JOURNAL AND PROCEEDINGS OF THE

INSTITUTION OF AGRICULTURAL ENGINEERS

VOL. 16 NO. 2 - APRIL 1960

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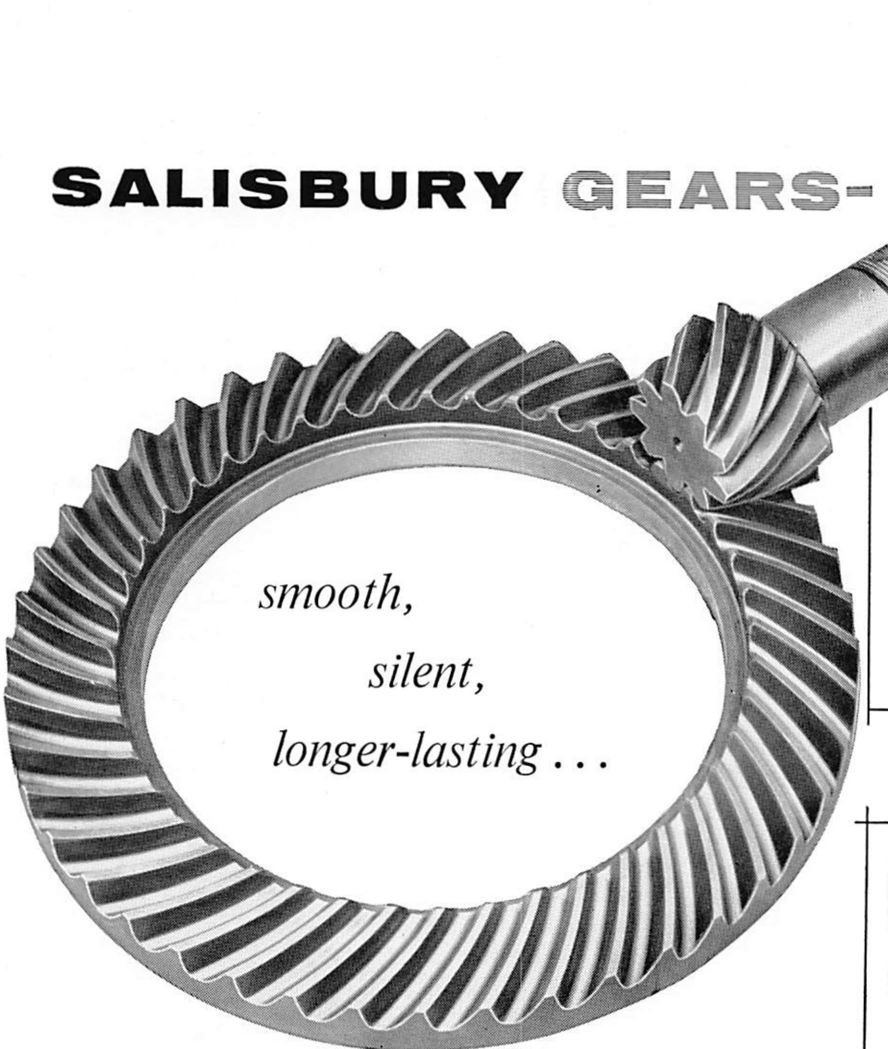

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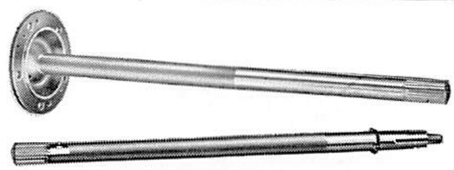

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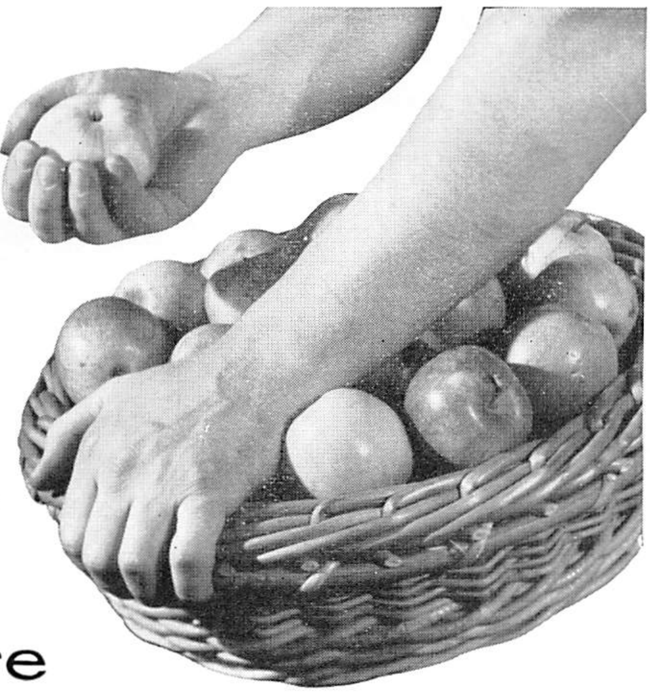

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JOURNAL AND PROCEEDINGS OF THE INSTITUTION OF AGRICULTURAL ENGINEERS

VOLUME 16 - NUMBER 2 - APRIL, 1960

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INSTITUTION NOTES

Submission of Papers

IN earlier issues of the Journal, reference has been made to the willingness of the Council to consider Papers submitted for possible presentation at Open Meetings and subsequent publication.

Further consideration has recently been given to the matter, and it has been decided to inaugurate a premium or premiums for award to the authors of the best Papers received.

Further details will be announced in due course, but meanwhile members who feel they have material likely to be of interest and value if published are invited to submit manuscripts. Papers submitted by non-members are also eligible for consideration.

Copies of the Institution's " Notes for the Guidance of Authors," outlining the requirements for Papers, may be obtained from the Secretary.

Conference on Bulk Handling

A Conference on Bulk Handling on the Farm, organised by the Scottish Branch and held at Perth on April 9th, attracted an audience of nearly 300. Papers on the bulk handling of potatoes, feeding stuffs and fertilisers were presented by Mr. J. Arbuckle, Chairman of the Machinery Committee of the Potato Marketing Board ; Col. J. F. Cramphorn, immediate Past President of the Association of Corn and Agricultural Merchants ; and Mr. R. T. Drysdale and Mr. D. C. Hamilton, of S.A.I., Ltd.

The Conference, under the Chairmanship of Mr. G. R. Reekie, Chairman of the Branch, was opened by the President, Mr. W. J. Nolan.

At the Annual General Meeting which followed the Conference, Mr. G. S. Bowman, a former Honorary Secretary, was elected Chairman of the Branch in succession to Mr. Reekie.

The Guest of Honour at the dinner which wound up the proceedings was Mr. A. A. Thornbrough, President of the Massey-Ferguson organisation.

Written Discussions on Paper

Attention is drawn to the summary of a Paper by W. H. Boshoff and D. Innes, appearing on page 47. The full Paper will appear in the next issue of the Journal, with appropriate written contributions.

The Council consider that the procedure will enable more members to take an active part in discussions on subjects of particular interest to themselves, and hope that they will take advantage of this opportunity.

National College of Agricultural Engineering

A full meeting of the Board of Governors, under the chairmanship of Sir Gilbert Flemming, is to be held on May 9th. The Minister of Education, in response to a question in Parliament recently, said it was hoped that the College would be functioning in two years' time.

Membership Certificates

Certificates are now available and may be obtained upon application to the Secretary. As a service to members, arrangements have been made to provide the Certificates already framed for those who so wish. The charge for this service, including postage and packing, will be 15/-. Unframed Certificates will be provided without charge.

Members are reminded that the Certificates remain the property of the Institution.

Portrait of the Founder President

As a mark of appreciation of the services of the Founder-President of the Institution, past and present members of the Council commissioned a portrait of Lt.-Col. Philip Johnson. The portrait, which was presented to the Institution by the President at the Annual Luncheon, will hang permanently in the Council Room.

Lt.-Col. PHILIP JOHNSON, C.B.E., D.S.O., M.I.Mech.E., Hon.M.I.Agr.E.

FOUNDER-PRESIDENT OF THE INSTITUTION

This portrait by RUSSELL REEVE, R.B.A., was presented
by past and present members of Council 1938-1960

NEW METHODS OF SILAGE HANDLING

by F. S. MITCHELL, B.Sc.

A Paper presented at an Open Meeting of the Institution, on Tuesday, 12th January, 1960.

Introduction

IN this country the accepted method of handling silage has been by means of a rear-mounted buckrake. Its popularity is based on the fact that it is a cheap method in terms of capital outlay, and that it fits in admirably with an equally low capital cost system of storage. From a handling point of view, its chief merit lies in the continuity of the process ; the grass is picked up from the swath, transported and deposited in the storage receptacle without having to be removed from the buckrake, and as a result the buckraking system divides itself into a number of self-contained units. It is a method suitable for small-scale operations, while at the same time being equally suitable for large-scale production by the simple multiplication of the individual units without creating any tremendous problems in co-ordination.

The disadvantages of the system are, firstly, that the grass has to be cut by a previous operation before it can be picked up, and secondly, since the buckrake will only deal satisfactorily with long material, the grass is in a fairly advanced stage of maturity. Thus, by virtue of its maturity and length, consolidation of the grass becomes a major problem at the point of storage. Also, if the system is to be used to its best advantage as a continuous flow process, then the storage receptacle must be in a horizontal form with the exposure of a large surface area in relation to total bulk, with the risk of major fermentation losses and wastage.

Finally, the output per man is comparatively low ; according to a N.A.A.S. survey, the overall cost being in the region of 81 man minutes per ton[1].

Flail-type Harvester

The introduction of the flail-type harvester in the last few years has been readily accepted by a large number of farms as a satisfactory method of handling the silage crop. This system is not without some merit, in that the same N.A.A.S. source[2] shows that on average only 36 man minutes are required per ton for the complete operation of harvesting and ensiling. Nevertheless, difficulties have been encountered in practice in making this system any more productive in terms of overall output than by using an efficient technique of buckraking. The purpose of this Paper is to discuss some of these problems and to suggest ways by which they might be overcome.

Harvesting

From a materials handling point of view, one of the difficulties is the quantity of material that has to be handled both in and out of storage in relation to that which can be effectively utilised by the animal. Since most of these flail-type harvesters are designed to cut and load direct without allowing a period for the grass to wilt, for every ton of dry matter ensiled it is necessary to transport an additional 3 tons of water with grass at 75% moisture.

Recent work[3] produced by the Grassland Research Institute indicates that at a comparatively early stage in the development of the plant digestibility is at its highest, and although beyond this stage total crude protein may increase, the proportion of digestible protein will diminish. The tendency in the future may therefore be to cut the grass at a stage younger than it is cut at the moment so that direct cut and loaded grass will be ensiled at moisture contents nearer 80% than 75%, entailing the movement of 5 tons of material for every ton of dry matter conserved.

So far as the total weight of material to be handled is concerned, the removal of water by wilting before loading is of no mean importance. For example, in conserving 30 tons of dry matter as 100 tons of silage at 70% moisture, the saving would be the transport and handling costs on 50 tons of water compared to direct cutting and loading the same weight of dry matter in silage with a moisture content of 80%. If, on the other hand, the grass had been wilted to 65%, the saving in this case would be on 75 tons of water.

Taking the N.A.A.S. figure of 36 man minutes per ton to harvest and ensile one ton of silage by flail-type harvester, wilting the grass to 65% would entail a saving of around 45 man hours for the conservation of 30 tons D.M. Against this must be set the time taken to cut the grass, and at 12·6 man minutes per ton for 175 tons of grass at 80% moisture would absorb approximately 35 of the 45 man hours, leaving a seasonal net saving of 10 man hours only.

On the other hand, average figures show that it takes about 90 man minutes per ton to cut, load, transport and distribute grass from a pit silo or clamp[4]. Reducing the intake of water by 75 tons would mean a saving of approximately 112 man hours over the feeding season, while at the same time still presenting the same weight of dry matter to the animal.

There are, however, other advantages in wilting grass for silage. Work[5] carried out at the National Institute for Research in Dairying has shown that where the grass is wilted the chances of making a good-quality silage are much enhanced, especially where it is either lacerated or chopped.

In comparative trials carried out in America with tower silos[6] the estimated seepage losses of dry matter were 8–15% with silage at 80% moisture, 5–8% at 75% moisture, 1–2% at 70%, and about 1% at 65% moisture.

In addition to these losses, there are, of course, fermentation losses in the silo itself and losses in the field due to respiration during wilting and to the mechanical inefficiency of the pick up.

The difference of 13% in Table I is the equivalent of 4·5 tons of dry matter in the making of 100 tons of wilting silage at 65% moisture. Reverting to the figures quoted earlier in the Paper, the conservation of 175 tons of wet grass at 80% containing initially 35 tons dry matter would ultimately yield only 25·2 tons for feeding purposes, whereas the same grass wilted to 65% moisture would finally yield 29·75 tons.

How much these figures, however, would apply to conditions in this country is a debatable point at the moment. Although there are innumerable published figures comparing the losses from wilted and unwilted grass in the silo itself, none are so far available that

TABLE I

	Wilted	*Unwilted*
Moisture content ..	65%	80%
Fermentation loss ..	12%	15%
Field loss	3%	—
Seepage		13%
Total loss	15%	28%

include respirational and mechanical pick-up losses during the period of wilting in the field. Extrapolating from our own work[7] our wilting loss in connection with early cut grass for hay, the figure of 3% quoted for field loss would appear to be extremely low. It could well be, and there is a certain amount of experimental evidence to substantiate this, that under adverse wilting conditions the dry matter losses accrued in the field could well outweigh the high seepage losses encountered where the grass is ensiled without wilting.

Nevertheless, from the weight of material to be handled, from the saving in labour and the possibility of the greater recovery of dry matter, there is sufficient evidence to suggest that in the design of future forage harvesters these must contain some provision to allow the grass to be wilted as far as is practicable under our climatic conditions.

The majority of flail-type harvesters in this country are designed primarily to cut and load direct, and although a number have been demonstrated and used to pick up grass from the swath, there is no substantial evidence to indicate the extent of the losses that may occur. The flail as a cutting mechanism has proved to be extremely popular, not only because it can deal with a wide range of crops, but because it has a high rate of working and cuts without any apparent effect on the recovery of the crop, and has proved in many instances, so far as forage crops are concerned, to be superior to the reciprocating knife type of cutter bar. It may well be that the rotating flail will be the mower of the future, and the forage harvester will revert to an orthodox-type pick-up feeding into a lacerating or chopping mechanism before elevation.

Power and Output

Although tractors of a high power output are accepted as standard units on many farms, the output from a flail-type harvester can be very low compared to the amount of power consumed. It has been shown that anything up to 40-h.p. can be consumed at the power take-off to give an output of 10 tons per hour, although the relationship between total power input and the output of the harvester is not linear.

Work carried out at the N.I.A.E.[8] has shown that a considerable proportion of the horse-power available at the p.t.o. is consumed in rotating the flails under no load. Calculations made on this data indicate that the relationship between rotor speed and the " no load " horse-power consumed is curvo-linear in nature and at relatively high rotor speeds the " no load " horse-power requirement may be as high as 27-h.p. Further calculations on this data have shown that at any one rotor speed there is a straight line relationship between the maximum output of a forage harvester in tons per hour and the residual horse-power available ; *i.e.*, the total horse-power available at the p.t.o., less the " no load " horse-power requirement at that particular rotor speed. There is some evidence to suggest that the actual speed of the rotor may influence output to some extent ; the higher the speed at which the flails are rotated the higher the output per unit of residual horse-power. This increase, however, appears to be very insignificant compared to the reduction in residual horse-power brought about by increasing the rotor speed.

At this stage it is not proposed to discuss these equations quantitatively because further work is necessary to establish the effect of different types of crop and of different facets of design within the machine itself. However, it is fully anticipated that it will only be the magnitude of the relationship and not its nature that will be affected by these other considerations.

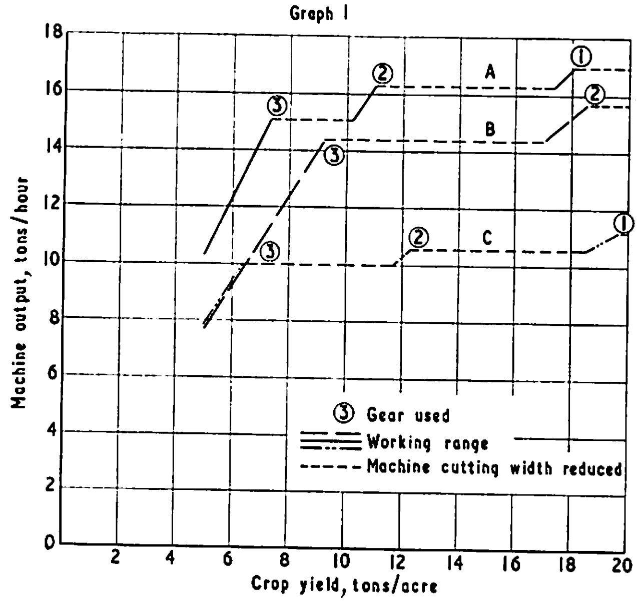
While the maximum output of the harvester is governed by the residual horse-power available, the actual output is controlled by crop yield, width of cut of the machine, and the forward speed of the tractor.

At a constant rotor speed, not only is the residual horse-power and therefore the maximum output of the harvester fixed, but so also is the forward speed of the tractor in each of the gears available, so that within the maxima laid down by availability of power it is the crop yield in combination with width of cut or crop input that determine the actual output of the harvester.

Table II shows for three different makes of tractor used with the same harvester the restrictions placed on

Calculated Output for Forage Harvester

Graph I



maximum output and on the forward speed of the tractor by keeping to a constant p.t.o. speed of 580-r.p.m.

The relationship between these figures and crop yield are given in Graph I.

Taking Tractor A as an example, the Table shows that with a p.t.o. speed of 580-r.p.m. in third gear the residual requirement, without necessarily increasing total power, is to make available a greater proportion as " residual " horse-power which can be put to effective use.

Work carried out in America[9] has compared the horse-power requirement of a number of makes of forage harvester at two levels of output.

TABLE II

Tractor type	Forward speed m.p.h. at 580 p.t.o. r.p.m.			Total h.p. at 580 p.t.o. r.p.m.	H.P. available after deducting draught h.p.			Max. attainable output (t./hr.) in gears			Max. attainable cutting widths, ins.	Width to which cut should be reduced before engaging lower gear	
	1	2	3		1	2	3	1	2	3		From 3 to 2	From 2 to 1
A	1·75	2·77	3·88	41	39	38	36	17·0	16·3	15·1	53	38	34
B	1·06	1·59	2·91	39	38	37	35	16·3	15·7	14·4	53	29	—
C	1·07	1·60	2·94	31	30	29	27	11·2	10·6	10·0	53	29	35

horse-power is equivalent to a maximum output of 15·1 tons per hour and the forward speed of the tractor to 3·88 m.p.h. The graph shows that this maximum output is not attained until the crop yield reaches 7·3 tons per acre. Up to this point crop yield is the limiting factor to output.

A crop yield of 9 tons per acre at full cutting width and at 3·88 m.p.h. is beyond the capacity of the forage harvester. Engaging a lower gear and at the same time maintaining the correct power take-off speed raises the potential output of the harvester to 16·3 tons. The forward speed, however, has been reduced to 2·77 m.p.h., so that with a 9 ton per acre crop the maximum possible input is only 13·4 tons per hour, which is below the 15 tons per hour obtained with a lower crop yield and the higher forward speed.

In order to obtain maximum output from the harvester under these circumstances, it is necessary to remain at the higher speed of 3·88 m.p.h., and as crop yield increases to reduce the width of cut to adjust the input of grass to the equivalent output of 15 tons per hour until such time as the crop yield will allow the input to be the same as that obtained when the lower gear is engaged. In this example the change-over from third to second gear would take place at a crop yield of 10·2 tons per acre, by which time the cutting width will have been reduced in the higher gear to 38 ins. from a maximum of 53 ins.

The graph also shows the effect of crop yield on the output of the same forage harvester associated with a tractor of comparable horse-power to tractor A, but with different gear ratios, and of a tractor of lower horse-power.

Since the flail-type harvester absorbs so much of the available horse-power as " no load," the obvious future

From Table III it will be seen that the output per unit of horse-power available at the p.t.o. is considerably higher for the Allis Chalmers fitted with a cylindrical chopping mechanism than it is for either of the flail-type harvesters or indeed for the two harvesters fitted with chopping mechanisms of the flywheel type.

Also, the fitting of a separate engine would do much to maintain actual outputs nearer to that of the potential of the harvester. The tractor becomes a towing vehicle and can therefore adjust its speed more readily to crop conditions, thus maintaining the correct input for the available " residual " horse-power. Alternatively, a tractor with a larger number of gears than the tractor A of the example would make a contribution in this direction.

These points cannot readily be substantiated by evidence from this country, but one example was recorded of a forage harvester of the cylindrical chopping type fitted with its own engine of about 30-h.p. giving a net output of 26 tons per hour in a 17 ton per acre crop. It is not known how much of this horse-power was being used, but it compares very favourably with the example of the flail-type harvester quoted in the graph. At a yield of 17 tons per acre, this machine will give an output of 16·3 tons per hour at a cost of around 38-h.p. in order to do so.

TABLE III

	Lundell Standard		Lundell Economy		Allis Chalmers Cylinder Type		Case Flywheel Type		Gehl	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Length of chop	2·00		2·94		2·25		1·02		0·79	
Feed rate, 8·0 tons per hour	23·5	(12·8)	15·5	(19·4)	6·5	(46·1)	19·0	(15·7)	14 5	(20·7)
Feed rate, 13·4 tons per hour	34·5	(14·5)	19·2	(26·1)	10·2	(49·0)	28·5	(17·6)	22·0	(22·7)

Unloading

Another disadvantage of the current design of flail-type harvester is that it lacerates the material only with the result that the bulk of material differs very little in length from the original material. Even where chopping does take place there is a considerable lack of uniformity in the actual length of chop. From a conservation point of view, laceration is particularly good as regards consolidation, but it is just this tendency to consolidate without at any stage an inclination to " flow " that makes it so unsuitable for mechanical handling.

While the flail-type harvester has done much to speed up the harvesting of the crop in the field, it has done nothing to ease the problem of getting the material into the silo. Compared to the way in which the buckrake was used originally, the present system of tipping a trailer load of forage harvested material on to a concrete slab and then picking it up with the buckrake in order to get it into the silo can be regarded as a retrograde step.

According to an N.A.A.S. survey[2], this operation takes 14·6 man minutes per ton, but what is, perhaps, most important is that the overall rate of working is only in the region of 8 tons per hour. While such a system appears to cope with the average overall output of the majority of flail-type harvesters as used in practice, it would seem to be a limiting factor if the field machines were being operated at anything like their full capacity.

Evidence available in this country indicates that if grass is to be handled satisfactorily by mechanical means it must be chopped in comparatively short lengths of reasonable uniformity. In a fully mechanised system in which the grass is conveyed direct from the trailer into the silo, then the grass should be chopped in the field to take full advantage of its bulk handling capabilities in that form. Lacerated grass can be loaded into the trailers in the field as readily as when chopped, but only in that form can it be fed from self-emptying trailers of the moving floor or chain and slat variety into a mechanical conveyor or blower. Forage harvester blowers have not readily been accepted in this country, largely because of their size, power requirement and because, in its absence, the blower usually proved to be the bottleneck in the silage handling systems. With a different outlook on the use of power and with changes in both trailer and blower design allowing the grass to be fed into them mechanically from the trailers, there is no reason why they should not become more popular. Uniformity of feeding is one of the prime requirements in the successful operation of a high output blower.

In many instances mechanical conveyors could be used with advantage, especially if they were designed, not as general purpose implements, but for the specific job in hand, as is done in many instances with grain drying and storage installations.

It is claimed[10] that a 42 ft. elevator set out 18 ft. from the bottom of the silo will elevate into a silo 35 ft. high. A conveyor with 2 × 4 in. cross-slats fastened to a single malleable chain travelling at 260 f.p.m. and using a 5-h.p. electric motor has ample capacity to deal with the average output of a field forage harvester working steadily.

In the example quoted above, using a cylindrical chopping-type forage harvester, the self-emptying trailer fed the grass direct into a blower at a net rate of 18½ tons per hour, a 4-ton trailer being unloaded in approximately 13 minutes. A tractor of about 30-h.p. was used to drive the blower and a separate 2-h.p. engine to operate the self-unloading trailers. For the complete operation of both field and silo work the overall time requirement for a team of four men was 11·6 man minutes per ton.

Organisation

The introduction of the forage harvester has increased the problems of management, both as regards maintaining the efficiency of each individual unit and in the co-ordination of these units. It is not proposed, however, to deal with this aspect of forage harvesting in this Paper, as it has already been the subject of a Paper presented this year to one of the branches of the I.A.E.

Storage

The accepted method of storage at the present time is either in pits, surface silos or clamps. While the high losses normally associated with these methods of storage may be acceptable when grass at a comparatively advanced stage of maturity is being used, it is not anticipated that this will remain the case when younger and more nutritious material is being ensiled.

A survey[14] carried out in the South-West of England showed that of 78 pit silos examined 27% had a wastage of 25% or over, whereas of 40 stacks examined 40% had an equivalent or greater amount of wastage.

An analysis of the forms of wastage showed that top wastage amounting to an average depth of 14 ins. was the most common form, with waste at the bottom due to inadequate drainage and waste at the sides of the silos being next in that order of importance.

These figures emphasise the importance of an air-tight construction with some form of roof to exclude rainwater. Top waste was in all cases the result of failure to seal the oils effectively immediately filling was completed, whereas side wastage was invariably due to the seepage of rainwater down the side-walls bringing in with it a fresh supply of oxygen. Adequate consolidation of the centre of the silo is of vital importance to prevent the silage, on settling, pulling away from the sides of the silo wall.

Overheating, although rare, was entirely due to the use of over-mature and dry material, and as a result the impossibility of obtaining adequate consolidation. Consolidation at the time of filling should aim at leaving only sufficient air in the silage to allow the requisite amount of fermentation to take place and to exclude excess air which will carry the process too far. At the same time, consolidation is necessary to restrict ingress of air and water during the storage period, as both will give rise to wastage. Unfortunately, it is impossible to define adequate consolidation in accurate quantitative terms.

Chopping or lacerating the material will give a certain amount of consolidation automatically as weight for weight chopped material occupies about one-third less volume than material in the long state. It is extremely doubtful, however, if this by itself, because of the lack of depth in horizontal silos, is enough to prevent excessive fermentation. A recent innovation is to cover the horizontal-type silos with polythene sheeting, and this, in conjunction with chopped material, may have the desired effect. American work[6] has indicated that with a horizontal silo with air-tight sides and with a polythene cover placed on top immediately after filling and at each intermediate stage the overall losses are very much the same as in a tower silo containing wilted grass, provided that in the horizontal silo unwilted material is used and that filling has been carefully carried out.

Difficulties as regards adequate consolidation arise when the material has been wilted, and there is a greater need to take precautions to exclude as much of the air as possible. It has been shown[12] that with chopped material at 70% moisture the density of the material in the top 12 ins. of a silo is in the region of 18·5 lb. per cubic foot, whereas at 10 ft. it is 35 lb. per cubic foot. Generally speaking, density is a function of moisture content. In other words, if chopped material is blown into a silo and allowed to settle naturally, the silo when full will contain approximately the same amount of dry matter, irrespective of the moisture content of the material, but, of course, the wetter the material the greater the weight to compress the material underneath. For comparatively shallow silos such as pits, it would appear beneficial at this stage to load it with unwilted or only slightly wilted material so that the proportion of unconsolidated or only partially consolidated material is reduced to a minimum.

Tower Silos

Tower silos, by virtue of their small surface area in association with their very much greater height, overcome much of this difficulty of consolidation, the density of silage[12] at the bottom of a 30 ft. tower being 59 lb. per cubic foot, and at 40 ft. 67·4 lb. per cubic foot. As a result, more silage can be stored in a tower silo than in a horizontal silo of equal volume. In a horizontal silo, for example, 10 ft. in height, the mean density of the silage is around 27·3 lb. per cubic foot for material at 70% moisture, whereas in the 40 ft. tower silo it is 47 lb. per cubic foot.

In general, wastage[11] is lower in the tower silo. In the survey referred to earlier of the 20 tower silos examined 95% had 5% or less wastage, with none as high as 25%.

It can be accepted that if tower silos are well constructed with air-tight sides the only source of wastage will be in the top few feet, and that with chopped material far fewer precautions need be taken than with the horizontal silo to produce a good-quality fermentation and silage.

Trials have shown that seepage loss from tower silos is greater with unwilted than with wilted, thus suggesting that preference should be given to wilted silage, although, as pointed out earlier, this is not necessarily the case when field losses during the wilting period are also taken into account.

How important it is to seal these tower silos has not yet been established for conditions in this country. It is essential to have a roof over them to keep out rain and snow, but with grass ensiled at between 70 and 80% moisture the losses obtained in the top layers only may be economically justified in themselves. On the other hand, it may still be necessary to seal these silos with a polythene sheet in the same way as with the horizontal silos.

For the general run of silage made in this country it would not, at this stage, appear necessary to go as far as the hermetically-sealed silo in order to keep losses at a reasonable level. Where the grass is in the long state, fairly mature or has been wilted down to between 50 and 55% moisture, and there is a considerable risk of overheating, then it would appear that a considerable benefit would be derived from ensiling the material in a hermetically-sealed silo.

Until such time as it is possible to wilt young grass of high nutrient content down to 50% without risk of serious loss in the field, then it would appear that the standard design of steel tower silo with or without a polythene covering over the silage itself will meet the requirements of most users in this country.

Where steel is used in contact with silage it is necessary to protect it in some way other than by galvanising. Vitreous enamel is used in the hermetically-sealed silos, but trials are going on to see if the same protection and life can be obtained with cheaper plastic coatings.

Unloading

Self-feeding, where suitable facilities are available, is regarded as the most economic way of getting the silage out of a horizontal silo, but it is possible that the wastage, both direct and in animal utilisation, may become too great to justify its continuance with high-quality silage.

Where the grass has been chopped, considerable success has been achieved by using a front end loader and manure fork. In this case, only the minimum of cutting is required, and the silage can either be transported direct to the stock on the fork or loaded into a trailer.

However, it is possible that the future may see some more automatic device, cutting at the face of silage and taking it by conveyor either into a trailer or on to conveyors unloading the silage direct into bunker-type feeders. Cutting would generally have to be on the narrow face of the silo and certainly not from the top, in order to expose only the minimum of new face at each time of loading, thus reducing the area of silage subject to deterioration.

Tower silos can be unloaded mechanically by either bottom or top unloaders, provided that only chopped grass is ensiled. It is generally held that bottom unloaders will only work satisfactorily with wilted silage of about 50–60% moisture content ; otherwise with unwilted grass there is a tendency for the silage to bridge over the cutting mechanism of the unloader.

It is claimed for the bottom unloader that they are the only means of unloading hermetically-sealed silos without breaking the top seal, and that they can be moved from silo to silo while the silos are still partially full. Moreover, the silo can be replenished with fresh material blown into the top over the same period that the silage is being cut out of the bottom.

With the top unloader the silo has to be completely emptied before it can be filled again, otherwise the material being unloaded is that which has just been put in. Normally, each silo has its own top unloader, which is built into the silo before the domed roof is placed in position. This is probably a disadvantage only where the silage requirements of the farm require more than one silo, in which case it is conceivable that the silos could be sited under a common roof, with the top unloader transported from one to another on a mono rail system. Normally, a single silo would meet the silage requirements of most farms.

The top unloader is more positive in action than the bottom unloader and is certainly more accessible should anything go wrong.

Tower silos, with their smaller ground area, can be sited nearer to the stock than is often the case with horizontal silos, and with mechanical unloading the silage can be conveyed mechanically into bunker feeders of one sort or another, and will once again allow a certain degree of rationing of individual or groups of cows to take place.

The future requirements in the handling of silage must be, firstly, to reduce the total weight of grass handled in relation to its dry matter content, presumably by intensive forms of wilting that will keep field losses to a minimum, and secondly, to bulk handle at all stages on a continuous flow process. To do so will entail the use of a forage harvester in the field, self-unloading trailers, mechanical means of filling the silo and presumably tower silos, because of their greater bulk handling potentialities, to facilitate unloading and the mechanised feeding of livestock.

The prerequisite of any such system is that the grass must be chopped into short, uniform lengths at as early a stage in the harvesting procedure as possible.

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DISCUSSION

MR. D. A. YOUNG* : I disagree so strongly with most of what Mr. Mitchell has said that I can only conclude that such controversial statements have been made with the object of promoting discussion, and that I have been selected as the one who should take the bait.

I would question Mr. Mitchell's statements about power requirement and output of Flail harvesters.

Is it right to say that anything up to 40-h.p. can be consumed at the p.t-o. to give an output of ten tons per hour ? In order to be fair to all concerned, the figures at the other end of the scale should also be quoted. May I refer to the N.I.A.E. report No. 227/A on a well-designed 40 in. forage harvester conducted in 1959. This report says that an output was achieved of some 15 tons per hour, with a p.t-o. h.p. of 28 ; report No. 197 indicates output 23·8 = 40·2-h.p.

Is this not very different from the figures quoted by Mr. Mitchell ?

Again, quoting from the same N.I.A.E. reports, the no-load power requirement is between 8–10-h.p. when the machine is operated at the manufacturer's recommended speeds. On well-designed machines it is only when the rotor is driven at speeds much in excess of those recommended by manufacturers that this high no-load power requirement—such as those quoted—becomes operative.

I feel I cannot emphasise too strongly the vital importance of flail harvesters being operated at the manufacturer's recommended rotor speeds, and I think you will agree that machines should be judged and appraised when operated according to manufacturers' instructions.

I am sorry that Mr. Mitchell failed to emphasise sufficiently that one of the great advantages of flail-type harvesters is their reliability and low maintenance costs.

At the Oxford Conference last week it was stated that under three hours' work had been lost in three years with the speaker's flail harvester—a record unequalled by any other implement or machine on the farm.

In this field where development has been extremely rapid, is it not a little unfair to the manufacturer to quote reports published on work done some five to six years ago ?

Does Mr. Mitchell really think it true to say that flail-type forage harvesters only lacerate the material, with the result that the bulk differs very little in length from the original material. I would again refer to N.I.A.E. report No. 197 ; you will then see that the degree of chop is very considerable—this is illustrated by photographs.

I do not regard the system of tipping a trailer load of material on to a concrete slab and then picking up with a Buckrake as a retrograde step, and I would also suggest the figure of 14·6 man minutes per ton as the time required for this operation is unrealistic.

An efficient buckrake operator can move a 2-ton trailer load of lacerated material and correctly place it on the silo in five to seven minutes, thus reducing this figure under four man minutes per ton, thus increasing the tons per hour to between 16 – 20.

These figures were published by Mr. Rex Paterson some twelve months ago.

We must all realise, manufacturers and farmers alike, that mechanisation is only a means to an end, and in this case the end should be to enable the British farmer to produce his milk, beef and mutton at the most economic rates.

I feel that manufacturers and technical advisers should be very careful in advising farmers to tie up large

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amounts of capital in machinery and fixed equipment which might be more profitably employed in purchasing livestock.

I feel that this Paper has served an extremely useful purpose, if only because it has proved that there is a vital need for an efficient comprehensive and up-to-date survey to be undertaken of the whole position.

So vast has been the development in this country, even during the last twelve months, that it makes many of the references referred to in this Paper quite out of date.

There have been such rapid strides in the design nad operation of flail-type forage harvesters during the last two or three years that nothing short of a complete new survey can accurately assess the position.

MR. RICHARD WELLESLEY : I farm 700 acres and we milk 180 cows. I am only interested in farming and have no axe to grind. I am prepared to try out any new machine. In my short farming career we have had many machines on the farm and have had the opportunity to try them out under our particular conditions.

I was fortunate enough to go to America on a Nuffield Scholarship and was fascinated with the whole attitude towards material handling. I would like to tell you what we are doing on my farm. I am interested in making silage as a complete chain of events : I want a good end product to feed cows easily and simply. Each link is important. We have two harvesters ; these must cope with heavy crops such as 30 tons or more of maize, wet lucerne which has grown a little old and wet grass—or light crops as we had last Summer. The machines have a fairly wide task to perform.

One machine, the " New Holland 800," has a cylindrical chopper with a reciprocating cutter bar which cuts and chops heavy crops extremely well. We have another machine, which is a " New Holland 33 Crop Chop," with a swinging flail type of cutter, but the blades are set sideways like a niblick. They cut and flick the grass iuto an auger about 18 ins. behind, then a chopper with three knives chops and blows the material into a trailer behind, or towed at the side.

This machine has a surprising speed and we have harvested a medium crop at 6 miles per hour. This is important in a light crop as it is an advantage to travel at high speed.

These two machines harvest our particular crops as we want them, and they are both true choppers. I agree with Mr. Mitchell, the flail we tried and which I have looked at would not chop sufficiently uniformly to go easily through our trailers at the present time. I am not saying that anyone will not invent a self-unloading trailer which will handle flailed grass—good luck to them if they can, it would be a great help to British Agriculture. Unfortunately we smashed our self-unloading trailer trying to unload flailed grass.

You actually saw our " New Holland " self-unloading trailer on the screen unloading at the rear. The other photograph was the Gehl unloading at the front at the rate of 3 tons in 8 minutes. The " New Holland " unloads at the rear at $1\frac{1}{2}$ tons in $1\frac{1}{2}$ minutes. We need two trailers for short hauls and three for long hauls. They are driven alongside the harvester and filled and brought back to the blower. We have a " New Holland " 22 Blower. This is a perfectly straightforward machine and not a Chopper-Blower. We have found that it works extremely well, receiving chopped grass from our self-unloading trailers in a controlled stream.

We bought three cheap Army lorries and put false end gates on them. It is not a bad system and is used quite often in the United States, but it is hard work. Two men have to use their muscles all the time, and even then the flow is not very even. We no longer use this system and are thoroughly satisfied with the self-unloading trailers. We have two or three trailers working with the Blower. We test weighed and found we were blowing at the rate of 18 tons an hour. We are fortunate in having a weigh-bridge on the farm and can check loads.

When making silage we blow the chopped grass into our barn-type silos, which is a Dutch Barn 45 ft. long with three bays of 15 ft., and the Barn is 25 ft. wide. We board the sides with 7-ply resin-bonded exterior-grade plywood up to 14 ft. on all four sides and make an airtight box jointing with selastic. The floor is concrete with two drains running longwise down the building. Next year we are going to board up to 20 ft. on all sides. We start silage making by putting 2 ft. of straw on the floor of the silo. When filling the far end of the barn we fit an extension to the Blower pipe and move the whole pipe like a fire hose, and we find we can spray the chopped grass very evenly into the silo in such a way that it requires no further handling. When we are filling the middle bay we fix a flexible end to the pipe, and when we are shooting the grass close we use a deflector plate on the end of the pipe and so can place the silage evenly over the whole floor of the silo.

Last year we made hot silage by scattering molassine meal on top of the trailers, and the action of the self unloading mixed the molassine meal surprisingly well with the grass. When the silo was filled to the top we covered the silage with a plastic sheet and sealed it round the edge with Copydex and a batten to make an airtight container.

To get the silage out we take the end wall of the barn off, which leaves a wall of chopped silage. We then proceed to lift the silage out, using a standard fore-loader, lifting 2 cwts. of silage per forkful. The tractor then backs out and drops the load into one of the self-unloading trailers. It takes the operator between half and three-quarters of an hour to load up sufficient silage for 180 cows.

The operator then takes the trailers to one of our two herds, 80 cows in one place and 90 in another. He then drives the trailer along the driveways in front of the long mangers, unloading the chopped silage in a controlled stream. In this way 80 cows can be fed in $2\frac{1}{2}$ minutes. The trailer is left by the dairy buildings and the cowmen then give the cows the other half of their feed later on in the day.

I am in favour of chopped material for my particular farm. I am interested in material handling with no physical effort. If silage is to be handled really easily I think it should be chopped. I have tried various other ways and I am thoroughly satisfied with my present system.

MR. MITCHELL : Replying to Mr. Young, I must confess I did write this Paper primarily in the hope that a discussion would ensue, and if you want a discussion you cannot be right in all respects.

As to the potential high-power output of the flail-type harvester, the evidence available bears out that if you get away from specific makes of flail-type harvester, whilst some of them have been comparatively low, others have been excessively high.

Speaking in general terms, the rotor-speed requirement can be extremely high ; I mentioned the fact that the relationship between the rotor speed and the no-lead horse-power was curvo-linear.

If you have a forage harvester with a low no-load horse-power, the particular rotor speed will be low.

I quite agree it might have been far better if we had expanded this point a bit more.

The other thing is, I cannot quite agree with Mr. Young—he was probably over-emphasising the fact—that the material is not much different from the original material, but I emphasize that even when it is so-called chopped, whether it is the same length or half the length of the original material, it is often inadequate for mechanical handling. The chopping of these harvesters generally is not good enough. That was brought out in what Mr. Wellesley had to say.

I cannot do more than completely agree with Mr. Young in his reference to the rather out-of-date sources and references that we had to compare the different makes of harvester. I went through a lot of literature and could find nothing so detailed, of more recent origin, than this one. Even that data will show that basically there is a fair power requirement needed and a considerable reduction would be necessary to make it comparable.

MR. REX PATERSON : I am worried that some people might follow the recommendations of the last two paragraphs of Mr. Mitchell's Paper without realizing all the capital expenditure involved.

We should not examine the problems of making silage without considering all the varying conditions which will be found on farms. Many grass farms are of only moderate size, and often hilly. The mower and buckrake may still suit many of these conditions. However, where ground conditions and the size of the business warrant the use of a forage harvester instead of a mower it enables one man to both cut and transport his grass to a silo, often in the same time he would take to cut the crop with a mower. The investment in a forage harvester need be little more than twice that of a mower, and most farmers already have tipping trailers. Therefore if a farmer is content to work with a small self-contained outfit, such as the trailer permanently attached to an in-line forage harvester, and to taking all loads to the silo without unhitching the trailer, his investment remains small. Yet he will have enough capacity to make sufficient silage to winter 150 cattle, if there is a second man to help with a buckrake and tractor at the silo. This is more cattle than most farmers carry. Alternatively he could stop periodically and put the crop in the silo himself and still make more silage than most farmers would require.

Let us examine another point. Mr. Mitchell condemned the method of dumping the loads on the ground and putting them in the silo with a buckrake. However, Mr. Young agreed that this was a satisfactory method when storing in the type of horizontal silo which has proved most satisfactory for self-feeding, a practice which is increasing in popularity. At the demonstration organized by Shell Chemicals in 1958 some of you may have noticed that one buckrake at each silo was storing the grass as fast as it was brought in by three and sometimes more forage harvesters working nearby. In fact, however, silos should not be filled too fast. They require time to settle if they are to be properly filled, yet the work should be continuous to avoid spoiling the surface. The work on any one silo is better if spread over a month, and this also helps to provide a more even supply of grazing for the stock, both before and after cutting.

Mr. Wellesley mentioned the great height required in the walls of his silo. Was this because of the amount to be stored, or the rate at which he filled ? I suspect that it finally settled to only a moderate height because he said it was removed with a front-end loader. The problem is even worse in a tower which has been filled very fast. It may be only half full when it settles.

Crop yields of 17 tons per acre were mentioned. It may be more economical to harvest these heavy crops, but from the grassland and stock point of view moderate crops from the whole acreage are better than large crops from a small acreage.

I feel that Mr. Mitchell's recommendations will lead to too big a machinery and silo investment, without adequate advantages, and must condemn it.

I am pleased to hear that Mr. Mitchell is only informing us of these particular methods rather than suggesting that they are the recommendations of the N.I.A.E. In reply to his reference to the desirability of using these methods to allow wilting of the crops, I suggest that the action of the flail harvester appears to drive off a good deal of moisture and that, while wilting may be necessary in a tower silo, it is not necessary in a 6-ft. deep surface silo.

He said in the Paper you needed to retain it in the shallow type of silo. Is not this where it is done inefficiently ? Mr. Mitchell referred to a 14-in. waste at the top ; if that occurred it cannot have been adequately sealed and is therefore not typical.

MR. MITCHELL, replying : The object of the Paper was to discuss new methods of silage-making, and none of what I have said is the recommendations of the N.I.A.E. It is an assessment of the methods by which silage is being made at the moment.

I would like Mr. Paterson to consider whether there is not a lot to be said for wilting, even if it means introducing another system.

MR. PATERSON : This is important—if you go for a high-tower silo it is essential to wilt. If you put it in to a settled depth of 6 ft. you will spread it over a fairly large area—a lot of drying goes out in the flailing out and evaporation, and you can do with all that moisture. It does not appear to cause harm.

MR. MITCHELL : You do not get the appearance of moisture. A depression in the dry-matter weight of the material takes place, and that is why wilting is not advocated in the shallow-type silo.

MR. PATERSON : You said in the Paper you need to retain it in the shallow-type silo.

MR. MITCHELL : I am not certain we are discussing the same aspect of the problem. In shallow depths one can get excessively high dry-matter losses—figures of 30–40% dry-matter loss have been quoted.

MR. PATERSON : Is not this where it is done inefficiently? Mr. Mitchell referred to a 14-in. waste at the top ; if that is feasible, it was not compacted in the silo.

MR. G. G. BALDWIN : I am surprised at Mr. Mitchell pushing this wilting point. He mentioned if you wilt it you save a certain amount of labour, but against that one ought to offset the extra labour for cutting the grass. There is a very small amount of time saved by wilting. Putting the crop in the silo—he said you would not put wilted material in a horizontal silo, therefore you must have a tower silo. The vast majority of farmers are more interested in low capital outlay with low silos, and therefore they would not be interested in wilting.

He mentioned losses from seepage, and he based his argument for wilting on high seepage loss, but it turned out his results were based on figures from tower silos ; and later he mentioned much higher pressure from tower silos, which result in higher seepage losses, and not much loss of unwilted material in a horizontal silo.

Mr. Paterson pointed out these are larger silos, and Mr. Mitchell said probably you would not get as high a loss in a horizontal silo. So I am convinced that is the future line for most people who must be concerned with capital put in.

Two more points—quoting again from those N.I.E. posters. No-load power requirement is meaningless if one is comparing machines. In one case there is a no-load horse-power requirement of 25 horse-power, but at full load the difference in power requirement was very little. The no-load power requirement as such therefore means nothing.

I would like to draw the attention of Mr. Mitchell and Mr. Wellesley to chopping and lack of self-loading equipment for handling flailed material, and to say that a machine will be demonstrated this coming year, and the manufacturers are looking forward to making that million that Mr. Wellesley forecast.

MR. MITCHELL, replying : On the question of wilting—one of the points brought out was the very small difference in the load requirement, but all this is pre-supposing that the material is being chopped. When the material has been chopped there will be no need for further means of consolidation.

The dry-matter loss in shallow silage of chopped material will be comparatively high. In this case, therefore, if one is going up in height in a Dutch Barn or any high-type silo—the Dutch Barn is less expensive —then wilting does become important to avoid seepage losses.

I am not quite clear about your reference to no-load power requirements. Is it a fact you can relate your output to horse-power ?

MR. BALDWIN : Anyway it is a straight-line curve whichever way you look at it.

MR. MITCHELL : That is the way I understood you were doing it, taking off the no-load power requirement.

MR. C. CULPIN : I would like to say a word about estimation and measurement of losses in silos. It is not much use going round doing surveys on these subjects. We can say that one is very bad and that one is very good, and that is as far as one gets ; but there are experiments on this subject in progress on the Ministry's experimental farms.

Silage is being measured into silos of various kinds, and it is being weighed out and sampled, each day and each load, and estimates made of what the actual losses are in various types of silos. The job is generally reasonably well done on the Ministry's farms, and with clamped silos the dry-matter losses have been averaging round about 30%, and given the best wall clamps, well covered with polythene sheets, the dry-matter losses have been in the region of about 20%.

We rather fancy it might be possible with tower silos that are equally well done to get this dry-matter loss a little lower, but whether it is worthwhile or not is a question of economics, as I think everyone would agree.

MR. J. R. WARE (Norfolk) : Mr. Paterson deplores the tremendous expense of putting down on a farm a lot of expensive equipment in cutters and blowers and conveyors that we have seen on the screen. Are we absolutely sure we want chopped silage ? Are we determined we require the silage to be of very high quality always ? There is another way of looking at this. I am farming, and I feed a lot of cattle. I do not want this very high-quality silage, not the very top quality. I want a lot of good honest food all through the winter. We deliberately make our silage of long odd stuff, somewhat over-matured for making top quality. We make it into clamps, covering with polythene, and self-feed it out to the cattle in self-feed troughs.

I have not bought any equipment except two old secondhand green crop loaders which cost £40 apiece. That is the only equipment I have got, and I make 60–70 tons of silage every year.

I am wondering whether I am right or whether I have to go to the other extreme and put down two or three thousand pounds in equipment. Am I right or not ?

MR. MITCHELL : There is no question of right or wrong to a specific case ; it simply means how much it is profitable—if it is profitable, I would suggest you carry on as you are. If you say there is no necessity for high-quality silage, then I think I indicated there is probably nothing better than the buckrake method of dealing with silage of long and more mature type.

I was basing my assumption on recent research work and the tendency towards the use of more immature material of higher digestible nutrients. The methods used for long material will be uneconomic in terms of this new material.

Unless you put it into a container which will reduce the losses—and the losses in the horizontal-type silo can be high—they will be higher with this more nutritious material. If there is no necessity to deal with nutritious material, and the system works, there is no necessity to invest any amount of capital in the job.

MR. A. B. LEES : Is there any real difference between grass in America and in Britain in relation to chopping ? I have had a lot of enquiries made this past season as to the use of forage wagons. I gather three particular makes—and the information does not come from the makers—are used 70% with flail-cut material. Either they keep their best forage at home, or our grass is tougher than theirs.

The whole problem of chopping would seem to be one of convenience for mechanical unloading, and the question is whether it can ever be worthwhile.

MR. MITCHELL, replying : I agree chopping is primarily a convenience for mechanical handling. Our grasses are not nearly so tough as the American, as they are dealing with a much more fibrous material in the majority of cases, so that I feel it is probably more important to a separate chopping mechanism in this country than in America.

MR. A. B. LEES : They do 70 to 80% flail harvesting.

MR. MITCHELL : They are using a more fibrous type of grass, unlike our lush grass.

MR. SPEAR (Kent) : There seems to be quite an argument between users of flail harvesters and cutter blowers. Both machines have been imported from America, and they use cutter blowers quite a bit.

Can Mr. Mitchell say whether there are more of this type than the others ?

Can he indicate the trend adopted for the moment ?

Has Mr. Mitchell, or anyone else, ever worked out the nutrient losses between the two types of machine before the product gets in the trailer ?

MR. MITCHELL : I would pass that to Mr. Wellesley, who has been to America.

MR. WELLESLEY : Not lately—I am three years old.

MR. PATERSON : I can answer that. Cutter blowers are more popular, primarily for maize, and secondly for grass.

MR. A. B. LEES : The trade is 80% flail type.

MR. MITCHELL : I cannot answer Mr. Spear's second question, about nutrient losses.

There is laver work going ahead. The difficulty associated with measurement of losses is that of getting a satisfactory technique by which measurement of losses can be done. As to the losses overall, again we have no real evidence on that.

DR. PAYNE : A point in favour of the low capital equipment—a large number of unit-type implements, the buckrake or, as Mr. Ware mentioned, secondhand green crop loaders—is that you can mix the crops on a large farm ; so if you have a high carbohydrate crop and a low protein crop you can mix them in silos, which is of value.

MR. J. W. WESTON : Regarding the forage harvester mentioned, most of the advertisements put it forward as a multi-purpose tool. In Germany they are replacing combine harvesters with flail harvesters.

Is it a good all-purpose machine, even to the point of haymaking ?

MR. MITCHELL : There is no doubt of the versatility of the flail-type harvester. The number of its jobs is almost legion. Whether it is a practical proposition to do some of those jobs wants looking into. Our experience of making hay and treating it with the same treatment as by flail-type harvester would suggest it is unfortunate that the first year hay was made by flail-type harvester to any great extent in England happened to be 1959, one of the driest years we have had. Our experience was that treating the grass in this way was very satisfactory indeed when weather conditions were good.

Firstly, the material does feel drier than it actually is ; secondly, because it has been lacerated twice, when baled, it goes into a more solid bale, and again because it has been lacerated it has to be drier to store satisfactorily than if crushed or only shredded.

Although the forage harvester has been used in this way, there is insufficient evidence yet to assess its value as a haymaking machine. Hay made with the flail-type harvester is eaten more readily by stock than hay in the long state. Usually the hay is more palatable, but whether any more valuable I do not know.

This idea of using the harvester as done in Germany for harvesting of grain is one that has been given a lot of thought in this country. Theoretically it is a good idea if one could make silage and hay for the same capital outlay. There are a number of snags, even in making hay, and one sees in Germany that they start off with a forage harvester and end up with a combine, so many things are added to it. All the same I think it is an ideal worthy of further consideration.

A Paper prepared by W. H. Boshoff and D. Innes on

"METHOD OF INCREASING THE LOAD-CARRYING CAPACITY OF BICYCLES IN UGANDA"

will be published in the next issue of the Journal

THE importance of the bicycle as a means of transport can be gauged from the figures of cycle imports to Uganda for the ten-year period 1949 to 1958, when some 639,000 were imported at a total cost of about £6½ million. The increasing use of cycles for load transportation is well appreciated, and some of the more common loads transported by carrier are illustrated in Figs. 1 and 2.

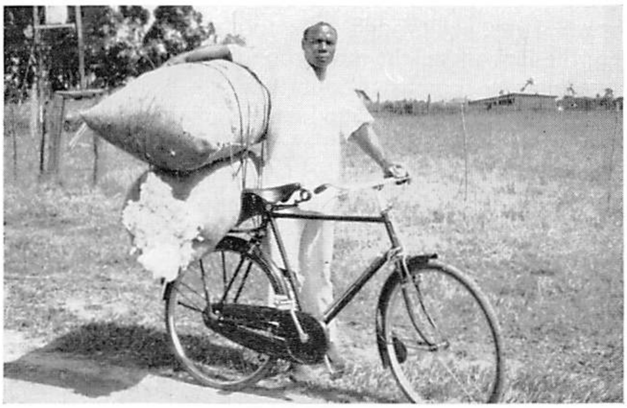

FIG. 1

The limitations of carriers, three-wheeler cycles and cycle trailers are discussed, and suggestions made of the optimum conditions required for the effective use of a cycle trailer in preference to a carrier, as in Fig. 3.

As stated above, this Paper will appear in full in the July issue of the Journal. Copies are now available, however, for those members who are interested in the subject, and they are invited to submit written contributions to a discussion which will be published with the Paper.

FIG. 2

It has often been suggested that it would be possible to use the bicycle more effectively for transporting heavier loads by employing methods or attachments other than the rear carriers at present in use.

FIG. 3

BOOK REVIEW

Principles for British Agricultural Policy. A study sponsored by the Nuffield Foundation and edited by H. T. WILLIAMS, Deputy Principal of Seale-Hayne College. Published by the Oxford University Press at 18/-.

This Report, which has been in preparation for over 10 years, begins with a survey of the part played by agriculture in British economic history during the past 120 years, and will enable the agriculturist to look at his own particular specialisation in its proper historical perspective. It includes an interesting section on the changing social life of the farming community, and concludes with a careful consideration of Britain's dependence on her own food production in time of war, and the necessity of adaptation to a developing world economic policy.

Farm mechanisation is dealt with under the chapter on " The Possibilities of Increasing Agricultural Efficiency," considered as one of several developments in farming efficiency. While we have made much progress in the use of farm machinery, the authors think that we have not begun to think sufficiently seriously about the more rational layout of farm holdings, the more rational design of farm buildings and a more intelligent use of rural electrification. Agricultural machinery, it seems, cannot " go it alone " towards greater agricultural efficiency.

While the Report recognises the importance of long-term planning and thinking, it considers that the strength of British agriculture in the past has been its flexibility and adaptability, and that too high a degree of capitalisation or the wrong kind of capitalisation might militate against the very flexibility which is its strength. Altogether, a valuable book which will repay careful and detailed study.

EQUIPMENT FOR MILKING AND MILK HANDLING

by H. S. HALL, B.Sc.*

A Paper read at an Open Meeting on Tuesday, 8th March, 1960.

THE past few years have produced some significant trends in techniques and equipment for milking and milk handling on the farm. In every case the objective is to improve efficiency, and so reduce costs, of milk production, mainly by saving labour. Where milk is concerned, as with other foods for human consumption, no new idea has much prospect of development if the product quality is likely to suffer ; improvement of product quality may, in fact, often be an important objective. Most of the developments discussed in this Paper are at the interesting stage. They have proceeded far enough for at least a small proportion of milk producers to try them. Most of the advantages can already be seen, but many of the problems remain to be solved.

Milking, cooling and packaging for sale are the principal operations directly concerned with milk on the farm. It is, perhaps, elementary that they should be chosen to form a rational sequence, with a method of milk handling to suit, but too often this is not the case. This lack of integration is most in evidence in the innumerable journeys between cowshed and milk room, carrying two or three gallons of milk at a time. Walking never seems to be a hardship for the farm worker, and it is too seldom recognised as an expensive operation.

The use of dairy equipment cannot be dissociated from the essential process of twice-daily cleaning and sterilising. This also can be a time-consuming operation, sometimes unnecessarily so. Almost anything can be cleaned and sterilised given time and labour, but therein lies the weakness, because occasions inevitably occur when the quality or quantity of labour is not forthcoming. Design for hygiene is therefore just as important as design for performance.

MACHINE MILKING

It is convenient to consider first the milking machine from the standpoint of milking. In principle it has changed little for more than 50 years—at least, so far as this country and North America are concerned. The effectiveness of the milking process can be dissociated entirely from the type of installation and the purely mechanical or structural features of the plant ; the design of the teat cup assembly and the characteristics of the pulsation system are the only items which need be considered from this point of view.

The Teat Cup Assembly

The teat cup shell affects milking in an indirect way. Its shape and dimensions determine the pulse chamber volume, which in turn affects the pulse characteristic. Its weight contributes to the weight of the cluster—a characteristic already known to affect the amount of strippings(1). The use of stainless steel for teat cup shells is now well established, and is an improvement for reasons of hygiene and durability. A determined effort to introduce plastics has taken place in New Zealand. The purpose is to produce a " sealed " liner-shell assembly which can be used for one season and then thrown away. Although it is too soon to judge this idea, the lack of weight is a strong disadvantage and the economics are somewhat doubtful.

The design of the teat cup liner or inflation is clearly a fundamental factor in milking performance. Natural rubber is still unsurpassed so far as physical properties are concerned, though attempts to use synthetic rubber alone and in conjunction with natural rubber are being made with some success. Perbunan has been shown to give a substantial resistance to fat absorption(2). Red rubber is still a persistent survivor, in spite of the known advantages of carbon black as a filler.

Liner shape is still a happy hunting ground for inventors, and we are still far from being able to design the ideal liner. New designs are evolved, rather than calculated, from field observation or from reputed shortcomings in milking efficiency or ease of cleaning. It is at least certain that different designs produce different results when all other factors are kept as constant as is possible. Dodd and Clough(3) showed a comparison for milking rate and weight of strippings of two designs of liner. The one consistently better in milking rate was consistently worse in completeness of milking. Equally, some designs are better than others in both respects.

It appears that stripping properties are derived from the characteristics of the liner mouthpiece(3) and so are a function of dimensions, shape and material. Good stripping seems to be correlated with air leakage past the teat, which is clearly linked with the tendency of teat cups to fall off and perhaps with cluster weight.

Milking rate characteristics appear to be determined by the liner barrel. The analysis of factors in this case is likely to prove more difficult because dynamic as well as static properties are involved. The differences between designs must therefore be considered in conjunction with the pulse characteristic applied.

It has already been demonstrated(4) that increase of liner tension over the normal practicable range increases milking rate. Clearly, liner tension will affect the rate of movement during pulsation, delaying collapse and speeding up the return to the open position, thus extending the effective pulsation ratio.

The bore of the liner barrel when assembled must always be a matter for compromise in view of the variations of teat size which must be catered for. It is

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practicable for the operator to use liners most suited to the breed of cows he keeps, or even to use different liners for cows and heifers, but the variation of teat size for an individual cow must be accepted. This and other factors of shape and dimension still remain to be explored.

The Pulsation Characteristic

The function of pulsation is generally accepted to be maintenance of blood circulation in the tissue of the teat ; without this the resulting discomfort will affect milk ejection. The cessation of milk flow which occurs during the " squeeze " or collapse phase may be presumed incidental ; there is no evidence to show that it is necessary. Nevertheless, so long as a squeeze action is used to maintain blood circulation probably a time factor is involved so that a squeeze phase of very short duration or of sufficient intensity may not fulfil the objective, and may be no better than the complete absence of pulsation. No work has yet been done on alternatives to the conventional method with a view to maintaining a continuous milk flow.

Experiments to discover the effect of pulsation rate and ratio on milking rate were discussed in a Paper to this Institution some years ago(5). For reasons which are not evident, the results reported did not indicate that rates and ratio were particularly important. More recent work by Clough and Dodd(6) showed a significant increase of milking rate could be obtained by increasing pulsation rate and pulsation ratio, either alone or in combination. Their results suggested that a rate of 50 to 60 pulsations per minute and a ratio of 3 : 1 or a little greater might be the most suitable for practical application.

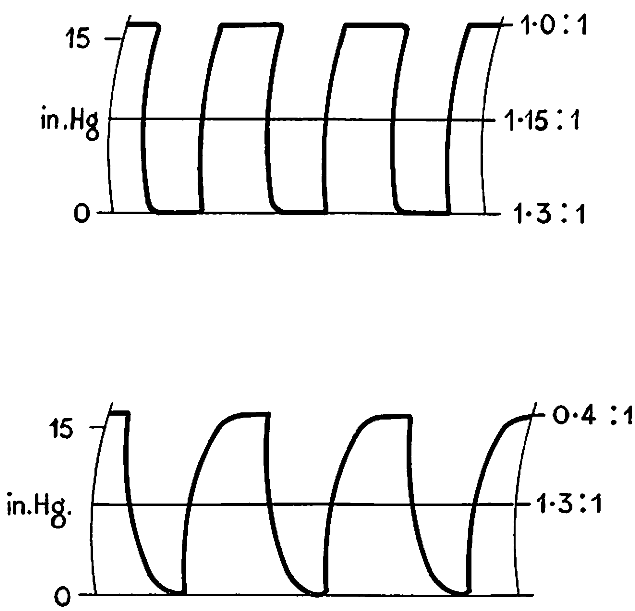

FIG. 1. Typical pulse characteristics from a pulsator (upper) and its pulsation system (lower). The pulse ratios measured at zero, half and full vacuum are shown.

Most of the experimental work on pulsation and all manufacturer's specifications suffer from the lack of a clear definition of pulsation ratio. The necessity for this is seen in Fig. 1, which shows a typical pulse characteristic taken from a pulsator or pulse relay and the characteristic when the pulsator or relay is connected to a teat cup cluster under milking conditions. In the first case, the vacuum level at which the ratio is measured is not important. In the second case, ratio has virtually no meaning unless the vacuum level at which it is measured is stated.

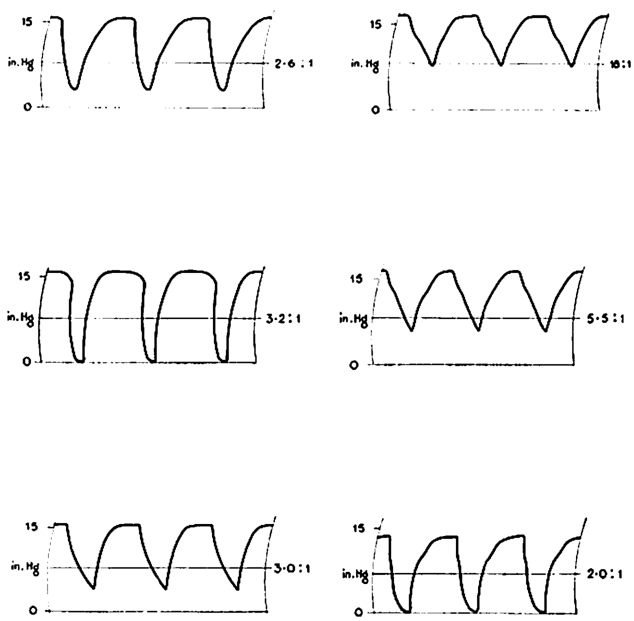

FIG. 2. Characteristics of 6 pulsation systems rated at 3 : 1 ratio. The characteristic *bottom right* was obtained from a system operated by an electrical controller the ratio of which was actually 3 : 1.

The method which appears to be accepted in New Zealand is to measure the ratio at the atmospheric pressure line ; this is clearly impracticable for normal operating conditions. A method which has been used in this country is to measure the ratio of the times for which the pulse chamber is at approximately full vacuum and at approximately atmospheric pressure. This does not account for the whole of the cycle and also is impracticable with certain forms of characteristic, particularly where the squeeze is attenuated.

The convention adopted by the author for many years is to measure ratio at half maximum vacuum. The validity of this convention was discussed(5), and from observation of a teat cup liner in a glass shell it was suggested that it might be preferable to measure ratio at 90 per cent. of maximum vacuum. Further work correlating liner movement with pulsation characteristic by cinematography indicates that different designs of liner assembly behave differently, and that measurement of ratio at half maximum vacuum is probably the best compromise.

The milking : resting ratio was studied by Ardran and Kemp, Clough and Dodd(7) using cineradiography under various conditions of liner tension, pulsation rate and pulsation ratio. In this case, pulsation ratio was measured cinematographically, the criterion being the point where the apparent width of the liner below the teat, viewed in the plane of collapse, was half normal.

Correlation of this with the pulse characteristic was not reported.

Using this criterion, it was shown that with a pulsation rate of 40 and ratio of 1 : 1 the milking : resting ratio was 55 : 45. The same result was obtained for liner tensions of 25 lb. and 5 lb., these figures being typical of those normally obtained with extruded and moulded liners respectively. At higher pulsation rates the milking : resting ratio agreed less well with the pulsation ratio indicated by the cinecamera. An important observation in this work is that the flow of milk from the udder to the teat is not a limiting factor in the rate of milking except when the udder is nearly empty. There is therefore still an opportunity to improve the effectiveness of the milking machine.

Wide pulsation ratios, having been shown to increase milking rate, are now selling points. An agreed and standardised method of measurement, therefore, is necessary to prevent unequal competition. Whatever the method, it should, of course, refer to the teat cup pulsation system under operating conditions and not to the controller, pulsator or pulse relay.

The pulsation characteristics of several pulsation systems rated by their manufacturers at 3 : 1 ratio are shown in Fig. 2. In each case the pulsation or pulse relay was connected to its normal teat-cup system under conditions similar to milking. In four of the characteristics atmospheric pressure is not reached during the collapse phase, indicating a weak pulsation.

MILK HANDLING

The type of milking machine installation may often be decided by considerations of cow management and labour utilisation. However, the latter cannot be divorced from the work of handling the milk ; it is important, therefore, that the problem is examined from this point of view. A wide variety of equipment has been devised by manufacturers, and the farmer must often be in some difficulty in choosing what will prove most economic under his particular conditions. From the milk handling point of view, we can recognise three main types.

Bucket Milking

The majority of existing milking installations are bucket machines ; up-to-date figures are not available, but the proportion is probably between 60 and 70 per cent. It is likely always to be substantial because of the adaptability and relatively low initial cost.

The common method of use involves a great deal of labour in milk handling, particularly in large cowsheds. Frequently, the farmer does not recognise this, probably because he has accepted as a necessity the carrying of milk in small quantities from cow to cooler ever since the days of hand milking (Fig. 3). This apparent lack of enterprise is not confined to British farmers, for most of the bulk milk tanks in U.S.A. are still filled by this method ; in fact, " low pouring height " is an advantage commonly quoted by the tank manufacturers. However, this particular problem is now recognised and the remedy being offered is discussed below.

In this country one can safely predict that many farmers will retain bucket milking in a cowshed and will have no prospect of adopting bulk methods at least for many years. The solution to their problem is obvious

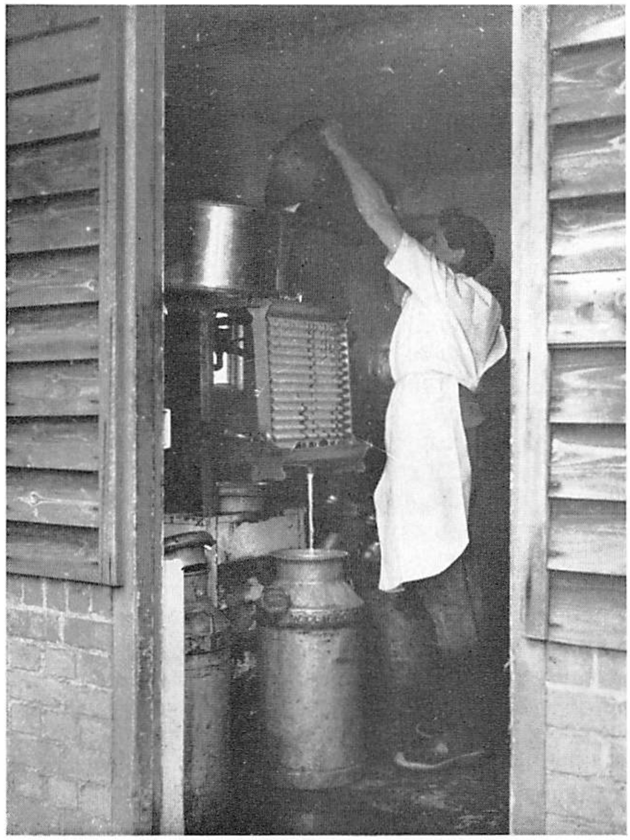

FIG. 3. Carrying milk in buckets from the cowshed and tipping over a surface cooler involves unnecessary time and effort.

and inexpensive. It consists simply of tipping the milk into the transport can, the requisite number of which are carried on a trolley, which the milker moves as milking

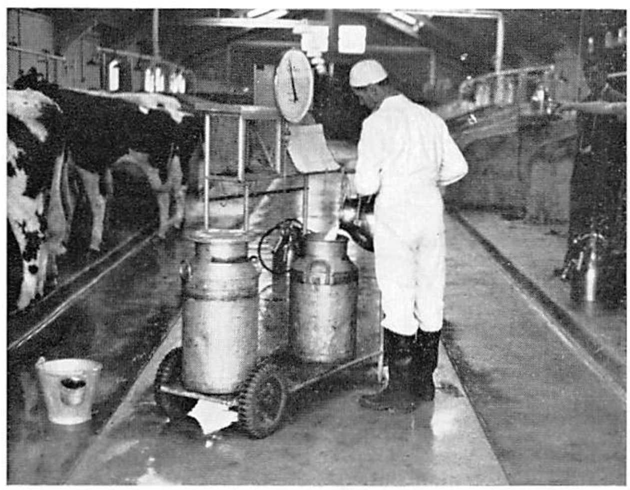

FIG. 4. The most effective method of using the bucket milking machine.

proceeds. If yields are to be recorded, the trolley can be designed to provide the necessary facilities at little cost (Fig. 4).

The legal and technical admissibility of this simplification has been questioned in the past and possibly still gives rise to doubt in some quarters. The law was not very clear on the point, and even the latest Regulations(8) do not encourage the method. Technically, the danger of contamination may well be far less than with the common, and approved, method of pouring milk over an open surface cooler.

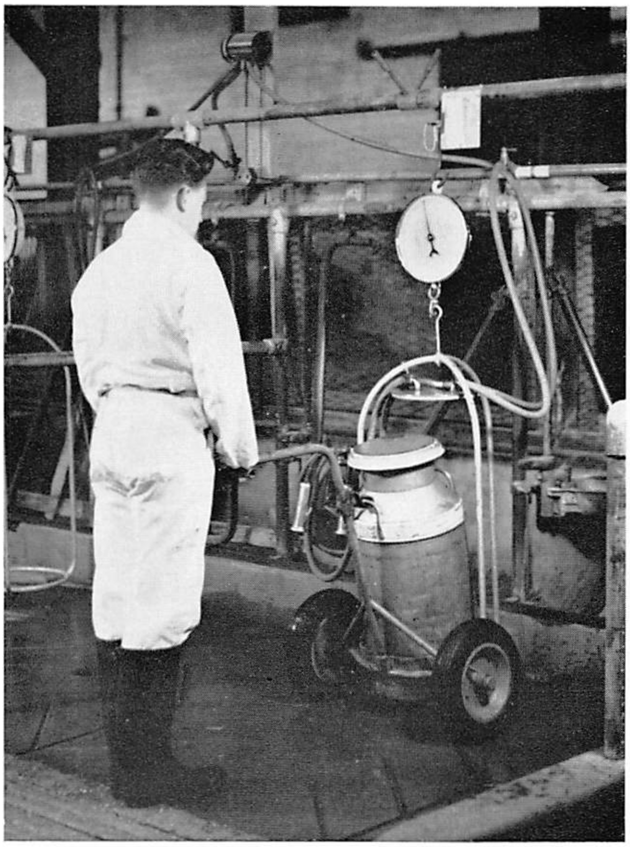

FIG. 5. The simple method of moving full cans of milk from the milking point in a direct-to-can parlour.

Having transferred the milk from the individual cow to the transport can with the minimum of time and effort, it would, of course, be a retrograde step to use an open-surface cooler. In-can coolers can be used with mains water or chilled water and give a cooling performance adequate for the purpose. Cleaning presents no undue problem, although it probably must remain a manual labour.

The functional details of moving full cans from the cowshed, through the cooling station to the point of collection is worth a little study in every case (Fig. 5). Man-handling can usually be eliminated by arranging the cooling station at the same height as the trolley bed, or even cooling on the trolley. If there are as many in-can coolers as cans to be cooled at one milking, cooling becomes a single-stage operation lasting only 15 minutes or so. An arrangement which may be more economic is to have half this number of coolers and to start cooling halfway through milking. The choice should be made by reference to the relative values of labour and capital charges, bearing in mind, of course, that saving in time may not have any value in terms of real money.

Direct-to-Can Milking

The substitution of the transport can for the bucket as the milk interceptor was a feature of some makes of milking machine in the last century. The obvious limitation that a milk-can is not easily moved from cow to cow has been met by a variety of appliances ranging from two-wheeled trolleys to extensive overhead run-ways. All serve the purpose of saving effort if not time, but it is very doubtful if any are more efficient than the simple milk can trolley used with a bucket milker. Certainly most are more expensive. Direct-to-can milking in a cowshed therefore seems unlikely to survive except in a few special cases.

Where the method is used in a parlour this disadvantage does not arise. Movement of the milking unit either is not required, as in abreast parlours, or at most is limited to two adjacent milking positions, as in the various forms of two-stall/unit tandem parlours. This limited movement is easily provided without man-handling. Yield recording introduces no problem. The only difficulty which may arise is changing cans at the milking points, and disposing of them, where large herds are concerned. If one takes 10 cows per milking point as representative, one or perhaps two changes will be necessary at morning milking. For herds up to 30 to 40 cows the accumulation of full cans in the working area may be no embarrassment ; above that herd size removal to the dairy once or twice during milking will usually be necessary.

Direct-to-can milking in a parlour has been combined with cooling during milking. The idea is attractive from the labour organisation standpoint. In theory, chilled water could be used, but this would involve expense in distribution and recovery of the cooling medium. In practice, it is normally limited to the use of mains water. Cooling efficiency is relatively low, and water consumption will be at least 50 per cent. more than when cooling full cans. Thus cost and availability of water may be the deciding factor.

Pipe-line Milking

The idea of milking directly into a pipe-line under vacuum which would transport the milk to a central point also dates from the last century, although it did not find practical acceptance until some 50 years ago. In New Zealand, where milking bails were, and still are, universal, it quickly became the normal method and came back to this country with the Hosier system. Its application to milking parlours rapidly followed.

This simple and effective method of milk handling has not been without its problems. The most universal is that of removing the milk from vacuum into atmospheric pressure. Pneumatic releasers actuated by the weight or volume of the mlik or by a pulsator are commonly used, but all seem to require a construction which does not lend itself readily to easy cleaning. Releaser pumps of various types are used and are also accompanied by a cleaning problem. Undoubtedly the simplest solution to this problem is leave the milk under vacuum until the end of milking by passing the milk from the pipe-line into the requisite number of milk cans, all kept under vacuum. The main difficulty then is to make cooling effective without involving labour after milking. All the various methods involve substantially more cooling water than would be required for full cans.

The benefit of piping the milk from a parlour seem small in comparison with a cowshed. Yet pipe-lines in cowsheds are a comparatively recent development. No doubt, this is due not only to the high cost of suitable equipment, but also to the problems, real and imaginary, which may be involved in keeping long lengths of piping in a satisfactory hygienic condition. There is also a problem, as yet unsolved, if daily recording of individual cow's yields is required. The cowshed pipe-line, of course, presents the same problem as the parlour pipe-lines when the milk arrives at the far end.

Finding the best solution to transporting milk in the cowshed is made difficult by the advent of bulk collection. Bulking in cans in the cowshed, with the subsequent cost of transferring the milk to the bulk tank, is not then attractive as a technique. Carrying buckets is even less attractive, which virtually leaves us with the mlik pipe-line as the only practicable solution.

Having suffered with this problem through the early years of bulk collection, the larger American producers are rapidly installing glass or stainless-steel permanent pipe-lines. The cost is still a deterrent to the medium and smaller farmer. For him the " portable pipe-line " has appeared on the market in the past year and undoubtedly will find a ready market.

The portable pipe-line is transparent p.v.c. hose, $\frac{5}{8}$ in. or $\frac{3}{4}$ in. bore, of wall thickness to withstand kinking and the milking vacuum (Fig. 6). It is in one continuous length, perhaps 100 to 200 ft., and is coiled on the outside of a cylindrical stainless-steel vessel which acts as the dump tank in the cowshed. The pipe-line is paid out just before milking and recoiled immediately afterwards. It is cleaned by circulating the necessary rinse water,

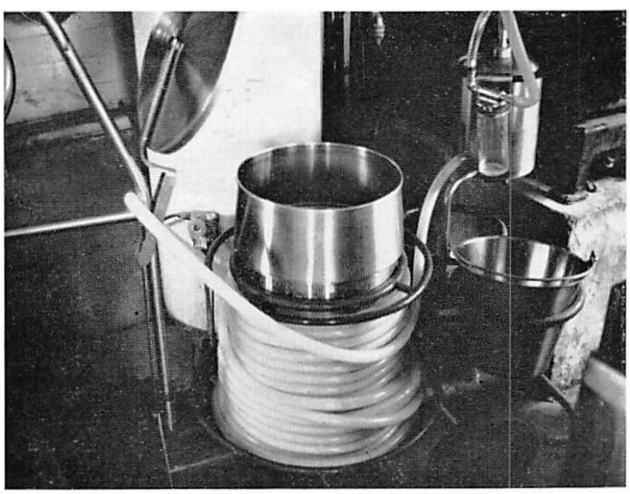

FIG. 6. An American "portable pipeline" of the vacuum operated type.

detergent and sterilising agent through it ; being in one length, this process is equally effective, or ineffective, when the pipe is coiled.

Two methods of moving the milk are used. In one, the discharge end of the pipe-line has a pneumatic releaser which keeps the pipe under vacuum. The dump

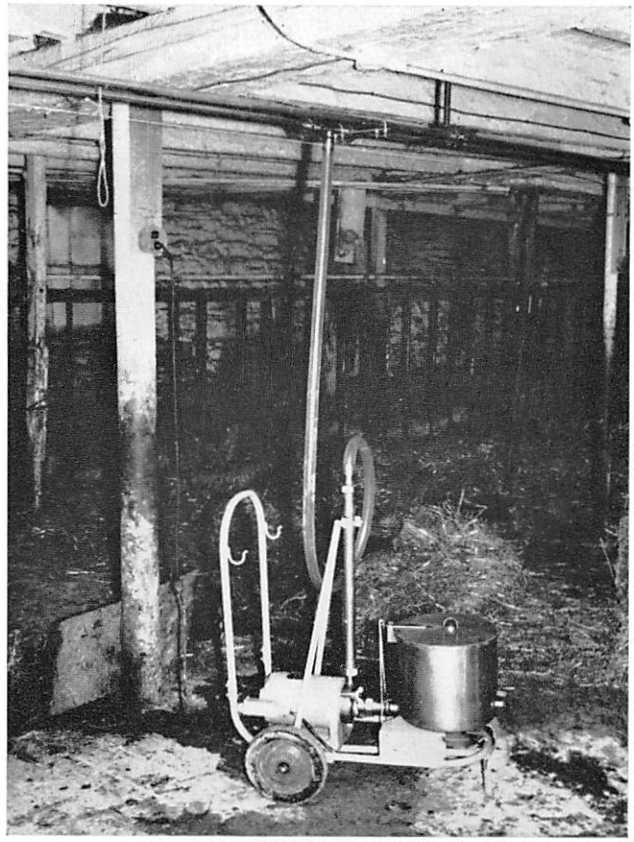

FIG. 7. A pump-operated dump tank connected to a permanent milk pipeline. It can also be used with a plastic portable hose.

tank contains a large rubber ball, which seals the outlet when the milk level reaches a minimum. In the other method the dump tank incorporates a milk pump and electric motor, automatically switched on and off by the weight of the milk awaiting transfer (Fig. 7). In both cases the dump tank is on wheels and is moved through the cowshed as milking proceeds.

There seem to be two unknown factors. The life of the plastics hose has yet to be determined ; if it proves less than about three years the permanent pipe-line will be a more economic proposition. The more difficult problem is what contamination an aged pipe-line may contribute. So far the authorities seem satisfied with the effectiveness of cleaning, but these views are based on comparatively new equipment.

BULK COOLING AND COLLECTION

We are now on the threshold of substantial developments in the bulk collection of milk. After five or six years of pilot schemes, the economic picture is considerably clearer ; the individual farmer's problem has been reduced to manageable proportions, even though it leaves the Marketing Boards with organisational headaches of considerable magnitude. Technically, we have reached an acceptable standard ; it now remains to maintain that standard and reduce costs.

The difficulties of past and future progress can be appreciated by reference to some of the special features of our conventional procedures.

In very few cases is refrigeration a necessity on the farm. Our temperate climate, the relatively short distance involved in first-stage transport and a reasonable standard of hygiene reduce keeping quality problems to negligible proportions for most producers, however good or bad their milk-cooling facilities may be. Thus the cost of refrigeration, which is not likely to be less than ¾d. per gallon, is not a normal component of the cost of milk production. Refrigeration is a necessity, however, for bulk handling, because for various reasons the buyer cannot be expected to accept the method without it.

A farmer who has chosen his equipment wisely and taken the steps already open to him to improve his milking and milk handling operations cannot expect much further saving of labour by installing a bulk tank. In many cases, particularly where cowsheds are concerned, he may find an increase of work. This applies particularly to the smaller producer—the man for whom the cost of bulk handling will always be relatively high.

The potential benefits of bulk transport by using tankers with a better payload than our present can collection lorries are partially offset by more man-hours and route-miles per stop for most farms. Because of the increased responsibility involved in accepting a farmer's milk, the tanker driver must be more highly trained and more highly paid than the lorry driver.

Bulk collection implies bulk reception, the benefits of which can be realised by the buyer only when he can dispense completely with a can reception line and the cost of all that goes with it—cans, weigh-bowls, can washers and so on. This aspect is really the key to the whole situation, and it involves in every case the solution of a complex marketing and transport problem.

Bulk Tank Design

While the primary purpose of the experimental period has been to reveal the organisational and economic problems, it has also been essential to demonstrate to the farmer and the milk buyer that the equipment design problems could be overcome. This purpose would have been ill-served if it had been left without co-ordination and control. Provisional specifications were drafted by the English and Scottish Milk Marketing Boards, and ultimately in 1957 a joint specification(9) was accepted by the five Boards of the United Kingdom.

This specification prescribes in some detail a standard of construction comparable with that used for milk processing plant—that is, the normal standard to which the milk buyer is accustomed. It controls tank proportions so that errors of measurement of the contents by dipstick are not excessive. It requires a cooling performance which will be adequate for the most severe conditions. Finally, it requires every design and size of tank to undergo a type-test to prove compliance with every requirement of control, performance and construction.

In many respects the specification is more exacting than the American 3-A specification, which finds acceptance throughout most of North America. A comparison of the cooling requirements was made by Hall and Hutchinson(10). This showed that the English specification required about 50 per cent. greater heat extraction capacity during the milk-cooling period. Using heat-transfer coefficients obtained with some of the early designs of bulk tanks, they calculated that direct expansion refrigeration of the tank bottom would not give the required cooling performance with tanks above 116 gallons capacity. No such limitation occurs with chilled-water cooling, as heat transfer coefficients will be much higher and the whole of the milk tank surface can be utilised..

Practically all of the farm tanks made to the Boards' joint specification so far are in the capacity range 175 to 350 gallons. All have used chilled water for cooling and have given the performance required without undue difficulty. Most use a chilled water jacket containing the evaporator, which is designed to build an ice-bank between milk-cooling operations. This general design is open to one objection—if the ice-bank controller fails, the inner vessel may be distorted, so affecting calibration. The resultant error would, incidentally, always be in the farmer's favour.

As new collection schemes are introduced it is inevitable that a greater proportion of smaller tanks will be required. It is estimated that the most common size will be about 125 gallons capacity, serving 100 gal./day farms on daily collection, or 50 gal./day farms on every other day collection. It is therefore possible that at this smaller size designs using direct refrigeration will be introduced. Such tanks would not create the electricity supply problems which certainly would exist with larger tanks. Their introduction therefore depends almost entirely on the relative cost of manufacture.

It is not unreasonable to consider why the specification laid down for the United Kingdom should involve a higher cooling capacity than the American specification particularly in view of our less severe climate. The difference arises simply because we have designed for the worst conditions—maximum loading in high ambient temperatures with effective cooling for the earliest collection. It can be argued, of course, that a continuous ambient temperature of 90° F. never occurs in this country for more than a few hours per year, that maximum loading will not coincide with highest temperature conditions, that it would not matter if the first load picked up were a little above 40° F. in temperature. No doubt these arguments will be examined as we progress. In this we can draw on considerable experience in U.S.A., where the milk buyer has come to be satisfied with the smaller margin of safety provided by the American specification.

The limitations on tank proportions imposed to prevent undue error in gauging the contents of the tank must be viewed against the background of present procedures. With can collection the dairyman measures, usually by weight, the milk which is delivered into his equipment at the dairy, and pays accordingly. With bulk collection the milk is measured, by a method inherently less accurate, in the farmer's container. Thus the buyer has no direct control and must rely on the safeguards provided by the specification in fixing a maximum for specific capacity in terms of gallons per inch of depth and in prescribing the technique of initial calibration.

Dipstick gauging suffers from one important disadvantage—the accuracy of the method is generally over-estimated. This illusion, which is even more evident in U.S.A., arises from the arithmetical operation involved in constructing the calibration table. There is no limit to the number of significant figures which can be calculated for an interpolated dipstick reading, but they do not represent greater accuracy. Our present custom of expressing tank contents to 0·1 gallon should be abolished ; nothing less than half-a-gallon for small tanks, or 1 gallon for large tanks, should be considered significant.

For some years the potential benefits of departing from dipstick gauging has been realised. It is essential, of course, that the measurement takes place at the farm before the milk enters the tanker. We are limited to volumetric or gravimetric measurement, or to flow metering. Most of the conceivable methods have been considered ; some of them have been tried. The most promising from all points of view appears to be flow metering, and efforts are now being made at N.I.R.D. to perfect such a method.

Milk metering under any conditions is not an easy problem. Milk is not homgeneous fluid and its composition, particularly as regards fat content, may vary. The apparatus used must have a high precision, yet it must be able to withstand the normal daily cleaning and sterilising processes. When used for this particular application the system must accept air as well as milk without introducing further error of measurement.

Our target is to measure a batch of about 50 gallons of milk during its transfer to the tanker at a rate of about 5,000 gal./h., with a total error not exceeding $\pm\frac{1}{4}$ gallon. We are using a turbine-type flowmeter with electronic counting and an air-detecting probe which interrupts the signal when it is not in contact with milk. The meter must be placed at the farm-tank end of the transfer hose, and this introduces flow-straightening problems.

Should this technique not prove to be successful, the next line of attack would seem to be the introduction of air separating equipment, with the meter situated on the tanker. By one method or another, therefore, there are grounds for optimism that the dipstick bogey, with its limitations on tank design, will eventually disappear.

The bulk-tank clearly fits in best with pipe-line milking, as the Americans have come to realise. In such an arrangement it would clearly be an advantage to have the tank under vacuum to avoid the necessity for releaser equipment (Fig. 8). But, other things being equal, a vacuum tank must be a more expensive construction than an atmospheric tank. This is unfortunate, because the

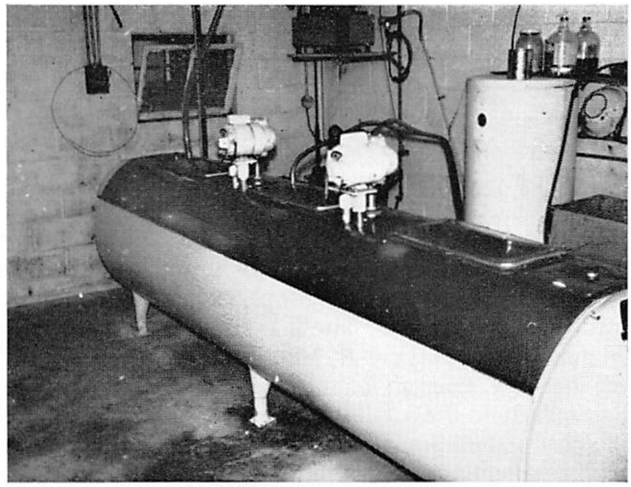

Fig. 8. A 400-gallon vacuum tank with direct-expansion cooling.

greatest need at the present time is to reduce tank costs, particularly in the smaller sizes. It is probably no exaggeration to say that the future of bulk collection depends on this, irrespective of the solution of the many technical problems.

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DISCUSSION

MR. A. PERROTT* : We have, as usual, heard a very interesting Paper from Mr. Hall. Sometimes, when I have listened to Mr. Hall for an hour or two, I wonder if we will be producing milk by the cow at all in the next seven or eight years ! However, it is obvious from his Paper to-day that we in the engineering business have a lot of problems to overcome.

Farming is becoming much more of a business to-day than it was in the past, and the farmer expects to get better equipment each year at a lower price. That is the problem which we have to face. It is not an easy one to overcome when we take into consideration that we cannot mass-produce much of our equipment due to the limited market. However, with the advent of the common market and the possibility of installing more equipment, there is a possibility that we can mass-produce more equipment, which will lead to many economies.

There is one thing which I have always thought would be a good idea. Mr. Hall has mentioned a specification

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for bulk tanks, which we manufacturers welcome very much. We have now a standard to which we can make tanks. During the past seven or eight years there has been quite an amount of development on milking-machine equipment, but not so much on the actual milking, which, after all, is the important thing. I should like to see a standard set for machine milking as well as for bulk tanks. After all, the actual milking is more important than the equipment.

To deal with the milking problems on the farm to-day we in the dairy industry must, first of all, understand the problems of the farmer, and the first essential is, I would think, that we have to be honest with ourselves and honest with the farmer with whom we are dealing. In other words, we have to recommend to him the equipment best suited to his requirements and not what many of our salesmen would like to do—go along and sell equipment costing an extra £100 or £200, when in actual fact it might not suit his requirements at all. Mr. Hall has shown on a slide a parlour adaptor which is very suitable in many instances for the smaller farmer. It is quite inexpensive, and a farmer could very easily spend £500 or £600 on putting in a parlour for a small herd of cows for which he would get no return. After all, as I said previously, farming to-day is a business, and the only thing a farmer is interested in is a return on the money invested. That is why it is essential that we recommend the most suitable equipment for each individual job.

Mr. Hall has mentioned in his Paper that there has been very little progress with the actual milking machine over the last 50 years. I think that is quite correct. The development of milking machines is quite a problem. They are unlike many other types of machine. First of all, you have to develop a machine which is working on a living animal, and to obtain the best results you have to get the response from the animal and from the operator. I think that is the most important fact we have to face. The next thing is that much more money has to be spent on development and scientific research, and that is why I should like to see a standards committee, or something to that effect, setting a standard for the performance of milking machines. Perhaps Mr. Hall would speak on that at a later stage.

We are all, no doubt, quite familiar with the different types of machines on the market to-day. The bucket plant is in the majority, in most places, and is likely to continue. It probably suits the small farmer better than any other type of machine. One of the problems which we will be up against when bulk collection comes in is the taking of the buckets to the bulk tank where a bucket plant is used. But I should think that, when circulation cleaning has been approved and is 100% satisfactory, a simple, cheap pipeline could be fitted in most small cow stalls to pipe the milk direct to the bulk holder, and that should overcome a lot of the difficulties. The trouble is not the actual cost of the pipeline to-day, but the cleaning of it. It requires quite a lot of expensive equipment to clean the pipeline, such as boilers, sterilizers, etc.

There are many types of milking parlours offered to-day, such as the abreast, the tandem, the chute, the herringbone and the outdoor milking bail. They all serve a very useful purpose if they are supplied for the right job. The chute parlour seems to be coming to the fore in the last year or two. It is inexpensive and quite efficient, particularly for herds up to about 30 cows. One of the problems which has been quoted in the past is the fact that with slow-milking cows you hold up the whole side of a row of cows for that one particular slow cow. But that has been overcome now by collecting the three or four slow-milking cows in the yard and milking them either first or last on one side. With the chute parlour there is not as much waste of time as many people think. With the tandem parlour there is quite an amount of work involved in opening the gates to let the cows in and out and, if it is not properly planned, there can be congestion in the passages, which is not the case with the chute or the herringbone parlour. For large herds of 60 cows upwards, the herringbone parlour has a lot to recommend it. The parlour, from a milking point of view, is probably one of the smallest problems. A milking parlour is not of much use unless it is well planned with proper collecting yards and housing for the cattle ; the feeding of the cattle has also to be taken into consideration and, if self-feed silage is employed, the access of the cows to the self-feed silos is very important.

When Mr. Hall spoke of bulk tanks, I wondered how we were going to manage with the bulk tank in those parts of the country—particularly the south-west—where during the summer months the cows are kept away from the farmstead and quite large amounts of milk are produced, such as in Somerset. Is the answer to have a portable bail-cum-dairy-cum-bulk tank on a tractor operating a vacuum pump and perhaps a direct-expansion bulk tank cooler ? I do know that some farmers are trying to develop this, and one will be in operation in Scotland in the coming spring.

Another problem, of course, is the small producer. I am just wondering whether in a few years' time there will be small bulk tanks, containing 20 to 30 gallons, something like big thermos flasks, which will be portable and will be moved down to the end of the lane, where a lorry would collect the milk in the same way as it collects the churns in many cases at the moment. No doubt Mr. Hall would like to comment on that later.

I should like to ask Mr. Hall whether in America they are satisfied with the results so far obtained from circulation cleaning ?

MR. J. C. MAUGER* : The interest I have in the development of bulk collection stems particularly from my work in connection with the organisation and costing of the collection arrangements for milk from farms and its delivery to the first point of destination.

As the marketing authority, the Milk Marketing Board are concerned continually with the promotion of better methods of wholesale milk distribution which will improve quality and reduce costs.

The collection of milk from farms is the first link in the marketing chain between producer and consumer ; it is a task of some magnitude and one in which the producer, the buyer, haulier and the Milk Marketing Board all co-operate.

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* *Marketing Officer, Milk Marketing Board*

Each day about 4¾ million gallons of milk have to be collected from some 125,000 farms in England and Wales and taken to 1,800 dairies and depots.

Since the war, and particularly during the last ten years, there have been increasingly rapid changes in the pattern of milk distribution. Whereas 20 years ago more than 13,000 dairies in this country received milk directly from farms, to-day there are only some 1,800 such dairies, but these are handling twice as much milk.

The churn, as a container, has served a very useful purpose over a very large number of years, and it will continue to do so for a good many years to come. The collection and delivery of milk from farms in churns, however, has a number of unavoidable limitations.

Mr. Hall has referred to some of the special features of which he terms " our conventional procedures." He mentions that in very few cases is refrigeration a necessity on the English farm and cites the relatively short distances involved in first-stage transport as one of the supporting factors in this connection.

It is indeed true that—thanks to an efficient ex farm collection service—milk is being handled satisfactorily with our conventional techniques, but this ignores the fact that we are entering a period in which rapidly increasing changes in the supply position are creating new problems and new circumstances which require new methods of handling milk from farms.

Refrigeration on the farm must be used to safeguard well-produced milk ; it will not in itself make good milk. Milk of good quality begins at the cow, and much depends on the design, use and maintenance of the milking equipment.

The lowest overall costs of getting milk from the cow to the consumer are obtained when milk from the farm can go direct to the processing dairy. With the changing pattern and the continually reducing number of processing plants, the trend all the time is for farm milk to have to travel greater distances to its first destination.

At the same time, many of our dairy premises, particularly those in Urban areas, are becoming increasingly handicapped by traffic congestion, lack of space, and noise problems.

The collection of milk from farms in churns necessitates a collection service which has to be geared to collect and deliver all the milk each day between the hours of 7.30 a.m. and about 3 p.m. This lack of flexibility is becoming an increasing problem, and in itself restricts the distances over which milk from farms can travel to direct markets and the quantity of farm milk which can be dealt with at individual plants.

With this picture in mind, it is understandable that the Board has shown considerable interest in the possibilities of bulk collection, and after very careful consideration during recent months has now decided on a policy which is designed to promote a very much more rapid development of the bulk system of handling farm milk in this country.

I would say that there is no doubt about the long-term advantages of bulk collection in physical economy, improved quality and overall financial savings. But bulk collection must be looked upon and pursued as a long-term policy and as a process in which the larger farms will come in first.

Anyone who has had experience of bulk collection in this country would agree with Mr. Hall that many problems remain to be solved, but I think he is a trifle over-cautious in the views he expresses in his Paper on some of these problems.

The full advantages and the true economies of bulk collection will not be obtained in the short term, and the Board have recognised this and are basing their policy accordingly.

From the larger producer's point of view, bulk collection can now offer quite a number of advantages and a satisfactory economic picture. Even the type of producer to whom Mr. Hall refers, who has already chosen his equipment wisely and has taken steps open to him to improve his milking and milk handling operations, can, I think, make some further saving by the introduction of a bulk tank.

What must be borne in mind is that this type of farmer is not typical of more than a very small percentage.

We know from the experience we have had with our Pilot schemes that a number of producers who have introduced bulk tanks have used them as a starting point round which to re-design their whole milking system, with considerable advantages in terms of savings and in the maintenance of quality.

What to-day is possible and financially attractive to the larger producer will, as development proceeds, become increasingly of interest to the smaller producer. Many of our present problems are in the nature of growing pains and are unavoidable during the transition stages.

Bulk collection will not necessarily bring savings in haulage if the tanker vehicle is used merely as a substitute for the conventional type of churn lorry. We shall all have to become educated up to new methods of handling milk from farms.

Bulk collection offers considerably greater scope for flexibility in times of collection and delivery than does our present system of handling milk in churns, and we must adopt arrangements which will enable proper use to be made of the relatively expensive equipment which is an essential requisite of bulk collection systems.

I agree with Mr. Hall when he says that the buyer is not likely to make much saving from bulk reception unless he can eliminate at least one entire churn line with all that goes with it. This, however, is not by any means a very high target at which to aim in a very large number of cases.

We are finding that buyers with problems of congestion, parking and traffic restrictions, and so on, are becoming increasingly interested int he prospects of handling farm milk in bulk.

Again, the changes which are taking place on the distributive side of the industry are, in some cases, involving either the rebuilding of existing premises or the provision of entirely new dairies. Where these circumstances apply, bulk collection can make a very big contribution towards a substantial reduction in the buyer's capital outlay and in his costs of handling the incoming milk.

One of the biggest problems we face at the present time and which we shall continue to face for the foreseeable future is the size of the average milk-producing unit in this country.

Of the 125,000 wholesale milk producers registered with the Board, probably about a quarter have an average daily production of 50 gallons and over, and of these not much more than one-third are producing over 100 gallons a day.

At the present time, even with the financial incentives which the Board are now offering to producers for bulk schemes, the current level of tank prices does not make bulk handling of milk on the farm attractive to a producer who is averaging less than 60 to 70 gallons a day throughout the year.

The most pressing need is for a cheaper small farm tank of approved design and performance. Up to now, it is fair to say that tank manufacturers have not had much opportunity of producing farm tanks in very much more than "penny numbers." This position is now changing and a better order book should have some effect on costs.

A very much greater contribution towards lower costs could, however, be made if the present development towards a flow-meter can be carried to a satisfactory conclusion. My Board is particularly interested in this possibility ; we feel that tank design at the present time is unavoidably restricted by the limitations imposed by the need to use the milk tank as a calibrated vessel.

We are indeed very grateful to Mr. Hall and his Staff for the work which they are currently carrying out at the Research Institute on this particular development. There are, indeed, many other ideas which are under consideration, but it would seem that a flow-meter which could be fitted to the collection tanker could make probably the biggest single contribution to the development of bulk collection under the present circumstances.

MR. P. GREGORY* : I have four questions, and I think they will be very quick ones.

Where will straight liners appear in your figures of output in relation to stripping and speed of milking ? Will they be good, bad or average ?

In your Paper—though not in your talk—you referred to the known advantages of carbon black in milking rubbers. I want to know what benefit is to be derived from carbon black. Would it improve the length of life of rubbers and possibly have some effect on their deterioration in use ?

Do you know of any experimental work being done to see whether 17 ins. of mercury might be better than 15 ins., and whether a ratio of 2 : 1 would be as good as you could get ?

Do you have any figures on the life of plastic permanent pipelines made from perspex or its equivalent, as distinct from p.v.c. pipelines ? They seem to be very good, but I would like to know what the defects may be, as they have not been in existence long enough to know how they will last.

One point about bulk collection—from the farmer's point of view, which is our point of view. We produce a vast quantity of milk, most of which goes to London. We still use churns, and churns are cheaper than bulk tanks, which is a major consideration. One penny a gallon is not good enough because, if we are going over to bulk tanks, we shall have to make roads to our bails from which the bulk tankers have to collect the milk. Bails tend to be situated rather remotely, and it would be extremely difficult to get the tankers to the dairies through snow and ice. We are a little alarmed about that. But we were much encouraged not very long ago because one of our biggest buyers, who are still a private concern, said that they had no real inclination to go over to bulk buying of milk, as they could put through 25,000 gallons in churns, which would be 2,500 churns, empty, sterilize and load them back on to lorries in the time it took them to empty and clean, ready for the next day, a 1,500-gallon tanker.

I am making these points not because I think bulk handling is not feasible, but merely to raise one or two practical difficulties.

MR. T. SPEAR : Many small farms with small cowsheds could keep more cows if they had a better system of grassland production, etc., and introduced a pipe-line system into their cowsheds. Quite a lot of farmers are commercial farmers who do not want to record for breeding purposes, and perhaps here a comparatively simple pipe-line system would be adequate. I am wondering what objections there would be to having a pipe-line in, say, 2 ft. 6 in. lengths which could be taken off clips, connected with rubber hoses, and put into an immersion tank. It would probably be much quicker to put this pipe-line out than to assemble buckets, and I am wondering whether Mr. Hall has any objections.

Is it possible to obtain some sort of flowmeter which would indicate to the farmer which of the cows were being passengers ? I should mention that in this case the farmer does not need to record for breeding purposes, but would like to know within $\pm\frac{1}{2}$ gallon whether a cow is a passenger or not.

MR. P. FINN-KELCEY : I would just like to ask Mr. Hall what method he had in mind for the cooling of milk in the bulk tank. He hinted darkly that the jacketing system might not be the answer. Would he tell us what he has in mind ?

MR. HALL (in reply) : I must thank our discussion openers for filling in quite a number of gaps which, unfortunately, I had to leave.

Mr. Perrott referred to the need for some sort of standard for milking machines. He said "machine milking," and I am not quite sure he did not mean "milking machines." There is quite a difference. It would be one thing to arrive at a standard which would materially assist a number of points concerning milking machines, but it would be very much more difficult to standardize machine milking, where you would obviously have to have something rather more in the nature of a code of practice. I suppose 10 or 12 years ago I would not have said this because I was then quite willing to test and report on a milking machine. The experience that I have obtained in so doing opened my eyes to the difficulties of the problem.

The first and most important difficulty is that we have no optimum. With what do you compare a milking machine ? The method we have pursued over the years has been to try and find out what are bad points and what are good points and to try and persuade everybody concerned that we have reliable facts and then rely on them to use them. It has some importance too in relation to this question of pulsation ratio that I touched on, because pulsation ratio is being made so prominent. It is there where I begin to feel a little bit worried, partly from the facts of the situation and partly from the way in which I am sure the average farmer is thinking. He is tending to be perhaps a little bit misled by what he is being told. I am not suggesting that the manufacturer is wilfully misleading him. I am suggesting that what is referred to by the manufacturer as the " pulsation ratio " may well be nothing of the kind, because he himself has not a commonly agreed standard on which to base his statement. It would be a good thing certainly if we could get that point clear and agree on some method of expressing pulsation ratio, so that when a farmer is told by a manufacturer that his machine has a pulsation ratio of " x " he will know that that figure is comparative with a statement made by somebody else. At the moment it just is not, as you saw from the slide I showed you.

Mr. Perrott also asked me whether in America they are satisfied with circulation cleaning of pipelines. No farmer with a pipeline would ever dream of doing anything but circulation cleaning. That is not to say that the results are all they should be. I think you have to look back here to what the American has been conditioned to over a long period of years. I looked into this rather carefully a good many years ago in an attempt to correlate the standard of equipment designed in America with our own standards here. Even at that time refrigeration was almost universal on American farms. Where refrigeration was not used excellent cold-water supplies were available, so that the standard of cooling always has been better in America than in England. But, in spite of that, when one compares—as I did in Pennsylvania—the quality of farm milk treated in the same way it would be treated in this country, one finds that, in fact, there is very little difference. It seems that the American farmer with his standard of hygiene and with his standard of cooling is doing about the same sort of job that the British farmer is doing with his very much poorer standard of cooling and, by inference, rather better standard of hygiene. That is the background. It is universally agreed in the United States that the advent of the bulk tank has improved the bacteriological quality of milk supplies to the dairy. I am certain that is due to the better cooling which is derived from bulk tanks where the refrigeration is applied much more conscientiously and much more thoroughly than it was previously with immersion coolers. I am sure that that has obscured any changes in the standard of hygiene which arise from the use of a pipeline, and it is one difficulty that we have to face in this country. It is all very well to say that we must not let refrigeration hide bad hygiene. The fact is you cannot stop it hiding bad hygiene. The course which we have pursued so far, and which I hope we shall continue to pursue, is to ensure as far as possible that the standard of equipment and the standard of techniques are good enough to prevent a degradation of hygiene standards which will not come to light with the improved cooling facilities that bulk handling would make available. So it is probably true to say that if we had bulk tanks and bulk collection universally in this country, we could take liberties with the hygiene of milk production and get away with it. But that does not mean to say that that is a good thing. I am sure that the proper method of attack is to get cleaning methods right, irrespective of whether milk is going to be bulk-cooled or not. The man who wants a pipeline but cannot be included in a bulk scheme will then not suffer. That, I think, is the right approach.

One other point that Mr. Perrott made was about portable bulk tanks. In 1949 I was shown a cowhouse in Sweden for 100 cows in two rows head-to-head. One of its features was that the manger between the cows was on rails and was moved by an electric motor into the silage shed between milkings for filling. When the cows were in, a button was pressed and the whole manger moved into the cowshed. This farm also had milking into a portable vacuum tank. The tank was chilled-water jacketed and was cylindrical, slung on a gantry which ran right around the cowshed. Two men operated the four milking units connected with it, moving the tank along the gantry as they went. At the end of milking the tank was moved into the dairy and connected up with the chilled water unit, which then circulated water through the jacket until the milk was ready for collection. In the summer this tank was detached from the gantry and dropped on to a four-wheeled vehicle, which was complete with vacuum pump. It then became a field milking outfit. The only other case of a portable tank that I have seen was a very fancy affair in America consisting of a rectangular vacuum tank with a surface cooler incorporated for preliminary cooling of the milk, and the whole thing was complete with a driver's seat, electric motor and everything else.

I agree it is a problem to apply bulk collection to bail farming. We saw one attempt in the Newbury scheme, where one of the producers had used a field bail in the summer. He brought his milk to the farm in cans on a tractor trailer and tipped the milk from the cans into the bulk tank. It may be that that simple method is perhaps still the best.

Now I shall try and deal with the quick-fire questions from Mr. Gregory. I assume that by " straight liners " you mean " extruded liners." I think it is fair to say that, generally speaking, they have good milking characteristics, although not necessarily good stripping characteristics.

As regards the virtues of carbon black, I am only repeating there what has been said by a number of people more qualified than I to talk about rubber technology. Carbon black is an excellent filler for rubber, particularly from the point of view of length of life. I would like to know why red rubber still persists. I think it originally came into the picture because somebody called it surgical rubber, and rubbers associated with medical practice were generally red, and so everybody thought they must be the highest quality. Then came the war and rubber substitutes, which were always black. Many of them were very bad, consequently all black rubber was thought to be bad. I personally would like to see a much more general return to the use of black rubbers rather than red rubbers, because I am sure that the life of the article would be improved.

Coming to the virtues of 17-in. mercury vacuum, I would advise you to read the Ministry's Bulletin No. 177, and in particular the chapter which deals with mastitis and the milking machine. You will find there a very good, long review by Mr. Neave on this particular topic. It has often been said, of course, that high vacuum is the real cause of the association of the milking machine with mastitis. The fact is nobody has ever proved it. Experiments are quoted there exhaustively, and the most one can say, I think, at this stage is that there is probably a high limit beyond which trouble inevitably occurs. You must not forget, too, that as you increase vacuum the capacity of your vacuum pump, in terms of free air, goes down. So, other things being equal, you want a bigger pump capacity to work at 17 ins. of mercury compared with 15 ins. You will increase the rate of milking with an increase of vacuum. That is just a straightforward mechanical effect. Probably the best guide one can give at the present time is that one should not milk with less than 15 ins. of mercury at the teat cups. That means that with most plants the vacuum pump should operate at something like 15 to 16 ins. of mercury at the inlet. With a high-line recorder plant probably 17 ins. at the pump will be required. But there is no benefit to be gained by dropping down below 15 ins. Where the upper limit comes is extremely difficult to say. The evidence on the possible ill effects of higher vacuums is still incomplete.

Plastics milk pipes was the other point—it is too soon to give a firm opinion. I think that the first portable plant came on the market roughly a year ago in the United States after 12 months on trial in two or three States. The greatest virtue, as I see it, is that they are generally in one length—there are no joints, and so most of the cleaning headaches are removed. We in this country can clean unbroken lengths of pipe or glass jars as well as the Americans can, and we may be able to do it better, but it is the joints between the pipes which are the problem. If you have a 200-ft. length of unbroken pipeline, the problem of circulation cleaning is really quite small. The plastics pipeline will stand or fall on its length of life. It seems to me that if it does not last more than three years it is probably cheaper to install a permanent pipeline. But that, of course, remains to be seen.

One other point you mentioned was the problem of roads. I appreciate that it can in some cases, and particularly in your case, be quite a headache. This argument is often over-emphasized. One tends to think that a tanker of 1,750 gallons is a heavy vehicle, but, in point of fact, it presents no greater problem than much of the traffic which is already using the farm roads at the present time. It can be argued, of course, that other traffic does not have to go when the roads are snow-bound. However, this is a problem which is acute only in some areas and in wintry conditions.

Mr. Spear referred to the benefits of short lengths of pipeline in cowsheds. I would still maintain that the simple system of tipping from a bucket machine into cans on a suitable trolley in the cowshed is better. It certainly is cheaper, and I think it is probably quicker, if you add up the total labour involved. As for the question of dismantling pipelines, I think that requires too much time. I am quite sure that one can put units together quicker than erecting short lengths of pipeline.

As regards a meter with a rough accuracy which is adequate for rationing purposes, there is no satisfactory answer at the moment. As you probably know, there is only one meter on the market for use in a cowshed, that is the American " Milk-o-Meter," made in Florida. One point which militates against its general acceptance is its cost. I do not know how much a farmer can afford to spend on this item, but it is priced at 160 dollars in the United States. It would not be much cheaper if it had an accuracy of only $\pm\frac{1}{2}$ gallon instead of the accuracy which, it is claimed, can now be achieved. In point of fact, that principle has accuracy limitations which become apparent as soon as you apply it to fast-milking cows.

As regards the question about permanent plastics pipelines, made of perspex or its equivalent, as distinct from p.v.c. pipelines, experience is too limited to give you a full answer. However, I would regard the possibility of using long lengths of jointless pipeline as being one point in its favour. Perspex, as we know, has some disadvantages. Stress cracking is a common one, and we have had trouble and know of others who have had trouble in this respect. Nevertheless, I think it has some possibilities, but it is too soon to judge what they are.

Finally, to answer Mr. Finn-Kelcey's question. I was referring more particularly to bulk tanks with a water jacket right up to the brim, as distinct from any form of applied heat exchanger. At the moment we have concentrated on the water-jacket system, but we hope to see other methods explored.

Note by Author

Mr. Perrott's comments on the parlour adaptation shown in Fig. 5 may be somewhat misleading. In this particular case four standings in a cowshed were adapted to serve as a milking parlour, the cows being brought from the remaining standings in the shed. No difficulty was found in training the cows to walk in and back out of the milking stalls, and an efficient routine was established within a few days.

The adaptation involved :—

Concreting the dung channel behind the four stalls concerned.

Fitting a 2-in. pipe as a rail over the standings with over-centre lifting devices for the two milking units.

Making two can platforms and fitting with spring balances.

Providing one pendulum pulsator to serve the two units.

Providing two direct-to-can milking lids.

The total cost of this was probably well below £50.

ELECTIONS AND TRANSFERS

Effected at the meetings of the Council on the 9th February, 8th March and 12th April, 1960.

ELECTIONS:

MEMBERS

Foxwell, W. J. .. .. Essex

ASSOCIATE MEMBERS

Chapman, G. W. A. ..	Surrey	Osborne, A. T.	Derbyshire
Davies, E. W. ..	Wilts.	Shew, K.	Warwicks.
Ferreira, P. D. F.	Notts.	Swift, M.	Kent
Hargreaves, P...	Yorks.	Waddington, J. C.	Cambs.
Klinner, W. E.	Beds.	Whitson, W. S.	Dorset
McDonogh, K. G. H.	Northumberland		

Overseas

Donaldson, A. G.	New Guinea	Rajapurka, K. N.	Sudan
Llewellyn-Jones, A. D.	Kenya	Saravanamuttu, G. L.	Ghana
Norbye, E.	Norway		

ASSOCIATES

Carter, J.	Caerns.	Martyn-Johns, A. J.	Sussex
Crofts, J. S.	Lincs.	Mitchell, D. J.	Somerset
Hope, W. B.	Northumberland	Scott, C. C.	Perths.
Hosier, F. H. ..	Wilts.	Spratley, N. G.	Surrey
Mander, E. H.	Warwicks.	Wrixon, H. K.	Surrey

Overseas

Muange, A. T. .. .. Ghana

GRADUATES

Askins, J. A. C.	Oxon.	Patterson, D. E. ..	Beds.
Blake, T. J.	Oxon.	Smith, P. H. S. ..	Surrey

Overseas

Plunkett, A. J.	Australia	Richardson, J. P...	Australia

STUDENTS

MacInnes, A. J. M. ..	Lanarks.	Robinett, L. R.	Northants.
Miller, C. N. ..	Essex	Wakeham, G. F. D.	Suffolk
Pomeroy, E. G.	Wilts.		

TRANSFERS:

FROM ASSOCIATE MEMBER TO MEMBER

Baldwin, G. G.	Yorks.	Percival, W.	Warwicks.
Brown, A.	Suffolk	Shewring, J.	Norfolk
Howell, H. F. ..	Warwicks.		

Overseas

Godlewski, K. J. M... .. Canada

FROM ASSOCIATE TO ASSOCIATE MEMBER

Bunting, J. F. ..	Derbyshire	Sainsbury, R. M. J.	Glos.
Cattermole, H. F.	Worcs.	Watford, P. H.	Somerset
Hepherd, R. Q.	Herts.		

FROM GRADUATE TO ASSOCIATE MEMBER

Barber, R. D. S.	Cambs.	Hudson, J. E.	Salop.
Catling, H.	Glos.	Moorhouse, K.	Essex
Codrington, C. de B.	Kent	Plowman, R. W. ..	Yorks.
Gray, J.	N. Ireland	Underdown, P. J.	Cheshire
Hardcastle, M.	Essex		

Overseas

Bulba, E.	Israel	Yates, P. I.	Brazil
Mohamed, W. D.	Malaya		

FROM GRADUATE TO ASSOCIATE

Billot, M. R. .. .. .. Jersey

FROM STUDENT TO ASSOCIATE

Le Cappelain, C. G. H. Jersey

FROM STUDENT TO GRADUATE

Brain, D. M. .. .. Devon

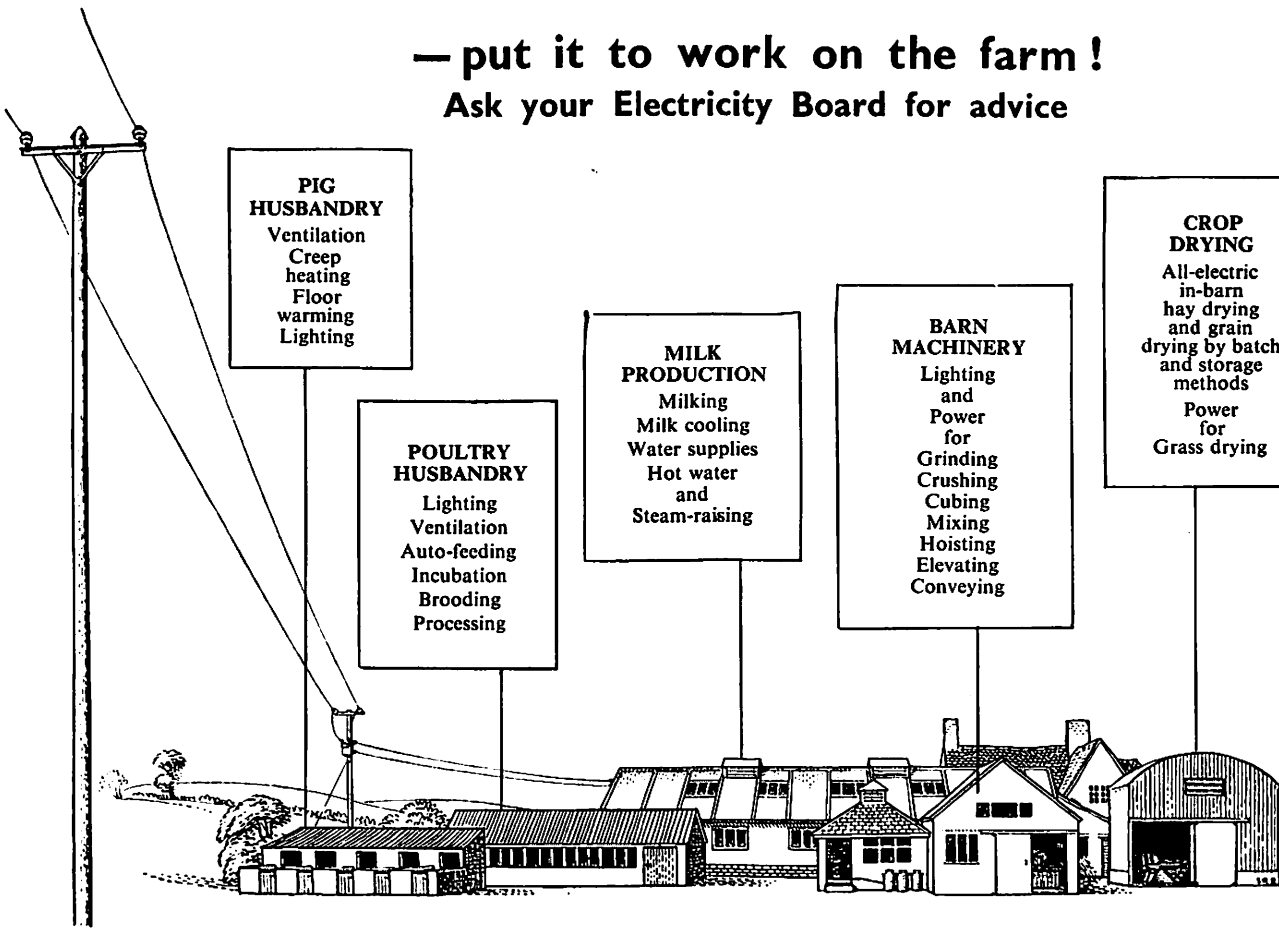
Overseas

Olubode, S. O. .. .. Nigeria

Electricity -don't shut it up in the farmhouse

—put it to work on the farm!

Ask your Electricity Board for advice



Put your Electricity to work on the farm!

Issued by the Electrical Development Association, 2 Savoy Hill, London, W.C.2.

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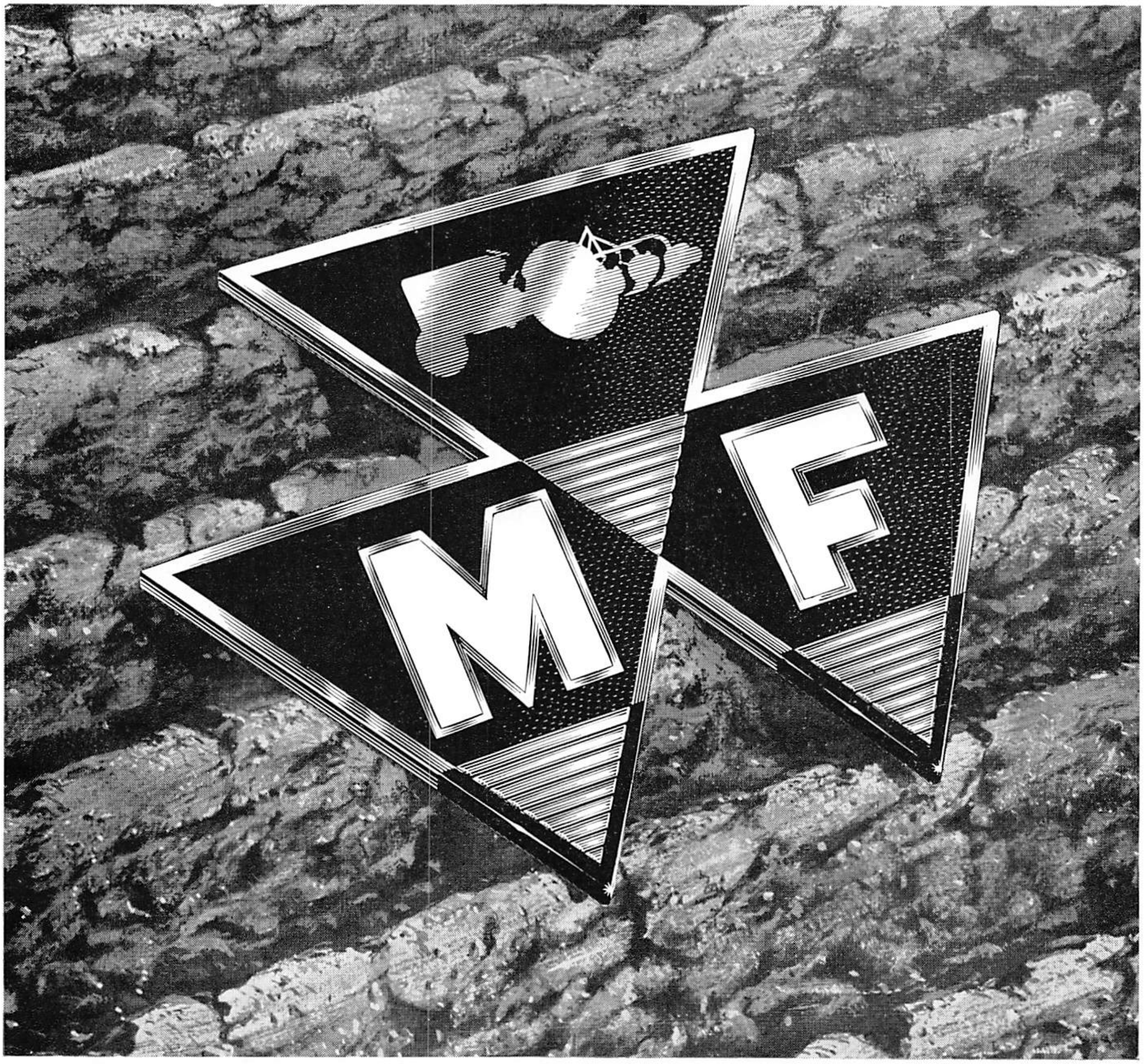

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Particulars may be obtained from local tax offices, and form P.358 should be completed, as a claim for adjustment on P.A.Y.E. coding.

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