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Incorporating Soil and water

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10th. & 11th. July
at St. John's Fen End
Kings Lynn
Norfolk

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Front cover: The ADA demonstration of flood defence and land drainage systems – scenes from past events. (This year's event is at King's Lynn, 10-11 July. See page 43)

Journal and Proceedings

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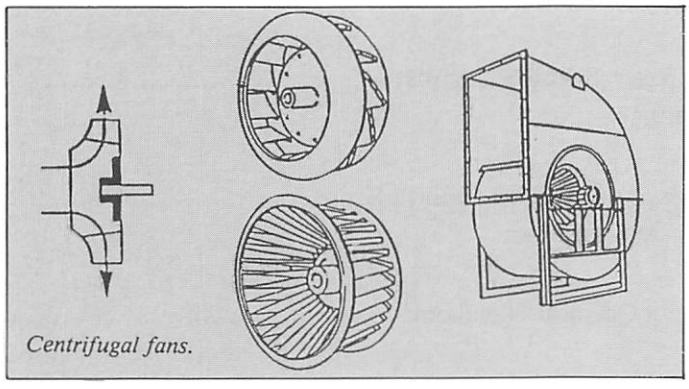
Fans for today's agriculture

part 2: Centrifugal fans and mixed flow fans

In part 1 of this paper, in our last issue, W T W Cory considered generally the principles of operation of fans and the various types of fans now available. He then dealt in depth with axial fan classification, construction and theory.

In this issue, W T W Cory now takes us through the theory of centrifugal fans. He goes on to examine centrifugal fan types and their applications and the special role of the mixed flow fan.



Centrifugal fans.

To appreciate fully the significance of various centrifugal fan designs – the range of impeller types, the methods of flow control – it is necessary to have some background of elementary theory.

Elementary centrifugal fan theory

A centrifugal fan receives air or gas at the impeller eye and delivers it to the casing volute at high velocity by imparting rotational energy. The kinetic energy produced by the impeller is converted into pressure energy within the volute. Fan efficiency therefore depends on how much kinetic energy is produced, how low the impeller losses can be kept and how well this kinetic energy is converted into potential energy (or static pressure) within the casing.

For the sake of simplicity the analysis presented here is not mathematically exact and further assumes that the air or gas is incompressible.

Considering the velocity triangles in Fig 18, the work done on the gas by the impeller will be the energy difference between exit and entry in the direction of rotation.

– Energy in air at impeller exit
  = torque × angular displacement
  = rate of change of (tangential momentum × radius × angular displacement)
  = tangential momentum × radius × angular displacement
  = $m\, v_{w2} r_2\, \omega$

– In like manner the energy in air at impeller inlet
  = $m\, v_{w1}\, r_1\, \omega$

Now $r_1\, \omega = u_1$ and $r_2\, \omega = u_2$

– Energy given to the air by the impeller
  = $m\,(v_{w2}\, u_2 - v_{w1}\, u_1)$

The theoretical or Euler head H developed by the impeller is defined as the height of which the same weight of gas could be raised by an equal amount of work.

Thus $mgH = m\,(v_{w2}u_2 - v_{w1}u_1)$

or $H = -(v_{w2}u_2 - v_{w1}u_1)$

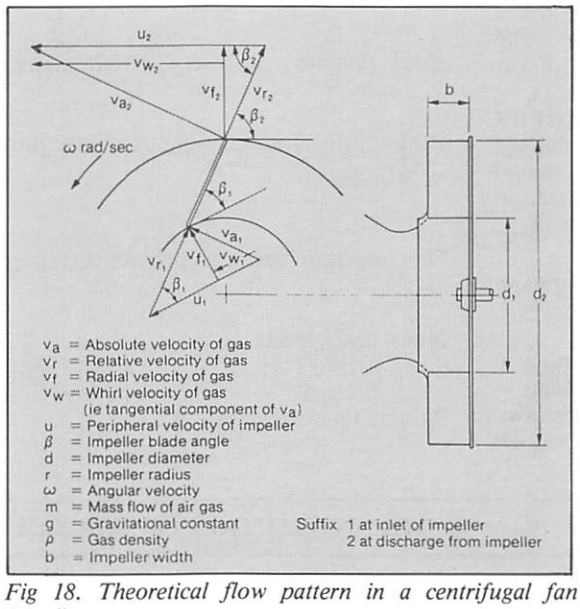


Fig 18. Theoretical flow pattern in a centrifugal fan impeller.

In fan work we usually need to know the pressure developed ($p = \rho gH$) and therefore $p = \rho\,(v_{w2}u_2 - v_{w1}u_1.)$

Under normal circumstances at the design duty, the air will enter the easiest way, ie radially, and then $v_{w1} = 0$.

Thus $p = \rho\, v_{w2}\, u_2$

Theoretical to actual pressure

The theoretical pressure will be reduced by the following factors, the aim of the fan engineer being to keep them to a minimum:

Relative rotation losses: In addition to the normal flow of fluid within the impeller, the inertia effect of the fluid causes a rotation of the fluid relative to the impeller. Also, when the impeller is mounted between bearings, due to the effect of the rotating shaft, the fluid will have a definite tangential whirl velocity at entry to the impeller blade. Both of these factors reduce the pressure that the fan is capable of producing, but they do not affect the efficiency.

Friction losses: These are caused by gas friction and also include volute losses. (The volute is that part of the fan which converts velocity energy into pressure energy. This is normally achieved by arranging the discharge channel so that the cross-sectional area gradually increases, thus reducing the flow velocity.)

Shock losses: Losses arise at entry to, and exit from, the impeller blade because the blade angles are only correct for the design duty. On both sides of this shockless flow condition losses will occur.

Other losses: These losses differ from those of the other three groups in that whilst they affect the overall efficiency they do not alter the basic fan characteristic.

i) **Leakage:** occurs from discharge to suction and through the shaft entry hole.

Bill Cory is Technical Director at Woods of Colchester Ltd, a GEC Company.

ii) **Disc friction:** due to rotation of the impeller shroud and backplate within the gas.

iii) **Mechanical losses:** caused by the bearing friction and friction at any shaft seal.

Considering the impeller in cross-section with a width at its tip of b_2, we may say that the volume of air or gas delivered per unit time $Q = \pi d_2 b_2 v_{f2}$.

Now the impeller blades at the outlet may be either:

a) *Backward inclined* (straight, curved or aerofoil) as in Fig 19:

$$\text{when } u_2 = v_{w2} + v_{f2}\cot\beta_2$$
$$\text{or } v_{w2} = u_2 - vf_2\cot\beta_2$$
$$\text{Now as } p = \rho\, v_{w2}\, u_2 \text{ and } Q = \pi\, d_2\, b_2\, v_{f2}$$
$$p = \rho\, u_2 \left(u_2 - \frac{Q\cot\beta_2}{\pi d_2 b_2}\right)$$

This theoretical characteristic is a straight line with a downward slope.

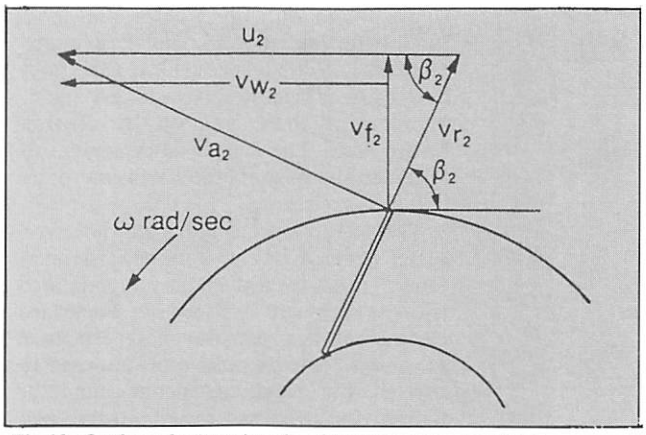


Fig 19. Outlet velocity triangle of backward inclined fan.

All these theoretical characteristics are shown in Fig 21 whilst the actual characteristic, with its losses, is shown for a backward inclined impeller in Fig 22.

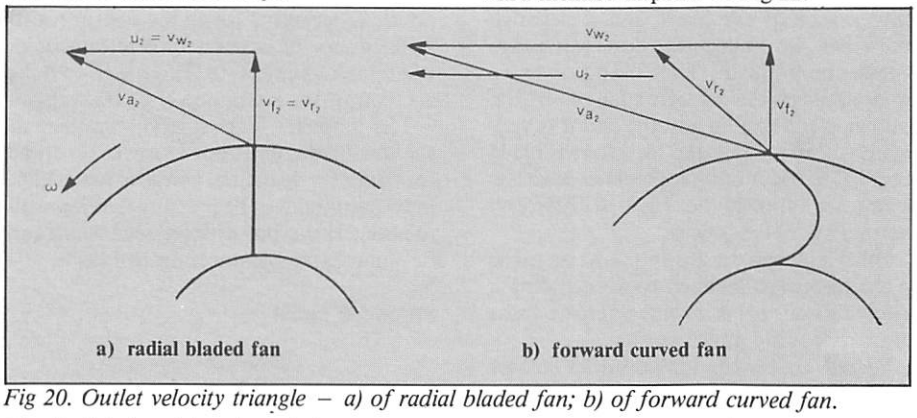


Fig 20. Outlet velocity triangle – a) of radial bladed fan; b) of forward curved fan.

b) *Radial* (straight shrouded, open or backplate paddle, or radial tipped) as in Fig 20a

$$\text{when } v_{w2} = u_2 \text{ and } v_{f2} = v_{r2}$$
$$p = \rho\, u^2_2$$

This theoretical characteristic is a horizontal straight line.

c) *Forward curved* as in Fig 20b

$$\text{when } v_{w2} - u_2 = v_{f2}\cot(180° - \beta_2)$$
$$p = \rho\, u_2 \left[u_2 + \frac{Q\cot(180° - \beta_2)}{\pi\, d_2\, b_2}\right]$$

This theoretical characteristic is a straight line with an upward slope.

It will be seen that for a given speed of rotation and a given pressure, the volume flowrate is dependent on the width of the impeller and the blade angle. It is therefore essential for the manufacturer to have a series of widths to ensure that all combinations of volume flowrate and pressure can be achieved at a good efficiency. Too often centrifugal fans are selected away from their design point, and only with a combination of widths, diameters and blade forms can this be obviated.

Actual against theoretical characteristics for radial and forward curved fans are shown in Fig 23 and Fig 24 respectively.

Importance of straight flow into impeller

It must be emphasised that all the above assumes straight flow into the impeller eye and consideration of the equations will show that if this is not the case then the pressure developed will be reduced.

Variable inlet vanes purposely use this fact to impart swirl in the direction of rotation. This can be progressively increased by closure of the vanes with a corresponding reduction in the pressure developed. There will, of course, be some additional friction losses.

More importantly, from the system designer's viewpoint, it will be seen that if straight flow into the fan inlet is not achieved due to poor inlet connections, then the fan will not develop its test pressure. Insufficient straight ducting on the fan inlet side, sagging flexible connections, absence of straighteners in bends, and too tight bends can all be responsible. Where fans are mounted in plenum chambers there must be a sufficient distance from the fan inlet(s) to the chamber walls for the same reason. Often the system designer is himself short of space. He may then have to provide less than ideal connections.

Centrifugal impeller types and applications

The general shape of the pressure-volume flow characteristics is outlined in the section on 'Elementary centrifugal fan theory'. This section indicates operating advantages and preferred applications. Typical performance curves are given which also give information on operating efficiency and power variation. Limitations as to air/gas temperature, dust burden, and rotational speed are also included.

Backward inclined

These may be considered as the 'maids of

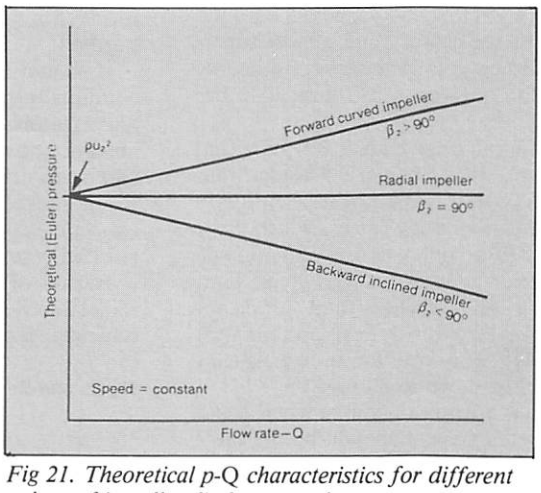


Fig 21. Theoretical p-Q characteristics for different values of impeller discharge angle.

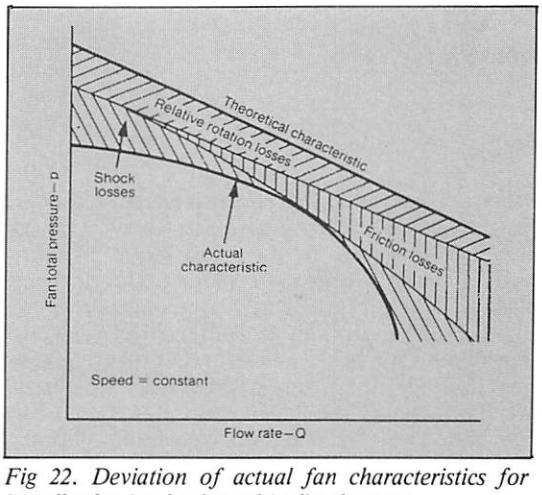


Fig 22. Deviation of actual fan characteristics for impeller having backward inclined vanes.

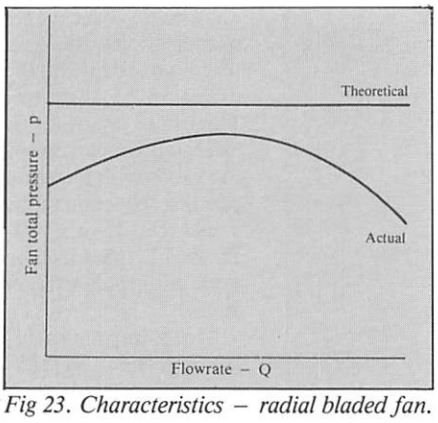


Fig 23. Characteristics – radial bladed fan.

all work'. Due to their simplicity the blades lend themselves to simple methods of construction, at a moderate price, and they can easily be flanged for rivetting and spot welding up to size 900mm. The design is of the high speed type making them suitable for direct connection for many duties.

Fan static efficiencies up to 80% peak have been achieved with the medium widths using the very latest aerodynamic knowledge. The wider fans have the additional advantage of a non-overloading power characteristic so that, with correct motor selection, the fan may operate over its complete constant speed pressure-flow curve. In its working range, the curve is also comparatively steep so that large variations or errors in system pressure will have a smaller effect on flowrate.

The blades are self-cleaning to a certain degree and are in any case easy to clean because of their single plate flat form. They are therefore suitable for free-flowing granular dust burdens or moisture-laden air. In the absence of special factors, this impeller is the recommended form for all applications.

Standard fans are available for operation at gas temperatures up to 350°C.

In general terms, the narrower the fan the fewer the number of blades and the greater the blade outlet angle. Both these factors are conducive to the acceptance of higher dust burdens, but counter-balanced to a certain extent by boundary layer effects and higher abrasive velocities.

Backward curved

Backward curved impellers are preferred for certain applications where there may be disadvantages in the use of backward inclined type. Due to the curvature, the blade angle at inlet can be made steeper for a given outlet angle. This generally enables shock losses to be kept low, whilst the curvature itself develops a certain degree of lift. It is therefore possible to arrange such fans with a pressure curve continually rising to zero flow.

Backward curved impellers are extremely stable, with none of the 'bumps' in their curves found with other types, and most suitable for operation in parallel on multi-fan plants. With the special blade curvatures now used, efficiencies exceed 82% static, approaching those attained by aerofoil bladed fans. The steeper inlet angle also results in a stronger blade which can rotate at higher speeds.

The performance benefits are, however, offset to a large extent by the need to run at higher speeds for a given duty as compared with the backward inclined type. Backward curved impellers are also more expensive as, unless complex press tools are used to 'stretch' the metal, the blades cannot be flanged for rivetting or spot welding and have to be arc welded in position.

The curvature of backward curved blades (concave on the underside of the blades) is inclined to encourage the build-up of dust. As the impeller in its rotation tends to develop a positive pressure on the working convex face of the blade and a negative effect on the underside, dust can lodge within the camber. This becomes more pronounced on the narrowest fans where the camber is substantial and the chord is very much shorter than the developed blade length. The wider units in the series have less curvature, although the effects are offset by the shallow outlet angles.

Other advantages are the same as those of the backward inclined type, including a relatively steep pressure characteristic and a non-overloading power curve.

For all duties, the higher initial cost of backward bladed fans can usually be recouped many times over during the life of the unit, as the energy consumption will often be reduced by 25% compared with foward curved fans. Driving motors will also be smaller, and as the fans have a non-overloading power characteristic only a small margin is necessary over the absorbed power.

Forward curved

These impellers first became popular around the turn of the century and almost superseded all other types. They are considerably smaller for a given duty than all other designs.

Flowrate can be as high as 2.5 times that of the same size of backward bladed fan. This is now seen to be not necessarily an advantage since casing losses, which are a function of the square of the velocity, will therefore be about six times as great. Thus even with an impeller total efficiency approaching the theoretical optimum of about 92%, the overall fan total efficiency would still be down to about 75%.

Such fans are now only used where space is at a premium, as they will be the most compact. Due to their smaller size they are usually cheaper although the differences are much reduced with the greater possibility for

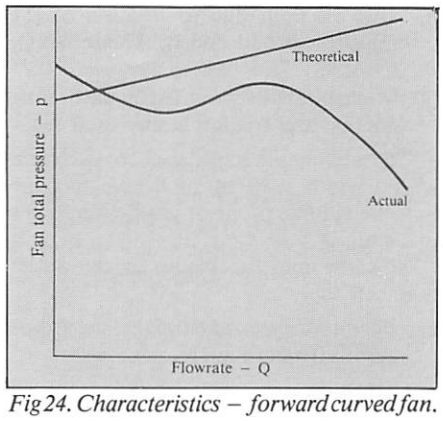


Fig 24. Characteristics – forward curved fan.

automated manufacture of backward bladed fans. Nevertheless the scope for improvement has been appreciated and current designs achieve static efficiencies of 65% and total efficiencies of 71% at even lower speeds. A large margin over the absorbed power is necessary where the system resistance cannot be accurately determined, or where it is subject to variation, to take account of the rising power characteristic.

The impeller has a large number of shallow blades and runs at lower tip speed for the duty. Structural considerations have in the past limited the pressure development to about 1kPa, but with reduced width can be suitable for pressures up to 14kPa.

Shrouded radial

A useful design for handling free-flowing dust-laden air or gas, shrouded radial impellers have the ability to deal with higher burdens than the backward inclined type. They are somewhat more efficient (up to 65% static) than the open paddle and also able to run at higher rotational speeds and thus develop higher pressures. The blades are inherently strong as centrifugal forces have no bending effect. They are also simple and in sizes up to 900mm can be easily flanged for rivetting and spot welding.

Blades are largely self-cleaning and are easily cleaned. Such fans are suitable for moderate free-flowing granular dust burdens.

It should be noted that the power rises continually towards free air (zero pressure) and a reasonable margin is necessary over the absorbed power, unless the system pressure can be accurately assessed. As the impeller has a backplate, wear is concentrated on this, but casing wear is correspondingly reduced compared with the open paddle.

Because of its characteristics, the shrouded radial impeller is widely used on gas streams having a significant dust burden.

Open paddle

This is the impeller for heavy dust burdens

in excess of those possible with the shrouded radial. Its efficiency is only moderate (up to 60% static) but it is suitable for high temperatures. As there are no shrouds or backplates, the blades are free to expand. Standard units may therefore be used with gases up to 350°C.

It will be seen that the pressure characteristic is stable over the whole range of flows but that the power rises continuously with flow. The narrower units are also suitable for high pressure applications such as direct injection pneumatic conveying.

Backplate paddle

Where the solids are fibrous in character, there is a tendency for them to wrap round the shaft of an open paddle and clog the unit. The backplate obviates this possibility. All characteristics are generally as the open paddle.

Aerofoil

These blades produce lift forces to counteract interblade circulation without requiring precise blade angles. The result is to preserve smooth flow conditions over a considerable portion of the characteristic. Pressure losses in the impeller are thus reduced, as are those in the casing volute. Fan static efficiencies up to 88% have been achieved and total efficiencies of 91% are possible. An efficiency of at least 80% can be maintained over 40% of the volume flowrate at a given speed. It will be appreciated that at low flows the blades are stalled, resulting in a discontinuity in the pressure curve which is not always acknowledged.

Aerofoils should be used on low dust burdens, since particles penetrating the hollow welded blades can produce imbalance. Similar problems can arise with free moisture. Although precautions can be taken, such as solid nosing bars for dust or foam filling for moisture, the backward inclined is preferred for these applications. Erosion of the blade noses will in any case reduce the efficiency. High temperatures may require 'pressure relief' for the air trapped within the blades.

Whenever operating costs are of paramount importance, as when large powers are involved and where there is continuous operation at high load factor, the aerofoil is to be preferred. In general the advantages are not significant for fans below size 1000mm.

Aerofoils may also be necessary when increased duty is required from existing power lines: in many cases the power saved may allow a smaller motor to be installed so that the overall cost is the same. In other cases the additional fan price may be recovered in energy cost differences long before expiry of the period allowed for amortizing plant costs.

Radial tipped

This blade form is used as an alternative to the shrouded radial. Generally there is an increased number of blades and the heel of the blades is forward curved to reduce shock losses. The efficiency and flowrate are therefore improved for a given size, but the characteristics are otherwise similar. Fan static efficiencies up to 73% are possible.

Mixed flow fans – for special applications

The suitability of a particular type of fan for a duty depends more on the relationship between the performance parameters than on their absolute values. This is especially true where there are limits to the size of the unit, and/or where the maximum speed is specified.

For agricultural applications, there is a region for which neither centrifugal nor axial fan is ideal but for which a mixed flow fan can be designed. For the centrifugal fan to be of an acceptable size, it has to be selected at efficiencies away from its peak; the axial fan has to have a high hub to tip ratio and/or has to be multi-staged to achieve the pressure.

The main elements of a true mixed flow fan are seen by reference to Fig 25, similar to a vee belt driven vane axial or in-line radial. The major difference is in the impeller which is generally of fabricated construction. Both the front shroud and backplate are at an angle, so that the air follows a path somewhere between axial and centrifugal flow. It will be noted that the casing is just slightly larger than the impeller outside diameter.

Mixed flow fans should not be confused with in-line radials. Their casing diameter is generally smaller and they run at a speed intermediate between axials and centrifugals.

Performance is intermediate between an axial and centrifugal of the same impeller diameter. A non-stalling characteristic is achieved and the power/flowrate curve is non-overloading. Pressures up to 2kPa are possible with standard construction. A typical performance curve is shown in Fig 26.

Derivation of fan efficiency

From the sections on Axial and Centrifugal, it may be deduced that the fan work equals the system resistance. For customer satisfaction this equality should be at the design flowrate.

It has also been noted that the fan pressure has the dimensions of work per unit volume. Thus the system resistance may also be regarded as the work required per unit volume of gas. This makes it easy to compute the powers required to maintain the flow of $Q m^3/s$ through a system where resistance is p_s(kPa)

$$\text{Power kW} = Q(m^3/s) \times p_s(kPa)$$

As an alternative we may say: –

$$\text{work} = \text{force} \times \text{distance}$$

We define power as the rate of work development per unit time, hence: –

$$\begin{aligned}\text{power} &= \text{force} \times \text{velocity} \\ &= \text{pressure} \times \text{area} \times \text{velocity} \\ &= \text{pressure} \times \text{volume per unit time}\end{aligned}$$

The ratio of this 'air' power to the power required to drive the fan is the **fan efficiency.**

It is important to note that this pressure may be 'total' (including the velocity pressure) or 'static' and the resulting efficiencies may also be 'total' or 'static'. More argument has probably been devoted to this question than to any other in fan engineering.

Whilst the former – the Fan Total Efficiency – is the true mechanical efficiency, a difficulty arises in practice in that the duct system has to be designed before

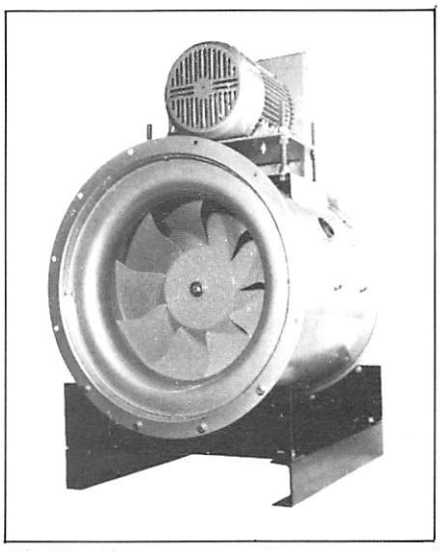
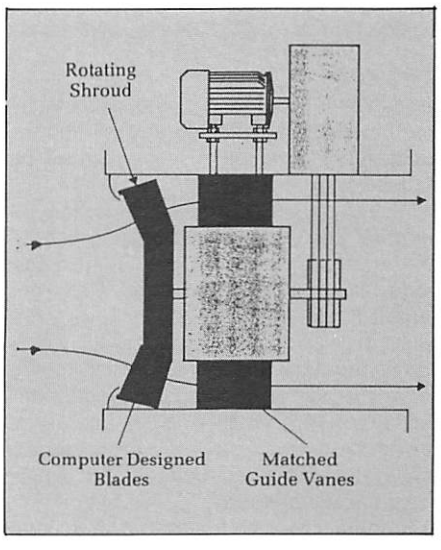
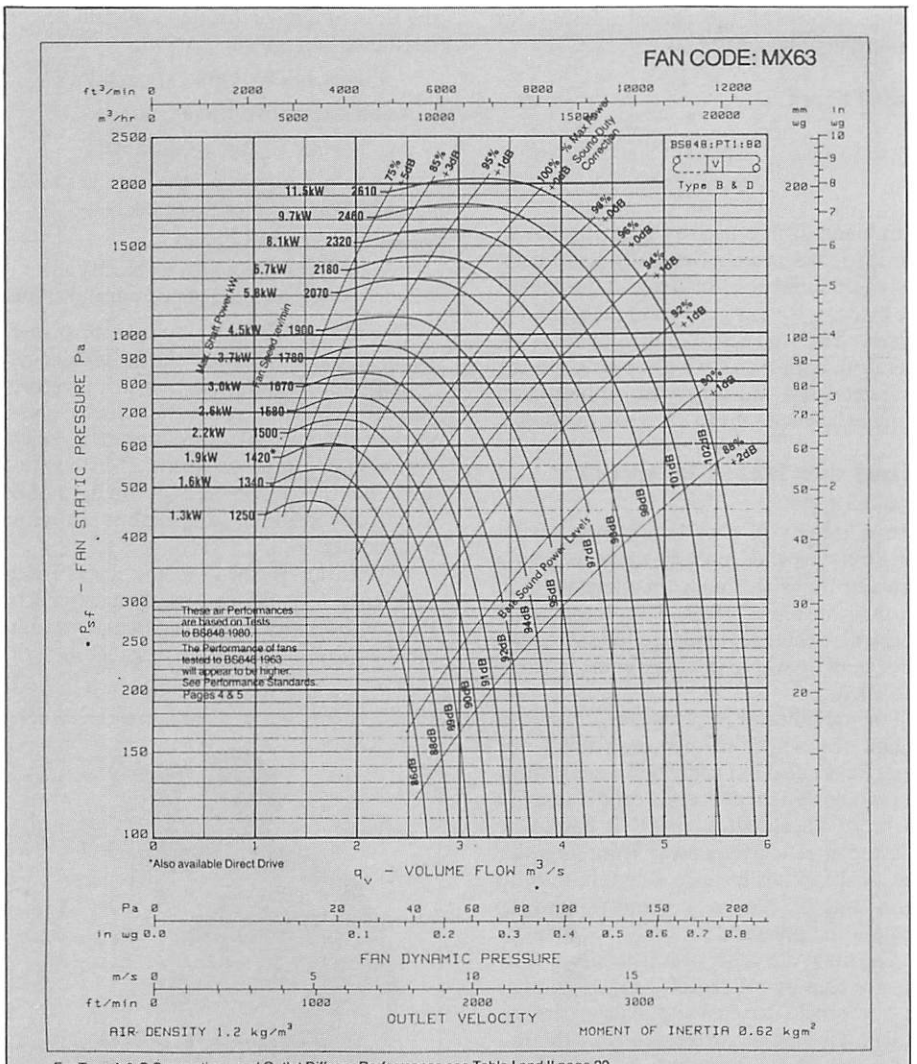


Fig 25. Above – general arrangement of Axcent 2 mixed flow fan.

Below – cross sectional arrangement.





For Type A & C Connections and Outlet Diffuser Performance see Table I and II page 20

Speed Range rev/min	INLET SOUND POWER SPECTRA									OUTLET SOUND POWER SPECTRA								
	Inlet Type	Octave Band Mid-Frequency Hz								Outlet Type	Octave Band Mid-Frequency Hz							
		63	125	250	500	1K	2K	4K	8K		63	125	250	500	1K	2K	4K	8K
1250–1420	Ducted	– 6	– 8	– 6	– 9	– 9	–13	–17	–23	Ducted	– 3	– 1	– 2	– 5	– 8	–12	–17	–23
	Free	–17	–13	– 7	– 5	– 9	–11	–15	–22	Free	–13	– 2	– 2	– 2	– 6	–12	–16	–22
1500–2070	Ducted	– 8	– 9	– 5	– 7	–10	–11	–15	–21	Ducted	– 6	– 2	– 1	– 3	– 7	–12	–15	–21
	Free	–19	–12	– 6	– 3	–10	– 9	–13	–20	Free	–16	– 3	– 1	0	– 5	–12	–14	–20
2180–2610	Ducted	– 9	–10	– 9	– 4	–10	–11	–14	–18	Ducted	– 9	– 5	– 3	– 1	– 5	–10	–13	–18
	Free	–20	–15	–10	0	–10	– 9	–12	–17	Free	–19	– 6	– 3	+ 2	– 3	–10	–12	–17

Inlet Sound Levels (dB re 10^{-12} Watts)
Outlet Sound Power Levels are approximately equal to Inlet Sound Power Levels + 2 dB

Fig 26. Typical mixed flow fan performance curve.

the fan may be selected. Hence the area of the fan discharge is not known and in an extract system the exit loss cannot be evaluated.

We can thus reduce the aggregate loss by omitting this exit loss at the fan discharge and at the same time a reduction in fan performance must then be made. Therefore we have an arbitrarily defined quantity which is called the Fan Static Pressure which equals the total pressure developed by the fan minus the velocity pressure in the fan discharge. We can then assert that for a fan operating as an exhauster the aggregate loss of the duct system up to the fan equals the fan static pressure.

It should here be noted that in general terms the Fan Static Pressure is a greater proportion of the Fan Total Pressure for centrifugal fans. Axial fans (especially low pressure types) have a higher velocity pressure component and thus, whilst their Fan Total Efficiencies may be of the order of 75%, their Fan Static Efficiencies are usually around 50%. Sometimes the use of a diffuser on the outlet can enable some of this velocity pressure to be regained as static pressure, but this is never a very efficient process for large area ratios.

W T W Cory will conclude this report in our next issue with a detailed look at the problem subject of noise in fans.

Sensor for water and liquid contaminants in soil

A newly developed sensor which provides highly accurate readings of water and liquid contaminant levels in soil and other porous materials has been licensed to a Seattle firm by the US Department of Energy's Pacific Northwest Laboratory. The licencee – Cambria Corporation – is an electronics and industrial control company specialising in the detection of contaminants in soil.

Originally, the sensor was produced under DoE's Office of Energy Research, Subsurface Science Program, which was aimed at studying the movements of organic fluids in the subsurface environment and methods to reduce or repair their ecological effects. The sensor has the ability to read liquid levels in a variety of porous materials such as soil, sand and cement and may be used in several applications such as an irrigation meter for farmers or a monitoring device for remediation measures.

The licensing of the sensor is an example of how PNL's technology transfer program enables private industry to manufacture and commercialise technology developed at the Laboratory.

The sensor consists of an optical switch containing a solid-state infrared light emitting device that is joined to a porous disc. The material the disc is constructed from is dependent on the type of liquid to be detected.

The disc is placed into the soil where liquid, if present, is absorbed. Light transmitted through the disc is measured and is proportionate to the amount of water or organic liquid absorbed into the pores. The amount of liquid in the disc can be related to the amount of liquid in the surrounding soil. The disc remains in the soil the entire time the measurement occurs and can be left in the ground for repeated measurements.

Design principles for automatic milking systems

T T Mottram and M Street set out the principles of design for automatic milking systems: – attention to animal welfare; suitability for a variety of dairy management systems; operational efficiency equal to human performance. The principles are illustrated by reference to the automatic milking system developed for research at AFRC Engineering.

T T Mottram

In recent years there has been much comment and speculation on the feasibility of fully automatic milking. There have been claims of the imminent launch of commercial systems which have not yet appeared. Progress has been reported, chiefly in the difficult area of automatic teat cup attachment (Frost, 1990). However, before automatic milking can be fully implemented, further milking tasks have yet to be automated.

Financial benefits of automatic milking

In any milking system, whether manual or fully automatic, a number of operations are to be carried out. These are set out in the panel – with asterisks marking those which can currently be automated.

The financial benefits of automatic milking can be seen in terms of increased milk yield and reduced labour costs (Parsons, 1987). The milk yield of cows milked four times a day increases by 15% compared to twice daily milking (Hillerton *et al*, 1990). The labour situation will certainly be improved as the drudgery of milking twice daily will be eliminated, however, the skills of the herdsman will still be needed on the farm. This could mean part-time working in some situations. The labour most likely to be displaced is the assistant herdsperson or tractor driver, with the herdsman being partly deployed on other farm duties.

It is possible that automatic milking will change the economies of scale of milking parlours to favour the development of small dairy units. This would have a major impact on housing design, pollution control and farm mechanisation.

Operations required to milk a cow.

Physical manipulation	*Information recording*
Collect cow	Cow behaviour
Position cow	
Prepare teats	Teat condition
Examine foremilk	Milk condition
Attach teat cups*	
Milk cow*	Milk yield,* flow,*
Remove teat cups*	temperature,* conductivity*
Post milking teat care*	
Release cow	Machine performance
Return cow	

* indicates operations which can currently be automated

Improvement in cow health

The development of automatic milking is also seen to be justified by the probable improvement in cow health and welfare (Ipema *et al*, 1988). In principle, cows should be free to be milked at times of their own choosing. There is evidence, that when housed and fed at milking, cows will present themselves for milking more than four times daily (Rossing *et al*, 1983). To maximise this major benefit careful engineering design is necessary.

Principles of the design

In addition to the normal design criteria applied to agricultural equipment such as ruggedness, low cost and ease of maintenance the following should be applied: –

- **Livestock welfare;** many features of modern livestock farming have been criticised as tending to reduce the welfare of animals, (Ewbank, 1983). The needs of the animals must be incorporated into the design brief. The important considerations in automatic milking are to give cows the freedom to choose to enter the milking stall, to minimise the force applied to restrain the cows in the stall and to ensure that should the system fail the cow is released and not harmed.
- **Diverse implementation;** there are many systems of managing dairy cows, most of which are represented in the UK. Each has effects on the location of the cows relative to the milking area, on the amount of feed offered during milking and the cleanliness of the cows. An automatic milking system should be designed so that it can be applied in all farming systems.
- **Operational efficiency;** the automatic system should be able to milk a cow as well as a human operator. As a minimum requirement the milk should be as clean, and the cow as undamaged as when a skilled human has carried out the task. The speed of operation should be determined by the cow's requirement for stimulation of milk ejection.

The total time taken between the cow entering the stall and the completion of milking should not exceed a few minutes (Dodd and Griffin, 1979). Since the cow will take three to six minutes to milk (Clough, 1979), the time taken to prepare the cow for milking and attach the teat cups should not exceed three minutes.

Selection gate to identify cows for access to feed or for milking

The effects of these principles can be seen in the design of the AFRC Engineering automatic milking system which is being developed for research into automatic milking.

The cows can be selected for milking by managing the traffic flow around the

Toby Mottram is Milking Systems Engineer with the Milking and Mastitis Centre, Silsoe Research Institute.

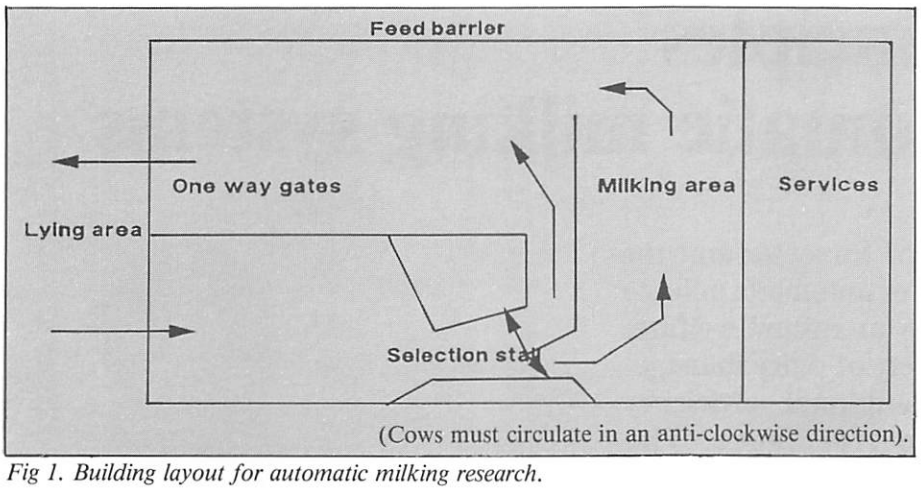


Fig 1. Building layout for automatic milking research.

building (Swierstra and Smits, 1989). In the current AFRC system, cows are loose housed and have access via a selection gate to a forage feeding area, the cows can leave by means of one way gates to return to the lying area, Fig 1. The selection gate identifies the cows by means of transponders and then allows the cows access to the feeding area or diverts them to the milking area. The decision to milk the cow can be made by reference to the time of last milking stored in a database. Thus, if the cow exhibits normal behaviour in her foraging habit and visits the forage feeder frequently (Albright and Timmons, 1984), she can be milked at least four times daily.

At present the cows are encouraged to enter the stall by means of feed in the stall. This may not be essential, as experience with training of cows indicates that a conditioned reflex can be encouraged (Wieckert *et al*, 1966). Once in the stall the length and breadth are adjusted automatically to fit the cow.

Positioning the cow

Research has shown that the floor of the stall can be designed to modify the posture of the cow (Mottram, 1990a). If the front feet are raised relative to the rear, the cow tends to stand with her udder clear of her rear legs which otherwise obstruct the access of the robot arm, Fig 2.

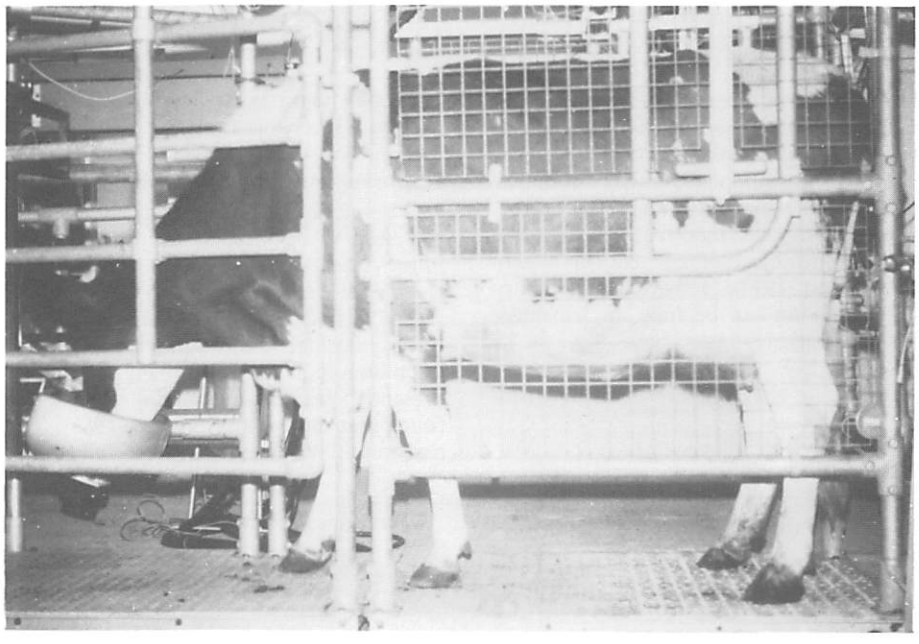
The cow is free to move her legs and her udder is thus not stationary relative to a fixed point. The position of the cows teats is found by using a coordinate system relative to the position of the cow. The location of paddles pressed by pneumatic actuators against the rump and flanks is measured, Fig 3. The system has to be trained the first time that it meets any particular cow but thereafter the position of teats is stored in a database.

Robot arm attaches the teat cups

Attached to the end of the robot arm is an open jaw which can pick up teat cups or other devices. An array of photoelectric cells creates a grid of light beams across the top plane of the jaw.

As the robot approaches the teat, the teat enters the grid. The robot then uses the position of the teat in the grid to steer itself to a position where the jaw is directly below the teat. Teat cups or other devices can be positioned on the teat by this means (Street, 1990). Unlike other systems (Schillingman, 1990), the cow does not have to be still for the robot to locate the teats, and the time needed to attach teat cups can be minimised.

The motive power of the robot is compressed air which has many advantages in matching the design principles. The linear actuating cylinders can be selected to exert a limited force. The system is designed so that the maximum load that can be applied is in the range 80-120 N. The robot arm yields if the cow forces its leg against it.



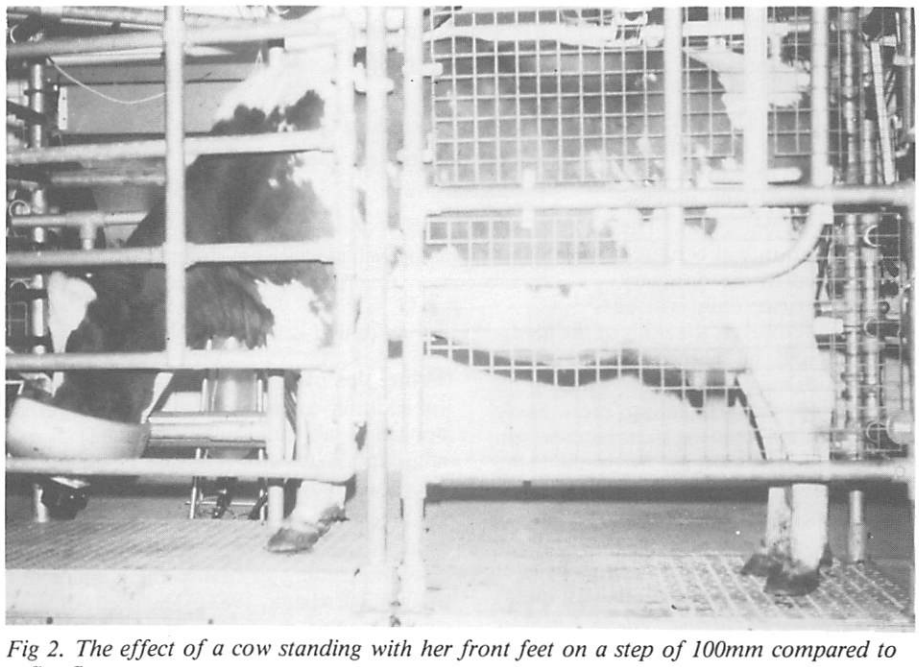


Fig 2. The effect of a cow standing with her front feet on a step of 100mm compared to a flat floor.

Use of air also allows a structure which is very light, allowing a good dynamic response. If the air supply fails or is cut by an emergency switch the robot sags to the ground, allowing the cow to step over it. A further advantage of compressed air as a motive force is that it is non-polluting, unlike hydraulic oil, and unaffected by water, unlike electric actuators (Marchant *et al*, 1987).

The robot arm has few operating parts under the cow. The movements are controlled by actuators which operate within a framework which can be screened from contamination, Fig 4. The frame, of aluminium alloy, is less than a metre in any dimension and could fit into most existing milking systems. It is currently being developed to pick up teat cups from a magazine, and attach them to the cow. The arm can withdraw and the body of the robot can be moved so as to service another stall whilst the cow is milked. Teat cups can be removed on an individual basis by a separate removal system shutting off the vacuum and retracting the milk pipe into the magazine.

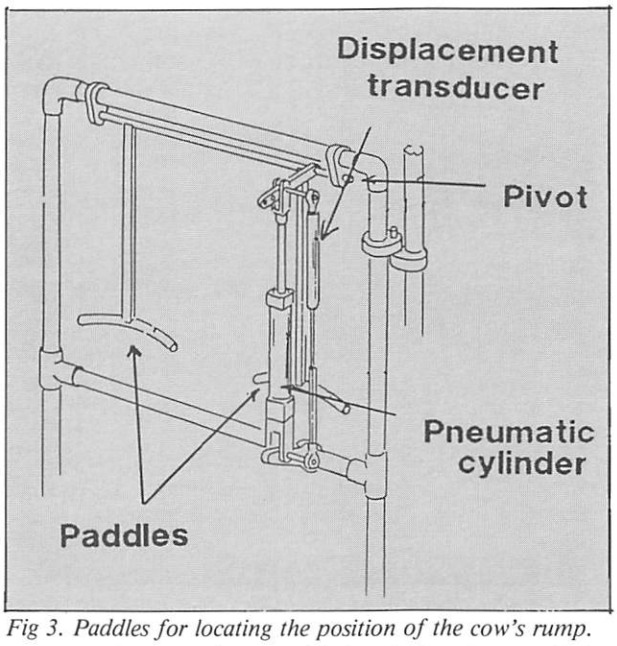


Fig 3. Paddles for locating the position of the cow's rump.

Selective teat cleaning

A teat preparation method is being developed. The principle of operation is that teats should only be cleaned as required.

The best strategy used by farmers is to clean only those cows which are seen as dirty. Washing cows on a routine basis increases the risk of colonisation of pathogens (Grindal and Bramley, 1989), is unnecessary to ensure milk hygiene and leads to a greater incidence of teat sores and lesions (Philips *et al*, 1981).

It is proposed to develop a feedback control loop using remote sensing techniques to detect teat cleanliness so that cleaning need only be applied as required.

Further work is planned to research the main areas of automatic milking systems particularly where they affect the welfare of animals and the hygienic quality of the product offered for human consumption.

Deployment of automatic milking systems

In designing automatic milking systems the potential costs and benefits are difficult to predict because of the variety and complexity of the farming systems to which they will be applied. In particular, we know nothing about the behaviour of cows when offered the possibility of being milked voluntarily, whether in buildings or at pasture.

In systems where cows are housed throughout lactation, a number of milking stations could be deployed around the livestock housing. The cows would be free to exercise their preferred time of visit to the stall. Cows failing to appear for milking can be identified and the reason determined by the management. The design requirements would be for a module which could be factory assembled and plugged into farm services for water, electricity, drainage and milk collection (Street, 1985).

For the UK – an automated tandem parlour

On a typical dairy farm in the UK, where cows are housed during winter and graze in summer, the use of an automated tandem parlour is suggested, Fig 5, (Mottram, 1990b).

In winter the cows could be allowed free access to the parlour, whether as a herd or in management groups. For example, high yielding, recently calved cows would benefit most from frequent milking and could be kept nearest the system, with the lower yielding cows brought to the system at fixed times.

In summer, it is unlikely that cows will volunteer to leave pasture to be milked and cows could be kept in groups matched to their grazing requirements. They could be brought to the farmstead for milking and buffer feeding, with the herdsperson ensuring that all cows are milked and inspected.

Such a tandem would also allow efficient manual operation for training heifers or in the event of a robotic failure. It would suit traditional methods of parlour sale and installation in that it could provide a route for upgrading conventional installations.

With year-round grazing – a simpler system possible

In systems where cows are rarely housed and graze throughout lactation such as in New Zealand, full voluntary automatic milking may not be possible.

However, the tools for inspecting teats and applying teat cups could be implemented in the modern rotary systems which are now being installed in numbers (Smith, 1985). The herdsperson would then have a role in dealing with cows needing attention.

Such systems could be less sophisticated than totally autonomous systems in the identification and handling of unexpected events, as a human operator would be close at hand.

Major area for future work must be to investigate cow behaviour

In this review of work being carried out by AFRC Engineering, the main principles underlying the design decisions have been shown. The welfare of the animal is ensured

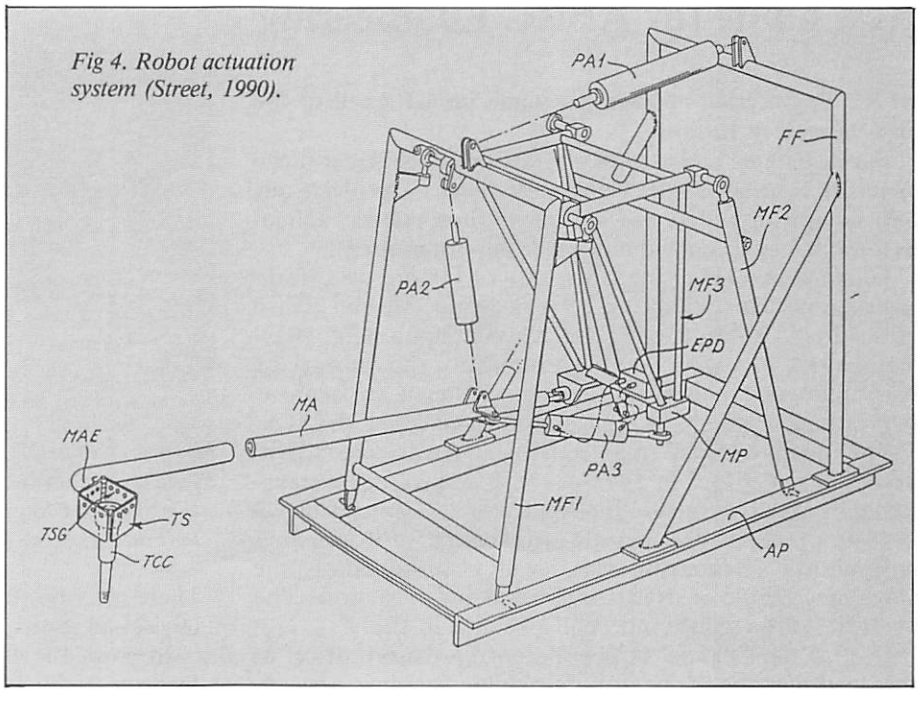


Fig 4. Robot actuation system (Street, 1990).

by means of pneumatics, passive restraint methods and feedback control in teat preparation. Possible implementation in a variety of farm systems has been achieved by designing a small robot, attaching teat cups from a magazine. Operational efficiency has been achieved by reducing teat preparation time and developing the ability to attach teat cups to a moving udder.

Although there is a large amount of research, design and testing of elements of the automatic system yet to be done, it is clear that a major area for future work is in the effect on the behaviour of cows and the systems effects on the total dairy enterprise. Such research needs a multi-disciplinary approach.

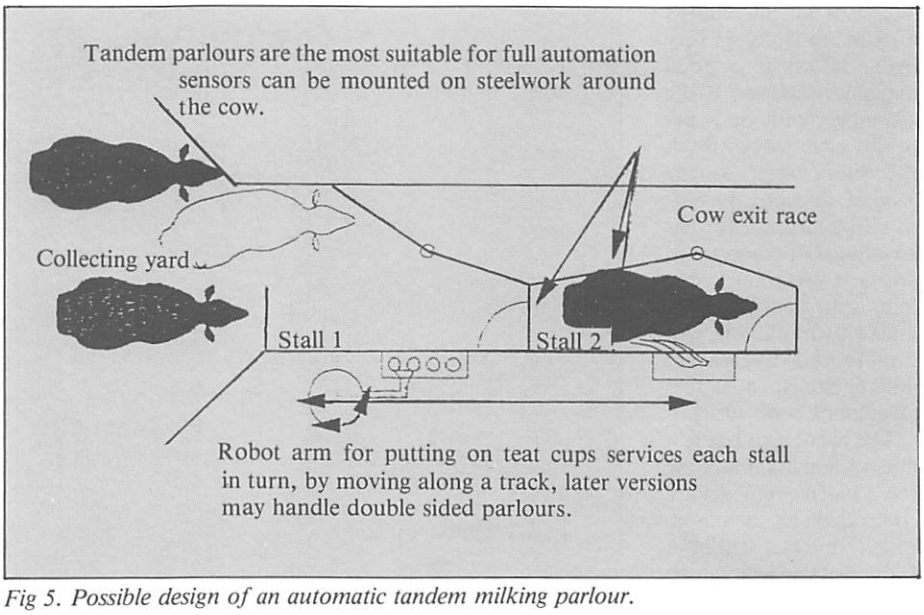


Fig 5. Possible design of an automatic tandem milking parlour.

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New name for AFRC Engineering

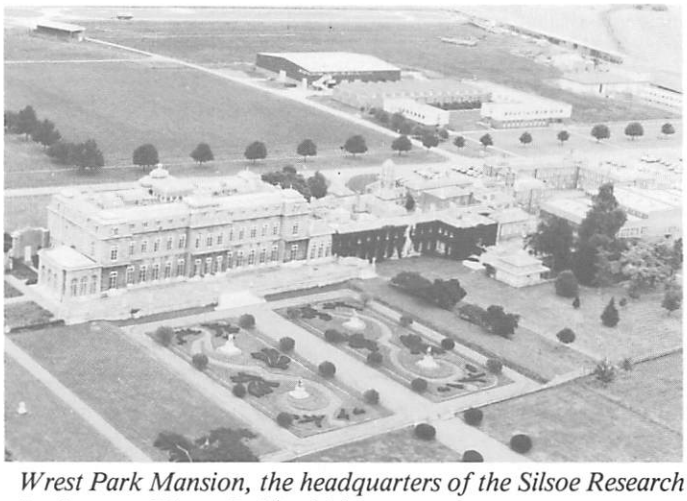
AFRC Engineering changed its name on 1st April to the Silsoe Research Institute.

The new name is chosen to indicate the much wider range of research projects now being undertaken – projects not only in agriculture but also in forestry, horticulture, animal welfare, the environment and other important areas.

Founded in 1924 at the University of Oxford as a 'farm engineering and testing unit', the fledgling research centre grew into the Institute for Research in Agricultural Engineering in 1932. In 1942 it became a branch of the Ministry of Agriculture and re-located to Askham Bryan in Yorkshire as the National Institute of Agricultural Engineering (NIAE).

The Institute moved to its permanent site at Wrest Park, Silsoe, near Bedford in 1947/48, with control being transferred from the Ministry to the Agricultural Research Council in 1949. In the same year the British Society for Research in Agricultural Engineering was legally constituted as the Governing Body of NIAE and its Scottish station. The Scottish station gained independent status in 1987.

In 1955 the Colonial Office stationed a liaison officer at the Institute and work for developing countries began.



Wrest Park Mansion, the headquarters of the Silsoe Research Institute at Silsoe, Bedfordshire.

These activities have been expanded over the years to full Divisional status.

In 1986 the Institute changed its name to the AFRC Institute of Engineering Research (AFRC Engineering).

Demonstration of flood defence and land drainage equipment

Established as the largest event of its kind in Europe, the ADA Demonstration is organised every three years by the Association of Drainage Authorities – and 1991 is the year. It is to be held on the 10th and 11th July on a site at St John's Fen End, some 5 miles to the south west of King's Lynn, Norfolk.

The event is unique in that whilst including a wide range of equipment, products and services used in the flood defence and land drainage business, it does so on both a static site and working areas. Careful selection of the location for the Demonstration ensures that visitors can talk to company representatives in the static display site, and then view the equipment working on adjacent waterways and embankments.

Within the site extensive lengths of waterways are available, upon which the full range of equipment can be adequately demonstrated. Excavators, grasscutters and weedcutting launches from a number of different suppliers will be operating in adjacent working areas, enabling the potential purchasers to compare them directly and determine which equipment most readily meets a particular need.

A policy of the organisers is to retain the specialist nature of the event, and to resist the temptations of a county show approach. For those with a direct involvement in the business attendance is a **MUST**, for those with a related interest a visit will prove both informative and enjoyable. Entrance to the event, including car parking, is free and the usual services, catering, etc, are available on the site.

From its relatively small beginnings 20 years ago, the Demonstration is now the accepted European leader. Attendance this year will include overseas visitors confirming its status, further acknowledged with the presence on the first day of the Minister of Agriculture, Fisheries and Food, The Rt Hon John Selwyn Gummer.

With over 70 exhibitors on the Demonstration site all aspects of flood defence and land drainage are covered, and at the end of April the following companies are attending, with more expected: –

A F Trenchers Ltd
Agricultural Development and Management Advisory Service
Andrews Sykes Ltd
Asset International Ltd
Atlas Hydraulic Loaders Ltd
Aqua Pipes Ltd
B A Bush Tyres
The Bedford Pump Co Ltd
Bomford Turner Ltd
Charrington Hargreaves
Complete Weed Control Ltd
Construction Industry Training Board
Corrugated Steel Pipes Ltd
Crane Engineering Service
Cranfield Institute
Darby (Sutton) Ltd
Drake Towage
D T S Systems Ltd
Engineering & Hire Co
Evergreen Tractors Ltd
Flygt Pumps Ltd
G E Child & Son Ltd
George Law Plant Ltd
Grantham, Brundell and Farran
Greenbase Ecological Ltd
Greenfix Ltd
Hannah, Reed & Associates
Harford Engineering Co
Hayes Pipes (Ulster) Ltd
Henry Oakland & Sons Ltd
Hydrainer Pumps Ltd
Hydrema UK Ltd
Imperial Chemical Industries
Inter-Drain (England) Ltd
Institute of Fisheries
IRPC
J C B Sales Ltd
J K H Drainage Units Ltd
John Martin Construction Ltd
Land Drainage Contractors Assoc'n
H Leverton Ltd
Lee Dickens
Liebherr GB Ltd
Lincoln College of Education
Mabey Bridge Co Ltd
Marbeni Komatsu Ltd
Marmax BCM
J Mastenbroek & Co Ltd
M F Industrial Ltd
Ministry of Agriculture, Fisheries and Food
MMG Civil Engineering Systems
Monsanto plc
Mott MacDonald
National Rivers Authority
Natural Environment Research Council
Norflex Ltd
R-B (Lincoln) plc
Rhone Poulenc Environmental Products
Simon-Hartley Fluid Control Systems
Tarmac Masonry Products
Taylor Dredging Ltd
Turner World Mowers
Watermasters (UK) Ltd
Wavin Industrial Products
Wells Spiral Tubes Ltd
Witham Oil and Grease Co Ltd

Review of recent British Standards

by M D P Matthews

BS 5401 : 1990 **Guide to information content and presentation of operators manuals provided for tractors and machinery for agriculture and forestry** (14 pages)

This British Standard is a revision of BS 5401 : 1982 which is now withdrawn. It takes note of the consumer protection act of 1987 and requires designers, manufacturers and importers to take account of reasonably foreseeable circumstances of use of their product, including activities closely related to the use and to provide information, rather than simply making the product available.

The standard allows for differences in complexity in products and therefore a manual can be a small metal information plate or a book running to several volumes.

The first part of the standard covers the required content with items such as information on serial numbers, comprehensive contents list, introduction to the information given, statement of the function of the product and any known hazards, safety notes and warnings, pre-commissioning procedures, operating information, maintenance instructions, storage and parts list when relevant.

Section two deals with the manner of presentation covering the general size, covers, binding system and the handling of amendments. It goes on to discuss the style of the text and level of language, the typographic design, use of colour within the text and the need to maintain textual conventions. Illustrations are recommended and the standard highlights points to be noted when preparing drawings, charts, or tables. Advice is given on highlighting warnings, cautions and notes.

BS 6913 Part 4 : 1990 (ISO 6012 : 1989) **Operation and maintenance of earth moving machinery. Part 4: Recommendations for service instrumentation** (7 pages)

This British Standard sets out in table form a list of diagnostic instruments to check earth moving machinery at the work site. Its intention is to ensure that machinery is designed with proper accessibility and the necessary connections to enable these checks to be made easily using portable instruments. The standard applies to crawler and wheel tractors, crawler and wheel loaders and hydraulic excavators, but can easily be extended to apply to other basic earth moving machines such as graders, tractor scrapers and dumpers.

The instruments specified include oil and air pressure gauges, vacuum meter, thermometer, pyrometer, timing electronic tester, flow meter, tachometer, feeler gauge, spring scale, steel tape and rule, cylinder compression gauge, fuel nozzle tester, depth gauges, hydrometers, vernier caliper, electrical tester, torque wrenches. All are graded as being definitely required or being desirable.

BS 7293 : 1990 (ISO 8524 : 1986) **Methods of test for equipment for distributing granulated pesticides or herbicides** (16 pages)

This standard was produced to establish tests which are reproducible to allow results in figures and graphs to be obtained and compared. For the purposes of the standard seven aspects of the machine and its operation are defined. General test conditions are specified in terms of the machine and granules.

The procedure for selection of the machine is specified and the required manufacturers instructions are listed. The need for a check of machine specifications is highlighted as being necessary within the test.

Granules used in test must be agreed between the manufacturer or distributor and the test office. If simulated products are required for safety reasons, three should be selected from pumice, quartz, calcite, gypsum and any other which is considered of significant importance which differs from the previous four. The physical characteristics of each sample of granule must be determined and the ambient conditions of the test should be recorded.

The mandatory tests are evenness of flow rate and evenness of distribution.

BS 490 : Section 10.8 : 1990 (ISO 9856 : 1989) **Conveyor and elevator belting. Part 10: Testing for physical properties, Section 10.8: Method for determination of elastic modulus (including permanent and elastic elongation)** (4 pages)

The elastic modulus of a conveyor belt can be determined by the application of a sinusoidal stress between 2% and 10% of the minimum breaking load on a test piece cut from the full thickness of the belt in the longitudinal direction. At least two hundred load cycles are required and the elastic modulus is calculated from a graph giving the load as a function of elongation. Apparatus required is a dynamic tensile testing machine and extensometer and a device to record the curve of tensile stress of a function of elongation.

The standard specifies size and shape of test pieces, the number and the preparation required. The procedure, the method of expressing results and the information required in the test report are all included. The method of obtaining a sample and its conditioning and the use of the tensile testing machine are covered in 3 ISO standards (ISO 282 : 1975, ISO 283 : 1980, ISO 471 : 1983).

BS 7195 : 1989 **Guide for prevention of corrosion of metals caused by vapours from organic materials** (10 pages)

This standard highlights the emission of corrosive vapours from some organic materials and their ability to corrode certain metals, along with the measures which can be taken to avoid corrosion. The standard is limited to the general surface corrosion of parts in use as well as in store.

Metals and alloys in common use are divided into groups susceptible to severe attack, moderate attack, very slight attack and resistant to attack from vapour corrosion. The conditions under which vapour corrosion can occur are discussed including ventilation, humidity and temperature. Preventative measures concentrate on the elimination of unsuitable materials and the application of protective coatings, including temporary hard films.

Tables are provided of organic materials and their tendency to cause organic vapour corrosion and a selection of protective schemes for metals most susceptible to that corrosion.

Copies of British Standards

are obtainable through libraries or can be purchased direct from:

BSI Standards Marketing

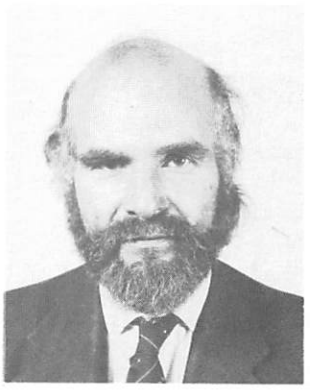
Linford Wood, Milton Keynes, Bedford MK14 6LE

Mike Matthews is Commercial Officer at Silsoe Research Institute, Silsoe, Bedford.

Re-drainage of a saline soil in North Kent

J G Rands and A A Thorburn report on the preliminary results of an experiment aimed at improving soil water movement where a sub-surface under-drainage system had failed.

J G Rands



A A Thorburn

The blockage of sub-surface drains by sediment was found to be a serious problem on some clay marshland sites in the early nineteen eighties. Soil examination in North Kent revealed that the soil had a high exchangeable sodium percentage (ESP) and was therefore prone to breakdown due to deflocculation. As the existing sub-surface pipe drainage was defunct and the land was waterlogged, re-drainage was necessary. To combat the deflocculation problem gypsum was applied to some experimental plots and the effect of this ameliorant on re-drained land was monitored. Mole drainage was also incorporated in the experimental treatments. To restore soil water movement gypsum application was found to be essential. Mole drainage only gave marginal benefit.

Detailed soil examination of the North Kent marshes (Hazelden *et al*, 1986) has established that the problem soil is a non-calcereous clayey marine sediment known as the Wallasea Soil Series. This soil is naturally rich in sodium, a condition that has persisted for many years after reclamation.

Sodium affects soils in two different and opposing ways depending on the amount of sodium in the ground water and the amount of sodium attached to the clay particles.

Prior to drainage the sodium is present mainly in the ground water and the soil is stable. After drainage the sodium attaches itself to the minute clay plates which causes dispersion and structural breakdown.

The way to stabilise the soil is to replace the sodium with calcium. Gypsum as a readily available soluble calcium salt is used for this purpose.

Ameliorant essential to prevent soil breakdown and poor water movement

The extent of the structural breakdown in North Kent can be gauged from hydraulic conductivity measurements.

Armstrong *et al*, (1988) present results from North Kent which indicate that undrained marshland has a mean K value of 1.87 m/day which falls to 0.09 m/day after drainage. This reduction in permeability means that even if the drains were not blocked the existing drainage systems at 20m spacing would be completely inadequate.

Re-drainage without some form of amelioration to improve soil water movement was considered to be a recipe for failure.

John Rands is a Soil and Water Engineer with ADAS based in London; Andy Thorburn is a Senior Scientific Officer at the ADAS Field Drainage Experimental Unit, Cambridge.

New drainage system with gypsum application

By 1980 on St Mary's Marsh (aerial photo, Fig 1) severe surface ponding was occurring in a field previously drained in 1972. The owner was planning to redrain and apply gypsum on this field.

The new proposal was to install 80mm corrugated plastics tube mid-way between the existing straw backfilled 75mm clay drains. This work was carried out in October 1984.

Both the old and new systems were similar in respect of pipe gradient, 0.15%, and average depth, 850mm, but the new drains were backfilled with shingle (40mm grade). This material was brought to within 230mm of the ground surface.

As the sodium content of the subsoil is known to increase with depth, the trench

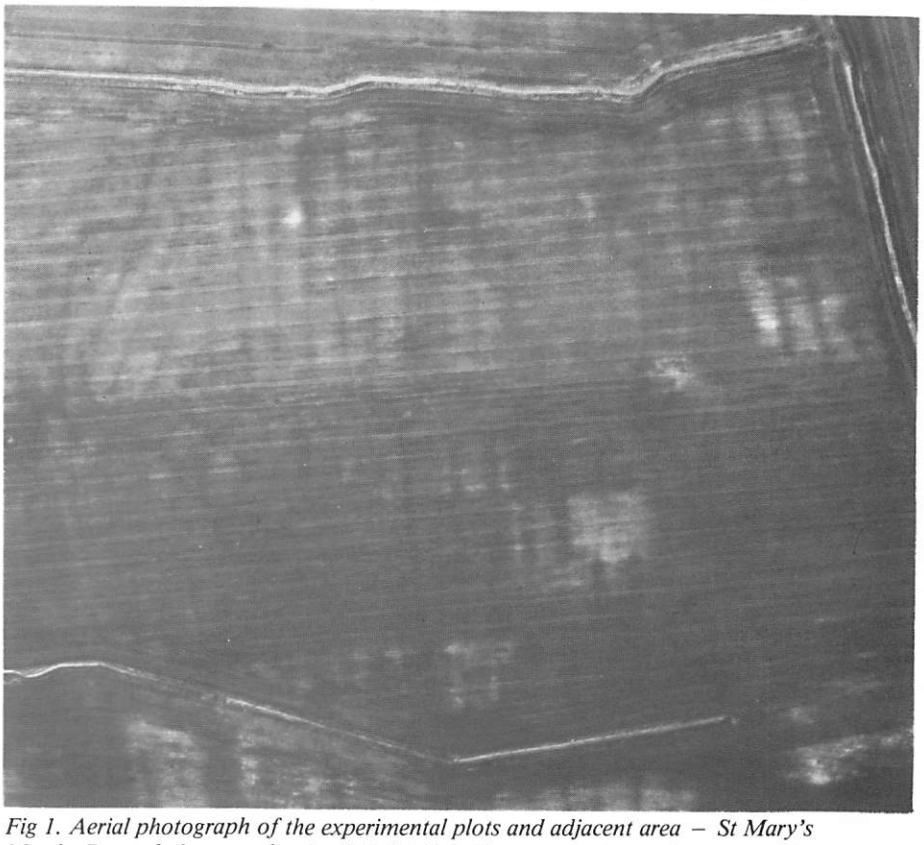


Fig 1. Aerial photograph of the experimental plots and adjacent area – St Mary's Marsh. Date of photography April 28th 1986. The crop is winter wheat. Note the distinct boundary between the re-drained and gypsumed southern half of the field and the poorly drained northern section where the 1972 drain lines are still visible.

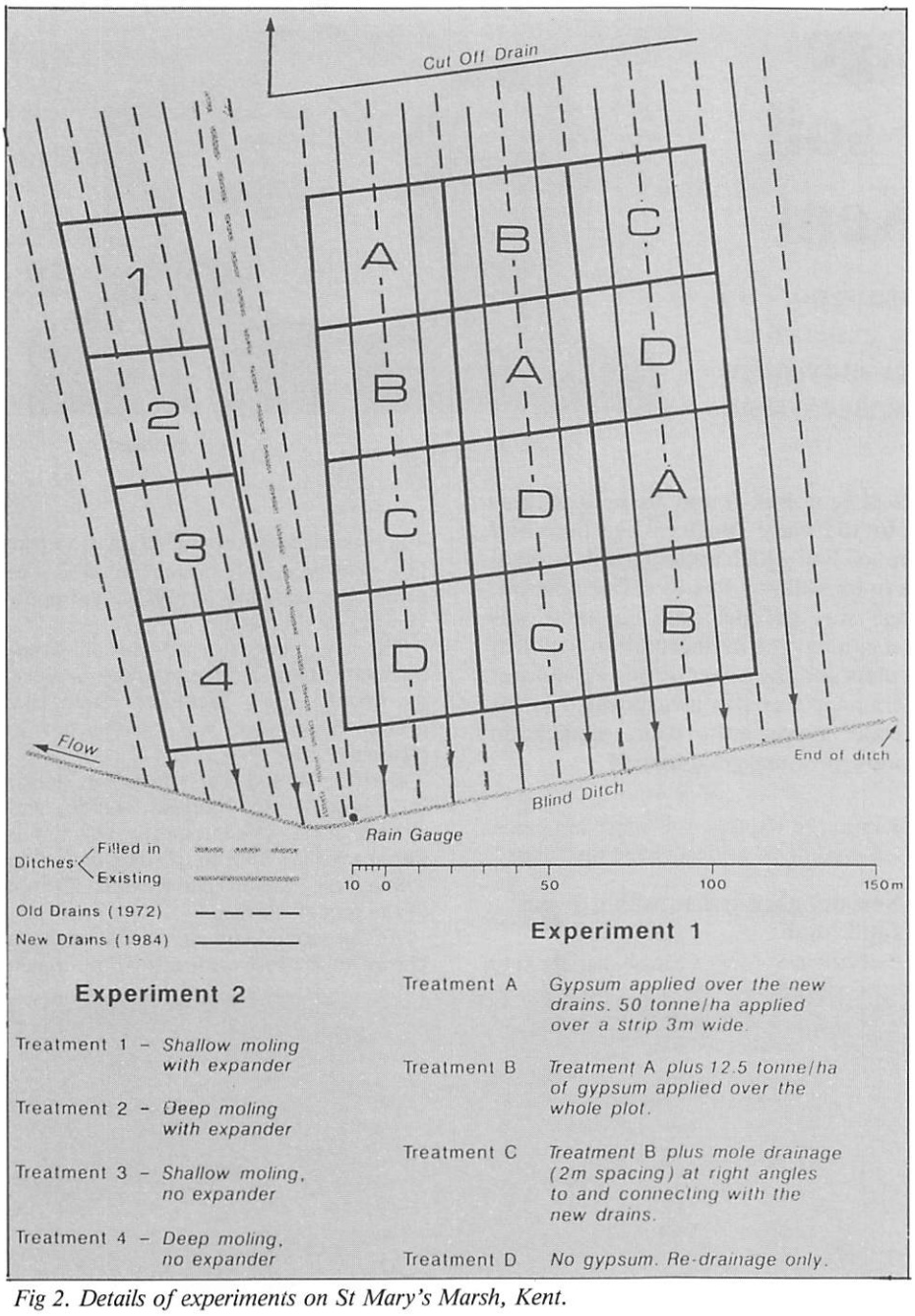


Fig 2. Details of experiments on St Mary's Marsh, Kent.

spoil levelled out above the drain creates a zone of potential instability. To overcome this problem gypsum at a rate of 35 t/ha was applied on a strip 3.5m wide over the drains. The spreader compressed this trench spoil heap creating some compaction.

In addition to this application, gypsum at the rate of 12.5 t/ha was applied overall to the re-drained land. This application rate was based on previous experience following saltwater inundation (see Marks and Robins (1986)).

Details of the trials

Within the re-drained area land was set aside for experimental purposes. See Fig 2 for the plot layouts and treatments. Experiments 1 and 2 were installed in October 1984. Moling was carried out immediately after gypsum spreading. Mole spacing was 2m. On Experiment 1 the moling depth was more or less 550mm (to the base of the channel) and a 90mm expander was used. On Experiment 2 shallow moling was attempted at a depth of 375mm. However, the soil was too dry at this depth and upward heave was producing a subsoiling effect. As previous subsoiling work on this farm had been considered detrimental (the aggregates produced quickly deflocculated) the bullet was lowered by one notch (50 mm) to achieve a stable channel. The deep moling on Experiment 2 was at 525 mm. From the surface down to 600 mm there is little variation in soil texture, clay content varying from 54% to 68%. Normally this soil type is ideal for mole drainage.

Once the autumn cultivations were completed the site was instrumented and recording commenced. The data collected included rainfall and ditch water level (continuously recorded) and at weekly intervals an assessment of plot ground conditions using the FDEU scale. These recordings ceased in the spring when the soil moisture content was below field capacity.

A more detailed assessment of the soil surface structure was made each spring using the Peerlkamp Index. When plot difference were visually apparent, aerial photography was obtained if circumstances permitted. Crop yield data was also recorded.

Annual changes in soil chemistry were recorded by measuring exchangeable sodium levels and the electrolyte concentration of the soil solution.

Field condition in spring and crop yield used as measure of drainage benefit

The results of drainage experiments are obviously dependant on weather, the greatest benefits occurring after prolonged wet spells.

As the North Kent coast is one of the driest places in the UK with an annual average rainfall of 500mm the critical rainfall event which pays for the drainage investment occurs perhaps only 1 year in 5. Data collection on arable sites is also hampered by the need to get the winter crop established before recording can commence. These limitations always pose difficulties in the interpretation of any data set, particularly if the number of recording years is limited.

For these reasons most drainage experimenters record the benefits obtained in the spring and crop yields. This policy was adopted on St Mary's Marsh.

For this area the average annual rainfall in the first three months of the year is 125.0 mm. Details of the rainfall for the period January 1st – March 31st for the recording years is as follows:– 1985 – 119.4mm; 1986 – 128.3mm; 1987 – 116.90mm.

As this indicates average conditions the data was sifted to find short periods of intense precipitation. In these periods of stress, drainage benefit was quantified by comparing the ground conditions for the treatments in Experiment 1. (See Table 1). At weekly intervals the site operator walked the field and scored the ground conditions on each plot on a scale of 1-9. (The FDEU Scale).

The points on the scale are defined as: –

1 = snow covered,
2 = frozen,
3 = very soft,
4 = squelchy all over,
5 = squelchy in places,
6 = damp and soft,
7 = damp but firm,
8 = dry on top,
9 = baked hard and cracked.

Whilst some of the definitions are somewhat subjective, an individual's interpretation tends to be consistent. As the same

person collected the records in the period 1985-87 the assessments are a good reflection of plot differences and tie in well with other scientific measurements.

In Table 1 the performance of the experimental treatments are compared for the wettest week (disregarding wetness due to snow melt) in the first three months of the year. This period has been selected as in all years the soil was at or above field capacity at this time.

Gypsum treatment preserves soil structure; avoids rutting and ponding

It can be seen that the difference in ground conditions between the non-gypsumed control (D) and the plots that received an overall application of gypsum (B&C) is at least two points on the scale.

The 1985 event is of particular interest as the rainfall amount recorded in the week ending January 31st occurs only once every two years. It gave rise to ponding on the control but on Treatments C and D the surface was damp and soft. This wet spell was followed by a week of light snow and when next inspected Treatments B&C had recovered sufficiently to give potentially ideal conditions for land work.

In the autumn of 1986 intensive cultivation was necessary to prepare a seed bed for winter beans. The results of this and subsequent land work was to create soil instability and severe rutting on the areas which had not received an application of gypsum. This compaction impeded water movement and the surface ponding that resulted gave rise to severe soil slump, deflocculation and slurry conditions. Beneath this slurry a relatively firm soil base remained. Thus in 1987 the yield of the control plots (Treatment D) was significantly reduced.

From inspection of Table 1 it can be seen that a poor ground condition score is not necessarily the result of heavy rain. Once soil damage has occurred a seal is formed which prevents further infiltration. The ponds disappear only as a result of evaporation when the soil surface changes from porridge to crazy paving virtually overnight.

On Treatment A where gypsum was applied over the drains only, improvement in soil tilth was limited to these strips. Thus in Table 1 this plot is generally rated midway between the control and the plots with an overall application. The higher rate of gypsum application over the drains did not give any increased benefit with regard to tilth but it did extend the life of mole channels in the section close to the drain.

Table 1 – Walk over assessments following heavy rain in 1985/6/7.

Date	*Rainfall*[1] *mm*	*Ground condition Score*[2]				*Comment*
		Treatment			*Control*	
		A	*B*	*C*	*D*	
31·1·85	34.29	5	6	6	4	A one in 2 year event
7·2·85	Nil[3]	5	7	7	5	
29·1·86	20.32	5	7	7	5	10mm on Jan 28th
25·3·87	10.3	7	7	7	4	Steady light rain for 3 days before visit

Notes
1. For previous 7 days.
2. Median value from the three replicate treatments. The median value is used in preference to the mean because it eliminates distortion of ground conditions due to atypical micro relief.
3. Dusting of snow.

Crop 1985 Winter Wheat; 1986 Winter Wheat; 1987 Winter Beans.

Conclusions

– Mole drainage questionable

The walkover score and the soil structural assessments are no different between Treatments B and C and therefore the value of mole drainage is questionable.

It is of interest to note, however, that the winter beans yield in 1987 and the spring barley yield in 1988 was highest on the moled plots.

– Gypsum treatment beneficial

The application of phosphor-gypsum at the rate of 12.5 t/ha over re-drained land on St Mary's Marsh reduced waterlogging, improved soil structure, increased the number of potential working days and in some years gave statistically significant increases in yield. The experiment terminated before the gypsum was exhausted but soil chemical and physical data (Marks 1991) indicates that after 4 years a further dressing would be beneficial.

Acknowledgements

The work was funded by the Chief Scientist's Group, MAFF. The authors wish to thank Robert and Ian McClean who provided the experimental site and gave enthusiastic co-operation. We would also like to thank ADAS colleagues, past and present, at Maidstone, Wye, the Aerial Photographic Unit, Cambridge and the FDEU for their valuable contributions.

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Producing an Operator Handbook

I Duncan has been assessing the quality of Operator Handbooks alongside the latest guidelines and standards on content and presentation. He recognises that improvements are being made but the general level is still not up to requirements. He highlights points to be followed in Handbook preparation.

During the last two and a half years as a part-time consultant specialising in writing Operator Handbooks, or User Manuals, I have been asked to look at 46 Handbooks describing a wide range of machinery. It has been most interesting, quite demanding, and has kept me in touch with the Farm Machinery Industry. At present, there is a reduction in pressure due to the recession, and recently I have been able to take stock and draw some conclusions about the general level of Handbooks being issued.

Complaints from users and dealers

For many years both users and dealers have been highly critical of Operator Handbooks dealing with farm machinery. Complaints were made to me in my former capacity at many meetings, and in defence of machinery suppliers, I said that there was insufficient guidance as to how these books should be produced.

Of course, there has been a requirement for adequate instructions in Section 6 of the Health and Safety at Work Act 1974 (HSW Act), applying equally to British and foreign products, and a rather brief British Standard but the last three years have seen great changes.

A European Directive 89/392/EEC was published in June 1989 and required specific details to be included in instructions for the use of machinery, and this Directive applies to **ALL** machinery. Section 6 of the HSW Act 1974 has been amended and expanded by the Consumer Protection Act 1987, which became law in March 1988.

In 1989, HM Agricultural Inspectorate of the Health and Safety Executive circulated notes on the production of Operator Handbooks to their Agricultural Inspectors. Then the British Standards Institution published BS 5401 : 1990 – Guide to information content and presentation of operator manuals provided for tractors and machinery for agriculture and forestry.* Also, for some time now there has been a similar American Society of Agricultural Engineers standard EP 363 : 1 – Technical Publications for Agricultural Equipment.

* See *Review of recent British Standards* – page 44, this journal.

Iain Duncan was Technical Director of the Agricultural Engineers Association until September 1988.

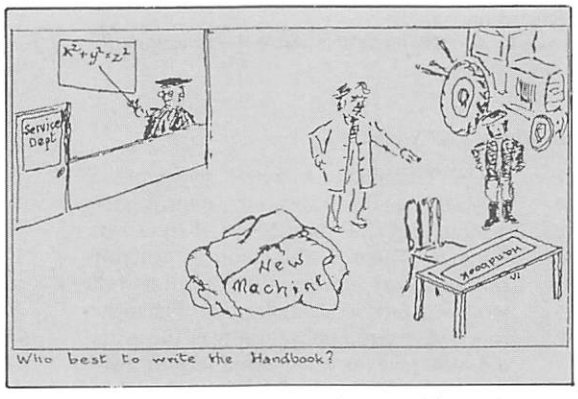
With all this information, no one can now say that they do not have enough guidance.

Efforts to improve publications

In looking at the range of 46 Handbooks mentioned above, I must say that, in my opinion, I do not believe the general level to be adequate.

However, it is quite evident that leading machinery suppliers have made great efforts to improve their publications and, in particular, there is increasing emphasis on stating safety precautions. This is welcome in view of continuing farm accidents, and also, because of the penalties that can be imposed if incomplete Handbooks lead to an accident.

Much modern farm machinery has become more complicated, and a declining number of farm workers is having to cope with an ever widening range of work. Also, the educational standard of future farm machinery users seems uncertain. Then, there is greater pressure to reduce machinery production costs, and the writing of Handbooks is just one of these. Much of our farm machinery is imported, some from countries where standards are not the same as ours. All these factors increase the importance of good Handbook design.



Handbooks to be kept readily accessible and to be in simple technical English

From my recent experience, it seems to me that there are some essentials which need to be considered when producing any instructions for users. Assuming that there is a Handbook, it is important to have a signed acceptance from the user. This is proof that a Handbook has been supplied.

Then there is the question of size: while A5 is ideal because it fits most overall pockets, for more complex machines, A4 may prove suitable. For very simple equipment, an A4 sheet folded three times is usually adequate.

If Handbooks are to be accessible to the users at all times and not kept in the farm office safe, then stowage on the machine will be necessary. The Handbooks will need thorough protection against moisture and oil and a heavy duty clear plastic envelope is most suitable.

Simple technical English must be used throughout, printed on reasonable paper in a readable size of print. Many of the Handbooks I looked at were translations into English and several of them were badly done. In one book, it was only after reading to a different type of machine than I had at first thought, and in this case I had continually to refer back to the original language to discover the meaning of what was said.

The EEC Directive requires that Handbooks be supplied in the language of the country in which the machine is to be used, and presumably in an understandable form.

Small cartoons may improve 'readability'

The coverage of Safety Precautions must be comprehensive and clear. Where applicable, precautions against hydraulic oil and/or fuel contamination, battery acid spillage, fire, noise, vibration, chemical contamination, and safe use on slopes should all be included.

This section can seem boring and long-winded, but can be made more acceptable if some small cartoons are used to illustrate various points.

The instructions as to unpacking, setting up, using, maintaining and final disposal must be complete if the object of giving the greatest help to the user is to be achieved. Such items as circuit diagrams, light bulb sizes, tyre sizes and recommended pressures, lubricants to be used, and spare parts lists, must be included.

Dimensions and weights are always useful

concluded at foot of page 51

Agricultural Machinery Law

Continuing from our previous issue we are pleased to present some further details of changes in legislation affecting our industry. As before, these items are extracted from Farm and Garden Machinery Law.

Goods vehicles operators licences

Before 1989 the Vehicle Excise Licence Duty, the regulations controlling the use of red dyed fuel oil and the goods vehicles operators licence regulations, all related to virtually the same list of restrictions on the use of farm tractors on public roads in privileged status.

The restriction included transport to and from the farm or woodland occupied by the tractor owner and limited the radius of travel or haulage to fifteen miles. Under the Finance Act 1989 the fifteen miles restriction was removed and a new classification of 'special machines' was introduced for vehicle licensing – agricultural machines – ie tractors and ploughing engines; mowing machines; excavating and trench digging machines; mobile cranes; works trucks and fishermen's tractors.

Road haulage organisations were not happy about this change because of an anticipated loss of local haulage business in rural areas. Farmers under pressure from declining incomes might be tempted to try to skirt the law by doing contract haulage jobs for their neighbours etc.

The result is a draft Regulation designed to re-impose the fifteen miles haulage restriction for purposes of Goods Vehicle Operators' Licences. This means that if the farm is more than fifteen miles from the sugarbeet pulp factory, the farmer will need a 'Restricted Operators' Licence' – £60 process fee plus a renewal fee of £20 per year, together with the hassle of a local newspaper advertisement. If he does contract haulage for his farming neighbour, he will need a Transport Managers' Certificate of Professional Competence.

These rules will also apply to deliveries to the farm. Without a Restricted Operators' Licence, a farmer will not be able to bring back a load of redundant railway sleepers from a yard outside the fifteen miles boundary.

Once again, the Government is required to find a point of balance between conflicting economic interests. Clearly road haulage firms are seeing their margins cut back by the current decline in trade and farmers have retained the competitive advantages of lower Vehicle Excise rates and red fuel oil for use in connection with their farming activities. However, the need for a farmer to employ a local haulage contractor because he does not have a Restricted Operators' Licence, may seriously affect the economic viability of some farming projects.

UK farm unions – tax submission

The three UK farmers' unions have written to the Chancellor of the Exchequer asking for the reintroduction of 100 percent tax allowances on capital investment in plant and machinery used on the farm. The proposal is that the allowances would be limited to the first £20,000 expenditure in order to ensure benefit to small businesses. The farm machinery industry badly needs the boost that could result from the additional sales and they too hope the Chancellor is in a listening mood.

New regulations on pollution control

The Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations 1991 began to set new standards from 1 March and come fully into force on 1 September 1991. They deal with minimising the risks of pollution from silage effluent, slurry and agricultural fuel oil, by setting out the standards that are required for the design and construction of storage facilities in England and Wales. Slightly different arrangements apply in Scotland.

New, substantially reconstructed and subsequently enlarged facilities are covered, with certain exemptions where work was started before 1 March. Existing facilities are exempt. However, the National Rivers Authority (NRA) can serve a notice requiring existing facilities to be improved where there is a significant risk of pollution. Farmers may appeal against such a notice.

The main provisions are: –

Silage

New silos must have an impermeable base, with perimeter effluent channels leading to an effluent tank. This tank must hold at least 20 litres of effluent for each cubic metre of silo capacity up to 1500m³, 6.7 litres per m³ is required for additional silo capacity above 1500m³.

The Regulations permit silage making in wrapped or sealed bales provided the bales are not stored or opened within 10 metres of a watercourse. An impermeable base is not required.

The field heap method of silage making (where silage is stored with no impermeable base, perimeter effluent channels or effluent tank) will only be permitted on farms where the majority of silage has been made this way over the last three years. Farmers must also register with the NRA by 1 September to continue using this method. This exemption will be reviewed in five years' time.

Slurry

Four months' storage capacity (six months in Scotland) will normally be required for new stores, unless safe year-round disposal can be demonstrated. Reception pits and any channels must have capacity for two days' slurry production. Stores must be designed and constructed to be impermeable although the weeping wall system will be permitted.

Drainage pipes from slurry stores in most cases must have two shut-off valves, locked shut when not in use.

Earth-banked slurry stores must be designed with 750mm freeboard and other stores 300mm. The freeboard on earth-banked slurry stores must be maintained during use.

Slurry includes dilute effluents (dirty water) and run-off from solid manure stored in yards.

Fuel oil

Where more than 1500 litres is stored on the farm, above ground tanks and drums must be surrounded by an impermeable bund wall. The bund must be able to contain a specified volume of oil, which varies depending on whether fuel tanks or drums are used.

Fixed taps and valves on tanks must discharge downwards and be locked shut when not in use.

The regulations do not apply to separately-stored domestic fuel oils.

General provisions

All new facilities must be at least 10 metres from watercourses and inland or coastal waters. They are also required to have a 20 year durability life.

The NRA must be notified of new, substantially enlarged or substantially reconstructed facilities, at least 14 days before they are used; it is entirely the farmers' responsibility to notify, and it is an offence not to do so. Notification forms are available from local NRA offices.

The penalty for failing to comply with the Regulations is a fine of up to £2000 in a magistrates court or an unlimited fine on indictment.

Explanatory document available

The DoE have produced a document *Guidance Notices for Farmers,* describing the requirements of the Regulations more fully. Copies of this can be obtained free of charge by writing to: Department of the Environment, Water Environment Division, Room A405, Romney House, 43 Marsh Street, London SW1P 3PY.

The sampling of water in an unsaturated soil

In the light of increasing concern about the fate and behaviour of chemicals in the environment, R Earl and A D Carter emphasise the need to measure chemicals ' – in situ – ' in the soil water. They describe here the construction and method of use of the soil water suction sampler.

Chemicals may be applied to soil as a diffuse source, eg agrochemicals such as nitrate and pesticides, or from point source as in the case of disposal or spillages. The soil zone can act as an important buffer by adsorbing material and by providing a biologically active medium for chemical degradation.

However, contaminants have been found throughout the soil zone and into the deeper unsaturated layer in addition to groundwater itself.

It is, therefore, important to understand the soil and hydrological processes which control the movement and distribution of chemicals through the soil zone.

The need for water sampling

Soil sampling is expensive; it is site-destructive and the extraction procedures for analysis are tedious. Furthermore, detection limits are higher in soils than in water samples and so soil analyses may not identify low but significant concentrations of a chemical.

Sampling methods which obtain clean water from the soil zone are therefore preferable.

In a saturated soil, water can be collected by gravity drainage, but saturated conditions do not persist or even exist in many soil layers. Soil water may be held against gravity, that is under suction, in smaller soil pores. It will, however, move slowly in response to a hydraulic potential, carrying with it chemicals which are in a dissolved form or adsorbed to organic particles. It is this mobile water carrying potential contaminants that can be obtained using suction samplers.

Suction samplers were first used in the early years of this century but their use has increased rapidly in recent times due to their low cost, ease of operation and ability to provide clean samples from unsaturated conditions.

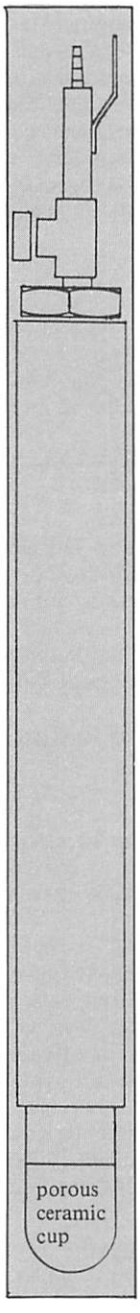


Fig 1. (Left): Soil water suction sampler.

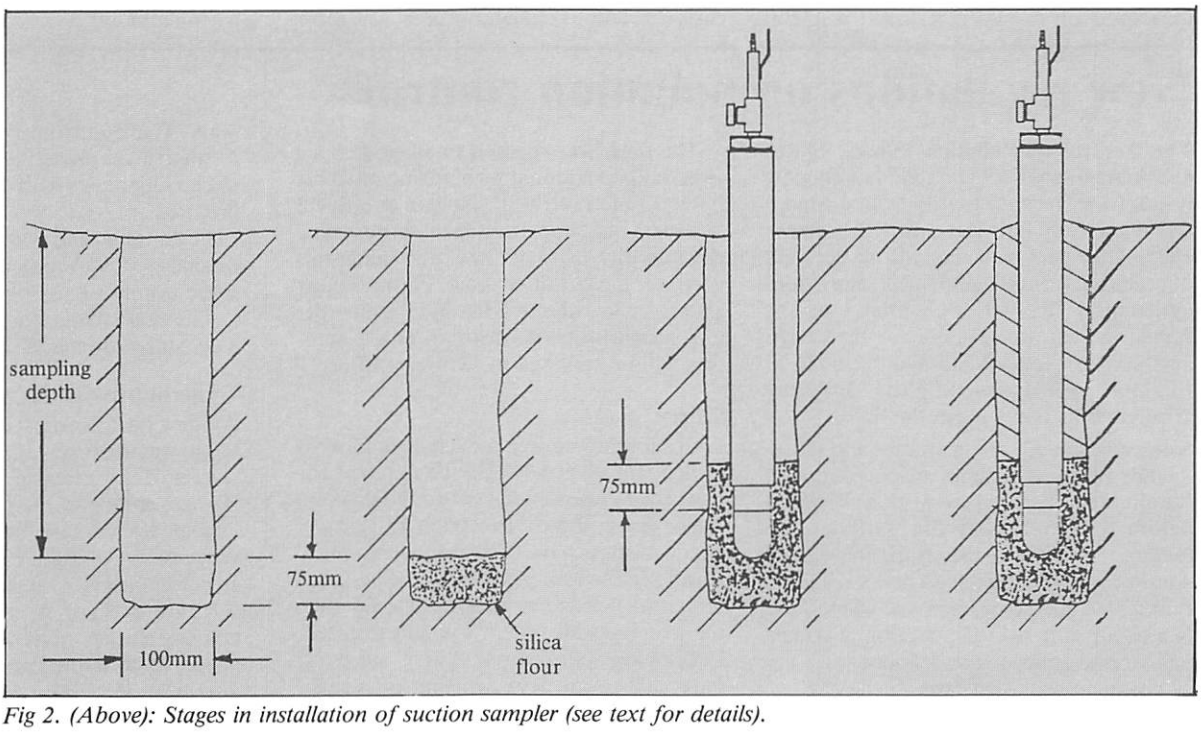


Fig 2. (Above): Stages in installation of suction sampler (see text for details).

Design of the suction sampler

The suction sampler comprises a hollow tube with a porous ceramic cup at the lower end and an arrangement of valves at the upper end (Fig 1). It can be manufactured to various lengths depending on the depth from which the user wishes to sample water.

The materials used in construction have been chosen to minimise the risk of contaminating water samples during sampling. The main components are fabricated from stainless steel and teflon™. The ceramic cup is joined to the stainless steel tube using a threaded collar to facilitate replacement.

For studies of nitrate movement, costs can be greatly reduced by using less expensive materials such as ABS or PVC in the construction of samplers.

Installation procedure

The samplers can operate in freely draining or slowly permeable soils even if the water-table is above sampling depth. They can be installed vertically or inclined if required.

A Jarrett auger is used to bore a 100mm diameter hole to a depth approximately 75mm greater than the sampling depth (Fig 2a). The soil from the hole is laid out on a sheet of polythene in the same order that it came out of the ground.

Silica flour is poured down the hole to a depth of 75mm and can be wetted with de-ionised water (Fig 2b). The sampler is inserted into the hole and held centrally while more silica flour and water is poured down the annulus created by the hole and the sampler body. The silica flour/water mixture is built up to a height of 75mm

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Dr Andrée Carter is Soil Scientist with the Soil Survey and Land Research Centre based at Shardlow, Derby.

above the porous ceramic cup in layers of 10-20mm.

Each layer is tamped to ensure intimate contact between the porous ceramic and the silica flour (Fig 2c). In less permeable soils there is the possibility of preferential movement of soil water down the repacked auger hole. In this case a 75mm layer of compacted clay either from the auger hole itself or as granular bentonite should be added following approximately 100mm depth of natural soil over the silica flour. The remaining space around the sampler is backfilled with layers of the original soil replaced in the correct order (Fig 2d).

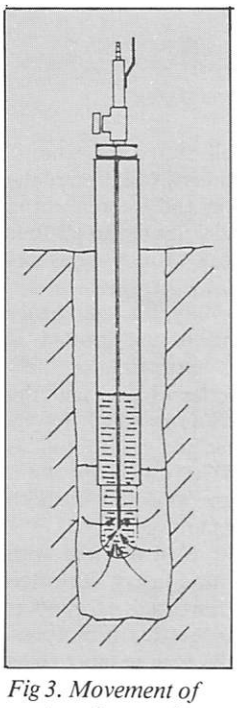


Fig 3. Movement of water into the sampler.

Obtaining a water sample

To obtain a water sample, a small hand vacuum pump is used to create a drop in pressure within the sampler of 0.3-0.7 bar. The main valve is then closed to seal the sampler under vacuum. This causes water within the silica flour, previously in equilibrium with the surrounding soil water, and from the soil pores, to move through the ceramic cup and into the sampler (Fig 3).

The rate at which the water moves depends on the soil moisture status and the pressure difference. However, a reasonable quantity of soil water can usually be collected after two hours.

To collect the sample, a flask or bottle is connected to the sampler via Teflon™ tubing. The main valve and air bleeder are opened and a vacuum pump used to reduce the pressure within the flask, causing water to move up from the sampler into the flask (Fig 4).

Field practice

This particular design of sampler should be installed after a crop has been drilled but before an agrochemical is applied.

After an autumn sowing the soil profile normally has a moisture deficit. As evaporation decreases in the late autumn to winter months, incoming rainfall recharges the soil and eventually a downward flux of water commences.

The MORECS (Meteorological office rainfall and evaporation calculation system) database is interrogated to identify when sampling should commence at a given location. A MORECS soil moisture deficit of approximately 30mm depending on site conditions is a suitable trigger.

Since sampling actually depletes soil water, care must be taken to obtain water only when there are known periods of flux or after recharge. The adoption of a routine and precipitation event based procedure avoids this problem. Trigger events can, for example, be a daily rainfall total exceeding 10mm or 2-3 days of consistent rainfall totalling 15 mm or more, whilst the timing of routine collections depends on the nature of the applied chemical and time elapsed following its application.

Sampler specific amber glass collection bottles with teflon™ lined lids should be half filled with deionised water and taken to the field along with two full bottles containing deionised water as field blanks. The sampling procedure described should be employed with the deionised water from each bottle being used to rinse the common tubing and fittings. Bottles are kept in insulated carriers with freezer packs to ensure minimal degradation of the sample.

In experiments on a range of soil types, individual samplers have yielded volumes in excess of 1 litre. Replicate groups of 3 samplers at a given depth usually provide adequate volumes and an indication of variability, though a far greater number may be required to fully characterise a site's spatial and profile variability.

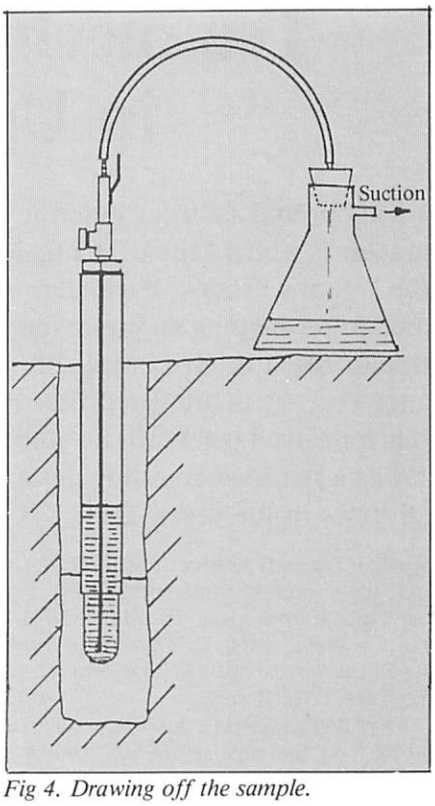


Fig 4. Drawing off the sample.

Applications include monitoring chemical movement, early leakage warning and so on

There are many potential applications for the use of suction samplers, either as a monitoring technique to follow the pathways of an applied chemical or to provide an early warning system, for example around underground chemical storage tanks. The authors have extensive experience of monitoring the fate of agrochemicals using this technique.

continued from page 48

in deciding questions of access to farmyards, size of towing vehicle or type of cultivation feasible.

A proportion in space of 1:4 of diagrams to text is ideal, bearing in mind the literacy level of our population, and the diagrams should be simple line drawings, using lettered captions, with a separate legend. Such diagrams are usually cheaper to produce, and to reproduce, than photographs, and give a clearer result. Also, they are cheaper to amend when a new model is introduced.

Colour is helpful, but increases costs.

Service Engineers 'know too much' to write Handbooks ...

Writing a Handbook is often made the responsibility of an engineer in the Service Department, and I believe that such a person usually knows too much about the machine to be able to explain it simply.

Ideally, the book should be written at the level of a user unaccustomed to the machine or process, and using terms which are generally understood, rather than specialised terms, unless a glossary is included.

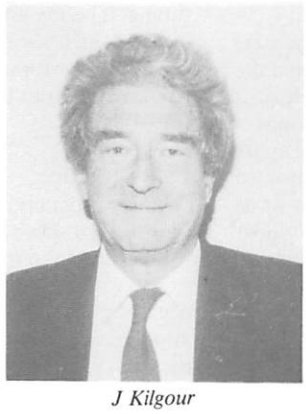
... but make sure those chosen do know enough

The revision of BS 2468 – Tractors and machinery for agriculture and forestry – Classification and terminology – is being undertaken at present, and will relate to International Standard ISI 3339 – Tractors and machinery for agriculture and forestry – Classification and terminology. There are standards dealing with other types of farm machinery, such as BS 6355 : 1983 – Glossary of terms for equipment for crop protection, and these publications are readily available to help whoever is asked to write technical literature, including Operator Handbooks. In ASAE Standards, there are many dealing with definitions of a wide range of machinery.

From what I have seen, many of the writers of Handbooks are under-equipped for their work.

In taking stock, and setting down my thoughts as I have, my conclusion is that much remains to be done by many machinery suppliers if the standard of Operator Handbooks in the UK is to improve to a level acceptable to dealers and users.

Tea mechanisation in Uganda



J Kilgour

J Burley

J Kilgour and J Burley describe the tea harvesting machines which Mitchell Cotts have introduced to the Uganda estates. Particular attention has been paid to developing an improved, heavy-duty, steel track system to give longer life and less maintenance cost. It is predicted that the harvester with this improved track will be able to maintain up to 190ha a year (ie harvesting this area approximately 20 times in the year).

Much of the early history of Mitchell Cotts and their venture into mechanised tea harvesting is covered in "The Mitchell Cotts Tea Combine" (Ref. 1). This includes the modifications carried out that resulted in the present Mk II version.

The Mitchell Cotts Group was purchased in 1987 by the engineering conglomerate Suter Plc, at about the same time that these modifications were being completed. Suters corporate policy did not include investment in the African part of their purchase and further development of the Mk II was ceased. The machines are now working satisfactorily but further harvesting capacity was essential to increase revenue and profitability.

All the available options were studied, resulting in a shortlist of three potential machines, these being the Japanese Valiant, the Williames T5000 from Australia and the MCTC Mk III. The Williames had been operating for 10 years in New Guinea, with reported good reliability and huge capacity. It was faster, lighter, cheaper to run, more fuel efficient and more manoeuvrable than the MCTC. The Mk III MCTC was still an unknown quantity as a prototype had not been built or tested. For these reasons the decision was taken to adopt the Williames machine.

Five Williames Tea Harvesters were purchased, upgraded even from the New Guinea model. The first of these was assembled on site from a knock-down kit in November 1988, and has since completed over 1500 hours. The other four were completed by the end of March 1989 and all have now completed their first 1000 hours use – the all-important first year of operation.

Machine specifications compared – Undercarriage/suspension – description

The overall concept of both machines is of a straddle-type with width adjustable from 2438mm to 3353mm to accommodate the existing crop spacings on the Uganda estates (see Figs 1 and 4 for general view of machines). Both machines are hydraulically adjustable for width. Adjustment is stepless and powered in both directions.

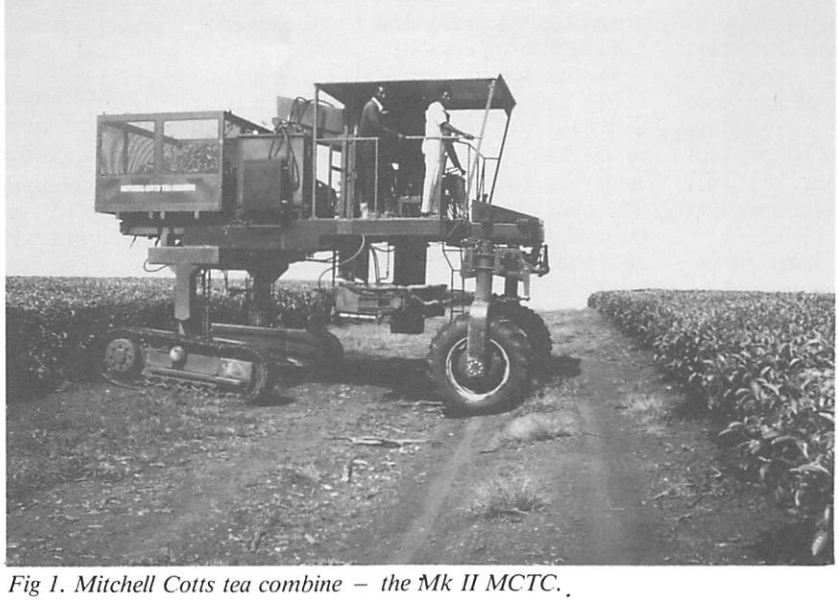


Fig 1. Mitchell Cotts tea combine – the Mk II MCTC.

As can be seen from Fig 1, the MCTC is of half-track design, with the powered tracks at the rear and unpowered steering wheels at the front. The rear track assembly is pivoted on spherical plastic SKF bearings, through its longitudinal axis, allowing a see-saw action to accommodate undulations in terrain (see Fig 2). The front axle is pivoted laterally, well above the wheels. Provided the undulations do not exceed the limit of travel of tracks and front axle, the load is fairly evenly distributed to all four corners, reducing peak ground pressures and chassis stressing.

The Williames is fully tracked, hence everything that contacts the ground is driving. The track is approximately 50% longer than that of the MCTC and the average ground pressure is much lower, especially as the machine is 1.5 tonnes lighter than the MCTC.

The most significant weakness on both machines is the undercarriage.

The Mk II MCTC is now fitted with ultra-heavy duty steel rims and earthmover specification tyres, with large taper roller bearings carrying the load. As a result of this design change, there has never been a single puncture or any damage to the rims or bearings. Steering can be a problem when weather conditions are adverse, the semi-lugless tyres tending to 'bulldoze' rather than grip and provide the necessary side thrust for turning. Being non-powered they do not self-clean either. The rear track chains are conventional steel Fiat 150mm pitch fitted with triple lug grousers. Track chain life is around 1000 hours. Track rollers and sprocket rings are also changed with each chain; the front idler lasts two chains out before needing a rebuild and the grousers appear to last indefinitely, with new nuts and bolts each time.

The Williames track system consists of two flat urethane belts which encase a single length of high strength multi-strand wire, wrapped around nine times. There is no join in the wire and the belts are endless and pre-drilled to accept the metal components that bolt on to them (see Fig 3). These consist of the ground engaging grouser, the

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Gerry Burley is Chief Engineer for Mitchell Cotts Tea Company, Uganda.

drive cleat that keys into it, and two deep side keepers that help prevent derailing of this very long belt. The four components sandwich the two belts and are clamped together with four 9/16" UNF cone-lock nuts and high tensile bolts. Five large diameter urethane-tyred wheels transfer both the weight of the machine to the track assembly and also carry the weight of the belt on their topside, hence the belt contacts idlers and rear sprocket all round. Large taper roller bearings support the idler wheel hubs and Caterpillar face-type seals contain the lubricant. Idler axles are solid steel pushed through pre-drilled holes in the 250 × 100mm box section undercarriage rail and welded in situ. Idler support is hence a cantilever arrangement.

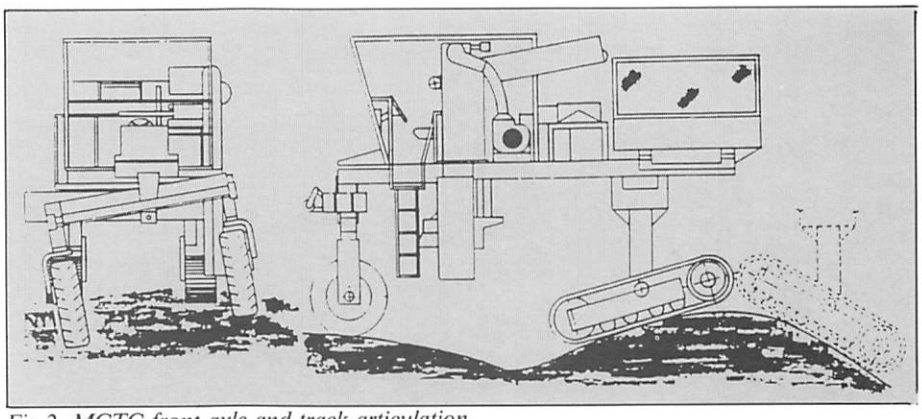


Fig 2. MCTC front axle and track articulation.

– Undercarriage / suspension – assessment

The simplest method of comparison of costs is to divide the purchase price of sub-assemblies or components by their estimated life span to give approximate costs per hour. This comparison is presented in Table 1 for the undercarriage assemblies for both machines.

The MCTC suffers from high wear rate of chains and rollers. Other components last longer but a complete refit is needed, on average, every 1000 hours. Abrasive soils accelerate wear still further and the system is very noisy. The components are surprisingly cheap and the system is very service-friendly. Even if the chain has to be split, any job can easily be done within a morning. The wear rates are known and can be very accurately predicted for ordering of spares.

The front axle has given no problems since all the machines were modified in 1987 and 5000 hours lifespan of its components is estimated as being the minimum.

With the Williames machine the belt system appears to be a better concept. With its solid urethane tyres, the whole assembly runs more quietly than the all-metal MCTC, so much so that the manufacturer has named it the 'Silent-Track'. The continuous wire-reinforced belts do not stretch or wear, and after initial tension has been set, further adjustment is unnecessary. Average ground pressure is lower and traction in wet conditions is also superior. The stability is also superior, but with higher peak ground pressures on rough and hilly terrains.

However, the Williames system is not maintenance friendly and if the belt has to be removed for any reason, due to it being endless, a three-day job is involved. The urethane-tyred rollers have a high failure rate. Undercarriage frame cracking has resulted in some lengthy repair work and as all components are handmade they are very expensive (see Table 1). Seals, bearings and stub axles have failed prematurely. Averaging out the wear rates of the components to date, it is estimated that a complete undercarriage rebuild will be required after 2000 hours of operating life (see Table 1).

– Main chassis frame design

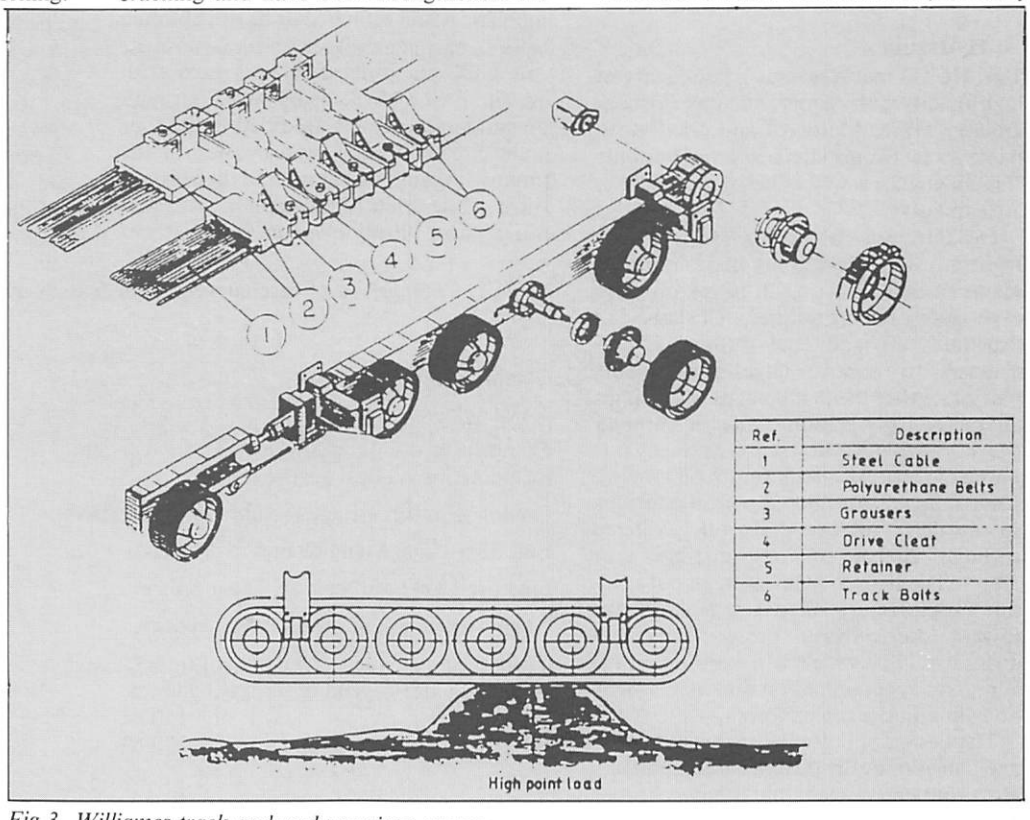
Both machines use box section mild steel for their chassis construction and of comparable section, wall-thickness and dimensions. Both have suffered from cracking and have been strengthened. As previously stated, the machines are of adjustable width to allow for the different crop spacing on the Mitchell Cotts Ugandan estates.

Both machines have fixed width cutter bars (3.35 m). However, due to the design differences of the cutter head and leaf transport systems, the MCTC has a 2.44m chassis and the Williames a 3.35m wide. This represents an enormous difference in the transport width of the machines, and in their weights and the cost of steel to fabricate them.

However, cracking in both machines has occurred. Capping top and bottom surfaces of the box with 5 mm plate to increase rigidity and section depth would pay dividends in longevity on both machines with minimal increase in cost or weight.

– Power units

The MCTC uses a Perkins 6.3544, normally



Ref.	Description
1	Steel Cable
2	Polyurethane Belts
3	Grousers
4	Drive Cleat
5	Retainer
6	Track Bolts

Fig 3. Williames track and undercarriage system.

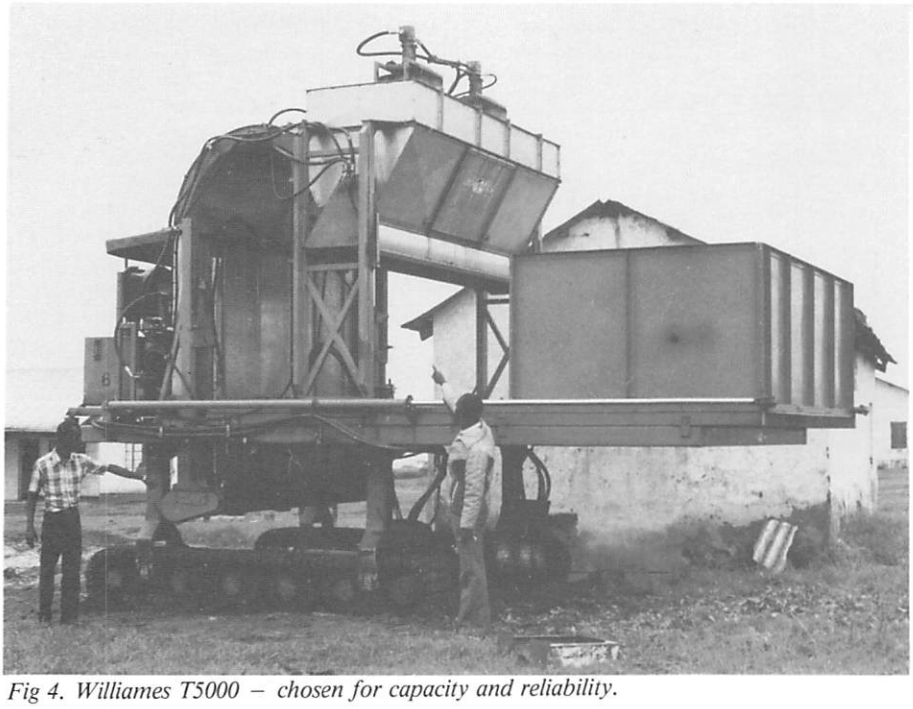


Fig 4. Williames T5000 – chosen for capacity and reliability.

aspirated, six cylinder diesel engine. It develops 80 kW (107 HP). The engine is fitted with a full torque front pulley as pumps are driven both from the flywheel, and the front of the crank.

The Williames employs a Cummins 4BT3.9 turbo charged, in-line four cylinder diesel engine developing 70 kW (93 HP). Driven off the flywheel is a two output splitter box. Six pumps are stacked 'piggy-back' style onto this, three off each output.

– Hydraulics

The MCTC machine uses components of high quality throughout, such as Poclain, Dowty, TRW, Marocchi and Danfoss to name a few. Longevity is assured but only if maintenance is well adhered to. Mistakes are expensive.

Oil filtration in the MCTC is of the highest order throughout, these improvements being a direct result of the previous experience of early failures. All supply oil ('suction' oil) is filtered through 50 μm strainers to remove large contaminant particles. After the first bank of gear pumps all oil is high-pressure filtered through 6 μm filters (except transmission charge pump, 2 μm). All circuit return oil is manifolded then 6 μm filtered before returning to the tank. All case-drain oil is filtered through 20 μm spin-on cartridge type filters. The main transmission circuit is in-line high pressure filtered to 6 μm in the foward loop only, to protect the transmission pump, which is a very expensive item, from contamination due to any wear or failure in the drive motors.

The design philosophy of the Williames machine is radically different. Components are proprietary again but much cheaper and of lighter duty construction than the MCTC. Circuit pressures in the transmission loop are much lower, the high torque being generated by mechanical gearing. Hydraulic complexity is comparable but due to the price of parts, many more can be held in stock. Assembly errors are less significant.

The filtration system of the Williames is not to such a high specification as the MCTC but due to lower pressures and temperatures, it is perhaps not necessary to be so. Suction oil is primarily strained from a single supply pipe. This pipe is manifolded for individual pump suction supplies. All oil is filtered to 20 μm absolute before reaching the gear pumps through two UCC suction cartridges, fitted with indicators and blockage bypass. Four high pressure in-line filters are fitted in the four main circuits on the pressure side of the pumps. Again indicators and bypass are fitted. Case drain filters are not fitted and nor is loop filtration in the drive circuit. Hydraulic rams are of the sealed type, re-building not being possible as in the MCTC.

– Harvesting attachments

Both machines differ greatly again in concept: the Williames system is superior in concept and is much easier to maintain as it contains far fewer moving parts. The MCTC system may, though it remains to be proven, cause less leaf damage in cutting, but this is possibly offset by an increase in damage in the transport system. Both machines incorporate fixed width cutting and to achieve a good cut, harvesting should always be done in the same direction in each row.

The MCTC uses a Busatis double reciprocating, double edged, plain knife section cutting bar. Leaf is brushed onto a cross conveyor leading to a chain and flight elevator. At the top the leaf is air assisted onto the top conveyor leading to the side tipping tank.

The Williames uses a cylinder type cutter bar, driven at a speed proportional to ground speed. Cut leaf is 'sucked' up the ducting placed above the knife and discharged into a 8m^3 bin with a false floor for emptying.

Machine performance

– Output

Both machines pluck at approximately the same forward speed; the Williames being approximately 10% faster at 9 km/hr. The Williames can turn around in its own track length about its track centre, with one track driving forwards and the other backwards. The MCTC cannot, being similar to a car in needing a 'three point' type of turn when space is limited. The Williames can turn in a theoretical track space of 4.6m in one move whereas the MCTC would need 24m to execute the same manoeuvre in one pass. Due to time loss in turning, the MCTC can handle only 150 ha/yr compared to the Williames 200 ha/yr.

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Table 1. Comparison of machine/component costs and performance (£ sterling)

Cost item	*MCTC*	*Williames*
Overall 'on the field' cost	85,000*	140,000
New engine complete	4,300	3,000
Complete hydraulic 'transmission' drive system including mechanical gearboxes, etc.	8,000	11,920
Complete undercarriage rebuild (excluding drive)	4,900	22,567
Full filter change (engine and hydraulics)	250	245
Fuel per 1200 hour year @ £2 per 5 litres	6,240	5,280
Theoretical revenue from max. controllable area × 2000 kg/ha/yr yield @ £1/kg made tea @ 150 ha =	300,000	
@ 200 ha =		400,000

*Approximate cost of machine built 'in-house'

From this and data provided elsewhere in this paper, an idea of the annual running costs versus productivity can be derived. This has not been done here as many different comparisons can be drawn, depending on viewpoint, to 'bias' costs one way or the other.

World Food Supply

Pub Sparfrämjandet AB
ISBN 91 7208-388 3 Price US $10

This report on world food supply is produced by the Swedish Savings Bank and is available from Lena Nordström, SPINTAB Sparbanken Lantbruk, Box 16426, 103 27 Stockholm.

The report attempts to give a comprehensive picture of what quantities of food are produced and where, and the various pricing systems adopted. It further attempts to answer the next question of why many people are starving.

The work has four main objectives:

1) to analyse the concept of food supplies from an interdisciplinary perspective;
2) to describe the changes in world food production over the past 25 years;
3) to show the extent and causes of undernourishment;
4) to provide insight into possibilities for providing food in the longer term to the world's population.

The report starts by outlining the ecological, biological, economic, political and social obstacles to funding the world. It seeks to argue the case for enough food but still undernourishment. Production and consumption in the USA and China are compared, including pricing, aid, and political policy and its effect on food supply.

The rest of the work deals with food production worldwide, the problems of malnutrition, and the amount of food needed. A final chapter tries to identify obstacles which need to be overcome as well as some possible solutions.

The work is backed up by a wealth of facts and figures as well as a comprehensive list of conferences. One particularly useful section is the student guide. This takes the form of a summary of each chapter together with a group of questions aimed at motivating the student into a more analytical approach to the problems. There is also a further study component which broadens the issues already raised.

This is an excellent book particularly for anyone interested in funding the world through agriculture and its associated industries. I thoroughly recommend it.

MJH

Coppiced Woodlands: Woodland Rides and Glades their management for wildlife. By R J Fuller and M S Warren

Published by Nature Conservancy Council
ISBN 0 86139 634 0 : 0 86139 6359 respect.

These two booklets are the first in a series on aspects of management of various habitats for wildlife. They are based on long term studies commissioned by the Nature Conservancy Council (N C C) at the British Trust for Ornithology.

The aim has been to develop management booklets which draw on the experience of research to provide discussion from which options can be assessed and strategies developed. Both of these works are very well presented; there are excellent photographs illustrating the text, as well as the diagrams and figures providing data and explanation of the technique involved in habitat generation and management. Those of us whose work is related to rural environmental planning and management will find these works of use particularly when we become involved in woodland.

The booklet on coppiced woodland deals with production of coppiced wood then consider the value of conservation within these areas and the wildlife response to the coppice cycle. There follows a useful but for me all to short section on coppice management including layouts, size rotation, stocking, reinstalment and some alternatives.

The second booklet deals with woodland rides and glades. The style as expected is very similar and again deals with the origins and history of these rides and glades as well as their value in terms of flora and fauna and finally a section on management issues in this case dealt with more thouroughly.

These are two very useful management aids and contain some very practical tips and policies presented with a refreshing sense of realism and practicality often missing in this form of text.

In this form it is obviously not exhaustive but I recommened it to any planners, managers or rural designers, a useful practical reference work.

MJH

Design your future in engineering

Pub: Institution of Engineering Designers
Contact: Mrs M Jackson Tel: 0373 822801.
Price £2.50

It is always pleasing to see new booklets providing more information on careers in engineering. This latest one is particularly useful as it looks specifically at the future in Engineering Design, an area often neglected.

The main body of the work is divided into 10 sections covering subjects such as:– On being creative; the nature of products; the design skills; the design process; costs; testing.

A final section entitled "A Career in Design" is devoted to various routes to a career in the profession. These flow charts often tend to confuse. This one is better than most but if we want to give encouragement to youth it must be easy to digest.

The main text is rather wordy and although making some very good points is rather dull. To attract more young people to our profession we have to show a more interesting face. Having said that it is still a useful text for students, parents, teachers and training officers concerned in the business of careers in Engineering.

MJH

continued from previous page.

– Quality

Crop quality differences are indistinguishable. Local management are claiming that the Williames is harvesting better leaf but it is believed this is due to tighter controls on cutter height recording and the insistence that fields are thoroughly weeded before harvesting. Plucking rounds are also being more closely controlled.

– Fuel consumption

The MCTC averages 13 l/h of diesel and the Williames 11 l/h.

Conclusions

There is never going to be the ideal tea harvester. It will always be a compromise of all the points covered in this paper. Both machines harvest leaf satisfactorily and of good quality. The harvesting attachments, though varying in complexity, work reliably. Engines and hydraulics are nearing the required longevity to be deemed satisfactory.

The undercarriages of both machines still require further development. In brief, the MCTC track system is reliable but too light and short lived, though cheap. The Williames system lasts longer but is more expensive to maintain and reliability/longevity of some components is still questionable. The new MCTC-type track system, which will soon be fitted on the Williames, being of a heavier, more durable design, may finally produce the acceptable compromise that is desired. It is hoped to report on this third generation 'hybrid' when sufficient testing has been completed.

Experience to date shows that mechanisation is the only way for the tea industry in Uganda to attain once more its former output. Further developments will lead, in the near future, to an overall machine design that is suitable for Ugandan conditions.

Acknowledgements

The authors would like to thank the staff of Silsoe College, Mitchell Cotts East and Central Africa, Mitchell Cotts Uganda, Toro and Mityana Tea Company and Richard J Hall Ltd for their contributions and for making available the information presented in this paper.

The views expressed in this paper are solely the opinions of the authors. Machine capacities and performance stated are those achieved by TAMTECO on their estates in Uganda. Stated costs are drawn from the latest figures available to the authors.

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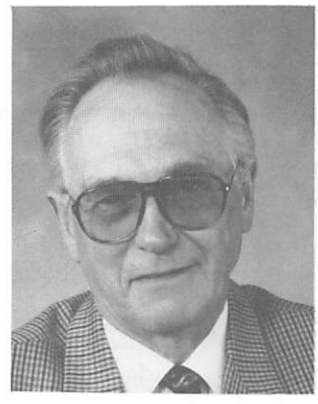
Innovation: commercial success or failure?

In this adapted extract from The Douglas Bomford Trust's 6th Memorial Lecture, W Klinner gives us an insight into how he and his team at NIAE (now Silsoe Research Institute) succeeded in turning an idea into a commercial success. He also gives his views on how many of the problems and pitfalls involved in the exploitation of innovation can be overcome. The full lecture, which includes another case study of the Stripper Header, is available from The Secretary of The Douglas Bomford Trust, 1 Manton Spinney, Knuston, Wellingborough, Northants NN9 7ER.



In the first part of my presentation I propose to examine briefly the sequence of steps leading to the introduction of new commercial products based on concepts originating outside the manufacturing sector. In-house developments are not considered separately; they should progress more straightforwardly because everything is done at company instigation and under company control. In the second part I will rely on two* case studies to illustrate important points.

The incentive for innovation

Powerful commercial incentives for innovation are: – the ongoing contest for a share of an existing product market, – the expansion of markets previously limited by perceived or real deficiencies of contemporary products or resistance to their use, – the expansion or re-establishment of frustrated or dormant markets and, most importantly, the creation of uniquely new markets.

In any particular sector of agricultural engineering it is prudent periodically to examine:

- what benefits might be derived from extending mechanisation to replace or supplement hitherto manually or inefficiently performed tasks, both in developed and developing economies,
- what new principles can be employed to raise existing standards of performance and levels of effectiveness,
- what use can be made of new materials or methods of construction to gain economic or functional advantage,
- how else improvements can be brought about in the productivity of labour and the reliability and/or economy of machine use,
- whether the time is opportune to attempt simplification of a machine, a system or a method which may have become so complex over a period of years that limitations have been reached or adverse consequences are becoming apparent, and
- how the achievement of objectives should be pursued in new areas where the agricultural engineer is capable of making contributions, currently for example in the implementation of new health and safety at work requirements, in the introduction and expansion of leisure pursuits utilising agricultural resources, and in the protection of the environment and agro-ecology of this earth.

R&D projects must be accurately assessed as to likely cost and benefits

Few people will dispute that research is an important driving force for innovation, often steering it in new directions.

Probably the most consistently recurring difficulty associated with new R&D projects is to predict accurately the likely effectiveness of investing time, money and effort, and to what extent technology will eventually be advanced.

Given that very careful scrutiny suggests a development project has good practical potential and can be justified on commercial and economic grounds, a succession of further steps must usually be followed in order to progress it effectively. Such steps are outlined in the adjacent panel.

Financial resources are at present scarce

Progressing a development project

- Study of general, scientific and patent literature can provide essential background, stimulate thought and point the way towards previously unrecognised approaches and solutions.
- Adequate resources must be secured to see the project through, including contingencies which may be needed when, typically, unforeseen difficulties arise.
- Whether the perceived ideas which are to be developed are based on research or intuition, the planned approach, whether scientific or impirical, needs to be checked for soundness and verified, either theoretically by calculation or simulation and/or practically by experimentation.
- Early possible embodiments must be devised and made up in some form.
  - A scale model is relatively cheap to make and can provide a focus for discussion of first impressions and lead to modified or new thought.
  - The first practicable embodiment of a new concept may be a rig with which realistic or typical work can be carried out as a further check of performance potential and project viability. The rig may be a scale model but, ideally, at least the critical dimensions should now be full-size.
- If prospects continue to be favourable, the building of one or more full-scale rigs or prototypes may become justified for more realistic evaluation, for modification and further testing, and for ultimate experimental design and functional optimisation.
- Throughout the development period brain storming sessions can help to concentrate the mind, particularly whenever a choice has to be made from two or more alternatives or when there are signs of the project losing momentum. It is highly desirable that several disciplines and backgrounds are represented, to ensure breadth, depth and vigour of discussion.
- Also during the development period an assessment needs to be made of the novelty content of the new concept and whether it constitutes valuable intellectual property. If so, a decision must be made and followed up on whether the rights to the intellectual property are worth protecting and which of the available methods is the most appropriate.

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among the various non-industrial agencies most likely to start and carry forward research-based development. However, in many instances these organisations have excellent facilities and expertise, and these can be commissioned in support of commercial projects. It seems a waste of valuable resources that many of these facilities are so under-used by UK agro-industries; certainly less use seems to be made of them here than in the USA and on the continent of Europe.

In the case of a development in which commercial interests have not been involved up to the stage when viability seems certain, the first concern of a potential partner or investor will be to see hard evidence that the concept works well enough for the eventual product to capture a worthwhile market share, to justify the usually high development costs and to ensure ultimate profitability.

When the original objective appears to have been achieved, there is sometimes the possibility that a new mechanism or device has alternative applications to those originally envisaged. Questions which should be asked as a matter of routine are: what relevance does the development (possibly modified) have to solving other problems, and how else can it be used? Wider potential can add to the commercial attraction and enhance product viability.

'Selling' the innovative concept or product

What can be done to help sell innovative concepts to industry and new products to users? I will mention just a few examples.

On the basis that first impressions are always the most important and can be difficult to change, the appearance of an item of hardware, when it is first shown to a potential producer, can have a profound influence on the outcome of an exploratory meeting. If a model, rig or experimental prototype looks like the Forth Road Bridge and as though it might cost a fortune to make, little credence will be given to protestations that it could be made lighter, simpler and cheaper. Therefore, eye appeal and minimal complexity are desirable design objectives even for early embodiments.

Members of a research team involved in the concept development can help to prepare the ground for the introduction of innovative technology by publishing relevant technical papers and popular articles, and by explaining background and potential in lectures and informal talks to eventual users, their advisors and suppliers.

Demonstrations are a particularly effective way of publicising new products but only if they are done convincingly by skilled operators. In the preparation and testing for market acceptance, prototype machines of respectable appearance can be exhibited as concept models, and as soon as good performance can be guaranteed, they can be demonstrated whilst final development is still proceeding out of the public eye.

Fig 1. Early experimental field rig for evaluating a high-speed conditioning rotor with V-shaped steel spokes above a reciprocating cutterbar (Photo: Silsoe Research Institute).

The relationship between parties co-operating on a project can have considerable influence on the speed of progress. A good rapport and willingness to listen and accommodate one another's views and suggestions are ideal. The least desirable attitudes which often lead to conflict and delay are the not-invented-here and the we-do-it-my-way-or-not-at-all syndromes. Tolerance and compromise can overcome such problems.

A case study – the forage conditioner

Forage conditioners are used to treat grasses and legumes physically to reduce their surface resistance to the loss of cell moisture after crops are cut for conservation. The prime objectives of conditioning are faster drying and better preservation of feed value than if crops were left untreated.

In the late 1960s three types of conditioning mechanism were available in the UK. Two were the roller crushers and crimpers designed for use on pre-cut crops; the third was the flail mower which cut and simultaneously conditioned by severe laceration.

The roller mechanisms had been developed in the USA for lucerne and were not very effective in grasses under UK conditions. The flail mower invariably increased crop drying rate significantly but often caused high dry matter losses and, in unfavourable weather, excessive leaching of soluble nutrients.

To improve the economics and efficiency of forage conservation we came to believe that a one-pass cutting and treatment system was essential and that the severity of conditioning should be limited to give fastest possible drying without incurring objectionable losses. We had no doubt that effective designs of conditioner could be developed and would find user acceptance.

Development and design

In 1969 the first patent application for a mower conditioner developed at NIAE was filed. As with all institute inventions at that time, the patent rights were assigned to the National Research Development Corporation (NRDC), now the British Technology Group (BTG).

The first disclosure was of a rubber-flailed rotor capable of being located from forward of a reciprocating cutterbar to behind it. Direction of rotation was in the undershot mode, and a contoured concave plate was provided under the rotor for retarding crop flow and increasing treatment severity.

This design was only moderately effective. We therefore planned to reverse the direction of rotor rotation into the overshot mode and to fit an overhead cover. However, first we made up models, to decide on linkage design, and only then did we build a new experimental rig.

The changes improved functioning and swath architecture but not the effectiveness and consistency of treatment.

We identified various problems – the need for creating slip between the crop and the conditioning elements to effect scrubbing; for narrow arms of adequate length to achieve full-depth penetration of the crop stream, and for a shape of element which achieved engagement of all the plant material. 'V'-shaped and 'Y'-shaped flails in which the arms were made of metal strips gave good but not always consistent results (Fig 1).

Use of a specially designed laboratory rig and high-speed photography disclosed that the swinging elements were often deflected into a reclined position which reduced effectiveness.

Fixing the elements by means of shear

pins overcame the problem, but all too often foreign objects caused the shear pins to fail.

As a final step, which met all requirements, a resilient mounting for the elements, using captive rubber blocks as shock absorbers, was developed and also patented. Details of this design are illustrated in Fig 2. A special rig was built for durability testing.

Simple attachments to rotary disc mowers were tried with the aim of treating only the thick lower parts of crop stems. However, these were not proceeded with because the high rotational speeds were thought to pose excessive risk. Later, the combination of rotary mowers with separate conditioning rotors proved successful.

Some of the physical and functional characteristics of the original rubber flails remained attractive, and when wear- and impact-resistant plastics became available, we adopted them in the design of alternative rotors.

Objectives included simplification, cost and maintenance reduction, performance improvement, and elimination of the risk of damage from lost metal elements picked off the ground later by forage harvesters.

New plastic elements comprised modified V-shapes, serrated ribs, and brushes, including tufts made up of multiple plastic rods retained in a plastic sleeve.

Treatment effectiveness of different conditioner configurations was again assessed in the laboratory initially.

Some plastic ribs were fitted in helical form directly to a rotary drum mower which had been provided with a split drive, to reduce the speed of the drums relative to the cutting discs.

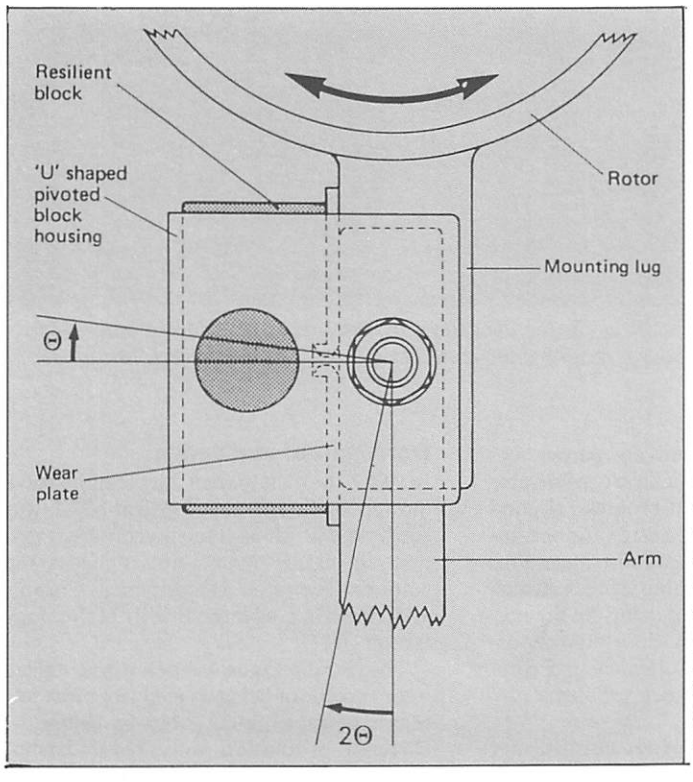

Fig 2. Design details of a resilient mounting developed to ensure uninterrupted operation of metal crop conditioning elements by protecting them against overload and damage (Photo: Silsoe Research Institute).

Alternative applications

Alternative applications which we proved to be practicable and effective included the use of modified conditioning elements on high-speed rotors for picking up forage and other crops; also the automatic detection and rejection on such pick-ups of metallic and/or non-metallic foreign objects, using an actuated deflector above a gap left between the pick-up and the feed intake to the chopping mechanism. The deflector was triggered by signals from acoustic or magnetic sensors, or both, attached to the front cover.

These and associated developments can receive only a brief mention here.

Bringing the product to market – early disappointments

The average time taken for products to reach the market place is 3 to 6 years from filing of a patent application.

This statistic reflects the problems and difficulties commonly experienced by the innovator in securing resources and commercial interest and by all concerned in completing the process of engineering for production.

In the case of the early conditioners using metal-spoke rotors, we at the Institute and NRDC tried hard to attract a UK manufacturer quickly. To this end every relevant company was approached, demonstrations were given at Silsoe and elsewhere in public and in private, and every help was offered to assist with commercial development.

Only one company, Rotary Hoes Limited, proceeded to market a small batch of around 20 machines for the 1974 harvest but discontinued production soon after.

Reasons for the short-lived involvement may have included initial problems which the first users experienced, and the cost of modifying the machines sold. With the benefit of hindsight it may have been better had more time been taken for product testing and had better protection for the tines been incorporated, even though this would have increased cost.

To help sell the mower-conditioner concept, my colleagues and I travelled many hundreds of miles in mainland Britain, sometimes taking our experimental machine along on a trailer, and we publicised the system extensively in lectures and papers.

In the USA two manufacturers had also taken options on a licence. One, the Hesston Corporation, proceeded quite early to build and evaluate a prototype and fairly quickly thereafter to market several designs. However, the products did not take on in sufficient numbers and, therefore, were discontinued. It is possible that a design so different from the indiginous machines and of foreign origin was viewed sceptically by many US farmers at the time.

The disappointing response from manufacturers to the new conditioning technology made the contemporary staff at NRDC somewhat despondent, and therefore it was not too surprising that patent rights in some countries were abandoned.

– the breakthrough

The breakthrough came in the second half of the 1970s, when first Taarup of Denmark, also Deere & Company in the USA, then Deutz-Fahr of Germany, M-F in the UK and more recently 'JF' of Denmark developed and marketed the original abrasion conditioners.

It is interesting that only a relatively short time after Hesston abandoned their versions the Deere equivalents found acceptance. Did Hesston pay the penalty of entering the market too early, and did Deere & Company benefit from their competitor's test marketing and from the early machines perhaps performing well after all when appropriate operating techniques had been adopted by users?

Plastic V-spoke and serrated rib conditioners are still marketed, the latter now in modified form.

The brush conditioner is licensed to two UK companies, Kidd Farm Machinery Limited and to Agrimech Engineering Limited, who also use a brush as a pick-up in a high-capacity windrower. All the machines employing brushes have gained the reputation of high rate and quality of work capabilities and of operational reliability.

A few years ago, when sales of mower conditioners based on NIAE designs were at their peak, it was said that the revenue earned from royalties was one of the highest in the BTG portfolio of inventions, despite protection having been relinquished in some markets.

To pass on as much knowhow as quickly

as possible, I travelled abroad frequently and at times for extended periods. Our designs have been copied in several countries, in some with impunity, but where protection existed, BTG have pursued and successfully settled with infringers.

Examples of commercial mower-conditioners are shown in Fig 3.

Fig 3. Examples of commercial mower-conditioners employing semi-rigid and swinging V-form elements, tufted brush rotors and serrated plastic ribs for treating forage crops (Photo: Silsoe Research Institute).

Few ideas achieve successful marketing

At this point I feel obliged to confess that not all the ideas I helped to spawn during my career have become commercial successes.

In this context it may be of interest that of the 35,000 to 40,000 patent applications filed annually in the UK, only 2½-3% are likely to reach the market place as commercial products.

Out of every 1000 technical enquiries received by the Design Council only 200 contain sound commercial ideas; only 20 come from people with the appropriate qualities to carry development forward, and only one new product is likely to be marketed successfully.

On the subject of commercial licensing of innovative concepts it is difficult to obtain reliable and generally applicable data. BTG state that, in respect of the farm machinery developments they support, the success rate is approximately 60%, 38% of licences going overseas. This is a significantly higher 'score' rate than in other engineering sectors.

The financial performance of farm machinery licences closely follows the financial health of the agricultural sector and farm incomes in general – and we all know the sorry economic state of world farming today.

Regardless of what the creator of an idea or development thinks, and most believe that their brainchild will have major impact on the world, what alone determines the success of a new product is acceptance by users. Unless there can be shown to be obvious advantages in terms of efficiency and economics and some of the other aspects we have identified, no amount of advertising and incentives to buy can make a venture profitable.

Probably the most common reason for private excursions into innovation failing is inadequate resources, particularly finance.

Innovators may underestimate the difficulties and misjudge product cost and potential. They may just have bad luck or the idea may be too far in advance for immediate exploitation.

If development takes an inordinate length of time, as it sometimes does or is allowed to do, then on completion any demand there may have been can have diminished or disappeared or become satisfied by competitors.

Regarding readiness to invest in innovation and to accept risk, experience with the early conditioners could be interpreted as suggesting that UK companies at the time were less adventurous and perceptive than their foreign competitors. Were the longer term potential and wider implications considered sufficiently alongside the immediate commercial prospects and existing markets? Are the claims that important UK inventions frequently fail to be taken up at home, only to be exploited abroad, defamatory in every case or are too many true?

I will not pursue this point but would plead that innovative projects offered for commercial uptake are never rejected lightly and that the originator is listened to carefully, interrogated closely and his record and the potential market checked thoroughly.

If support for a proposition is agreed, it must be given wholeheartedly and at an adequate level of finance in order to succeed in as short a time as possible.

Research institutes should keep commercial earnings to fund further projects

What can be done to improve the climate for innovation and provide better incentives for it?

A stable government policy for R&D funding and more enlightened and more generous inducements for industry to increase its competitiveness, particularly in export markets, would almost certainly achieve a great deal but seem too much to hope for at present.

In the private, public and industrial sectors, more and better incentive schemes offering tangible benefits for practicable ideas could, I believe, bring worthwhile results.

If agricultural research institutes were allowed in future to keep new commercial earnings over and above their normal budgets, and if such revenue could be accumulated, a fund would become available which could then be used at an institute's discretion to finance all or part of promising R&D projects on a profit-sharing basis with industry. This would also provide incentive and could lead in time to less public money being needed and to effective and financially attractive support for industry becoming available. However, industry would need to avail itself of the opportunities and use the services more freely and extensively than others offered in the past.

Inspiration, ingenuity, innovation – best efforts essential to meet demands of the future

I have little doubt that, to meet the ever-increasing global demand for affordable food for all, and hopefully soon also for more crops for industrial processing, we will progressively have to use more of the world's remaining, hitherto unused land resources.

One of the main challenges involving all the agriculture-related sciences and technologies will be to define and quantify much more precisely than up to now the nature and seriousness of any risks to mankind and world environment from past intensive farming practises and then to develop new solutions to achieve sufficiency of production safely.

No one is able to predict at present how we may attain this noble yet essential goal.

What does seem certain is that all sectors of agricultural engineering will need inspiration, ingenuity and our best efforts at innovation in order to meet the unrelenting demands for probably even faster change in future.

To stand still in this competitive world, with all its problems and needs, is to concede lack of ideas and drive and hands opportunity and responsibility to others.

I am sure that members of our profession can and will rise to all the challenges the future may hold.

** Only one case study is presented in this extract.*

New mechanisation to protect the agricultural environment

In this article we present a summary of the conclusions and recommendations from the second plenary meeting (November, 1990) of the Club of Bologna.

The Club of Bologna comprises more than 60 experts from 30 countries. The objectives of the Club are to:

- **discuss and define appropriate strategies for the development of agricultural mechanisation;**
- **identify new technological and operation solutions;**
- **promote the exchange of technical information and international co-operation;**
- **prepare technical and economic reports to be submitted to governments, agricultural machinery manufacturers and farmers.**

The background to the meeting of November 1990 was the general awareness that agricultural activity in every country – whilst providing an attractive rural environment and a natural source of balancing the environment (for example CO_2 reduction in the atmosphere) – is nevertheless one of the factors responsible for various forms of environmental pollution. Such environmental pollution affects: –

– the **atmosphere**, through the spread of noise, dust, unpleasant odours, ammonia, and the emission of noxious gases. These things have a direct impact on man's welfare as well as on soil acidification, damage to our forests and gradual planetary warming;
– the **water**, both surface and underground, due to the introduction of pesticides, herbicides and fertilisers (mineral and organic), which also contribute to widespread problems of eutrophication;
– the **soil**, as a result of the gradual accumulation of components that are not easily degradable with particular reference to heavy metals that may thus enter the food chain.

In addition, and of increasingly more serious concern is the gradual degradation of the soil itself and of its structure, due both to external causes based on erosion and endogeneous factors originating from unsuitable cultivation practices and/or extreme or inappropriate forms of mechanisation.

Three main problem areas have been identified: –

- interaction between soil and mechanisation;
- proper management of animal wastes;
- application of agrochemicals.

Interaction between soil and mechanisation

With regard to the interaction between soils and mechanisation, there is a need to develop innovative technologies designed to: –

- remove excess water and control leaching and salinity;
- reduce the loss of soil and nutrients;
- optimise seedbed preparation operations;
- minimise damage due to compaction of the physical structure of the soil;
- incorporate crop residues.

The adoption of techniques and technologies designed to meet these needs requires a common effort in the field of applied research. The goal is to make it possible for farmers to manage their own land in a more effective manner by greatly reducing production costs, increasing the useful periods during which various cultivation operations can be carried out, and defining forms of land tractability that will make it possible to carry out various cultivation practices without causing perceptible damage but rather improving soil quality.

Innovative product and process solutions (some currently being worked on), which are designed to reduce tyre slippage, decrease the pressure they exert on the soil, organise cultivation according to the criterion of traffic lanes, carry out combined operations (either at the same time as, or after, sowing) and reduce cultivation depth, will also be able to decrease current production costs by 30% and restore vitality to the soil itself.

Within this framework, there is scope for the adoption of remote control systems of tyre inflation pressure as well as of higher working speeds, whilst alternative traction devices should also be evaluated.

This scenario must be backed up by the use of: electronic systems for machinery guidance, control and regulation; the application of artificial intelligence; appropriate databases operating in real time, and tools for processing agrometeorological data for optimal cultivation planning.

This situation calls for a joint effort by research and industry in order to come up with fast, conclusive, technical and systems solutions.

Proper management of animal wastes

As far as the proper management of animal wastes is concerned it has to be noted that the nitrogen cycle in the soil is highly inefficient in the most intensive animal-breeding areas, where utilisation efficiency is often lower than 0.3, even though it would be possible to create a significant improvement. Therefore, the Club realises that soil pollution problems are directly related to the surplus of minerals distributed, and that this fact has an impact on: –

- the phosphorus saturation of the soil itself;
- the transfer of nitrates to underground water;
- the eutrophication of the water.

Furthermore, another important source of pollution is the emission of ammonia into the atmosphere by intensively housed animals and the cleaning methods in use. In some countries, emissions from buildings housing animals contribute over 35% to the national total for this compound. If the ammonia released during the distribution of wastes over the ground is also included, this figure reaches 90% of the total.

In many countries, laws limiting the quantities of nitrogen and phosphorus that can be distributed on various types of soils have been or are about to be passed in order to encourage more appropriate animal waste management. The goal is to create situations of equilibrium between the quantities distributed and the quantities absorbed by plants.

This means that technological innovations are required in both buildings, cleaning operations and the storage, transport and distribution of slurries.

Consequently, innovative systems and techniques for the design of buildings (which will differ according to the species bred there) and related equipment must be developed in order to reduce ammonia emissions and cause the NH_3 produced to precipitate. In this case, it seems possible to reduce current emissions by about 50%.

Radical innovation in technologies currently employed in storage, treatment, transport and distribution (of both farm livestock and municipal wastes) is another important requirement. On the one hand, solutions should be aimed at actual and complete soil incorporation of wastes (with a possible reduction in noxious emissions of 30-40%), and at increasing the dry-matter content of transported wastes on the other. In addition, the various processes carried out on the soil, on housing and in slurry collection tanks must be checked with the use of special sensors and automatic devices for active control and regulation.

Application of agrochemicals

With regard to the problems posed by the application of agrochemicals, it is necessary to reconfirm the importance of obtaining effective, uniform treatment (of both pesticides and fertilisers) with minimum formula consumption. Some countries already have

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The Vredo range of advanced slurry injection equipment from Holland is now being handled by Horsch UK Limited. The equipment is based around a unique double disc injection unit which accurately places the slurry at 2"-3" depth with row spacings of 8". This system is suitable for injecting waste into grassland at rates of up to 35m³/ha.
Horsch UK, 60 The Avenue, Southampton, Hants SO9 4UX. Tel: (0703) 233193.

ZINGA
unique anti-rust protection

Zinc galvanizing can now be applied on site without having to dismantle structures. A unique anti-corrosion product has been launched in the UK – ZINGA a zinc coating that can be applied by brush or spray.

ZINGA is a liquid compound which when dry contains at least 95% electrolytic zinc that bonds to steel or iron, even if it is mildly rusted, to provide maximum corrosion protection. ZINGA has been tried, tested and in use on the continent of Europe for 18 years.

ZINGA galvanizing system is a well-established anti-corrosion method. Like zinc galvanizing, ZINGA provides cathodic protection – in effect, the zinc coating rusts instead of the steel or iron base. Even if the zinc coating is scratched, the rust cannot creep under the coating and cause bubbling.

ZINGA is particularly popular with maintenance operators and painters because it is easy and safe to use. There is also no need to clean brushes after use. The hardened brush will soften quickly when it is re-immersed in ZINGA.

More information from: Galvatech Ltd, 193 St John Street, London EC1V 4QA. Tel: 071 251 4916 or 0865 54971.

New joint sealant for leaking silo floors

Increasing demand for high quality products to seal problem floor joints in silage pits and similar structures has been answered by SMS Ltd, with the introduction of its new product Surfajoint-3. The product now forms an integral part of the company's Siloshield system of coating, sealants and repair products for effluent containing structures.

Designed for easy use by farm labour or contractor alike, the two component product is cold applied, easily poured into prepared floor joints on old and new surfaces.

Supplied in 10kg two-component packs, Surfajoint-3 costs approximately £2 per metre run on standard joint sizes.

For further information, contact Surface Maintenance Systems Ltd, on Burnley (0282) 33280.

→

legislation limiting the quantities and formulae that may be used. The goal in this case is to decrease the risk of pollution and the costs of the operation.

Widespread, resolute action should be taken in favour of periodic on-site inspections of the machinery being used as well as its maintenance and performance. Considerable innovation is also needed in both machinery components and distribution systems.

The major improvements that should be made on pesticide spraying machines include: –

- tank size and shape and stirrer operation to guarantee the complete homogeneity of the mixture to be distributed;
- fan size and position in relation to nozzle layout to ensure accurate application with the minimum possible waste;
- the design of new types of nozzles designed to improve treatment effectiveness using eg injection methods as well as solutions for the emission of pesticide near the nozzle;
- the degree of precision and automation of onboard instruments that control and regulate operations, which should be handled by computerised systems;
- improved operator protection.

Options to be considered with regard to pesticide distribution systems (which would be especially useful in the case of trees) include improvements in droplet generation with or without protection screens. There should also be greater use of recycling devices and of active control and regulation devices for machinery based on electronics and sensors for registering plant needs as a function of climate and soil. The establishment of sensors could allow automatic localised or locally varied treatments.

Interesting possibilities are also offered by: systems of bio-control of insects; solutions combining mechanical and chemical treatments against weeds; new technologies based on physical techniques; development of combined solutions for the simultaneous distribution of pesticides and fertilisers.

If research is to focus on the area mentioned above, the result could be a reduction of 30% in the consumption of pesticides, all other parameters being equal.

Similar suggestions can be made in terms of the distribution of mineral fertilisers and product innovation with regard to technologies to be employed based on timely, continuous information about the nourishment required by crops in various soils. Again, this information should be obtained with the use of sensory techniques and advanced electronics.

Support for international research

In conclusion, the Club of Bologna feels strongly that there is a fundamental need to support international research groups (representing a joint effort on the part of research and industry) to achieve – in a short period of time – the above mentioned goals through the development of techniques and technologies designed to strongly reduce agriculturally-created pollution problems and improve the productive and economic results of agriculture.

Further information can be obtained from Prof Giuseppe Pellizzi, Chairman, Club of Bologna, Institute Ingegneria Agraria, Universita' di Milano, Via Celoria 2, 20133 Milano, Italy.

Nextgen biogas electricity generation and farm waste treatment plant

An unusual planning application has been received in South Shropshire for the construction of an electricity generating plant. This is no ordinary power station; the fuel is poultry litter, and as well as putting one megawatt of electricity into the National Grid, this plant will be rejuvenating the fertility of a 600 acre arable farm, heating up to two acres of greenhouses and producing the raw materials which form the basis of a peat-free compost.

'Nextgen' is the brainchild of James Murcott, farmer and engineer, who has for over 15 years been at the forefront of anaerobic digester technology.

Anaerobic digestion is the process whereby organic wastes are sealed in tanks, excluded from oxygen, and heated to about 35°. This gives the ideal conditions for certain types of bacteria to digest the wastes, reducing the polluting power by about 80% and giving off the natural biogas, methane.

Others are planning to generate electricity by incinerating poultry litter; in the opinion of James Murcott: "It's a criminal waste of resources. It costs a similar amount to build a digestion plant or an incineration plant. Incineration destroys a so-called waste material and produces electricity, smoke and ash. Digestion *treats* this waste and produces electricity, farm fertiliser, compost and heat. Nothing will be wasted."

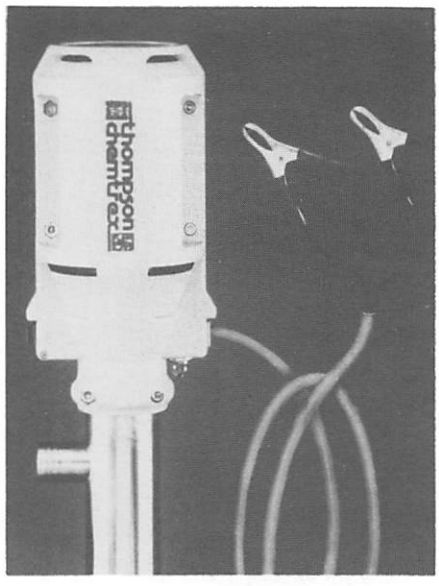
The plant consist of four digesters, treating about 60 tons of turkey litter per day. The biogas produced will run Combined Heat and Power engines, generating one megawatt of electricity and up to two megawatts of heat, which will be collected for heating greenhouses in the winter. There is a possibility that this heat could be also used for the farms grain dryers in the summer months.

When the waste has digested, it is separated. All the nutrients and trace elements are still there, mostly in the liquor, but some still are held in the fibrous part that has resisted digestion. As part of the plan for the Nextgen plant, a state-of-the-art irrigation system will be developed to spread the liquid portion of the digested manures onto the crops during the growing season only so the risk of water pollution is removed. Enough storage has been planned so that winter spreading is completely unnecessary.

The fibrous part of the digested wastes has already been successfully marketed by Waste Refineries International Ltd as an ingredient of 'Heritage Peat Free' composts. Continued milling of the peatlands will, leading ecologists believe, destroy some of the last wild areas of Britain that provide the habitat for rare species of birds, animals and plants, and many gardeners are looking for alternatives. This firm also sells digesters for on-farm and abattoir wastes.

With over 5,000,000 tons of this particular waste being produced every year, Nextgen look forward to many similar waste treatment plants springing up all over the country.

Nextgen Ltd, PO Box 99, Craven Arms, Shropshire SY7 9QA. Tel. (058) 61465.



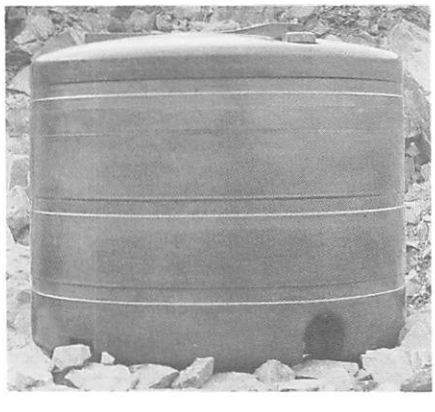
Michael Smith Engineers Ltd, Woking, Surrey (Tel: (0483) 771871) have added another motor to their Thompson PF series of drum emptying pumps, bringing to 36 the choice of pump/motor options. With the new 12 volt motor the Thompson PF pump can handle fluids with specific gravities up to 1.6 and offer a maximum capacity of 55 litres per minute or 3.7 metres head.

Extraction fans for agriculture

Machine Mart, Britain's biggest tool and machinery retailers, with 22 stores nationwide, offer a very extensive range of quality industrial extraction fans, ideal for agricultural ventilation, with free air flow ratings between 1323 and 5882 cu ft/min.

Extraction fans are just a small part of the Machine Mart range, they also have a large selection of power tools, mobile water pumps, generators and power washers.

A full colour catalogue is available from Machine Mart – Tel. (0602) 411200.



Atkinson, the Westbury, Wiltshire manufacturer (Tel. (0373) 822220) and supplier of oil tank gauges and fittings, has become a distributor for the Titan range of rotational moulded plastic storage tanks.

Titan tanks conform to British Standards. They are rotationally moulded in one piece, and incorporating in-built design reinforcements, the tanks are virtually damage proof. They require no painting or maintenance once installed. They are relatively lightweight and are easy to manhandle on-site.

For manufacture/distribution – Drip irrigation system

Torvale International, on behalf of a German client, are offering manufacturing and/or distribution agreements for a new system of irrigation that has already been tried and proved on the continent.

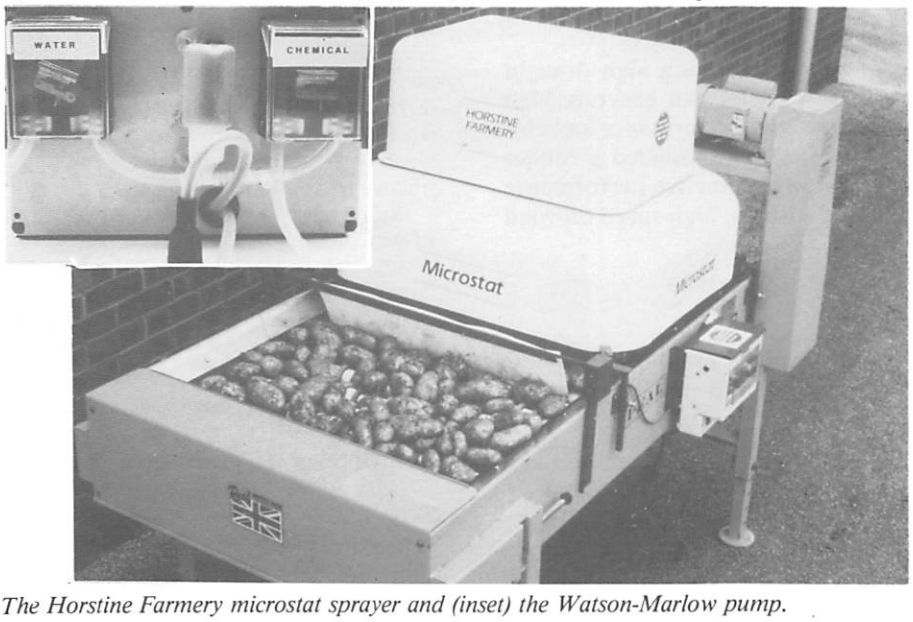
The agreement will include the manufacturing know-how, key hardware and necessary control systems.

The technology utilises lightweight plastic pipes which are UV stabilised and manufactured from heat and corrosion resistant polyethylene, together with a small number of other components to provide a complete package that is light, easy to assemble, durable and delivers the water exactly where it is needed with the minimum of waste.

The system is equally effective in open fields, under plastic or in glasshouses and, as water becomes an increasingly expensive commodity, the outlets for this type of economic irrigation system will increase.

Torvale International are part of the privately-owned Torvale Group of companies and are based at Pembridge, Leominster, Herefordshire HR6 9LA. Tel: (05447) 262.

Potato protection by Horstine Farmery



The Horstine Farmery microstat sprayer and (inset) the Watson-Marlow pump.

A major design feature of peristaltic pumps is the confinement of the pumped fluid inside a tube, allowing both aggressive and sterile fluids to be handled safely.

One company however, is using Watson-Marlow peristaltic pumps simply because of the electrical insulation properties of the tube.

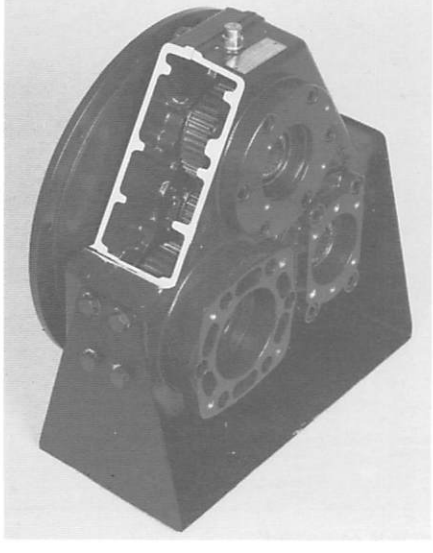
Horstine Farmery, a subsidiary of the Rhone-Poulenc chemical group, incorporates Watson-Marlow 101R twin roller pumpheads fitted with Marprene or Silicone tubing in the Microstat sprayer.

The Microstat electrostatic sprayer has been specially designed to apply fungicide treatments to fruit and vegetables, in particular potatoes, after harvesting. Spray droplets of fungicide are electrostatically charged as they are dispersed from a spinning disc and this electrostatic attraction creates a wrap-around effect to give an even cover to each potato.

A pump is needed to meter the liquid fungicide to the sprayer, but as the liquid has a negative charge, most designs of pump are impracticable because the electric charge earths via the motor. Using a peristaltic pump, the charge is automatically insulated inside the polymer tube element.

Further information may be obtained from: Watson-Marlow Ltd, Falmouth, Cornwall. Tel: 0326 73461.

Gearbox specialist Brevini has introduced a new range of pump drive gear units, for use in conjunction with hydrostatic systems. In five basic sizes, the splitter-type boxes offer the option of driving up to five hydraulic pumps, with a combined power rating of 500 HP, from a single prime mover.



Brevini's new 'pump splitters' feature unique universal outputs, which provide direct flange-mounting for virtually any pump available on the market, by means of special adaptor kits. Such versatility makes them suitable for the widest variety of applications, including skid-steer mobile plant, complex hydrostatic machinery like drill rigs, cranes, excavators, harvesters and road rollers, container handling equipment and stone crushing and screening installations, as well as for driving deck machinery on fishing boats.

Brevini UK, Planet House, Centre Park, Warrington WA1 1QX. Tel: (0925) 36682.

Hytek's new lever barrel pump is suitable for a vast array of fluids. These include diesel/gas oil, gear oils, paraffin, inks, light machine oils, neat cutting/additive oils, cutting fluids and emulsions, hydraulic oil, auto transmission fluids, light engine oils up to SAE 50 and some insecticides. The pump is self-priming, of light composition for ease of handling and is fitted with an anti-drip nozzle. Output is 0.45 litres per stroke.

Hytek (GB) Ltd, Golds Business Park, Elsenham, Bishops Stortford, Herts CM22 6JX. Tel: (0297) 815600.

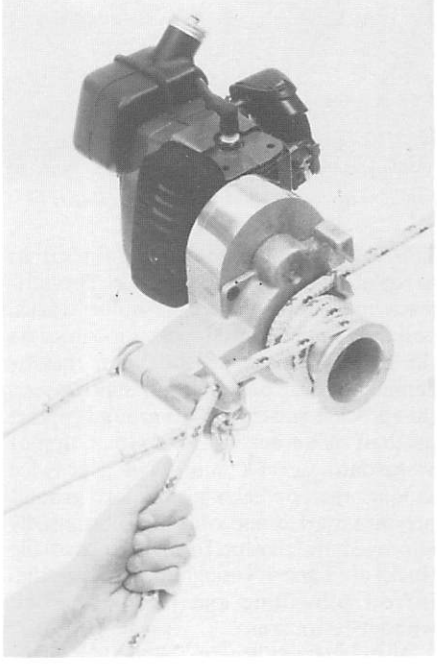
Oil spill problems solved through bioremediation

IBS Ltd (Walsall, Tel: (0922) 743585), part of the international damage management specialist Re-Tech Imbach, has adapted its environmentally friendly technique to solve land oil spill problems. Using biotechnology IBS offers a cheaper, more effective and faster method of decontaminating and disposing of oil.

Oil which has seeped into brickwork, building's foundations and the soil has, up until now, presented enormous problems. Detergents, chemicals and removal of the contaminated area to a dumping site, are all costly and often ineffective options which add to the pollution problem.

IBS uses specially selected naturally occurring dried bacteria cultures (DBCs) to simply speed up the degrading process of the oil. If left untreated oil will take many years to break down. However, IBS can turn this natural process into a matter of days and weeks. Thus the contaminated area can quickly return to its original state without leaving behind any unpleasant side effects.

Portable winch for forestry and other applications



For winching applications in such industries as forestry work where access to an external power source is limited, Ryders International of Liverpool has launched the Simpson capstan winch. This is powered by a built-in 50cc two-stroke motor.

Weighing just over 7kg, the winch has a maximum line pull of 900kg. Ordinary rope of the appropriate strength can be used and there is no limit to the length of rope.

Ryders International, Bootle, Liverpool L20 4NW. Tel: (051) 922 7585.

Suspended rubber track tractor

Many larger tractors spend over 60% of their time performing high draught cultivation work. The efficiency with which these vehicles can generate high drawbar pulls has a considerable influence on their overall performance and cost of operation. Researchers at Silsoe Research Institute have designed a rubber track ground drive system which combines the improved tractive performance and low ground pressure of a conventional crawler, with the high speed on-road capability of a wheeled tractor.

The design objectives for this system were:

- **Ability to transmit heavy draught loads;**
- **Ground contact area twice that of a standard tractor rear tyre;**
- **Suspension system to permit operation at typical wheeled tractor speeds;**
- **Track unit width to allow in-the-furrow ploughing and rowcrop work;**
- **Provision to incorporate instrumentation for experimental test purposes.**

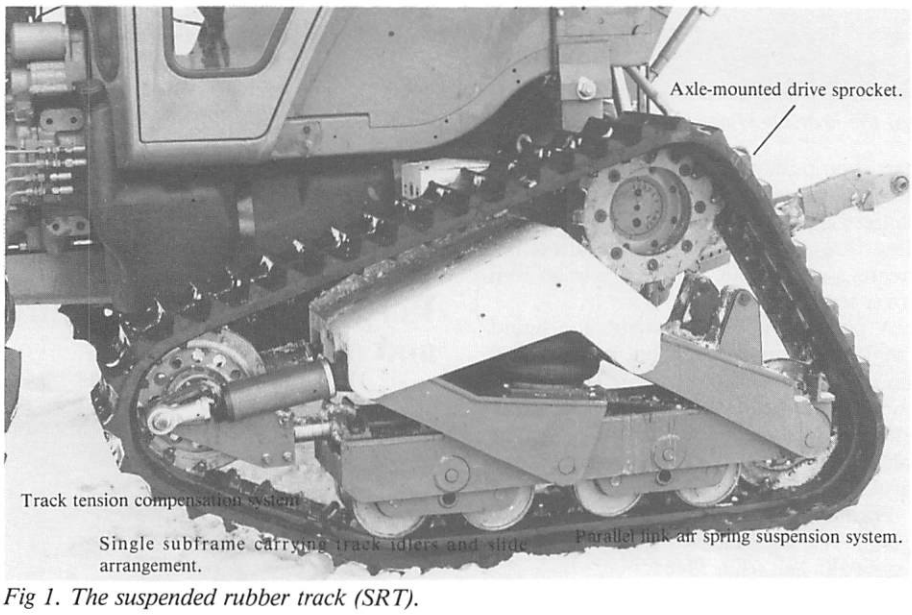


Fig 1. The suspended rubber track (SRT).

The SRT tractor uses rubber half-track units to replace the rear driving wheels. The half-track units utilise proprietary rubber tracks, positively-driven from sprockets mounted on the existing tractor axle flanges, thereby eliminating any possibility of slip between the sprocket and track. The ground contact patch of each track is no wider than that of a standard tyre (400mm), but it is twice as long, thereby halving the mean ground pressure exerted and offering substantially improved tractive performance. Also the tracks are narrow enough to permit in-the-furrow ploughing and inter-row work without restriction.

A unique feature of the design is the parallel link, air spring suspension system, which provides a comfortable ride at normal tractor operating speeds. The parallel link geometry causes the suspension system to be virtually unaffected by draught loads applied to the vehicle.

A patented track tension compensation system maintains constant track tension, despite changes in track geometry due to suspension movement. The system consists of a spring link, track idler and slide arrangement. If the suspension system compresses, changes in the geometry of the track unit cause the spring link to force the idler along its slide, thereby maintaining track tension.

Early results

Being a very new concept, few detailed comparisons have as yet been made or research results obtained. However, in a comparison between two equal-sized tractors the SRT was shown to outperform the conventional four-wheel drive tractor.

The tractive performance graphs (Fig 2) depict the respective drawbar performances of the SRT tractor and a wheeled tractor, both in a range of gear ratios. Both tractors had the same (75kW) engine power, they were ballasted to the same (optimum) axle loadings and were both operated with four-wheel drive engaged (in this particular case). The wheeled tractor was fitted with large radial tyres, deemed to be suitable for optimum tractive performance.

Both tractors showed themselves capable of generating a maximum drawbar power of approximately 53kW, but the SRT tractor could do so over a much greater range of drawbar pulls. Also, at any level of drawbar pull, the SRT tractor exhibited significantly lower levels of slip.

Practical benefits

The improved tractive performance of the system offers the potential benefit of developing a much lighter vehicle, which would exert an even lower ground pressure, whilst retaining the tractive performance of a similarly powered wheeled tractor.

The SRT can be used with existing implements; there is a high speed (24 km/hr) on-road capability and the track width permits in-the-furrow ploughing and inter-row work. The system can be retrofitted to conventional 2wd or 4wd tractors.

Research is continuing to reduce internal power losses within the track system. The Silsoe researchers estimate that performance can be improved still further, giving a 15-25% improvement in workrate, compared with a wheeled tractor of the same power.

Further information about the SRT system can be obtained from: Mike Dwyer/ Andy Scarlett, Silsoe Research Institute, Wrest Park, Silsoe, Bedford MK45 4HS. Tel: (0525) 60000. Fax: (0525) 60156.

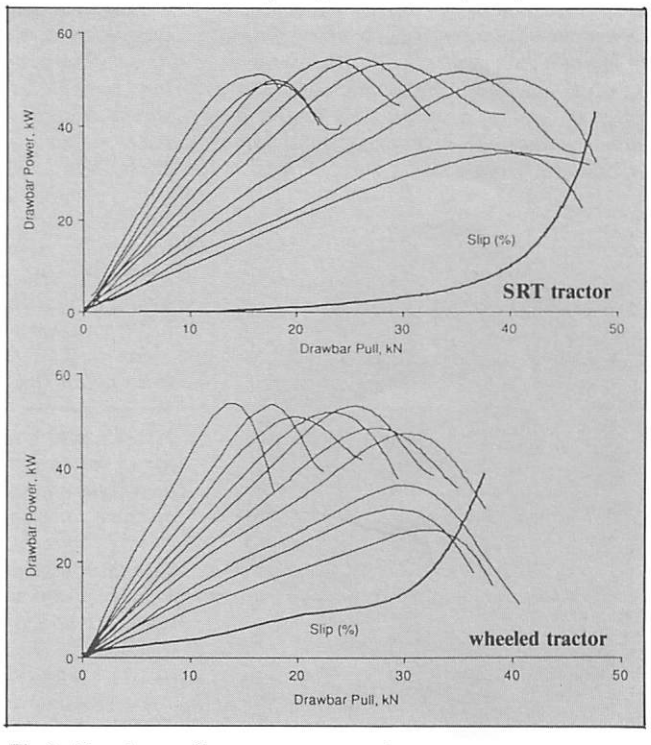


Fig 2. Tractive performance compared.

INDEX to the AGRICULTURAL ENGINEER

As announced in our last issue the index is now being prepared on a five-year basis. The index for volumes 41-45 will be circulated with the next issue, in September.

However, in response to some few requests, we have this year also prepared an annual index, for volume 45. This can be supplied (in A4 format as for previous years), on request, at a cost (postage included) of £2.50 UK destinations, £3.00 overseas destinations – cash (£ sterling) with order.

Please apply to: – I Agr E Publications, West End Road, Silsoe, Bedford MK45 4DU.

ADVERTISERS INDEX

BETTER ENVIRONMENT AWARDS FOR INDUSTRY

Entries are now being invited for the above Awards Scheme. The Scheme was set up in 1987 as the major annual competition for industry and the environment in the UK and throughout the European Community.

The Better Environmental Awards for Industry aim to raise the standard of environmental performance in the business community by rewarding good practice and promoting its adoption.

What the judges are looking for

The over-riding criterion will be: – evidence of significant environmental benefit, with the emphasis on achievement and practical implementation. The judges will also take into account: – economic viability; innovation and; resource saving, including energy efficiency.

Entries are invited from:

- any company that has initiated and developed environmental projects in the UK
- any non-industrial organisation, either with a formal link with industry or running projects on a commercial basis.

The closing date for entries is 12th September 1991

Apply to (for entry form): *The Awards Administrator, Better Environment Awards for Industry RSA, 8 John Adam Street, London WC2N 6EZ*

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THE INSTITUTION OF AGRICULTURAL ENGINEERS
FORESTRY ENGINEERING GROUP

1991 SYMPOSIUM

Newton Rigg, Cumbria
5-6 Sept 1991

5th Sept
(1.30pm - 5pm)
Developments in Farm/Forestry Engineering
Chairman: Prof. B D Witney

Presented Papers:
- Farm Woodland Hydrology
- Wheel Torque and Weight Transducer
- Machine Stability on Slopes
- Herbicide Application
- Harvesting Biomass Crops

Members: £25 + VAT
Non Members: £30 + VAT
(Lunch included)

6th Sept
(10.30pm - 4.30pm)
Timber Harvesting on Soft Ground
Chairman: Prof J Matthews

Presented Papers:
- Access
- Machine Design
- The Irish Experience
- The Future

Members: £35 + VAT
Non Members: £50 + VAT
(Lunch included)

Full Conference (including lunches): Members: £55 + VAT; Non Members: £75 + VAT
Overnight Accommodation - Bed and Breakfast (Bar available): £13.50 + VAT / night

Poster / Exhibitor Session
Posters and other exhibits are invited at a cost of £25 / 3m frontage.

Further information: Geoff Freedman,
Secretary - Forestry Engineering Specialist Group
231 Corstorphine Road
Edinburgh
EH12 7AT

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