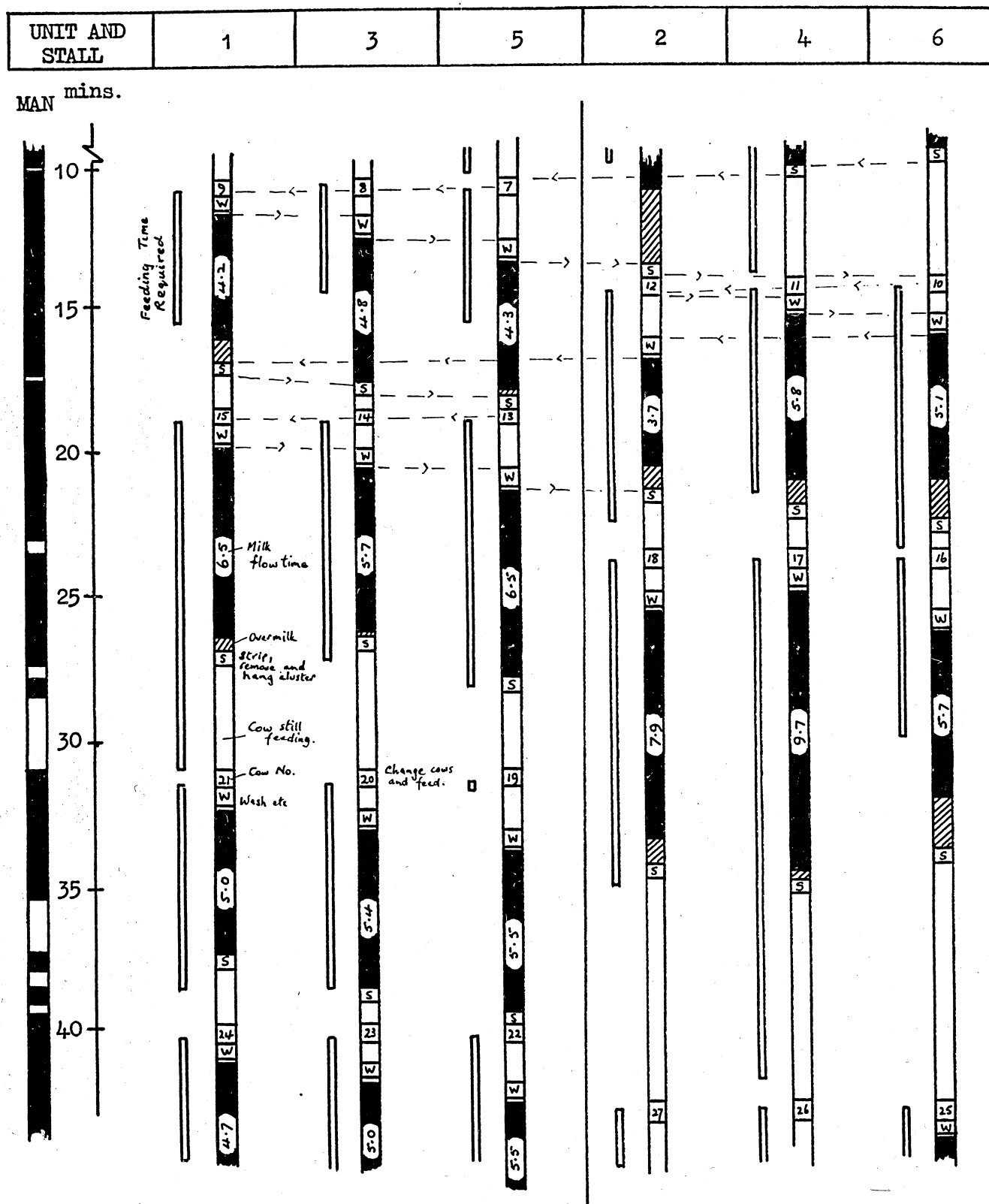


Figure 15 - Multiple Activity Chart - Extract

Milking in 6 stall/6 unit Chute Parlour. Milk Flow Time 5.64 minutes (standard deviation = 1.48). Cows enter in Random Order No.1. Feeding Time allowed - 1.5 mins./lb. concentrates, fed at 4 lb./gallon after M + 1.

has shown that such perfunctory dipping is an ineffective measure. However, if veterinary science produces evidence to the effect that a longer period of immersion - say about one minute - would eliminate the risk of transferring infection in cases where mastitis might otherwise, possibly, reach epidemic proportions then the parlour with a unit to each stall embodies a further advantage. Thus, if the vet recommends a one minute immersion of the cluster before its application, this modification can be easily introduced into the work routine here with a negligible effect upon the work rhythm or overall milking time. This longer period of immersion is not possible however, in parlours where one unit serves two stalls (or, for that matter, in cowsheds) without seriously disrupting the normal work method and adding considerably to the time required to milk the herd.

TABLE 2. Relative Performances of 2 Stall/Unit and 1 Stall/Unit CHUTE Parlours. (All times in minutes at standard performance.)

(41 Cow Herd. Milked by one man. Average Milk Flow Times: (A) 5.64 mins. (B) 4.04 mins. (Std. deviation = 1.48 mins. in each case).<sup>(a)</sup>

Milk Flow Times.			(A) Average 5.64 mins. (Std. Dev. = 1.48 mins.)						(B) Average 4.04 mins. (Std. Dev. = 1.48 mins.)									
PARLOUR SIZE		Stalls Units	No. No.	8 4	6 6	6(b) 6(b)	6 3	4 4	4(b) 4(b)	8 4	6 6	6(b) 6(b)	6 3	4 4	4(b) 4(b)	4 2	3 3	
HERD MILKING TIME (mins.)	"Optimum" Possible (d)			73.9	66.0	66.0	91.7	87.4	87.4	58.9	61.2	61.2	69.3	69.8	69.8	100.7	101.8	
	Total (Actual)			75.5	70.9	83.1	95.0	96.0	117.0	65.7	64.1	64.8	76.5	78.3	79.7	104.4	106.2	
	Effective Work Time			57.1	58.9	59.2	56.9	59.3	59.4	57.4	59.2	59.3	56.9	59.3	59.3	57.1	59.0	
	Man Idle Time (total)			18.4	12.0	23.9	38.1	36.7	57.6	8.3	4.9	5.5	19.6	19.0	20.4	47.3	47.2	
	" " " (last work cycle)			5.2	6.4	8.8	5.0	5.8	13.8	5.3	2.5	2.5	8.2	4.3	4.2	7.1	4.2	
COWS NOT FINISHED THEIR FEED (b)			No.	2	12	-	2	16	-	-	2	-	-	3	-	1	2	
MACHINE UTILISATION	Total Unit Time (c)			302.0	425.4	498.6	285.0	384.0	468.0	262.8	384.6	388.6	229.5	313.2	318.8	208.8	318.4	
	Milk Flow Time			← 231.4 →						← 165.6 →								
	Machine Stripping			← 16.4 →						← 16.4 →								
	Total Effective Use			← 247.8 →						← 182.0 →								
	Per cent. Effective Use		%	82.1	58.3	49.7	86.9	64.5	52.9	69.3	47.3	46.8	79.3	58.1	57.1	87.2	57.2	
	UNIT IDLE TIME	Total Unit Idle Time			54.2	177.6	250.8	37.2	136.2	220.2	80.8	202.6	206.6	47.5	131.2	136.8	26.8	136.4
		Change cows, wash, strip cup			5.3	47.0	47.0	4.6	39.8	39.8	5.7	46.3	46.3	4.6	39.8	39.8	1.9	46.3
		Arrange, apply, remove cluster			6.9	9.4	9.4	6.9	9.4	9.4	7.0	9.4	9.4	6.9	9.4	9.4	6.7	9.4
		Prep. work at (1st work cycle (c)			4.8	8.1	8.6	2.3	3.8	3.8	4.8	8.6	8.6	2.4	3.8	3.8	0.8	2.4
		other stalls (to last cycle			-	31.0	32.5	.8	15.4	15.4	-	31.0	34.0	-	15.4	15.4	-	28.6
		Over Milking			21.1	27.6	19.4	14.6	19.3	6.1	37.8	59.8	44.8	23.6	22.3	21.6	11.7	1.1
		Finishing Feed			-	-	43.5	-	-	54.3	-	-	3.7	-	-	7.3	-	-
		Others Finishing Feed, etc.			-	30.2	80.8	4.9	27.5	66.5	10.2	28.0	46.6	5.9	30.0	29.8	-	40.7
		Last Work Cycle (c)			16.1	24.3	9.6	3.1	21.0	24.9	15.3	19.5	13.2	4.1	10.5	9.7	5.7	7.9
		OVER-MILKING	Average per cow			.5	.7	.5	.4	.5	.1	.9	1.5	1.1	.6	.5	.5	.3
	Maximum reading			2.9	2.5	2.6	2.2	2.7	1.0	3.4	3.2	3.2	2.5	2.4	2.4	2.1	.4	
	Number (> 3 mins.			-	-	-	-	-	-	1	2	1	-	-	-	-	-	
	over-milked (> 2 mins.			3	2	4	1	3	-	7	15	8	4	3	3	1	-	
	(> 1 min.			8	12	7	7	8	-	14	26	20	10	10	9	1	-	

(a) Cows enter parlour in Random Order No. 1.

(b) When cows allowed time to finish their feed - Concentrates issued at 4 lb./gallon after "Maintenance + 1 gal." and consumed at 1.5 mins./lb.

(c) Assuming all units hanging alongside standings as first cow enters and until last cow leaves.

(d) If all cows had identical Milk Flow Time.

### CHAPTER 3

#### RESULTS OF THE EXERCISE COMPARED WITH CONVENTIONAL THEORETICAL PERFORMANCES

In this chapter results which may be found in practice are compared with theoretical performances based on herd average milking-out times.\*

In estimating theoretical performance the following notation will be used:-

- P = Performance, i.e. the number of cows which can be milked by the specified installation in a given time.
- WRT = Work Routine Time, i.e. the time required by the operator to complete the essential elements of work on each cow.
- MFT = Milk Flow Time, i.e. the time required for the cow to milk out to that stage when machine stripping can/should commence.
- MNT = Machine On Time, i.e. the time taken for the cow to milk out and for machine stripping to be completed, or, MFT + M/c strip.
- MOT = Machine Off Time, i.e. the time the milking unit is necessarily idle between completing the milking of one cow and starting to draw off milk from the next e.g. time spent removing the cluster, hanging it, the time it is hanging between changeover of cows (if any), the time taken to apply it.
- UT = Unit Time or Machine Cycle Time, i.e. the total time the milking unit is devoted to one cow, or, equivalent to Machine On Time plus Machine Off Time (MNT + MOT).
- N = Number of milking units installed.
- AWT = Available Work Time, i.e. the calculated time available for the operator to complete his work routine on each cow. This is usually also expressed as the Unit Time (UT) divided by the number of units (N).
- n = Number of cows in herd being milked.
- T = Total time, i.e. the estimated time taken in milking the whole herd.

If a herd were milked by a single machine unit, the process (T) would be completed in Unit Time multiplied by the number of cows -  $n(UT)$ . If two units are used, the overall time would be halved -  $n(UT)/N$ . With three units, only one third the time would be required - and so on, as long as the man's work routine time (WRT) did not exceed the available work time (AWT). Once WRT exceeds AWT, (i.e. WRT becomes the lead factor) the theoretical overall throughput will be related to WRT multiplied by the number milked, whatever the parlour size or type.

The herd used as an example for the present exercise contained 41 cows, and had average MFT of 5.64 minutes ( $s = 1.482$  mins). Allowing for machine stripping at .40 minutes and machine off time (MOT) of .16 minutes, UT becomes 6.20 minutes where a 2 stall/unit parlour is used. Working at standard performance, WRT has been noted earlier to total 1.46 minutes, (Ref. Figure 1) whilst AWT exceeds  $1\frac{1}{2}$  minutes. It follows, therefore, that the published theoretical performance of the 2 stall/unit parlour with 4 units is directly comparable with the details, shown earlier in Table 1, relating to the operation of the 8 stall/4 unit tandem. Theoretically the performance of this set-up should be 39 cows per hour - or alternatively, 41 cows could be milked in  $63\frac{1}{2}$  minutes. Multiple activity charts show that in the circumstances where all cows had identical milk flow times, (Figure 5 and Tables 1 and 3) the milking routine could not be completed in less than 71 minutes (12 per cent longer). Moreover, if allowances were made for the differences in MFT between individual cows and a random order of entry, milking would take some 76-77 minutes (21 per cent longer). In neither case is allowance made for contingencies outside the work routine.

Similarly with 3 units and 6 stalls, when average UT is 6.2 minutes, theoretically 41 cows could be milked in under 84 minutes, whereas charts show that the 'optimum' time would be about 92 minutes. This figure would be increased to about 98 minutes if cows, as described earlier, passed through the parlour in a random order. These figures represent increases of 9 and 16 per cent respectively. However, in this case WRT is only 70 per cent of AWT. If WRT were advanced to a figure similar to AWT (2.1 minutes) the minimum increase in herd milking time would be 20 per cent corresponding to that shown for the 4 unit parlour above.

The difference between the theoretical herd milking time and that indicated by multiple activity charts of the completed process are shown below in Table 3 for various tandem layouts. Similar comparisons are provided in Table 4 relating to the Chute parlour.

The times recorded in Tables 3 and 4 are based on the hypothesis that the various elements of work constituting the work routine are performed in standard time upon each cow. It is appreciated that in practice there will be variations in some times (e.g. udder washing) but the probability that the work on any cow will constitute the exact balance between milk flow time and average unit time is too remote to demand special consideration.

If more regard is paid to the differences noted in Tables 3 and 4 than to the absolute times themselves, it might be said that in practice, (again ignoring those extra contingencies which might arise,) milking a herd of 41 cows took 10-15 minutes or some 20 per cent longer than the time suggested by theoretical output. It is evident therefore that recommendations based on theoretical performance of the type of parlour which could complete the milking within a stated maximum will be over-optimistic. Moreover, it should be noted that in practically all the examples given, WRT is well within the estimate of AWT.

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\* See, for example, "Measurement of Performance in Machine Milking", Clough, P.A. and Dodd, F.H. op. cit.

TABLE 3. Comparison of Times to milk out 41 Cows at two levels of Milk Flow Time - Tandem Parlour

(a) Average MFT = (5.64 minutes) + M/c Strip (.40 minutes) = MNT = 6.04 minutes  
WRT = 1.46 minutes at standard performance.

Parlour ) Size )	Stalls Units	8 4	6 3	5 5	4 4
MOT (mins.)		0.16	0.16	1.06	1.06
UT (mins.)		6.20	6.20	7.10	7.10
AWT (mins.)		1.55	2.07	1.42	1.78
<u>Total Milking Times (mins.)</u>					
Theoretical Performance		63.5	84.7	59.9	72.8
Optimum*		71.0	91.7	65.5	77.9
Actual		76.7	97.7	70.8	80.1

(b) Average MFT = 4.04 minutes + M/c Strip (.40 minutes) = MNT = 4.44 minutes  
WRT = 1.46 minutes at standard performance

Parlour ) Size )	Stalls Units	6 3	4 2	4 4	3 3
MOT (mins.)		0.16	0.16	1.06	1.06
UT (mins.)		4.60	4.60	5.50	5.50
AWT (mins.)		1.53	2.30	1.38	1.83
<u>Total Milking Times (mins.)</u>					
Theoretical Performance		62.9	94.3	59.9	75.2
Optimum*		69.4	101.5	63.6	78.2
Actual		78.3	106.4	68.5	82.9

\* Optimum = assuming all cows have the same milking out time.

TABLE 4. Comparison of Times to Milk 41 cows at two levels of Milk Flow Time - Chute Parlour

(a) Average MFT - 5.64 minutes + M/c Strip .40 minutes = MNT = 6.04 minutes

Parlour ) Size )	Stalls Units	8 4	6 3	6 6	4 4
MOT (mins.)		0.16	0.16	2.88	1.96
UT (mins.)		6.20	6.20	8.92	8.00
AWT (mins.)		1.55	2.07	1.49	2.00
WRT (Mins.)		1.37	1.37	1.43	1.43

Total Milking Time (mins.)

Theoretical Performance	63.5	84.7	61.0	82.0
Optimum*	73.9	91.7	66.0	87.4
Actual	75.5	95.0	70.9	96.0

(b) Average MFT - 4.04 minutes + M/c Strip .40 minutes = MNT = 4.44 minutes

Parlour ) Size )	Stalls Units	8 4	6 3	4 2	6 6	4 4	3 3
MOT (mins.)		0.16	0.16	0.16	2.88	1.96	2.88
UT (mins.)		4.60	4.60	4.60	7.32	6.40	7.32
AWT (mins.)		1.15	1.53	2.30	1.22	1.60	2.44
WRT (mins.)		1.37	1.37	1.37	1.43	1.43	1.43

Total Milking Time (mins.)

Theoretical Performance	56.2	62.9	94.3	56.2	65.6	100.0
Optimum*	58.9	69.3	100.7	61.2	69.8	101.8
Actual	65.7	76.5	104.4	64.1	78.3	106.2

\* Optimum = assuming all cows have the same milking out time.

There are various reasons why theoretical output cannot be attained in practice despite the fact that the man works continuously at standard rate. These reasons may be summarised under the following headings:-

- (a) End effect
- (b) Random effect
- (c) Basis of the traditional methods of calculating UT and AWT (available work time) in relation to WRT (work routine time).
- (d) Goodness of fit between WRT, parlour size and machine cycle time (UT).
- (e) Other contingencies which, so far, have not been taken into consideration.

These points are discussed below in more detail.

(a) End Effect

At the start of the routine, the second and subsequent units are in delay until work at the previous point has been completed. The man is also obliged to suffer some delay after the first cows have been prepared because the full work routine cannot be carried out as there are no cows to be machine stripped. Similarly, ineffective man and unit time is repeated at the end of the milking. In effect, before milking starts on the second batch of cows to be milked and at the end of milking when the stalls are occupied for the last time, the equivalent of an extra complete work cycle elapses. Thus, if 30 cows were being dealt with by three units, the routine time would be approximately equal to 11, and not 10, complete work cycles. Time to handle the cluster during these periods can also be a little higher where 1 unit serves 2 stalls. Thus the lower the theoretical number of work cycles the greater will be the proportional increase due to the "end effect".

This factor explains most of the discrepancy between theoretical performance and the times charted for the herd with all cows having a milking time the same as average.

(b) Random Effect

Any concept that the lower time required by some cows to milk out will offset the extra needed for those with above average time, is erroneous except in some instances where the number of units being operated is well below the optimum. With the random entry of cows, and a WRT which approximates AWT, the man cannot recover the idle time which he may have forced upon him when he has to wait for cows with above-average time to milk out. This is readily understandable when it is realised that in these circumstances the minimum (or theoretical) time it would take to milk the herd is the sum of the work routine times upon each cow and, because it is impossible to "store" time, any idle time must be added to that sum.

Random entry also adds slightly to the amount of walking time.

(c) WRT in relation to AWT and the basis of calculating AWT

Where WRT is appreciably less than AWT the actual throughput is nearer to calculated theoretical performance. The throughput in these circumstances, however, is lower than could be obtained if AWT were reduced to approximately WRT by introducing an additional unit. This indicates that AWT (Available Work Time) can be a misnomer, and can give little idea of the satisfactory WRT. An example will explain this more satisfactorily:-

In Table 4(a) the 41 cow herd, having average MFT of 5.64 minutes, and UT (or Milk Cycle Time) of 6.20 minutes, could theoretically be milked in 84.7 minutes with AWT of 2.07 minutes. The WRT in operation occupied only 1.37 minutes. Thus, if the hypothesis is correct that 2.07 minutes is available to complete the work on each cow, WRT here could be increased by exactly 50 per cent. (i.e. making WRT = 2.05 minutes) without detriment to the performance of the parlour. If this modification is introduced, a chart shows that overall milking time, excluding contingencies, will be extended to 105½ minutes - an increase of 25 per cent on the theoretical figure.

The importance of this point is more apparent if viewed from the angle of the farmer assessing his labour efficiency in the light of theoretical standards. In this case, for example, he could have estimated his average milking out time, (for a yield at milking of a little over 20 lb./cow), fairly accurately at 5.6-5.7 minutes, and would have available the total time of some 105-106 minutes. A simple check would indicate a performance of 23 cows an hour or an AWT of 2.6 minutes. If he were satisfied that a 2 minute work routine time was ample for his layout, he might deduce that there was slackness in the parlour. Alternatively, if it had been noted that there were several unavoidable delays during the milking, he might consider that insufficient units were available. Both deductions would be inaccurate. Firstly, it is now known that a 2 minute routine is in operation. Secondly, already 10 cows are overmilked by more than 1½ minutes - the longest 3.9 minutes - and, although the use of another unit with 2 extra stalls would reduce milking time by about 10 minutes it would do so at the expense of much extra overmilking. In fact, it was found that with a WRT of 2 minutes, 9 cows of the 41 would have been overmilked by more than 3 minutes and a further 6 by more than 2 minutes. Thus AWT might sometimes be a useful guide to WRT if all cows were equal, but it can be far too liberal where milking-out times fluctuate about the average, as in practice. A partial explanation of this is apparent if those parts of the work routine comprising the "Machine Off Time" and those which form part of the "Machine On Times" are considered separately.

By definition AWT is equivalent to the Unit Time, or Machine Cycle time, divided by the number of units in use. Unit Time, in turn can be expressed as Machine On Time (MNT) plus Machine Off Time (MOT). Under the basic work routine, MNT consists of the period when the machine is working unattended (i.e. Milk Flow Time) and time when the man and machine are working together (i.e. Machine Stripping). MOT will be that part of the machine cycle during which the unit is necessarily idle. In the 2 stall/unit parlour this will be the time needed by

the man to remove the cluster from one cow, take it across and apply it to the next, whilst in the 1 stall/unit,\* besides the time spent in handling, there will be that during which the unit hangs idle awaiting the changeover of cows and preparation.

The drawbacks in the conventional method of calculation and use of AWT as a guide to WRT and throughput are examined further:-

Assuming standard performance, times to carry out the various elements of work in a 2 stall/unit tandem parlour have been noted as:-

		Per cent
Machine Strip cow	- .40 mins.	27.4
Remove cluster, across and apply to next cow	- .16 mins.	11.0
Changeover cows, wash and strip cow and walking time	- .90 mins.	61.6
WRT	1.46 mins.	100.0

Taking the hypothetical case where all cows have a MFT of 5.28 minutes:

$$UT = 5.28 + .40 + .16 = 5.84 \text{ mins.}$$

$$\text{With 4 units } AWT = 5.84/4 = 1.46 \text{ mins.} = \text{WRT precisely}$$

$$\text{With 2 units } AWT = 5.84/2 = 2.92 \text{ mins.}$$

The inference is that the man with 2 units need only work at half the pace of the one operating with 4, - albeit achieving only half the performance. However, this is not true, for to arrive at this conclusion, the jobs included under MNT and MOT have been assessed in the calculation at standard rating. Thus, the man with 2 units is expected to perform in standard time the elements of work which involve handling the cluster, but can work at well below half pace on other jobs. In this instance, having completed the handling of the unit, 2.36 minutes remain to perform the other work - or more than  $2\frac{1}{2}$  times the standard requirement. It is obvious, therefore, that before AWT could be used as a guide to WRT a reliable estimate is required of that part of the routine which will be within the Unit Time.

Still using the above hypothetical example as an illustration: If AWT is distributed between the various elements of work in the same proportions as for standard performance, then machine stripping, removing and applying the cluster would take twice as long with two units as with four. Assuming, therefore, that 2.92 minutes were the time available, .80 minutes must be allocated for machine stripping and .32 minutes for the other handling. UT now becomes  $5.28 + .80 + .32 = 6.4$  minutes. This compares with 5.8 minutes as shown in the earlier calculation.

It follows that if a system is adopted of estimating UT by adding 'constants' to the average MFT, then AWT based on this calculation is merely an assessment of the time to complete the job at standard performance added to which is an estimate of the amount of idle time during each work cycle. This is a different matter from having a specified time in which to complete the work. In other words, where AWT exceeds WRT at standard performance, the man, although experiencing idle periods, must nevertheless be able to work at the standard rate when there is work to do. But, if the estimated AWT is less than WRT at standard performance he will be doing those elements included in UT at the standard rate and those excluded at a much faster pace.

Assuming a constant rate of working (i.e. all elements are performed in proportional times to those at standard rating) a better estimate of AWT in the 2 stall/unit Tandem would be available from the following construction:-

Where N = No. of units

MFT = Milk Flow Time \*\*

Machine Strip = .274 AWT

Machine Off Time (MOT) = .110 AWT

AWT = (MFT + Machine Strip + MOT)/N

Hence:  $AWT = \frac{MFT}{(N - .384)}$

Similarly, with the 2 stall/unit Chute:-

$AWT = \frac{MFT}{(N - .412)}$

As some error is inevitable in any predicted figure for MFT, the following equation will provide a reasonably accurate estimate of AWT for the 2 stall/unit tandem and chute parlours:

$$AWT = \frac{MFT}{(N - .4)}$$

\* With the 1 stall/unit, unless the machine is allowed to hang idle for an additional period whilst a cow is finishing its feed,  $UT = MFT + WRT$ .

\*\* Clough and Dodd, op. cit. i.e. If average yield = x lb.  
MFT (predicted) =  $.164x + 1.93$

Comparable information for the 1 stall/unit tandem can be expressed as:

$$\text{AWT} = \frac{\text{MFT}}{(N - .986)}$$

$$\text{or AWT} = \frac{\text{MFT}}{(N - 1)}$$

A complication arises in assessing similar figures for the 1 stall/unit chute, because, as explained earlier, there can be periods of enforced idle time for the man, due to differences in the work content of the essential jobs before and after milking. The machine is also idle when preparation work and machine stripping are being completed for other cows in the batch. AWT, therefore, will equal something less than UT divided by N. (See Figure 11).

With a 4 stall/4 unit chute, and cows changed over in batches of two:

$$\text{AWT} = \frac{\text{MFT}}{2.80} = \frac{\text{UT}}{N + .392} = \frac{\text{UT}}{4.392}$$

$$\text{Hence: UT} = 1.57 (\text{MFT})$$

Similarly, with the 6 stall/6 unit chute, cows changed over in batches of three:-

$$\text{AWT} = \frac{\text{MFT}}{4.48} = \frac{\text{UT}}{N + .77} = \frac{\text{UT}}{6.77}$$

$$\text{Hence: UT} = 1.51 (\text{MFT})$$

In all cases it must be remembered that AWT can only be defined as the theoretical, maximum time available to complete the work routine without incurring overmilking; it is not the maximum time available to complete the work and still obtain the optimum throughput.

Any estimate of overall milking time, therefore, must be based on a Unit Time which in turn has been linked to actual WRT.

There is always some advantage from having a faster WRT. This can be demonstrated by the simple example shown in Figure 16. Here it is assumed that cows, all with the hypothetical MFT of 5.28 minutes are being milked in a 3 stall/3 unit tandem parlour with the man working at three different rates, viz.

- (a) at standard performance i.e. WRT = 1.46 minutes.
- (b) with a WRT equal to AWT, where the latter has been calculated as  

$$\frac{\text{MFT} + (\text{WRT at standard performance})}{N} = 2.25 \text{ minutes.}$$
- (c) with a WRT equal to AWT, where the latter has been calculated as  

$$\frac{\text{MFT}}{N - 1} = 2.64 \text{ minutes}$$

If all three routines had a cow ready to strip at 30.0 minutes the relative performance can be seen by referring to the times when the eighth cow would have milked out after this point, viz., at 46.4, 49.5 and 50.9 minutes respectively.

Thus, in these circumstances where all cows are said to have exactly the same milking-out times, it takes 27 per cent longer to milk cows where the routine occupied the estimated time available as opposed to doing the job at standard performance, despite the fact that in the latter the man had significant amounts of idle time. The man is also shown to have short periods of idle time under section (b) signifying the error in the usual method of estimating AWT.

Figure 16 is not intended to indicate that the 3 stall/3 unit parlour is the most satisfactory set-up under these conditions. Obviously, the productivity of the man working at standard performance would be improved here if he were given an extra stall and unit. However, it does show that, whatever the parlour, the first essential must be to instal the quickest basic routine if the best possible throughput is to be achieved. Invariably there will be some loss of productivity if the idea is fostered that there is some longer period available in which the job may be completed. In other words, to get the best possible performance at milking it is necessary to establish the time within which the man can perform his basic routine and then see that he has sufficient equipment to maintain his work pace. The problem should not be approached from the angle that with the particular equipment installed the man will have a certain time available.

This leads on to the point of the difficulty, in practice, of always operating the optimum number of units.

#### (d) Goodness of Fit

If WRT is used as a guide to the number of units which can be operated it is obvious that an exact fit between work time, number of units and milking-out times is most improbable because, not only do individual milking times vary from day to day but a 'discrete' number of units must be used. For example 3 units might be used where, theoretically,  $2\frac{1}{2}$  to  $3\frac{1}{2}$  are required. In these circumstances, although 3 units, give the best fit the man will have some enforced idle time on those occasions when more than 3 are theoretically needed, i.e. for up to 25 per cent of the milkings.

#### (3) Other Contingencies

As a general rule, dairy farmers and cowmen tend to overplay the need for dealing with other jobs which arise whilst milking is in progress but which form no part of the basic



routine. The tendency is to infer that such matters are the general rule rather than the exception and to consider that only a slack routine will allow the man time to replace the fallen, or kicked-off cluster, etc. On the contrary, the man with the good and quick work method is more likely to take any extra tasks in his stride. Nevertheless some allowance must be made for such contingencies in any estimate of overall milking time. This allowance can never be more than an arbitrary assessment and therefore has so far been excluded from our calculations. However, the overall time to milk the herd is not necessarily the time to complete the basic jobs plus the total time occupied by contingencies, because a share of the latter could be dealt with during those periods when the man would otherwise be idle.

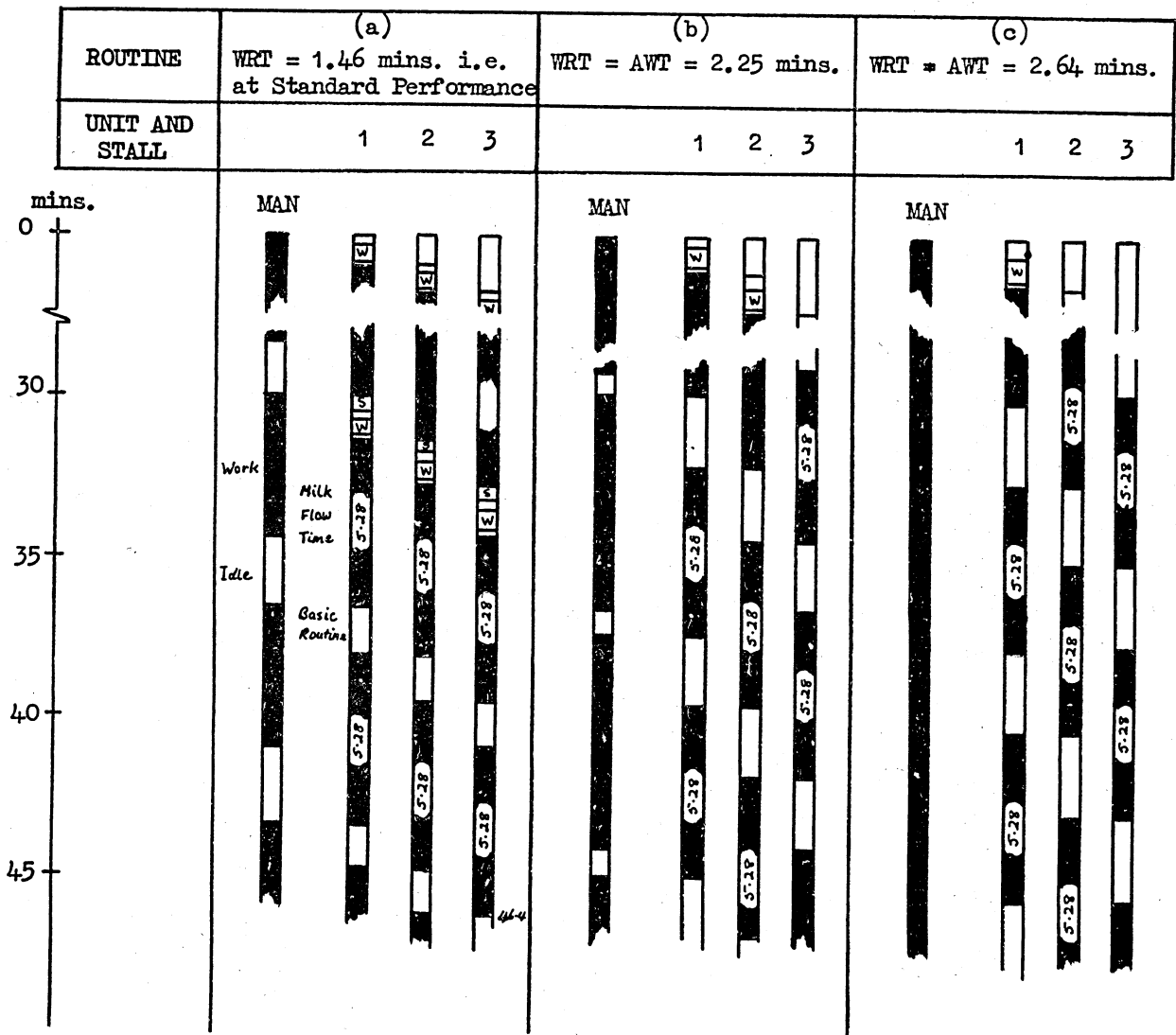


Figure 16 - Multiple Activity Chart - Extract Milking in 3 Stall/3 Unit Tandem. Milk Flow Time per cow = 5.28 mins. (No extra feeding time allowed)!

Time Required to Complete a Milking

Assuming the number of units in use is giving the best fit, (bearing in mind the WRT and average MFT of the herd), Table 5 shows the increases found in overall milking time attributable to the factors mentioned above.

TABLE 5\*

Actual Times Required (compared with Theoretical Time) to milk 41 Cows - Man working at standard performance and supplied with the number of machine units which give the "best fit" in relation to average Milk Flow Time

Type of Parlour	Stalls	Units	Effective Work Time Total	End Effect	Variation between cows	Goodness of fit	Contingencies at 10%	Actual Total	Milking Time Above Theoretical
	No.	No.	mins.	mins.	mins.	mins.	mins.	mins.	%
Tandem	3	3	60.5	3.40	4.66	8.20	4.72	81.48	34.7
	4	4	60.5	4.86	3.38	5.33	4.90	78.97	30.5
	6	3	60.5	4.84	8.65	7.79	4.44	86.22	42.5
	8	4	60.5	5.83	6.06	4.51	4.72	81.62	34.9
Chute	6	3	57.0	5.89	6.68	7.38	4.26	81.21	42.4
	8	4	57.5	8.86	1.79	4.10	4.56	76.81	33.5

\* Derived from Belshaw and Scott - op. cit.

The simple average of the extra time required in the six parlours listed is about 37 per cent. This figure compared with some 36 per cent as found from time studies carried out on six herds specifically for the report referenced.

## CHAPTER 4

### The Herringbone Parlour

If all the "good management" features of milking are included in the work routine, (e.g. washing, taking foremilk, machine stripping), and the same standard of 'quality' demanded in performing these elements, then there can be no significant difference between the productivity of the herringbone and the 2 stall/unit chute. The herringbone has some slight advantage in work place layout - the distance between udders being some 3 ft as compared with 7 ft - but this can be more than offset by the increased time required to issue feed unless more expensive, remote-controlled, issuing equipment is purchased. The times to change over a batch of cows are also similar.

Because the herringbone is generally installed to deal with relatively large herds and throughput of cows per man is considered more vital than ensuring that the routine meets all the particular requirements of each cow, some reduction in times is found to be possible for elements of work. Under these circumstances, a different "milking" job is carried out in the herringbone from that described for the other parlour types. Thus it would not be fair to use the data which follows as a direct comparison with the results for the tandem and chute. Obviously any advantages now ascribed to the herringbone could be (at least partly) duplicated in other types, if managements were willing to lower the "quality" standard demanded for such elements as machine stripping. On the other hand, the difficulties mentioned for operating the 2 stall/unit chute routine are apparent here, i.e. there is difficulty in maintaining a constant 'stimulus' time; the time needed by the slowest milker of the batch, and possibly the preceding batch, will have a direct bearing on the rate of throughput, etc.

#### Equipment and Routine

The assumed equipment and routine for a parlour operated by one man are as follows:-

Parlour: Two-sided, 1 unit/opposite standings with separate entrance to each side. Collecting yard with electric 'dog'. Pipeline milking. Stalls numbered from front to rear, odd numbers one side, even numbers the other. Front barrier hinged for vertical operation with alternative positions to fit this at other than the first stall.

Equipment: Warm water sprays for udder washing. Floor pads in lieu of strip cups. All gates/doors cord operated from working pit. Cord operated feed dispenser at each standing.

#### Basic work method and Element times at Standard Performance

<u>Brief Description</u>	<u>Minutes</u>
Wash cow (Warm spray and wipe with cloth)	.34
Extract foremilk (on to floor pad)	.08
To opposite cow	.02
Machine Strip	.25
Off cluster and across pit	.05
Apply cluster	.11
To next work place	.02
Basic Routine	.87

Machine On Time = Milk Flow Time + .25 minutes

Machine Off Time = .05 + .11 = .16 minutes

#### Changeover batch of six cows and feed

<u>Brief Element Description</u>	<u>Minutes</u>
(Time required to move cows past one work point	.04 minutes/cow
Assuming cluster applied to last cow in even-numbered stalls:-	
Pull up front barrier at stall 1	.04
Pull open exit door	.04
Drive cows forward	.05
Move to rear barrier (average distance)	.03
Open rear barrier	.04
Pull open entry door	.04
Pull in electric 'dog'	.05
Up to six cows out	(.25)
Lower front barrier	.05
Walk to position 1	.05
Close exit door	.04
Feed 1	.06
Move to 3	.02
Repeat four more times (.08 x 4)	.32
Feed 11	.06
Close entry door	.04
Fasten rear barrier	.07
To next work place	.02

Changeover batch of six and feed	(1.02 minutes)
" " " five " "	(0.94 minutes)
" " " four " "	(0.86 minutes)
" " " three " "	(0.78 minutes)
Work Routine = Basic Routine + <u>Changeover Time</u>	

	No. in Batch	
WRT = (For 6 cow batch)	.87 + .17 =	1.04 minutes
(For 5 cow batch)	.87 + .19 =	1.06 minutes
(For 4 cow batch)	.87 + .22 =	1.09 minutes
(For 3 cow batch)	.87 + .26 =	1.13 minutes

The WRT shown would theoretically provide an exact fit with MFT's of 5.83, 4.89, 3.95 and 2.98 minutes, (or, predicted average yields of 23.8, 18.0, 12.3 and 6.4 lb) in parlours with 6 units to 3 units respectively. Thus our specimen herd with 41 cows in milk, (average MFT 5.64 minutes) could be milked satisfactorily by one man in the 12 stall/6 unit, - although a larger herd would normally be expected to warrant such an installation.

A summary of the charts describing the milking is shown later at Table 6. It is assumed that the man adheres as far as possible to the standard routine, except that in this case rate of throughput is adjudged to be of greater importance than ensuring, for example, a constant stimulus time. Thus, if the occasion arises the man will try to avoid being idle by preparing additional cows to receive the cluster. This does not mean that he practises 'batch-washing'.

#### Batch-Washing

A different routine from that outlined under "Basic Work Method" is often operated to prepare cows for milking. Under this system, - which is said to be common practice in New Zealand, - the cowman washes all the cows of a batch (and extracts foremilk) before machine stripping the first cow of the preceding batch and removing the cluster. This is a deviation which naturally arises when the second batch to be milked has been let in and fed. At this point, the man will be faced with idle time which he tries to avoid. Charts show that once this deviation has been made there is encouragement to repeat it with each succeeding batch. Thus, stimulus time will never be less than the time required to wash and extract foremilk from all cows comprising a batch, plus the time to machine strip one cow. This might not appear to be too unsatisfactory if all cows were identical. However, if this were the case it could still be shown that no overall advantage accrues, because whether the "Basic Work Method" or the "Batch-washing" deviation is the general practice, the overall milking time is the same. For example, if a 41 cow herd (average MFT = 5.64 mins) were milked in an 8 stall/4 unit parlour the "optimum" time would be 67.8 mins in each case. In any case, to adhere rigidly to a batch-washing system with the random entry of the general run of cows, means that washing is no longer an effective let-down stimulus for quite half the herd, unless serious over-milking is occurring. Table 6 confirms this. Although the cowman here has only deviated occasionally from his basic work method, nevertheless 'stimulus' times of over 5 minutes have been noted.

#### Additional Characteristics of Work in the Herringbone

The satisfactory parlour must be adequate to deal with the a.m. milking at peak yield periods. Consequently, there will often be occasions, (particularly if there is a definite policy of winter or summer production) when it will be unnecessary to use all the units and stalls available. The by-passing of stalls in other types of parlour presents no great difficulty, but with the herringbone, all stalls between front and rear barriers must be occupied at milking. When fewer standings are to be used for a whole milking there is a slight advantage in change-over time if the front barrier can be moved back, rather than have the rear one, near entry door, moved forward.

The need to have all stalls occupied also affects the method of handling the last batch in. Where this is insufficient to completely fill one side of the parlour it is necessary to release from the front of the preceding batch the same number of cows that will enter with the last batch - the remaining milked-out cows being moved forward into the vacated standings. This is very convenient because the last cow in normally receives the cluster first in the conventional 2 stalls/unit parlour. It is probable, therefore, that cows forming the incomplete last batch can be dealt with immediately.

In all loose-housing set-ups the presence of bulling cows in the yard can create minor difficulties but the effective isolation of such cows once they are in a stall of the tandem or chute, minimises any trouble within the parlour. The same is not true, however, with the herringbone for with this layout it is possible for such cows to attempt to ride their neighbour whilst passing along the parlour, or even whilst standing awaiting milking. Obvious real danger is therefore involved.

This same layout can also be a disadvantage at any time when cows are scoured (lush grass, etc.). On such occasions it is possible for the operator, working pit and equipment to be fouled. This is not likely to the same degree in the other types of two level parlour.

On critical examination it has been concluded that significant reductions on the work content of the job of milking do not lie with the herringbone on the score of layout alone. Contrary to popular belief, the gains from having work points a little nearer are minor compared with the advantages often claimed. Such gains are almost entirely due to the different 'quality' of work, which, if acceptable, could be reproduced in the Chute or Tandem parlour. In fact, the element times stated above as relating to the Herringbone could justifiably be said to apply to the chute where a "short work routine" was operated.

TABLE 6 Charted Performance of Herringbone Parlour at Two levels of Yield

41 Cows Milked - All Parlours Operated by One Man

Milk Flow Times			Average 5.64 (s = 1.482 mins.)				Average 4.04 (s = 1.482 mins.)			
PARLOUR SIZE	(Standings Units)	No. No.	12 6	10 5	8 8	8** 8	8 4	6 6	6** 6	
HERD	("Optimum" Possible*		48.8	55.7	53.6	53.6	50.2	52.8	52.8	
MILKING	(Total		52.3	59.8	58.8	71.1	58.0	59.1	59.7	
TIME	(Effective Work Time		43.3	44.2	48.2	48.3	45.1	49.6	49.7	
(mins.)	(Man Idle Time - Total		9.0	15.6	10.6	22.8	12.9	9.5	10.0	
	( " " " (last work cycle)		5.9	7.2	5.4	6.6	4.2	3.2	4.2	
Cows <u>NOT</u> finished their feed -		No.	(3)	(4)	(7)	-	-	(2)	-	
MACHINE UTILISATION (mins.)	(	Total Unit Time	313.7	299.1	470.2	569.0	232.0	354.6	358.2	
	(	Milk Flow Time	————	231.4	————	————	————	165.6	————	
	(	Machine Strip Time	————	10.2	————	————	————	10.2	————	
	(	Total Effective Time	————	241.6	————	————	————	175.8	————	
	(	Per cent. Effective Use	%	(77.0)	(80.8)	(51.4)	(42.5)	(75.8)	(49.6)	(49.1)
	(	(Total Unit Idle Time	72.1	57.5	228.6	327.4	56.2	178.8	182.4	
	(	(Change Cows and feed	3.8	2.8	34.9	34.9	1.9	31.8	31.8	
	(	(Wash, extract foremilk	2.5	2.1	17.2	17.2	1.7	17.2	17.2	
	(	(Arrange, apply, remove cluster	7.0	7.0	9.4	9.4	7.1	9.4	9.4	
	(	(Prep. work at other stalls - )	9.2	6.1	50.9	57.4	3.7	33.5	34.7	
	(	(1st to last work cycles								
	(	(Overmilking	26.9	14.8	33.2	18.8	18.7	31.3	26.1	
	(	(Hanging - finishing feed	-	-	-	22.5	-	-	7.0	
	(	(Others finishing, milking, )	-	2.0	34.2	139.1	11.0	41.8	41.8	
(	(feeding etc.									
(	(Last work cycle	22.7	22.7	48.8	28.1	12.1	13.8	14.4		
OVER	(Average		0.7	0.4	0.8	0.5	0.5	0.8	0.6	
MILKING	(Maximum		3.0	2.4	3.2	3.2	2.1	2.7	2.2	
PER	(Numbers	{ > 3 mins.	-	-	1	2	-	-	-	
COW	(Overmilked	{ > 2 mins.	1	1	6	3	2	6	1	
(mins.)	(	{ > 1 min.	11	6	13	4	10	13	13	
STIMULUS	(Average		1.4	1.8			1.3			
TIME	(Minimum		0.6	0.6	0.6	0.6	0.6	0.6	0.6	
(mins.)	(Maximum		6.9	5.4			5.0			

\* Assuming all cows had identical Milk Flow Times

\*\* Feeding time allowed: 4 lb/gal. after Maintenance + 1 gal., eaten at 1.5 mins./lb.

## CHAPTER 5

### SELECTING A PARLOUR

#### General Considerations

Although labour requirements at milking time are important, they must not be regarded as the only criterion by which the right parlour to install is determined. In addition, it would be unwise to state categorically that a particular type was best under all circumstances, on the score of labour requirements alone. Other points must also be considered. For example, a first essential is to establish that a herd of particular size fits best with the overall farming plan. The installation then selected should be that which enables the most economical use to be made of all the resources available. It might well be that the set-up requiring least labour at milking was not the most economic overall, e.g. in circumstances where the opportunity cost of labour was very low or the investment of limited capital in some other way would show a better return. However, assuming that the installation should be the most effective as regards labour usage the following notes apply.

1. Because of the inevitable difficulties of balancing work load between a team, the one-man unit stands the best chance of being most efficient. Thus if the size of enterprise warrants the employment of more than one worker, generally there is an advantage if each is able to work separately. Selection then becomes a problem of choosing the most suitable type for the one-man unit - or multiples of this.

Nevertheless, some managements of large outfits may insist on a team-operated installation of the batch-entry type. In such cases some modification to this principle of separate working is necessary. Here, for example, the changeover of cows must be organised so that this task is divided as equally as possible. However, if two men share such a parlour the remaining work at milking is simplified if each starts his basic routine at opposite ends of the parlour and progresses towards his colleague.

2. The size of the selected parlour depends, ultimately, upon:-

- (a) The work routine time (WRT), which in turn will be determined by the quality of work demanded, the ability of the worker and the number of cows to be milked per man.
- (b) The milking-out time (MFT) of the cows during the herd's peak production periods.

A fair estimate of MFT, in minutes, can be obtained from two plus one sixth of the yield in lbs at a milking, i.e.  $MFT = 2 + \frac{\text{Yield in lb}}{6}$

- (c) The concentrate feeding policy.
- (d) How long milking should last.\* As this can never be less than the work routine time multiplied by the number of cows and number of machine units summed together, it either fixes, in conjunction with WRT, the maximum herd size, or determines how long is available for the completion of the work routine, and hence the quality of work.
- (e) Whether 1 unit serves 1 or 2 stalls.

#### 3. Number of units required

- (a) 2 stalls/unit Parlours (Tandem, Chute, Herringbone, Abreast)

- (i) Assuming that the standard work method is adhered to, and that the times in which the various elements of work are completed are in the same ratio as for standard performance, an estimate of the theoretical number of units (N) required to give the 'best fit', can be established as follows:

$$N = .4 + \frac{\text{Milk Flow Time}}{\text{Work Routine Time}}$$

e.g. WRT = 1.5 mins; Yield = 12 lb, i.e. MFT = 3.9 mins.

$$N = .4 + \frac{3.9}{1.5} = 3 \text{ units}$$

- (ii) However, if the machine stripping of cows were eliminated:

$$N = .15 + \frac{MFT}{WRT}$$

Thus, adjusting the above example, WRT would be reduced to 1.1 mins.

Hence:  $N = .15 + \frac{3.9}{1.1} = 3\frac{3}{4}$  i.e. 4 units would provide the best fit.

The range in MFT and WRT which will be best satisfied by a specific number of machine units is shown in Figure 17.

- (b) (i) 1 stall/unit, Tandem (or Abreast), whether or not machine stripping is practised:

$$N = 1 + \frac{MFT}{WRT}$$

Figure 18 below summarises the position.

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With work at standard performance and, dealing with cows entering in an average state of uncleanness and requiring a reasonable amount of machine stripping, it has been shown to require some  $1\frac{1}{2}$  mins on each cow. It would be pointless, therefore, for a farmer to expect a layout and system which would enable his cowman to milk, say, 65 cows within  $1\frac{1}{4}$  hours and yet still daily record, 'properly' machine strip every cow, etc. With present equipment no layout can possibly exist that will fulfil such a hope.

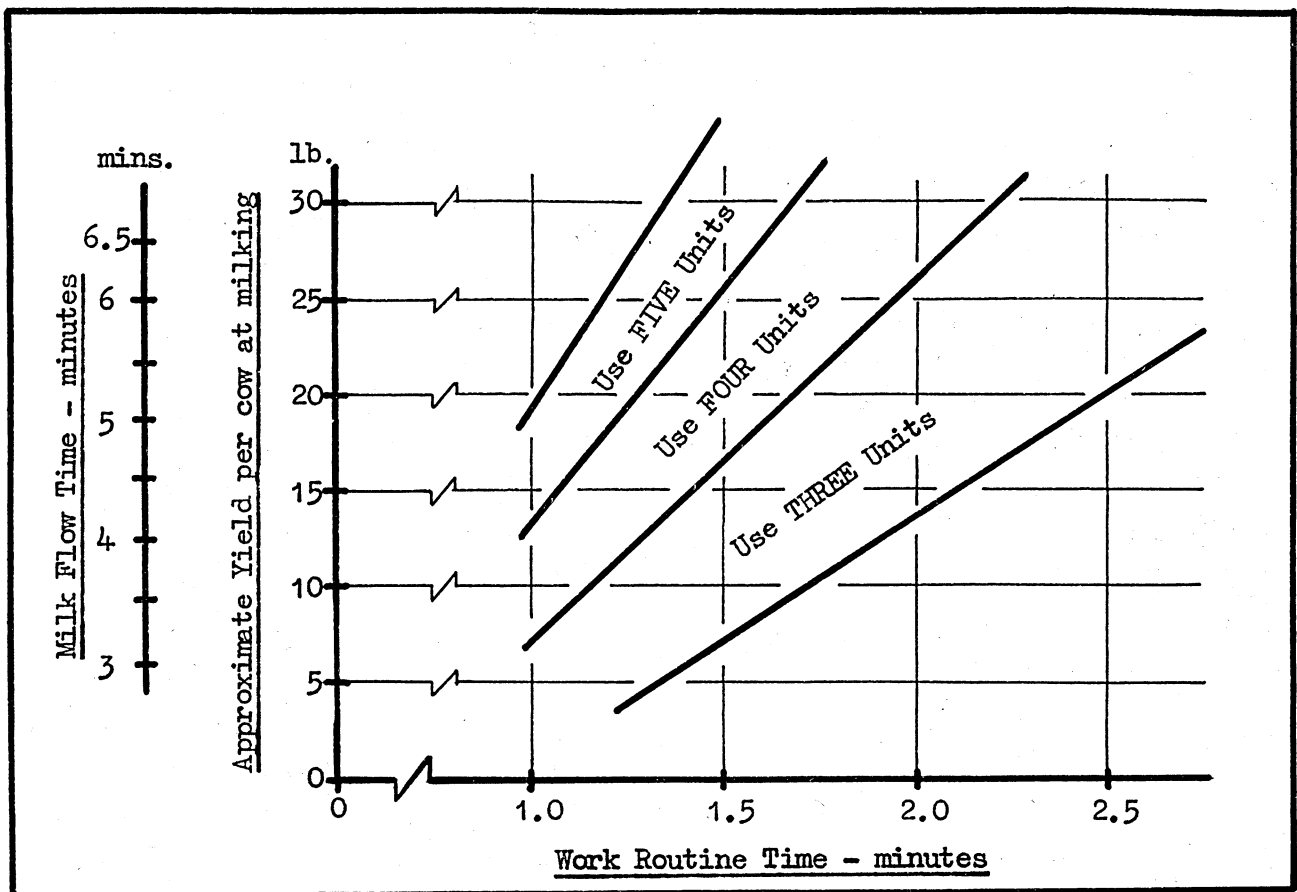


Figure 17 - Number of machine units giving 'best fit' in parlours equipped with one unit between two stalls. (One man operated)

- (ii) If concentrate feeding in the parlour has to be considered, then in some circumstances the installation of an additional unit is recommended. If the feeding policy is to obtain maintenance plus the first gallon from roughages then the extra unit would be needed above the line A-A' in Figure 18. However, if concentrates supply the whole production ration, then the extra unit would be required when yield averaged about 1 gallon at a milking.

- (c) 1 stall/unit Chute (or herringbone)

$$N = \frac{1.6 \text{ MFT}}{\text{WRT}}$$

#### 4. Type of Parlour

As shown earlier in Tables 2 and 3, there is no significant difference in rate of throughput between the various types of two level parlours as long as the standard work method is adhered to and the correct number of units are in use. Final choice of parlour should therefore be dependent upon:

- Capital cost: e.g. The batch-entry types are generally cheaper than the tandem.
- Site available: e.g. The chute fits best into a narrower building, whilst an existing building can usually be most easily adapted for use by the less efficient abreast type.
- Ease of working: e.g. The needs of the cow can be met most satisfactorily, and the worker's job is simplified if the tandem is installed with a unit to each stall, and is of sufficient size to allow heavier yielders time to consume their feed. This size will still be less expensive and require less space than the 2 stall/unit parlour of similar performance. Moreover, economies in feed are probable because the cowman will not be tempted to issue extra rations in order to keep the cow quiet, and, if cluster immersion between cows is ever specified this can be introduced with negligible inconvenience.

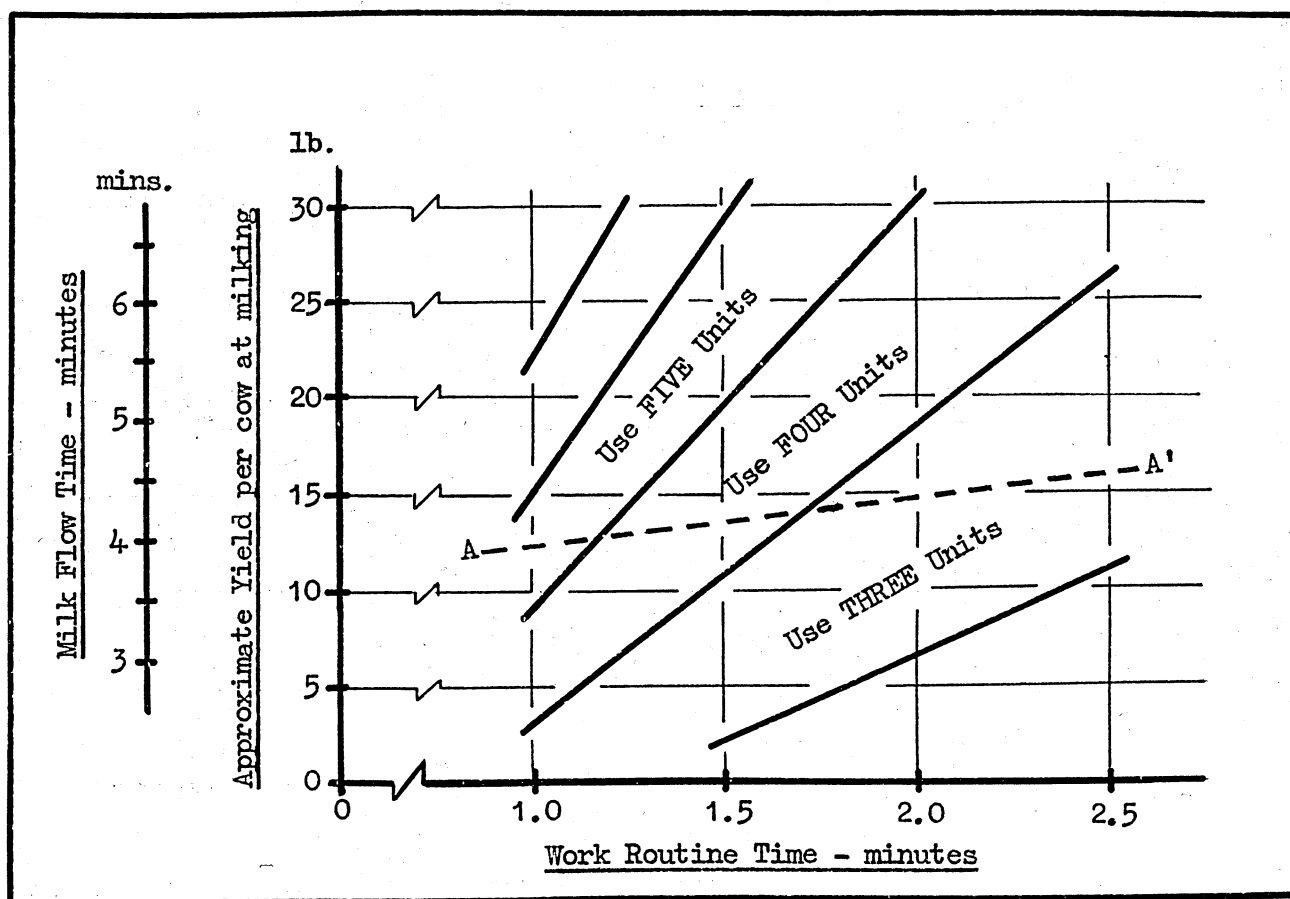


Figure 18 - Number of machine units giving 'best fit' in Tandem (and Abreast) type parlours equipped with one unit per stall. (One man operated)



## CHAPTER 6

### SUMMARY AND CONCLUSIONS

This report is mainly concerned with the results of assuming - as is realistic - that cows vary in milking-out time, time required to feed, etc. It indicates that basing routines upon 'averages' can give misleading information as to performance and work simplification. It also shows that flexibility of system is important because of this between-cow variation.

The exercise was carried out as part of a wider investigation into the economics and technical aspects of the loose-housing and parlour-milking of cows. The data presented relates mainly to modern two-level parlour layouts with pipeline milking and generally assumes that operating methods are those recommended by earlier work study investigations. Recorded data relating to a herd with 41 cows in milk has been used to demonstrate the problems which beset the milker in his work.

As long as the standard work method is adhered to there appears to be no significant difference in the work content of the job between the various types of two-level parlour. Moreover, herd milking time is similar when the same 'quality' of work is demanded and the man is equipped with the number of milking units that provide the best fit between his work routine time and the milking-out times of the cows.

In the past maximum machine utilisation has been considered of great importance. A system which includes a milking unit serving two stalls appears to meet this requirement with the added attraction that more time is allowed for the consumption of concentrates because the cow stands in the parlour whilst another is being milked. However, despite the operation of a simplified work method a much higher standard of skill is required to meet the needs of the individual cow than in the case when each stall is equipped with a separate milking unit. It is suggested that an extra unit in the latter type of parlour can be more economical, meets the needs of the cow more satisfactorily, makes work easier, reduces the opportunities for wasteful feeding and, in some circumstances could assist in the control of disease. Milking machine utilisation is of a lower order but this need not be regarded as a disadvantage.

For their validity these conclusions rely indirectly on the advice of specialists in animal physiology and hygiene as regards the conditions which must be fulfilled if the health and production capacity of the cow and the quality of milk are to remain satisfactory. However, opinions expressed by some experts are conflicting as regards such matters as the need to strip after milk-flow has appeared to stop, the adverse effects of overmilking and fluctuating let-down times and the most satisfactory vacuum level and pulsation ratios, etc.

Unless scientific evidence, as opposed to opinion, can be produced, contradicting the present idea of the dangers from overmilking and erratic stimulus times, the work study problems remain unchanged. Whatever the layout chosen successful milking will always depend upon a quick, effective work routine. However, expecting too fast a working pace could induce slipshod work with the result that the value of time saved might be less than that of milk lost.

# APPENDIX 1

Milk Flow Times and Yields per Cow at a.m. and p.m. Milkings  
for a sample of 20 herds

Code No.	No. Milked	A.M. Milking				No. Milked	P. M. Milking			
		Yield/cow		Milk Flow			Yield/cow		Milk Flow	
		Aver- age	Std. dev.	Aver- age	Std. dev.		Aver- age	Std. dev.	Aver- age	Std. dev.
		lb.	lb.	mins	mins		lb.	lb.	mins	mins
		(x)	(sx)	(y)	(sy)		(x)	(sx)	(y)	(sy)
1	41	20.34	6.46	5.64	1.48	41	15.20	5.75	4.89	1.41
2	20	13.50	7.41	3.81	1.69	20	8.55	4.67	3.04	1.07
3	36	15.31	5.06	4.28	1.04	36	12.22	6.07	3.62	1.14
4	47	14.06	6.29	4.01	1.23	46	9.48	5.22	3.39	1.06
5	19	13.00	4.56	3.96	1.15	18	7.95	3.26	3.67	0.81
6	31	13.53	6.16	5.08	2.00	23	10.87	3.36	4.09	1.31
7	43	14.30	5.15	4.41	1.18	39	8.62	3.86	3.87	1.05
8	37	18.81	7.24	5.21	1.53	33	10.55	3.79	3.99	0.88
9	16	15.13	6.43	3.84	1.11	16	9.50	3.93	3.41	0.99
10	39	11.72	5.77	4.32	2.01	39	8.54	3.46	3.82	1.43
11	48	16.40	7.02	4.30	1.47	48	11.94	5.60	3.57	1.07
12	56	13.14	4.04	4.21	1.32	54	8.46	3.57	3.23	0.98
13	59	15.02	5.51	4.38	1.69	59	10.27	4.09	3.43	1.21
14	38	13.82	5.23	3.43	1.04	38	9.39	5.02	2.95	1.16
15	16	24.12	8.01	5.26	2.30	16	17.94	6.88	5.08	2.63
16	25	13.60	4.65	3.85	0.90	25	9.60	3.38	3.19	0.91
17	31	17.52	7.42	4.57	1.41	30	10.93	4.47	3.65	1.15
18	34	12.24	3.93	3.71	0.98	34	6.53	2.44	2.69	0.77
19	69	13.19	5.51	4.28	1.28	69	9.01	3.61	3.26	0.84
20	61	16.34	7.42	4.99	1.63	61	9.79	4.36	3.65	1.09
766		15.09	6.44	4.40	1.54	745	10.11	4.86	3.58	1.24
<u>All Milkings</u>										
1511		12.63	6.23	4.00	1.46					

Regression of y on x    A.M. Milking     $y = .163x + 1.96$     ( $p < 0.001$ )  
                                  P.M. Milking         $= .162x + 1.94$     ( $p < 0.001$ )  
                                  All Milkings         $= .163x + 1.94$     ( $p < 0.001$ )

- N.B. 1. Results of regression analysis for a.m. and p.m. milkings are almost identical.  
 2. All herds milked by Alfa Laval machines with A/L2003B liners. Vacuum 15 ins. mercury. Pulsation Rate 60 p.m. Ratio 1:1.

Source: Unpublished data supplied by N.I.R.D.

## APPENDIX 2

### Standard Times to perform Elements of Work Connected with Milking in Tandem and Chute Type Parlours

TANDEM (i) 2 stall/1 unit parlours			CHUTE (i) 2 stall/1 unit parlours		
	mins.			mins.	
(a) Wash cow	.42		(a) Wash cow	.42	
Use strip cup	.15	.57	Use strip cup	.15	.57
(b) To next/opposite work place	.02	.02	(b) Move to opposite work place	.02	.02
(c) Open parlour door	.03		(d) Machine strip cow	.40	
Open rear gate to stall	.03		Off cluster and across	.05	.45
Shut parlour door as next cow enters passage	.05	.11	(e) Apply cluster	.11	.11
(d) Machine strip cow	.40		(b) Move to adjacent/opposite work place	.02	.02
Off cluster and across	.05	.45	(c) Open all gates and parlour door simultaneously	.03	
(e) Apply cluster	.11	.11	Drive out 4 cows and let in 4 more	.24	
(b) To opposite cow	.02	.02	(or - do - 3 cows	.16	
(f) Open front gate	.03		(or - do - 2 cows	.12	
Issue feed	.06		Shut gate No. 7	.04	
Close front gate	.03		Put in feed No. 7	.06	
Close rear gate	.03		To next place	.02	
Change cows in stall	x	.15	Shut gate No. 5	.04	
(b) To next work place	.02	.02	Put in feed No. 5	.06	
Work routine time		<u>1.45</u>	To next place	.02	
(ii) 1 stall/1 unit parlours			Shut gate No. 3	.04	
(a) Wash cow	.42		Put in feed No. 3	.06	
Use strip cup	.15	.57	To next place	.02	
(e) Arrange cluster	.06		Shut gate No. 1	.04	
Apply cluster	.11	.17	Put feed in No. 1	.06	
(b) Move to adjacent/opposite work place	.02	.02	Shut rear gate/parlour door	.02	
(d) Machine strip cow	.40		C2 changeover 2 cows	.40	
Off cluster and hang	.06	.46	C3 " 3 cows	.56	
(c) Open front gate	.03		C4 " 4 cows	.76	
Open rear gate	.03		C5 " 5 cows	.95	
Open parlour door	.03		Work routine time (approx.)		<u>1.36</u>
Put in feed	.06		(ii) 1 stall/1 unit parlours		
Shut front gate	.03		(a) Wash and strip cup	.57	
Shut parlour door	.03		(c) Arrange and apply cluster	.17	
Shut rear gate	.03	.24	(b) To next/opposite work place	.02	
Work routine time		<u>1.46</u>	(d) Machine strip and hang cluster	.46	
			(b) To next work place	.02	
			(e) Changeover/feed cows (as for 2:1 chute)	x	
			Work routine time (approx.)		<u>1.43</u>

# APPENDIX 3

## Order of Entry of Cows into Milking Parlour

List No. of Cow	Order of Entry from Random Selection No.				Daily Yield	Milk Flow Time (a.m.)	Approx. Feeding* Time Required	Modified a.m. Yield and Milk Flow Time (Av. = 4.04 mins., std. deviation = 1.48 mins.)	
	1	2	3	1A				mins.	Feed Time* mins.
1	39	33	30	16	70	8.2	18	6.6	11
2	12	17	28	25	37	3.7	8	2.1	5
3	17	5	36	6	70	9.7	18	8.1	11
4	25	36	25	9	39	7.4	9	5.8	5
5	40	27	3	40	32	5.4	7	3.8	3
6	23	18	17	8	41	5.0	9	3.4	5
7	30	15	27	11	37	5.7	9	4.1	5
8	9	24	35	23	24	4.2	4	2.6	2
9	7	40	29	21	23	4.3	4	2.7	2
10	36	8	38	14	52	5.5	13	3.9	8
11	41	22	24	41	29	7.0	6	5.4	3
12	21	30	21	30	32	5.0	7	3.4	3
13	2	13	16	17	30	5.6	6	4.0	3
14	10	9	9	3	38	5.1	9	3.5	5
15	20	25	13	29	33	5.4	7	3.8	4
16	38	38	6	15	49	6.4	12	4.8	7
17	6	26	15	20	30	7.0	6	5.4	3
18	4	11	8	19	30	4.1	6	2.5	3
19	26	29	31	33	31	3.6	6	2.0	3
20	34	34	20	13	42	9.9	10	8.3	5
21	28	14	2	10	43	5.4	10	3.8	6
22	33	23	14	37	28	4.3	6	2.7	3
23	18	20	7	7	47	7.9	11	6.3	7
24	1	1	1	1	43	6.0	10	4.4	6
25	5	21	26	2	47	5.4	11	3.7	7
26	29	32	4	35	36	4.0	8	2.4	4
27	32	1	22	36	28	4.3	6	2.7	3
28	31	35	19	12	43	6.7	10	5.0	6
29	15	12	5	5	49	6.5	12	4.9	7
30	16	31	33	27	30	5.7	6	4.1	3
31	13	2	23	4	38	6.5	9	4.9	5
32	24	37	39	32	27	4.7	6	3.1	2
33	27	3	10	34	31	4.8	6	3.2	3
34	3	19	41	18	29	3.4	6	1.8	3
35	14	6	32	26	34	5.7	8	4.2	4
36	35	4	11	38	13	4.2	1	2.6	-
37	37	28	12	39	29	6.1	6	4.5	3
38	22	10	34	31	32	5.5	7	3.9	3
39	19	16	37	28	10	5.5	-	3.9	-
40	11	39	18	24	33	5.8	7	4.2	4
41	8	7	40	22	18	4.8	3	3.1	1

\* If fed 4 lb./gal. after maintenance + 1 gallon; consumption rate approximately 1.5 min./lb.

# APPENDIX 4

## Operating a 6 Stall/6 Unit Chute Parlour

(Having placed cluster on cow in stall 5 to complete the work in stalls 1, 3 and 5)

	<u>Standard Time</u> (mins.)	
Move to stall 2		.04
Machine strip cow at 2	.40	
Hang up cluster	<u>.06</u>	.46
Move to stall 4		.02
Machine strip cow at 4	.40	
Hang up cluster	<u>.06</u>	.46
Move to stall 6		.02
Machine strip cow at 6	.40	
Hang up cluster	<u>.06</u>	.46
Open all gates and parlour door	.03	
Drive out 3 cows and let in 3 more	.16	
Shut gate at No. 6	.04	
Put in feed at 6	.06	
Move to 4	.02	
Shut gate at No. 4	.04	
Put in feed at No. 4	.06	
Move to 2	.02	
Shut gate at No. 2	.04	
Put in feed at No. 2	.06	
Shut rear gate/parlour door	.03	
Changeover 3 cows	<u>x</u>	.56
Wash cow at stall 2	.42	
Use strip cup	<u>.15</u>	.57
Pick up/arrange cluster	.06	
Apply cluster	<u>.11</u>	.17
Move to stall 4	<u>.02</u>	.02
Wash cow at 4	.42	
Use strip cup	<u>.15</u>	.57
Pick up cluster	.06	
Apply cluster	<u>.11</u>	.17
Move to stall 6	<u>.02</u>	.02
Wash cow at 6	.42	
Use strip cup	<u>.15</u>	.57
Pick up cluster	.06	
Apply cluster	<u>.11</u>	.17
Standard time to complete work on batch of 3 cows		<u>4.28 mins.</u>
Equivalent to work routine time of		<u>1.43 mins. per cow</u>

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