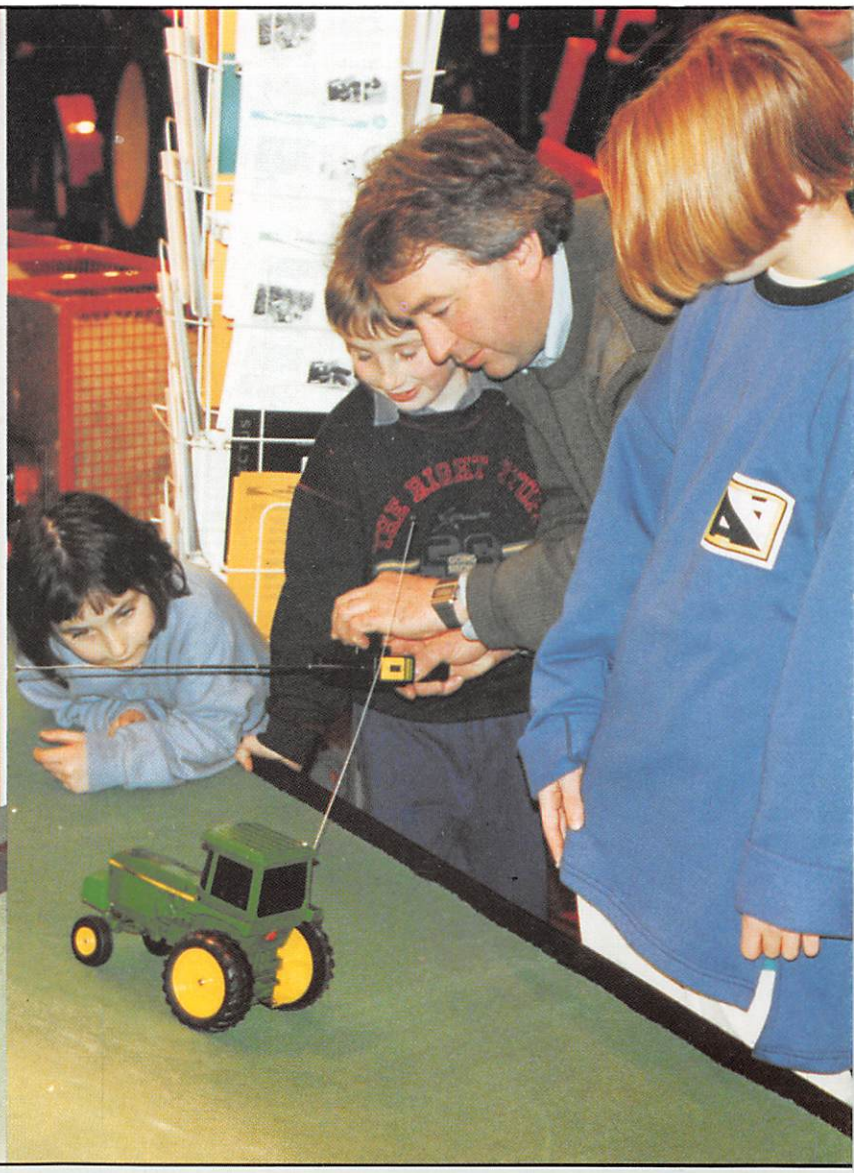
The Agricultural Engineer

Incorporating Soil and water

Volume 48 Number 1 Spring 1993



Automation and Robotics

Institution of Agricultural Engineers Forestry Engineering Specialist Group

Low cost unsurfaced roads

Nine speakers with a cumulative knowledge totalling 200 years will instruct on every aspect of constructing unsurfaced lorry roads in Britain. The speakers will come almost exclusively from the Forestry Commission therefore the emphasis will be on low cost, good value and difficult conditions.

See inside back cover for details.

The Agricultural Engineer

Journal and Proceedings

Incorporating Soil and water

Volume 48 No.1, Spring 1993

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Front cover: SAC's Scottish Centre of Agricultural Engineering drew the crowds at the Smithfield Show with a live demonstration of safe driving on slopes.

Regular Features

CONTENTS

COMMENT

Getting Value for Your Money

Denis Cartmel

In this opportunity to comment I want to remind you of the value of your Branch's AGM. Don't turn the page, however tempting it might seem, read what I've got to say then tell me if it doesn't make sense.

Your Branch AGM is your chance to influence the direction of the Institution at both local and national level. At local level you can lobby your Committee. You can put your views forward and discuss their merit. If those views are sensible and constructive they will win the support of the attended members. That, surely, is the way get improved 'value for money' from your subscription? Even better, offer your services to the Branch Committee and influence the direction of your Branch towards your personal interest area. Branch Committee membership takes very little time, really – a few hours a year and can be such good value.

At every Branch AGM will be either the President or his representative. They are there to gauge the feelings of the members at Branch level and report their findings to Council. Strong representations coming out of Branch AGM's will not go unnoticed, so make a point of going to your Branch AGM.

Shortly after the AGM your new Committee will turn its attention to next year's programme of evening meetings. Most Branches send out a reply slip asking for suggestions for meeting topics. Have your say on this – it's another good way of getting value for money.

To Branch Committees I would suggest a greater degree of co-operation with other organisations. Past experience has proven that other institutes, institutions and clubs welcome joint meetings – it furthers their cause, too. Above all, it earns our Institution recognition and respect, and that's the best value of all.

Denis Cartmel, Editor, Newsletter

ISSN 0308-5732

The Institution of Agricultural Engineers

High speed haulage vehicle sets new standards

The HSH 140, which is the product of specialist vehicle engineers SEM Engineering of Basildon, Essex, combines rough terrain capability with respectable road speeds, improving reliability significantly and enhancing ride quality.

The new vehicle is considered ideal for use in developing countries where hard working, arduous rough terrain transport is a necessity. SEM Engineering have adopted coil-spring front suspension, using a heavy duty industrial front axle and truck-style front wheels and tyres.

The engine is a 7.5 litre naturally aspirated Ford New Holland six-cylinder diesel and develops 143 bhp at 2,500 rpm. Stopping power is provided by a specially tailored air over hydraulic braking system with synchronised air-operated trailer braking.

The first of SEM Engineering's HSH 140 pre-production units is expected to leave for field trials in Africa shortly.

We offer our sincere apologies to Trevor Deakin Consultants Ltd for an error in the phone number in their advertisement in our last issue. A number of phone calls had to be redirected. The correct phone number (0225 760099) now appears in the Trevor Deakin advertisement in this issue.

New Dowdeswell plough offers greater clearances

– 1.2m point to point; 0.76m underbeam

The new Dowdeswell stretched plough has been designed specially to deal with large amounts of crop residues – turning in the straw left by the Shelborne Reynolds stripper harvester; returning set aside land to cultivation (Silsoe Link, Winter 1992).

New in Perkins 1000 Series

Perkins' latest agricultural version of the 1000 Series engine is the 1004-4T.

Rated at 74kW (99 bhp) at 2200 rev/min this four cylinder engine has a narrower front end and has been specifically designed for ease of installation into agricultural equipment, where space is at a premium.

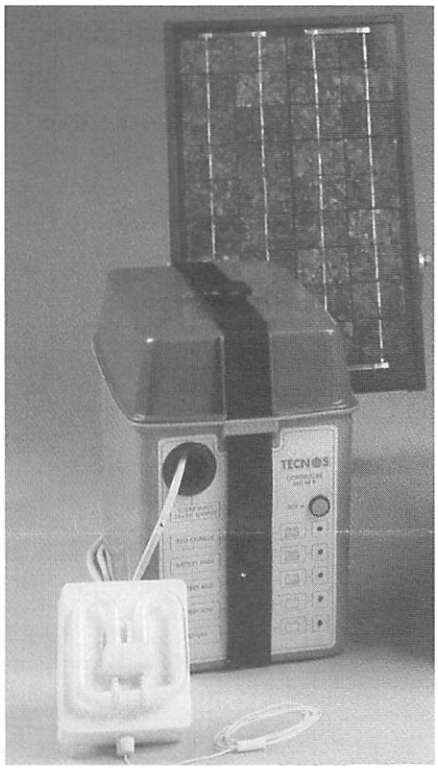
Available as four and six cylinder versions, naturally aspirated, turbocharged and charge cooled, the range incorporates stressed block units tailored to tractor operations.

The engine uses Quadram, Perkins' unique combustion system – a four lobed bowl set in the piston crown, optimising fuel and air mixing.

1000 Series, is the choice of a number of international agricultural equipment manufacturers, for example Massey Ferguson, Matbro and JCB in the UK, Claas in Germany and Manitou in France.

Perkins Engines is a business of Varity Corporation.

Solar lighting



The new, compact, solar lighting kit from Tecnos is offered for use in remote areas or as an emergency back-up system. Model SK10, illustrated, comprises a 10W solar panel and one high output LD10 light; model SK18 has an 18W solar panel and two LD10 lights. Both kits include the battery housing with integral MC60B controller, brackets, fixings, instructions, and plug-in wiring .

Prices per unit are: SK10 – £280; SK18 – £420 (reductions for quantity).

Tecnos, a division of Automatic Braiding Ltd, are at 33 King's Road, Melton Mowbray, Leics LE13 1QF. Tel: 0664 501105. Fax: 0664 501104.

Database system to help environment

Bringing a new pesticide to market can take anything from 10 to 15 years, and cost many millions of pounds. Much of this time is spent on exhaustive environmental safety tests.

A project at the Soil Survey & Land Research Centre, due to be completed in 1994, looks set to help both companies and regulatory bodies make rapid and accurate assessments of the relevance of such environmental tests to UK conditions.

Development of a national database system known as SEISMIC – or Spatial Environmental Information System for Modelling the Impact of Chemicals – is being jointly funded by MAFF, through its Pesticides Safety Division, and the British Agrochemicals Association.

SEISMIC is specifically designed for use with pesticide modelling systems, but because it enables the user to specify any relevant UK crop, soil and climate scenario, and to access the data relevant to that scenario, it has a wide range of other useful applications.

By detailing all the available expert knowledge in this way, the system will be a powerful tool for all those working towards the development of chemicals with more acceptable environmental behaviour.

Further information from: Soil Survey and Land Research Centre, Silsoe Campus, Silsoe, Bedford MK45 4DT. Tel: 0525 860428.

Hardi Sprayers pass new British Standard test

Hardi Ltd have become one of only two sprayer manufacturers to pass the primary British Standard Test applied to knapsack spraying equipment.

The new British Standard, BS 7411, is concerned with leakage, durability and performance. It involves stringent tracer dye tests at various pressures and with the sprayer in both normal, tilted and inverted modes. Tracer dye is also used to determine surface retention.

Other tests involve strainer performance, cut off reliability and durability of mechanism, tank and straps.

Hardi Ltd, Watling Close, Sketchley Meadows, Hinckley, Leics LE10 3EX. Tel: 0455 233811.

New drill designed to eliminate trash problems

The new Simba drill puts the coulters in an area between two large rollers which effectively form a bridge over the drilling bed.

Each of the coulters within the area is attached to a straight double coil tine with only minimal flexing, longitudinally.

The two rollers, fore and aft of the coulter area, follow the ground contours and ensure that if a farmer requires the seed to be at a depth of 1", regardless of trash, clod, stones, etc, the Simba drill will place the seed at 1" across the whole field.

The pressure on the rollers is variable, according to where the farmer requires consolidation, either before or after the seed.

The unit is trailed and minimum horsepower requirement is only 80HP for the 3 metre model. In turning at the headlands, the unit is tilted rearward, hydraulically, and the machine turns on the back roller only.

The Free-Flow drill will be capable of taking virtually any popular make of hopper. All the normal drill facilities such as bout marking, pre-emergence markers and tram-lining are available.

Simba International Ltd, Woodbridge Road, Sleaford, Lincs NG34 7EW. Tel: 0529 304654. Fax: 0529 413468.

NOTICE TO AUTHORS

With effect from our next issue the journal will be edited on screen. Authors are requested that, if possible, they submit their texts on disc (preferably 3½") supported by one set hard copy.

Sentinel diesel engine protection systems

Parker Hannifin's Racor Sentinel Protection Systems protect against diesel engine damage when problems such as low oil pressure, loss of coolant or high oil temperature occur.

Sentinel is an all-mechanical system, independent of electrical circuits, which works by automatically shutting the system down, or by controlling the fuel supply to reduce rpm. The all-mechanical advantage means electrical failure can never induce a failure in the Sentinel system.

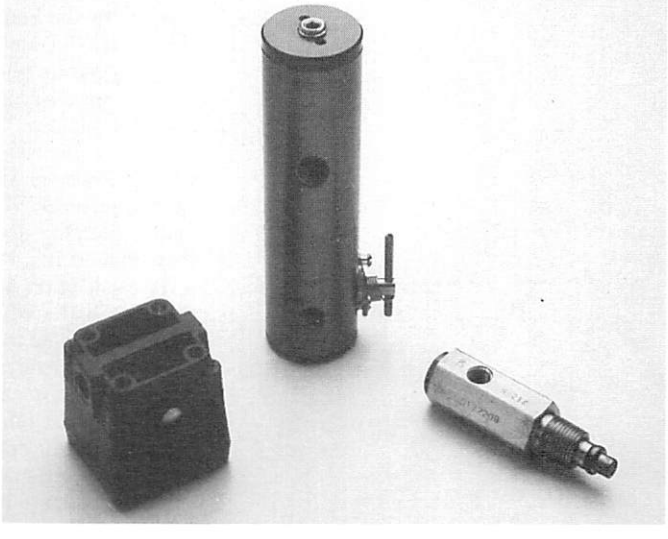
The system comprises:

Master Control – loss of oil pressure automatically causes the ball valve in the Master Control to drop, cutting fuel flow to the engine;

Heat Sentinel – when engine coolant or transmission oil temperature exceeds the Heat Sentinel setting, its seal opens and dumps oil pressure from the Master Control piston. The ball valve falls and blocks fuel flow to the engine. Heat Sentinel is factory set to activate at any temperature from 82°C to 127°C.

Coolant Loss Valve – loss of coolant flow pressure causes the valve to open and dump oil pressure from the Master Control piston, cutting fuel flow to the engine.

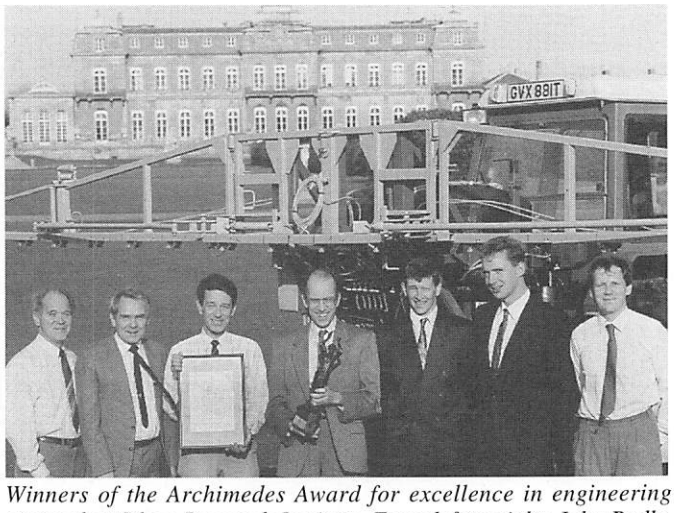
Sentinel systems include options for manual, hydraulic or electrical override.



Racor Sentinel is a product of Parker Hannifin Filtration, Peel Street, Morley, Leeds LS27 8EL. Tel: 0532 537921.

Environmental Award for Silsoe Research Institute!

AFRC Silsoe Research Institute has won a prestigious Archimedes Award for excellence in engineering. The SKF Archimedes Award for the product most likely to preserve or improve the environment was won by the Chemical Application Group at Silsoe Research Institute for a computer aided patch spraying system, part of a MAFF funded project with the AFRC Institute of Arable Crops Research.



Winners of the Archimedes Award for excellence in engineering pictured at Silsoe Research Institute. From left to right: John Bodle, Barry Ambler, Dr John Stafford, Dr Paul Miller, Andy Lane, John Power and Mark Paice.

Dr Paul Miller, Head of Chemical Applications Group, was presented with the Archimedes bronze statuette at a gala dinner in Birmingham Botanical Gardens hosted by Mr Cliff Michelmore. The award was sponsored by SKF (UK) Ltd.

Silsoe Research Institute fought off strong competition for this environmental award. A distinguished panel of judges, headed by Professor Heinz Wolff, selected the three most outstanding candidates for the award from a host of entries and the readership of the journal, Eureka – Engineering Materials and Design, was invited to cast the final vote. The awards were organised by the journal, Eureka – Engineering Materials and Design, and sponsored by Autodesk Ltd, Reed Exhibition Companies and SKF (UK) Ltd.

The key to the system's environmental success is in its selectivity. Instead of spraying the whole field, the objective is to target only those areas or 'patches' where weeds are growing. The potential benefits to the environment are considerable and herbicide costs may be halved! An illustration of the system is to be found in the article by Professor Jim O'Callaghan, Engineering Opportunities in the Environment, *Agric Eng*, **46**, 3, 80-83.

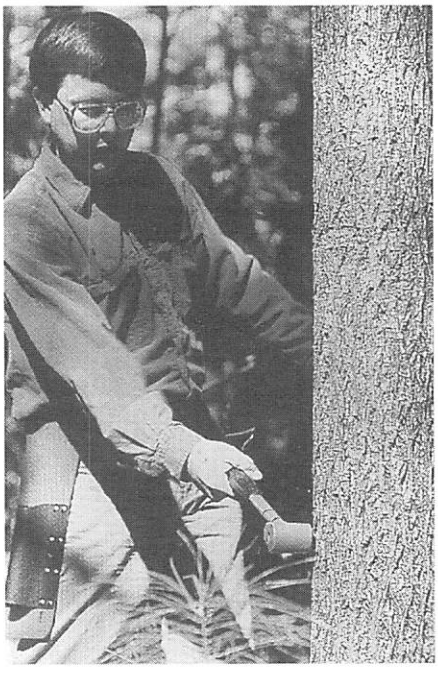
Queen's team win national farm machinery award

A team led by Dr Jim Stevens of Queen's University, Belfast has won an award for a 'Slurry Tanker Acidification System' in a national competition, sponsored by Barclays Bank, at the Royal Smithfield Show in London. The team's acidification system improves the reliability of slurry nitrogen for crop production, applies the slurry evenly at specified rates and minimises odour nuisance. It achieves this by the controlled addition of acid and the use of a bandspreader.

Two UK farms designated by Europe as national focus for health and safety in agricultural industry

CWS Agriculture's Stoughton Estate and the neighbouring Fleckney Grange family farm, owned by Edwin Bale and Son have been selected by the European Communities as a national focus on health and safety in the industry. During the next 12 months both farms will welcome farmers and visitors with a professional interest in agriculture to look at work practices and developments in health and safety.

Hammer and plug in Swedish method for tree control



Injections to eliminate unwanted trees and root sprouts in a safe and economic way have been introduced in Sweden.

Made by the Forestry Injection Company (FIC), in Eskilstuna, the system comprises simply a plastic plug containing herbicides which is injected into trees using a specially designed hammer. The steel core tip of the hammer is embedded into the selected tree with a powerful strike and the handle is twisted to break loose the wood core. The plug containing dry powered herbicides is then placed inside the opening and the reverse side of the hammer is used to rupture the side walls of the plug to force the herbicide into the trunk.

The manufacturers claim that the plug is equally well suited for the injection of nutrients whilst other possible applications include pesticide application in orchards. An outstanding advantage is that forest workers are not exposed to poisonous chemicals, nor are surrounding trees affected.

The patented system has undergone lengthy successful tests in Sweden and in the USA – in the Everglades marshes in southern Florida. The system is used by many forestry companies and organisations responsible for trees and pesticide control in Sweden.

Details supplied by Sweden's Pressombud in London. Tel: 071 498 3870.

New carrot cleaning and packing plant for Burgess

– recirculating wash water keeps demand low/avoids pollution

Consultant Bill Maunder of ADAS Cambridge has recently overseen the design and development of a new carrot washing and packing plant for Russell Burgess Ltd, Peterborough.

ADAS were called in to provide an engineering solution to the waste water disposal problem when the original plant was relocated. At the new site, close to a village, all the clean water had to come from the mains supply, so it was essential both to keep demand to a minimum, and also to ensure the discharge would meet the levels specified by the NRA.

Fresh water only used for final rinsing

ADAS advised on installation, to ensure that the treatment system met the necessary requirements and objectives. They subsequently carried out test sampling on the pilot system provided by Haith Industrial, to assess the levels of reduction in BOD (biological oxygen demand) and suspended solids.

Recirculating the initial washing water keeps overall demand as low as possible. Fresh water is used only for final rinsing, with the periodic overflow passing through the treatment system and sand filter before discharge.

After initial washing of the carrots and stone removal, the water is transferred into a settlement area, where heavy soil and leafy fractions are removed. It then passes through a clarifier, like a large funnel, which uses a flocculant to settle out the remaining solid fraction.

This sludge is removed for spreading back onto the land, while the clarified water passes to a self-cleaning gravel filter for further separation. The water then returns to the washing plant, and the cycle begins again.

The clarifier for waste water treatment to meet NRA specifications.

Silsoe Link, Winter 1992.

Safety Officer of the Year

The Safety Officer of the Year Awards programme, launched by the Royal Society for the Prevention of Accidents and Kimberly-Clark, is designed to draw attention to the unrewarded individuals responsible for health, safety and welfare at work. The awards programme is open to anyone responsible for health and safety at their place of work regardless of the size of organisation. A £1,000 travel prize including a VIP trip to the National Health and Safety Convention in Florida will be awarded to the overall winning entry.

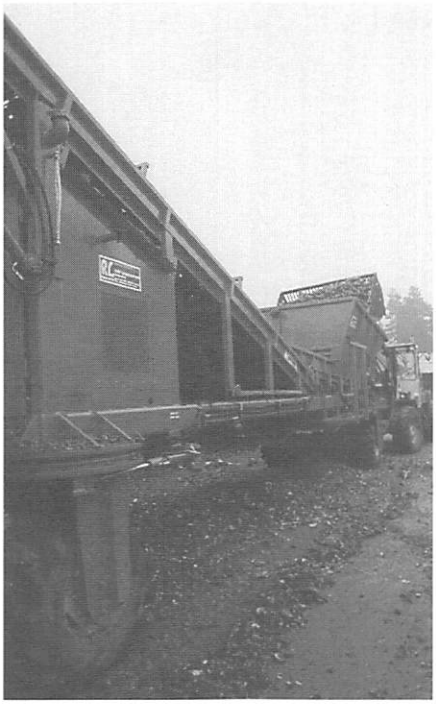
Application forms from: Awards Manager, RoSPA, Cannon House, The Priory, Queensway, Birmingham B4 6BS. Tel: 021 200 2461. Closing date 31st May, 1993.

Welding and Joining Society

The Welding Institute, the UK-based international consultancy, research, training and professional body, has launched a new technical society. The Welding and Joining Society (WJS), which opened on 1 January, 1993, has a single class of membership open to all who have an interest in welding. The new society will take over all learned society functions of the Welding Institute, including its Branches and Technical Groups. The developments recognise that there are many engaged in engineering who need contact with welding and joining technology and a source of information, but for whom a welding qualification is not important.

TWI, Abington Hall, Abington, Cambridge CB1 6AL. Tel: 0223 891162.

Beet cleaning giant moves under its own power



Time taken hitching-up, manoeuvring into a new position and un-hitching means cleaners can spend as much time being shunted around as they do cleaning beet. The new giant 300 tonnes-an-hour Larrington beet cleaner overcomes this problem with its four powered wheels, each capable of being steered through 90°.

The new cleaner has eight main controls:

- Flow control valves to the two webs,
- Front wheel steer,
- Rear wheel steer,
- Forward/reverse,
- Webs on/off,
- Elevator lift/lower,
- Fifth-wheel coupler,
- Speed control.

There are two pumps, powered by a 4.2 litre 36 Series Perkins diesel engine. The cleaner's chassis unit acts as a large self-cooling 450 litre oil tank.

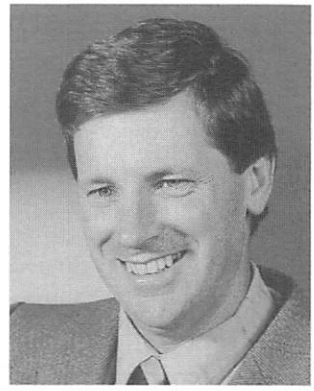
Richard Larrington Ltd, of Brothertoft, Boston, Lincs (tel. 0205 73757), now offer a range of Larrington cleaners priced from £15,000 for smaller, conventional models, to £59,000 for high-throughput self-propelled machines.

Export drive planned for award-winning agricultural invention

Twenty year old David Furber, whose innovative round bale wrapping device won a top prize in the national Toshiba Year of Invention competition nearly three years ago, was told at the recent Royal Smithfield Show that the Wiltshire manufacturers, P J Parmiter & Sons, are planning to push for sales in Europe, Japan and New Zealand in 1993. The device sells for £485 and can be purchased as an accessory to new machinery or a separate 'add-on' for existing bale wrappers.

Design and management of automatic milking systems Part III

by Toby Mottram



In the two earlier parts of his review, Toby Mottram has shown how greater automation of the milking system will relieve the herdsperson of routine chores and give more time for constructive herd management. In this final part he now shows how greater automation can also be directed to providing more detailed information on cows' health and performance and on the correct operation of the milking system.

The review concludes with a summary of the features still to be researched to achieve fully automatic milking systems.

There are two main reasons for gathering information during milking. First to ensure that the machine is operating as required and secondly to monitor animal health and productivity.

Monitoring machine functioning

Monitoring that the machine is functioning correctly is currently done only in a crude way. For example, the operator hears when a pulsator has ceased functioning and takes action to repair it. A more traditional engineering approach would be to attach sensors to all the critical elements of the system and monitor machine performance directly. However, this could be expensive and add to the complexity of the system.

An alternative is to monitor the progress of the operation in terms of the result. The response of the animal to an operation of the machine can be used as a feedback to determine whether machine conditions are correct. For example, Ordolff (1987) showed that measuring the movement of a cow's feet could be used to monitor her discomfort when touched by a simulated robot arm. Mottram *et al* (1991) devised a way of determining when liner slip was occurring so as to distinguish the cessation of milk flow due to liner slip from the true end of milking. Such methods could also be applied to determine, for example, whether milk flow from a teat had terminated prematurely, by comparing expected yield with actual yield. Other means would be needed to determine whether the failure of flow was due to the cow standing on the pipe, or a vacuum failure.

In most cases an operator would still be needed to determine the action to take and in most cases to execute it. However, it may be possible to develop back-up systems which can be deployed in the event of a failure. It will certainly be necessary to develop safety critical software procedures which will ensure that inappropriate machine conditions are not deployed and that the welfare of the animal is guaranteed.

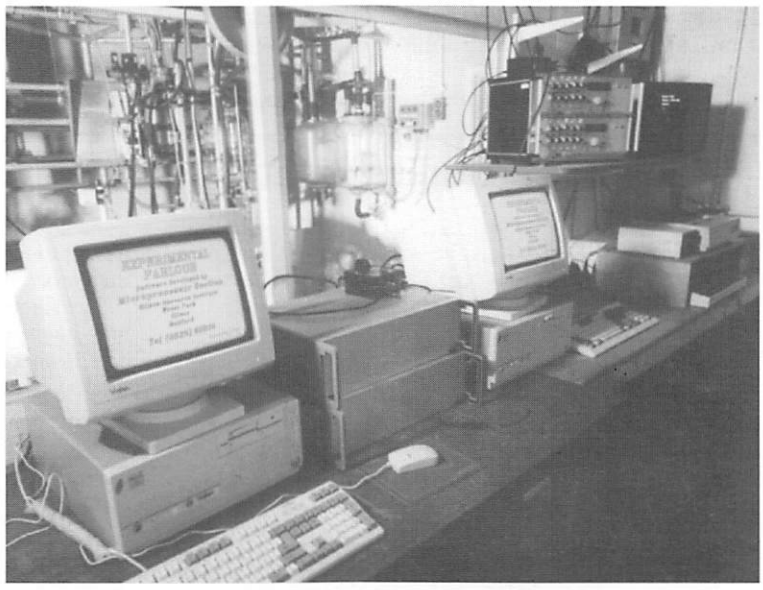


Fig 1. Silsoe Research Institute – experimental parlour and database.

Monitoring health and productivity

The other reasons for monitoring are related to the health and productivity of the cow. These can be monitored by a variety of sensors which are described later. It is first necessary to describe the physical conditions and their relative importance.

– mastitis

Mastitis is a major chronic production disease of dairy cattle, causing direct financial loss through reduced production, reduced milk price and loss through the discarding of milk contaminated with antibiotics used to treat it (Blowey, 1986). In the UK, mastitis in dairy cows has an effect on the price paid for milk, partly through its effect on quality and bacterial content, and by direct payment based on cell counts (Milk Marketing Board, 1991).

The lactating cow becomes infected through the teat duct by bacteria such as *Staphylococcus aureus, Streptococcus agalactiae,* and *Escheria coli.* The disease may remain sub-clinical but may eventually become a clinical case which has to be treated by means of antibiotic therapy. The ability to identify cases of mastitis at an early stage is a key element in any mastitis control strategy and must be an essential component of any automatic milking system.

– oestrus

The importance of oestrus detection, particularly in high yielding dairy cows, was shown by Esslemont (1974) to be a key element in profitability and it has continued as a key feature of profitable herd management (Esslemont *et al* 1985).

The behaviour of the animals is the principal indicator of the onset of oestrus. In all domesticated milking species the

T T Mottram is an Agricultural Engineer employed by Silsoe Research Institute to develop the science supporting automatic milking systems (refereed paper).

females are only fertile for a period of 12-72 hours every 20-23 days. There is only a short period during which animals exhibit behaviour indicating oestrus. The period of gathering the cows is a critical time for observing these signs. However, experimental trials of continuous visual observation have failed to exceed a detection rate of 87% of cows in oestrus (Maatje *et al* 1987). In commercial practice the level rarely exceeds 80% (Esslemont *et al* 1985) and so there has been considerable interest in developing automatic methods of heat detection (Moncaster, 1985; Maatje *et al* 1987).

Manual methods to detect the level of the hormone progesterone by means of testing milk samples with a bioassay technique have been shown to be reliable. Mechanisation of this may offer a more direct method of oestrus detection but has not yet been attempted.

– feed management

The chief variable cost of milk production is concentrate feed. Efficient management of feed in conjunction with a milk recording scheme can reduce the amount of concentrates consumed by a cow in a year by 500 kg (Webster, 1987). Monitoring milk yield is a key element in improving the efficiency of utilisation of feed.

– diagnosis of metabolic disorders

A high yielding cow needs careful management of her feed intake to maintain homeostasis. The dairy cow in early lactation is in danger of being over or underfed with key nutrients and minerals and risks developing a number of acute metabolic disorders (Webster, 1987).

Instrumentation of the milking system may allow metabolic disorders to be diagnosed, possibly by monitoring milk milk constituents or acidity. However, Paul (1987), showed that looking for small analogue changes in milk constituents with sensors so as to deduce physiological states is unlikely to be successful, a view shared by Lake (1987).

Sensing of gross changes in animal performance such as feed intake or milk output are more likely to be useful. For example, if the cow fails to consume concentrate feed offered to her it may indicate a metabolic imbalance.

Techniques for deriving information

Milk conductivity for detection of mastitis

It has been well established experimentally by Linzell & Peaker (1975) and many others that the conductivity of milk is related to subclinical mastitis. However, reliable detection of clinical and subclinical mastitis in field conditions has proved elusive.

Coliform bacterial infections in the lactating cow tend to develop very rapidly between milkings (Hillerton, 1992) and are unlikely to be detected subclinically. The other main forms of bacteria which cause mastitis, staphylococcal and streptococcal, have slightly different effects in their subclinical form.

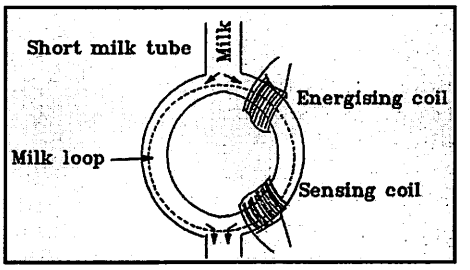
All cows release cells into milk throughout lactation. When a cow's quarter becomes infected with Staphylococci the cell count from that quarter usually rises sharply. Streptococcal infections do not cause the same rise in cell count. As an infection by either type of bacteria develops, the conductivity of the milk rises due to a change in the concentration of potassium and sodium ions.

Many infections are naturally suppressed by the cow's own defences. However, if the cow fails to suppress the infection of either main type of pathogen then clinical mastitis results. Clots visible in milk are symptoms of a clinical infection which will cause permanent loss of yield and be associated with higher cell counts. By monitoring the conductivity of the milk it is possible to detect some mastitis infections at an early stage of their development.

For any mastitis detector to be of practical value it must be a reliable indicator of infection, giving neither false positive nor false negative readings. It would preferably work on each quarter of the udder. Systems working on the mixed sample of milk from all quarters can only be used as an early warning that a cow is infected. Other methods will be needed to determine which quarter needs treatment.

– immersed electrode method may give erratic readings

A common method of measuring the conductivity of milk is to measure the voltage between two immersed electrodes, as this proportional to the resistance of the milk. The current is oscillated and the voltage rise measured. This method has the disadvantage that when used in the milk line the fats in milk and gases precipitating from milk under vacuum are deposited on the electrodes, causing fouling which cannot easily be removed by circulation cleaning. The fouling reduces the efficiency of the device and erratic readings may result (Onyango *et al* 1988). To prevent this the electrodes can be made of inert material such as platinum black and placed where precipitation is minimised, as far from the cow as possible, for example, in the milk meter (Carmi, 1987).



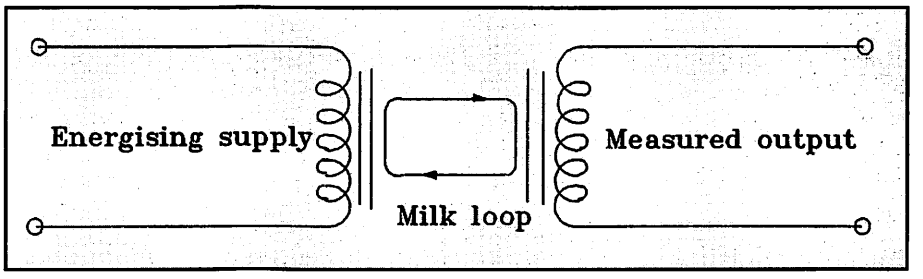


Fig 2. Conductivity sensor: right, general layout; below, circuit diagram.

Lake *et al* (1992) developed a device in which an electric current is induced in a toroid of milk. The current induced in the second coil is measured to determine the conductivity of the milk loop. This device overcomes the problem of fouling and by normalising the signals reliably detected infections by *Str. uberis* and *Staphylococcus aureus*. The principle is depicted in Fig 2.

– variations between quarters

The conductivity of milk varies between cows, between quarters of the same cow and between milkings of the same cow. In all quarters whether infected or not, conductivity is highest in foremilk, and higher in strip milk than from the main flow of milk. To compensate for these variations some researchers have suggested that a mastitis detector should compare the conductivity between quarters. However, although

a quarter infected with streptococci shows a dramatic rise in conductivity, Hillerton & Walton (1991) showed that the conductivity of the milk from the other quarters also rises, although not as much.

A more reliable method is to compare the conductivity from each quarter with the rolling average for each quarter. This comparison method was successful at detecting streptococcus infections before they became clinical (Lake *et al* 1992).

– further research needed to establish conductivity data as reliable indicator

All practical systems require the storage and processing of large amounts of data and must be linked to a cow management database.

Research is needed on how conductivity sensors can be used to minimise the number of clinical infections in the herd and thereby reduce cell counts. There is as yet insufficient evidence to predict reliably from conductivity data which quarters will develop clinical infections and which will recover without treatment.

Lake *et al* (1992) tested the conductivity sensor on teats challenged by streptococci, as these are more likely to lead to a clinical case. However, trials with staphylococci are less conclusive since these sometimes do not lead to clinical cases.

Since most of the direct financial loss caused by mastitis is the cost of discarded milk, antibiotic treatment should only be used where the natural immunity of the animal fails to cure the infection.

Any computerised decision making system will have to assess the likely progress of an infection, the cost of cure at any stage in the infection and the possible permanent loss of yield if the sub-clinical infection becomes clinical.

Further research is needed to understand how to convert conductivity data into a reliable indicator of the development of mastitis.

Table 1. Oestrus detection rates obtained when observations are based on twice daily measurements of milk temperature.

Author	*Number of animals*	*Number of oestrus periods*	*Oestrus detection rate, %*	*Percentage of false positives*
Ball *et al*	10	19	86	3
Maatje and Rossing	14	19	84	–
Fordham *et al*	15	30	73	11
Schlunsen *et al*	59	–	42	74
	31	–	35	–
McArthur *et al*	18	34	50	81

The herdsperson will still have the ultimate decision because the robot will be unable to infuse antibiotic tubes into the teat duct.

Milk temperature for detection of oestrus

Numerous researchers have shown that there is a rise in milk temperature during oestrus (Maatje and Rossing, 1976; Ball *et al* 1978). However, attempts to develop this into a reliable method of detecting oestrus have proved fruitless due to the high number of false positive readings (Fordham *et al* 1988, McArthur *et al* 1992).

The temperature difference between milk from cows on heat and those not on heat was taken to be 0.1°C (Ball *et al* 1978), 0.2°C (Fordham *et al* 1988) and 0.3°C (McArthur *et al* 1992), this is a relatively small change in temperature to detect with confidence.

McArthur *et al* (1992) present a table (Table 1) of results combining the best reported experiments which shows false positives ranging 3–80% and concludes that 'The twice daily measurement of milk temperature is not a reliable method of detecting oestrus in dairy cattle'.

– other data needed to interpret meaning of temperature change

The problems associated with using milk temperature as an indicator of oestrus are the same for all simple sensors. The temperature sensor will reliably detect a change, but determining the cause of the change is more complex. A change in temperature may indicate illness such as an infection (McArthur *et al* 1992). To determine whether a rise in temperature indicates oestrus or clinical mastitis other data such as conductivity and yield need to be combined to improve the probability of a correct deduction (Schlunsen *et al* 1987).

Yield – an aid to management, oestrus detection and system control

The obvious method of determining the performance of the dairy cow is to measure the daily yield of milk. With the development of cheap electronics, and particularly of milk meters, reliable automatic monitoring of milk yields has become possible.

The principle reason for monitoring milk yield is to manage the feeding regime, however, milk yield can also be used as an aid to oestrus detection (Carmi, 1987) and to determine whether an automatic milking system is operating correctly.

Daily milk yield varies through lactation rising to a peak in the first 12 weeks after parturition and declining thereafter. Wood (1967) demonstrated that the lactation curve could be modelled algebraically and non-parametric methods have been developed subsequently (Rowlands *et al* 1982; Goodall and Spravek, 1985; Elston *et al* 1989). These curves can be used to predict accurately the expected performance of groups of cows although they are less useful on an individual basis, given the large number of factors which can cause a cow to deviate from a normal lactation.

– Look for change from a rolling mean or in normalised yield

The simplest method of using milk yield as an aid to management is to detect a change in yield from a rolling mean. Herd management programs have used this technique for many years. Cows whose milk yield drops more than a given percentage since the last recording are brought to the attention of the herdsperson. The percentage drop required to identify the cow is usually set by the herd manager.

From parturition to peak, milk yield should be rising; after peak lactation a fall of 1.5-2% per week should be expected (Webster, 1987).

Carmi (1987) reported that the time since last milking had a large effect on the milk yield and so normalised yield against time to determine a change. Change in normalised yield was said to aid in the detection of oestrus and also in metabolic disorders.

Whilst the work of Carmi (1987) is very interesting, it is largely anecdotal and some points need clarification and further research before milk yield can be confidently used for controlling automatic milking.

Elliott *et al* (1960) monitored variations in the rate of milk secretion between milk intervals of 2-24 hours. They found a curvilinear response with secretion diminishing as the milking interval increased. This work needs to be replicated under modern feeding conditions as the amounts of milk being recorded, at about 13 l/day, were less than half those currently expected. However, the longer the time since last milking the lower should be the normalised yield. It must also be determined how much variation of normalised secretion rate there is between and within cows.

– yield as an indicator of udder health

Further potentially valuable research in this area is to assess the value of using yields of milk from the quarter of each cow as an indicator of udder health. In the Silsoe Research Institute prototype, milk from each quarter is taken to a separate recorder jar, allowing teat cup removal and yield recording on an individual quarter basis. Daily variations in yield between quarters are not known but it is possible that the fall in yield associated with infections of mastitis for example, might be detected by monitoring the normalised secretion rate.

Flow rate as a research tool and for machine control

The flow rate during machine milking of cows has been studied intensively as a research tool to study milking machines but it can also be used to monitor milking.

Butler (1987) reviewed the use of flow rate monitoring for milking machine research, the requirements were that the instantaneous flow of milk from the teat end could be determined throughout the pulsation cycle. This would allow the development of a mathematical model of the action of the teat cup and liner so as to allow generic experiments to be conducted. The lack of such a model has meant that single experiments on vacuum levels, pulsation features, liner shape, etc, have only limited validity.

However, the implication of Grindal and Hillerton (1991) is that further development of the milking machine cannot be justified unless it can be shown that there is preventable damage being inflicted on the animal by the application of the recommended machine conditions. It has also been shown that the application of simple control measures has reduced the incidence of both contagious and environmental mastitis to levels which show that milking machine research has achieved many of its objectives (Hillerton, 1992).

Monitoring the milk flow for control purposes is less complicated and is already carried out in a simple fashion for automatic cluster removal (ACR). Monitoring of milk flow is an essential part of determining the time at which to remove teat cups. Mottram *et al* (1991) showed that change in rate of flow could also be used to deduce when liner slip occurred as part of an improved ACR system.

There are potential benefits from using milk flow as an aid to automatically detect machine faults and monitor animal health and it is surprising how little it has been researched. Incorrect vacuum or pulsation characteristics could be detected if milk flow differed from that expected from the animal. For example, if vacuum is low, milk flow would be less than expected. Animal stress at milking time might be detected by extended or variable let down periods.

The chief advantage of recording milk flow is that it is already available as part of the recording of milk yield. However, whereas the yield of milk in litres from a cow can be stored as two bytes the flow curve needs a number of points to represent it. The problem is twofold, first how can a large amount of data be represented and secondly how much variation is there in the day to day milk flow rate?

– flow rate not constant – need to standardise measurement

Milk flow is determined by several factors, the milk ejection reflex, the diameter of the teat duct, the yield of the animal and the machine conditions (Dodd and Griffin, 1979).

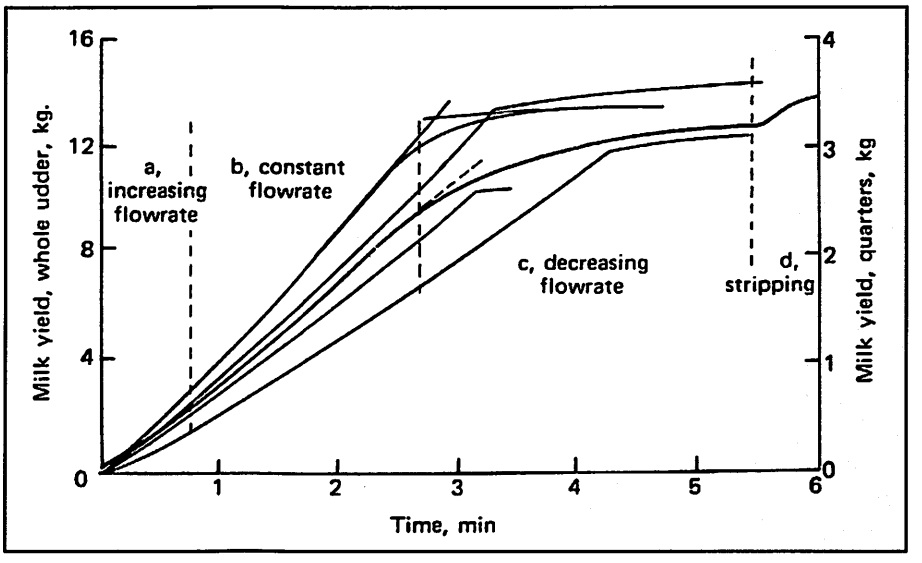


Fig 3. Typical curves of cumulative milk yield plotted against time for a whole udder at a milking, and for the separate quarters plotted on a four times more open scale. Note the long period of declining flowrate of the whole udder curve, and the sudden change from peak flowrate to low flowrate for three of the separate quarter curves (Thiel and Mein, 1979).

However, milk flow is not constant during milking (Thiel and Mein, 1979) and it is important to standardise the measurement of milk flow if it is to be used reliably.

Thiel and Mein (1979) showed (Fig 3) that flow pattern from the udder of a cow during milking can be divided into three main periods. At the start of milking, flow starts to rise as the milk ejection reflex is stimulated, there then follows a period of high flow rate followed by a period of declining flow rate.

Measurements of milk flow rate were made by Dodd (1953) to determine differences between cows and during lactation. He found that peak flow declined from the sixth week of lactation. He was unable to determine flow rate precisely due to the limitations of the experimental equipment of the time. He took readings only at morning milkings at 21-day intervals. However, this classic experiment appears to have established the main parameters of milk flow rate until it became possible with electronic techniques to investigate flow profile in more detail.

Thiel and Mein (1979) showed that as the flow of milk from each teat came to an end there is a step reduction in the flow of milk. Butler *et al* (1990) reporting on instrumentation to determine the quarter flow rates of cows show clearly a wide variation between the flow profile of quarters within cows. Each teat appears to have its own peak flow rate and a period

of reduced flow time.

Mottram *et al* (1992), defined the flow curve by means of the let down time, the peak flow rate and the stripping time.

The peak flow rate was defined as the rate at which the first 75% of milk was extracted and the stripping time as the time to extract the remaining 25%. Mottram *et al* (1992) showed that this was a robust and repeatable method of characterising milk flow from the dairy goat by recording a morning and evening milking weekly for 29 weeks of the lactation of four goats. The mean let down time was 12s with a standard deviation of 0.5s. Peak flow rate was found to be strongly correlated to time since parturition and milk yield whereas stripping time was highly variable.

This work needs to be repeated for dairy cows preferably on a per teat basis to develop a predictive tool for the let down time and the peak flow rate for individual animals. The usefulness of monitoring quarter flow rates could be assessed by experimental treatments such as changes in vacuum level and disturbances of the cow milk ejection reflex.

Activity and pulse rate – possible indicators of oestrus

Several researchers have examined the possibility of attaching sensors to the animal to monitor number of steps taken, pulse rate, deep body temperature, intra-vaginal conductivity, odours and pH (Lake, 1987). Lake (1987) concluded that attaching sensors to animals, other than for monitoring activity, was likely to prove impractical under farm conditions and that monitoring and analysing a number of variables from an animal through the milking system offered the greatest potential.

Schlunsen *et al* (1987) showed that the most successful of sensors attached to cows were for activity and pulse rate. Pulse rate monitoring has been conducted experimentally by O'Neill (1989) to determine the energy utilisation of draught animals but such techniques are unlikely to be useful commercially.

Kiddy (1977) and Thompson and Rodrian (1983) showed that the increased activity of cows during oestrus could be recorded by a pedometer attached to the cow's leg. Systems are available (Carmi, 1987; Dairy Equipment Company, 1991) in which a pedometer records the total number of leg movements made and transmits the data by radio to a loop aerial mounted at the entrance of the milking parlour. The number of movements are then compared with a mean.

These systems have yet to be shown to increase oestrus detection in field conditions (Lake, 1987) but there is a body of research evidence which suggests that they should give positive identification of 72% of oestrus, although false positive rates are high (Maatje *et al* 1987). Schlunsen *et al* (1987) were unable to achieve their target of 90% detection with a less than 10% error rate by combining activity and pulse rate.

The remote monitoring of activity may be feasible in automatic milking systems. As the animals pass from one area of a building to another their identity can be established and the individual level of activity compared with a reference. This would be information gathered with sensors deployed for other purposes and so requires no additional hardware.

Research is needed to determine whether the increased level of activity of cows in oestrus is reflected in an increased movement to and from feeding and milking areas.

It would appear that attaching sensors to animals has only limited benefits in the area of monitoring activity and is unlikely to form an essential part of an automatic milking system. Telemetry for the derivation of physiological information from cows is only likely to be of benefit in research.

Management Information System – not just Database

The amount of data that needs to be processed for the efficient management of dairy cows made it an early target for the application of personal computers. The principle use of the computer has been limited to the storage and retrieval of cow records, replacing cards and record books. Many software packages are available to aid the herd manager record cow data and to formulate rations, etc. Most computer management systems offer lists of cows, or action lists, for example, on the basis of abnormal changes in milk yield or date since last recorded oestrus. This reflects the behaviour of a stockperson who identifies animals with problems by looking for a divergence from normal behaviour or condition. 'Management by exception' accurately describes such a process.

Any cow management system will need regular contact with the skills of the herdsperson. Many existing computer systems are underused because the person for whom they are designed does not use them. It is a major challenge for software designers to produce a user interface which an expert in cows will use to both input information and extract it.

This review has concentrated on the potential for monitoring the performance of machinery and animals at milking. Conventional database systems have been chiefly aimed at improving the efficiency of feed utilisation, an activity that can be largely independent of the milking parlour.

There appears to be enormous potential for using modern database techniques (Doluschitz, 1990) to aid dairy herd management. The computing tools exist as do the instrumentation methods, what is needed is the integration of the techniques reviewed into a reliable system.

Summary

Dairy management has made dramatic progress in reducing the labour input at milking by improving the operation of manual tasks. Further progress can only be made by removing the need for a milker. This will allow animals to be milked more frequently at times suited to animal physiology thereby increasing milk yields and improving animal welfare.

- Getting animals to the milking system has formerly been an entirely manual operation. Methods are being developed which will ensure regular milking of housed cows. The main discipline in the development of techniques for regular presentation of dairy cows is ethology with some engineering support. The same techniques will be needed to ensure that animals leave the milking area.
- The gathering of grazing cattle will require human intervention for the foreseeable future. Development is required of automatic systems to milk groups of cattle gathered manually.
- High capacity manual milking systems have been developed by reducing the work routine time per animal. An unfortunate side effect of reducing the time spent on each animal has been to make the task of milking less attractive for staff.
- Cows can be positioned for milking by active or passive features of the milking stall. Passive features are preferable. A better understanding of the dynamics of animal physiology is required so that animal compliance and comfort can be optimised.
- Teat inspection has been an essential element of milking and automatic methods are required not only to determine cleanliness but also to detect damaged teats. Cleaning of all teats should be avoided. Automation of the inspection and cleaning of teats is a priority area of research for automatic milking.

- Research has shown that automatic teat cup attachment can be achieved and developments of systems are in progress. The essential elements are a robot arm with a database of teat co-ordinates, a global or coarse sensor and a local or fine position sensing system. Developing reliable teat cup attachment in field conditions remains an essential research objective.
- The milking system to extract milk from the cow needs no further research specifically aimed at automatic milking. Monitoring of the flow of milk may allow close control of the milking parameters to reduce residual milk in the udder. It can also be used to detect liner slip and is routinely used as a guide to signal the end of milking. Flow characteristics are consistent throughout lactation in goats and possibly in cows and thus change in flow characteristics can be used as an indicator of failure in the milking system. Further development is needed to allow the use of the flow signal as a feedback to monitor and control the milking system.
- A major task of the milker is the inspection of animals for signs of oestrus and to diagnose mastitis and other ailments. Research has been carried out over a number of years on a variety of sensors the most popular being pedometers, and temperature and conductivity of milk. No single sensor will give a reliable indicator of mastitis or oestrus.
- Twice daily sampling of the temperature of milk has been shown to be almost useless as an indicator of oestrus due to the very small changes in signal being masked by changes in ambient temperature. Temperature of milk can indicate infections and so might have a role in health monitoring but further research is needed.
- Conductivity sensors have been shown to detect some forms of mastitis infections at an early stage and should be deployed to sample milk from each teat. A large amount of data analysis and management is required to use conductivity as a tool in detecting mastitis. Further work is required to improve the understanding of the progress of both streptococcal and staphylococcal infections and their effects on conductivity. The benefits of more frequent sampling need to be evaluated. A reliable method of detecting coliform infections is a priority for the development of a comprehensive mastitis detection system.
- A sudden change in yield from a cow can be combined with information from pedometers and conductivity transducers to assist in the diagnosis of mastitis or identification of oestrus.

Many of the principal elements of a fully automated milking system have been developed. New work must be undertaken in animal behaviour and management, in developing teat preparation systems and in integrating existing knowledge into computer programs. These programs will then be able to control automated milking systems which will allow the skills of the herdsperson to be deployed during socially acceptable hours.

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ASAE publications

The American Society of Agricultural Engineers has published the proceedings of a conference in Chicago, December 1991, 'Automated Agriculture for the 21st Century'. This covers sensors and control technologies for agricultural systems, engineering for site-specific farming and engineering for plant culture systems. Examples of items covered are: a soil/water sensing system for automated irrigation; ultrasonic signal classification for beef quality grading through neural networks; robotic plant handling; continuous wheat yield measurements on a combine; sensing and mapping grain yield variations and microprocessor controlled technology to selectively spot-spray weeds. Price $44 + $3.50 p&p.

From: ASAE, 2950 Niles Road, St Joseph, MI 49085–9659, USA.

Also published are the proceedings of the 4th international conference, 'Computers in Agricultural Extension Programs'. This gives information on the use of computers in all agricultural disciplines. $53 + $3.50 p&p.

Risk: Analysis, Perception and Management

The Royal Society has published a report from a group of scientists, engineers and social scientists in order to open up discussion on risk. The report has sections on Estimating Engineering Risk, Toxicity, Toxicology and Nutrition, Estimation of Risk from Observation of Man, Risk Perception and Risk Management. The costs and benefits of risk reduction are also covered. Price £15.50.

From: The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG.

Engineering Council news

A 200-page book 'The Ivanhoe Guide to the Engineering Profession 1993' has been produced. The guide covers details of the engineering professions, their career opportunities and major employers and also information on the work of the Engineering Council and the 42 engineering institutions. It will be of use to engineering students, engineers and the general reader. Price £9.95.

From: The Engineering Council, 10 Maltravers Street, London WC2R 3ER.

Health and Safety

The new workplace (Health, Safety and Welfare) Regulations 1992 came into force on 1 January 1993. These replace large parts of existing regulations. They apply to almost all workplaces except construction sites and mineral extraction sites. New workplaces and modifications, extensions and conversions begun on or after 1 January must comply right away. Existing workplaces have until 1 January 1996 to comply. Five other sets of regulations also came into operation on 1 January: 'Management of Health and Safety', 'Provision and use of Work Equipment', 'Personal Protective Equipment', 'Manual Handling Operations' and 'Display Screen Equipment'.

From: HMSO or booksellers: Workplace Health, Safety and Welfare – approved Code of Practice, £5; The Workplace (Health, Safety and Welfare) Regulations, SI 1991 No. 3004, £3.10.

Agriculture in Eastern Europe

A market survey on Food and Farming in Eastern Europe by Hilary F. Marks. This 210-page report covers Bulgaria, Czechoslovakia, the former German Democratic Republic, Hungary, Poland and Romania. Their agricultural economies are examined and information and statistics are provided for decision and policy making. Of interest to agricultural economists, government departments, bankers, accountants, agricultural organisations and companies in the agri-business. Price £325.

Also from the same author is Food and Farming in the fifteen republics of the former USSR. Also priced £325.

From: Woodhead Publishing Ltd, Abington Hall, Abington, Cambridge CB1 6AH.

MAFF Census Digest

A new publication brings together the main results of the annual agricultural and horticultural censuses in England, Wales, Scotland and Northern Ireland. It presents both regional and county data for key items from the 1991 Census and there are maps illustrating a selection of these.

From: HMSO, 'The Digest of Agricultural Census Statistics UK 1991'. Price £15.

FRBC updates

The Farm and Rural Development Centre has published two new updates:–

Planning Sheep Handling, £5.50 + £1 p&p
Planning Sheep Housing, £4.50 + £1 p&p.

From: Eain Martyn, FRBC, National Agricultural Centre, Stoneleigh, Warks CV8 2LG.

European business directory

If you do business in Europe, or intend to, this Dun and Bradstreet Europa 1993 directory may help you. The first three volumes give leading businesses for all the European markets, volume 4 provides the opportunity to identify the leaders in key business sectors and to select businesses according to their activity. Typical applications are searching for new customers or suppliers, identifying competitors, seeking credit rating facts and locating agents or acquisition prospects. Price £425.

From: Nigel Dickinson, Dun and Bradstreet Ltd, Holmers Farm Way, High Wycombe, Bucks HP12 3BR.

AFRC Annual Report 1991-1992

The theme of this report is 'A basis for sustainability'. It highlights research aimed at: ". . . developing a systems approach to farming and the environment, meeting dietary and other consumer needs and using agricultural resources more efficiently".

Information on the report from: Dr W A Winstanley, PR Branch, AFRC Central Office, Polaris House, North Star Avenue, Swindon SN2 1UH. Tel: 0793 413200.

Waste, recycling and environmental directory 1993

This directory covers all areas of waste collection, disposal and environmental management. It gives suppliers of products, services, equipment and facilities in the waste industry.

From: The publishing arm of the Institution of Civil Engineers, Thomas Telford Directories, 1 Heron Quay, London E14 4JD. Price £40.

Total quality management

A BS 5750 directory is available from Wordsworth Publicity Services. It lists companies conforming to BS 5750 standard. It provides a reference guide for purchase managers wishing to locate suppliers in given fields in the UK and abroad.

From: Details from the BS 5750 Directory, Aerodene House, 41-53 Perth Road, Grants Hill, Essex IG2 6BP.

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Slurry treatment strategies in France

Problems of waste management from intensive animal farming in the Brittany region of France are stimulating research into the farmscale treatment of slurry. Emphasis is on nitrogen removal to minimise subsequent water pollution risks from nitrates.

A major project involving several partners is currently being led by CEMAGREF. The objectives include the systematic study of the various treatment options available. Colin Burton reports:

Despite its large area, France is not exempt from the problems of waste management resulting from intensive animal farming. A high proportion of animal production, including more than half of the national pig production, has become centred on the Brittany region.

Risk of water contamination

The relatively low activity in arable farming in that area means that there is a surplus of nutrient material (mostly in the form of slurry) over requirements, resulting in pollution risks. Such risks relate mostly to water contamination, in particular from nitrates. This problem is accentuated by the high local rainfall and the hilly nature of the area which limits the options for safe disposal of the waste.

Several farmscale treatment schemes

The treatment option figures amongst the large amount of research activity taking place in the Brittany area to improve animal waste management.

Several prototype farmscale schemes are currently under evaluation in the region with considerable commercial interest being shown by farmers co-operatives and manufacturers.

The main purpose of such plants is the reduction of the pollution potential of slurries prior to land disposal, ie. to reduce the nitrogen content and COD (chemical oxygen demand) value.

The former is achieved by the process of nitrification-denitrification, in which up to 70% of the nitrogen content can be removed from the slurry, mostly as di-nitrogen gas. This is achieved by a cycle of aerobic and anoxic treatment regimes.

Removal of the soluble fraction of the COD is achieved by aerobic treatment; separation techniques before or after an aerobic treatment can remove the remainder as a solid concentrate. Such material can be disposed of in specially identified farm sites. A more constructive alternative being explored is to use it as part of a composting recipe to produce a saleable product.

The CEMAGREF project

One of the major research projects on slurry treatments currently in progress is being led by the French agricultural research organisation, CEMAGREF.

Centred on a farmscale treatment plant (Fig. 1) set up an agricultural college at Caulnes near Rennes, this is a joint exercise involving local and national government, farming co-operatives and private industry amongst its partners.

The input has been further broadened by collaboration with other research organisations such as Silsoe Research Institute. The approach of the work has been to study each treatment stage as a unit operation as far as possible. Four stages have been defined:

- separation,
- aerobic/anoxic treatment,
- sedimentation,
- composting.

Research is presently concentrating on the aeration step (Fig 2) which is central to most process options. This operation is also important as it tackles the nitrogen problem which represents the main pollution concern.

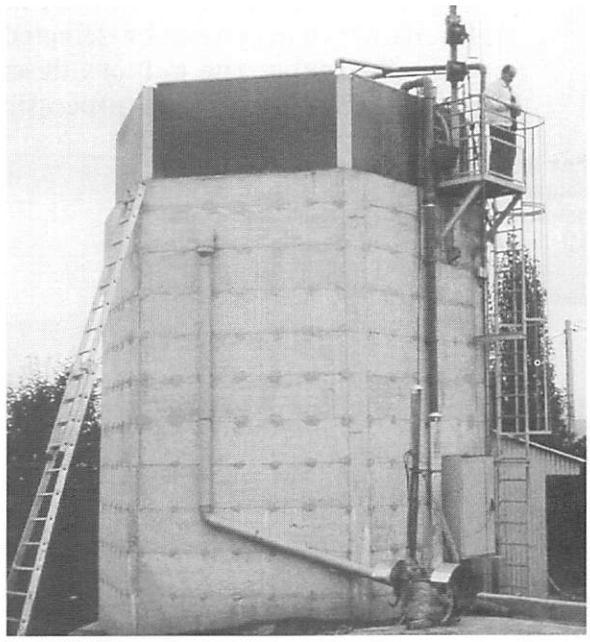

Fig 2. The aerobic/anoxic reactor.

The operating cycle consists of sequential aerobic and anoxic periods, each typically of one hour duration. The target throughput is six tonnes of slurry per day.

During the aerobic phase 600m³/h of air is bubbled through the slurry by 88 diffusers arranged evenly on a square grid at the bottom of the reactor. These are fitted with flexible membranes which protect the air ductwork from the ingress of slurry during the anoxic phase.

Studies are focussing on the effectiveness of the treatment in removing nitrogen and COD from the slurry and the extent of any air pollution from the effluent gases produced such as ammonia and nitrous oxide.

Further information on slurry treatment research can be obtained from Colin Burton, Silsoe Research Institute, Wrest Park, Silsoe, Bedford MK45 4HS or Marcel Bertrand, CEMAGREF, 17, avenue de Cucillé, 35044 Rennes, cedex France.

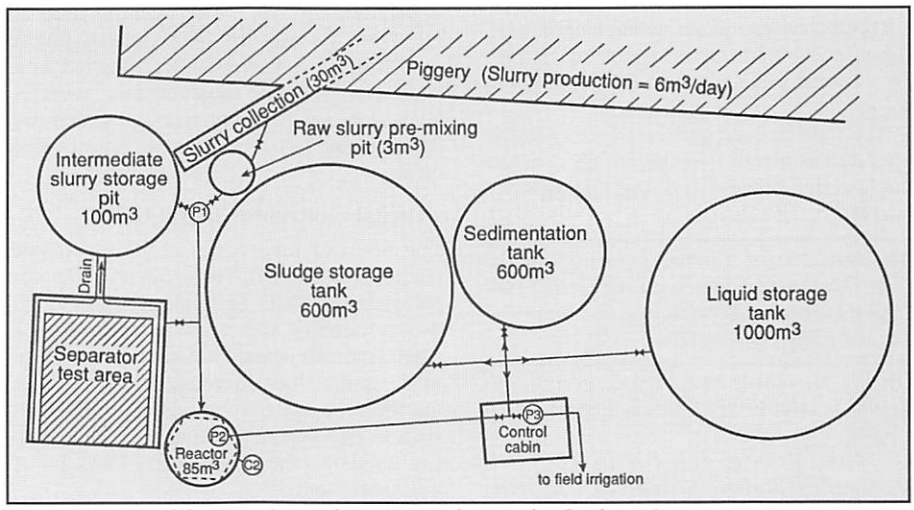

Fig 1. Layout of the experimental treatment plant at the Caulnes site.

Digital Electronic Hitch Control for Tractors

Horst Hesse and Gordon Withington

Electronically controlled hydraulic systems are on the increase. This opens up completely new possibilities for the tractor hitch control too. The function can be improved, operation facilitated and the application range considerably extended. Faults which occur can be detected and eliminated more rapidly.

In this paper the authors describe the latest stage in the EHR-D hitch control system with digital signal processing, developed and produced by Bosch.

For decades, the tractor hitch has been controlled in accordance with draft and position. Currently the mechanical/hydraulic MHR systems predominate. However, due to the many advantages offered by electrohydraulic controls, these have been on the increase for about 10 years.

Components of the Digital Hitch Control System

Fig 1 shows a tractor, equipped with all the components used today. The functions performed by these components are:

- Draft and position control;
- External control;
- Front and rear change over;
- Pressure control;
- Slip control;
- Vibration damping;
- Diagnosis.

– Proportional Control Valve

The main part of the electronic hitch control is the control valve, which is simultaneously the actuator and the electro-hydraulic converter. It is the load-compensated proportional valve which has established itself today. The valve for OC systems has three axes.

The first axis is a pressure balance for neutral circulation and load compensation (current control) after lifting as well as generating control pressure for lowering.

The second axis is the actual control axis, the spool of which is operated by two proportional solenoids directly against return springs.

The third axis comprises a hydraulically-operated non-return valve which controls the lowering process in a load compensated manner.

Abridged text of a paper presented at the joint IMechE/IAgrE/Silsoe Link Conference 'Fluid Power in Agricultural Machinery' – Silsoe College, 4 November, 1992.

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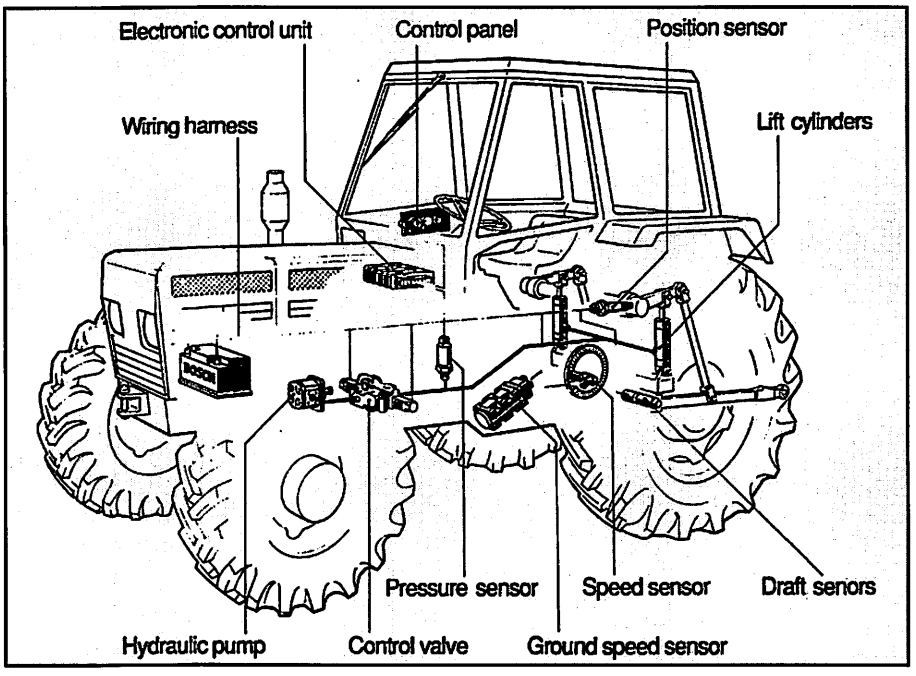


Fig 1. Components of the Digital Hitch Control System.

An important criterion is the dynamic behaviour of the control valve. Here stringent demands are made if the many different functions are to be fulfilled to the best possible extent. Pressure controls and vibration damping make the toughest demands these days. The opening time of Q = O to Q_{max} must be approximately 50 ms for lifting. The valve can be supplied as a flange-type or pipe mounted unit; work is being done on a slice-type design which can be integrated in the directional control valve blocks.

– Digital Electronic Control Unit

The brain of the system is the electronic control unit (Fig 2a). The extremely compact construction (SMD Technology) allows high power density and accommodation in a small, robust housing which is also used in other applications in vehicles and protects the 'brain' against environmental influences such as moisture, electromagnetic radiation. Fig 2b shows the block wiring diagram of the control unit.

The input signals of the operating unit, switches or sensors are filtered and conditioned for input to the microcontroller. The microcontroller is an 8-bit Siemens 80535 with integrated A/D and D/A converters. The programs for the control functions are stored in an EPROM with 32 kilobytes, an EEPROM with 8 kilobytes is available for input of erasable data which can be used to store customer-specific parameters on the customer's assembly line.

Output parameters are the currents produced from current controlled output stages for operating the raising and lowering solenoids. A serial interface is basically used for final testing at the plant of manufacture but to a limited extent can be used for communication with other electronic sub-systems on the tractor. Of the two additional outputs, one is used for diagnosis and the other for status display of the hitch for higher-order control systems.

Electronic controls for other sub-systems on the tractor or equipment which is attached or towed are currently developing rapidly. This makes it necessary for sub-systems to be able to communicate with each other. The

next development stage therefore envisages the integration of the CAN bus system which Bosch has developed.

The control unit is produced in the Bosch Reutlingen plant where other control units are produced, for example for fuel injection systems. The EHR-D control unit therefore also benefits from all the experience of large-scale manufacture of vehicle equipment.

– Force Sensor (KMB)

All sensors have integrated electronics and a standardised output. The measuring range is between 2.5 and 7.5V for 10V supply voltage.

The force sensor is formed as a pin (force measuring pin + KMB), with which the lower or the upper link are connected to the tractor. It thus replaces an otherwise existing purely mechanical pin (Fig 3).

To so-called magneto-elastic effect is used as the measuring principle. This effect occurs in ferromagnetic materials and uses the relationship of mechanical shear stress and magnetic permeability. The magneto-elastic effect is measured with the aid of primary and secondary coils in a central bore of the sensor. An additional pair of coils is present to compensate the effects caused by torque (friction when raising and lowering).

Fig 3 also shows the characteristics of the sensor. The zero point is at 5V. In each case 2.5 volts change of voltage are available for the compression and tension range. In this way sensor signals to be transmitted from the cable are at a relatively high voltage level and thus less susceptible to faults.

The electronics integrated in the sensor are supplied with a de-voltage. They generate the alternating voltages necessary for the coil systems and demodulate the sensor element output signals. The output signal has hysteresis which is dependant on the force. When operating with a plough, the changes in force and thus also the hysteresis are relatively low. The pin must be installed so that it does not rotate. The measuring plane (tension) is normally horizontal. The sensor is insensitive perpendicular to the measuring plane.

The sensor is hermetically sealed and the connection cable with plug is moulded to it. The cable can be equipped with a flexible protective tube. The product range has force sensors for measuring ranges of 25, 40, 60 and 90KN.

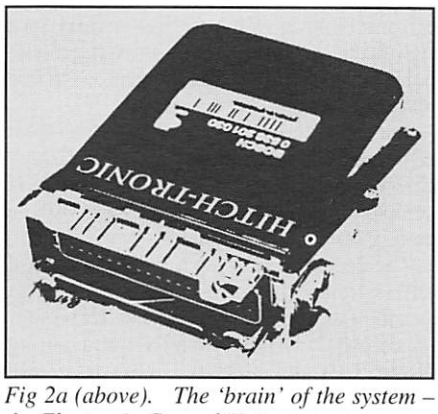


Fig 2a (above). The 'brain' of the system – the Electronic Control Unit.

Fig 2b (below). The block wiring diagram of the Control Unit.

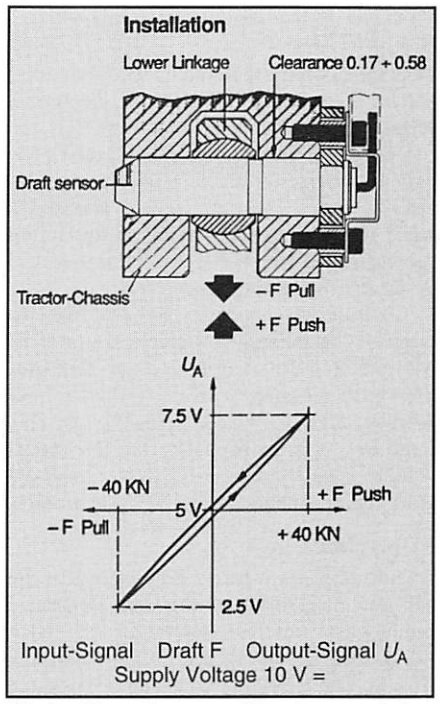


Fig 3. Force Sensor and its characteristic.

– Position Sensor

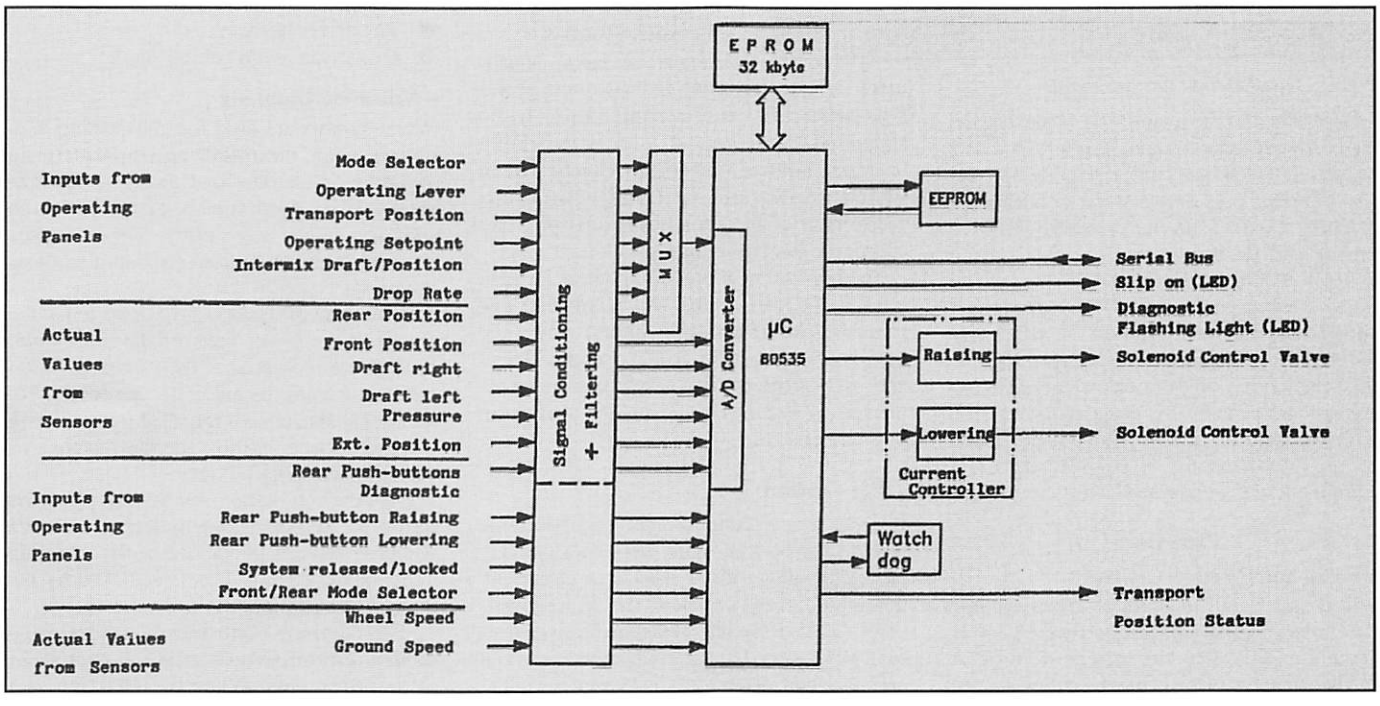
The position sensor works inductively in accordance with the differential choke principle. The latest version has – as in the case of the force sensor – integrated electronics which supply the coils and condition and amplify the sensor signal. The measuring range is 10mm, the signal stroke 2.5 to 7.5 volts. On the signal side the sensor has a moulded-on cable with plug. The sensor body has a thread with a locknut for mechanical adjustment. On the input side the measuring plunger is provided with a protective sleeve.

Attachment takes place on the outside at the hitch linkage housing with drive via a cam to the lifting shaft. Upon request there is an oil-tight version which can be installed inside in the power lift.

Currently work is being done on an angular sensor which works on the same principle.

– Pressure Sensor

The pressure sensor functions in accordance with the strain gauge principle. It has a steel diaphragm as measuring element on which thin-film measuring resistors are vapour-deposited. This design is robust, highly accurate and has long-term stability and small dead volume. The sensor evaluation electronics are integrated. The signal stroke is 2.5-7.5 volts. There are sensors for measuring ranges of 100-350 bar.



– Vehicle Transmission Speed Sensors and RPM Sensors

Two signals are required for recording slip, one for the actual and one for the theoretical speed.

A radar sensor which works in accordance with the Doppler principle is used to measure vehicle speed. The radar sensor provides a pulse frequency proportional to the actual vehicle speed which is standardised at 130 pulses per metre of distance covered.

An inductive speed sensor is used to measure the theoretical vehicle speed. This is installed in the transmission and measures the tooth frequency of a toothed wheel downstream of the manual transmission. This frequency is proportional to the theoretical vehicle speed. Adaptation to various tyre sizes is performed in the EHR-D electronics.

– Operating Unit

Operating units have to be adapted to the cab design. Therefore they are generally produced by tractor manufacturers. Bosch has a compact operating unit in its range (Fig 4). The EHR functions can be operated by means of this operating unit.

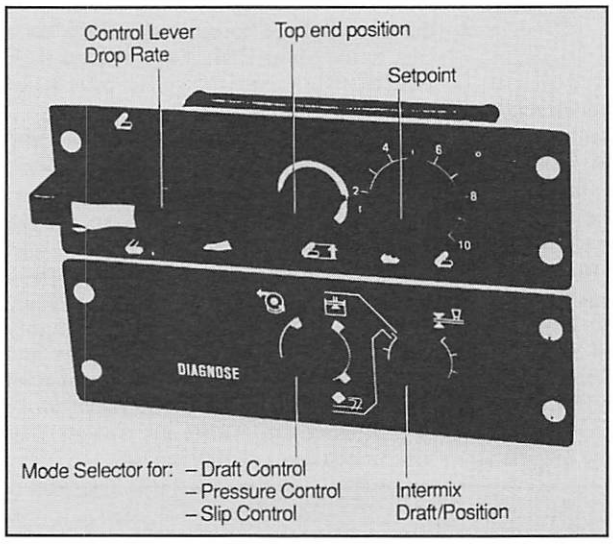


Fig 4. The Bosch Operating Unit.

Depending on the quantity of functions and the customer requirements, further operating and display elements can be provided eg. for slip control, pressure control or vibration damping. Apart from the operating unit, the raising and lowering functions can also be controlled manually from the rear of the tractors using push buttons. The movement speeds are in this instance significantly reduced for reasons of safety. On the EHR-D the sensitivity of the control is adjusted automatically. Thus it is possible to dispense with an operating button which was needed on previous systems to adapt to different equipment or ground conditions.

Functions

– Force and Position Control

Force and position control are the basic functions of hitch control and which today are a standard fitment on all tractors. A further development is the so-called mixed control. Here the position portions are mixed in with the pure traction control for the purposes of limiting the control amplitudes (changes in the ground). The basic functions can be simply achieved when using force and position sensors. The pure position control is used when equipment has to be held in a particular position relative to the tractor. The requirements on the static and dynamic characteristics of the control differ and depend on the customer.

– External Control and Touch Control

The first additional function which is difficult to achieve mechanically is the so-called external control. It is used on equipment which is fitted to the three-point linkage of the power hoist and has to be kept at a particular distance from the ground, for example. Fig 5 shows an example of a beet lifter. With this system, the position of the equipment frame relative to the ground surface is measured with a sliding runner (touch control) which is connected to the inductive position sensor. In this way the draft of the beet lifter body in the ground can be maintained very accurately.

– Front/Rear Changeover

Tractors are increasingly being equipped with front power lifts. The front power lift generally requires a position control, for which the expense of a separate control circuit with all its components is only worthwhile if work is carried out simultaneously. Therefore the electronics and valve of the rear power lift are utilised. By means of a changeover device, the valve and the electronics can be swapped over from rear to front.

– Pressure Control

There are numerous attachment devices for front and also rear power lifts where the full weight is not to be supported on the ground. Here with aid of a pressure control a solution can be found which allows an exact and continuous adjustment of the ground residual pressure and/or the load relief proportion.

The reversal of a pressure control for load relief is the load control. An example of this is in the use of packing rollers, where the inherent weight of the rollers is insufficient and part of the tractor weight can be transmitted to the packing rollers using the pressure control.

– Slip Control

In order to use the traction of a tractor in the field to the best possible extent, a relatively large slip of the drive wheels is physically unavoidable. However, if the slip exceeds values of 25-30%, unacceptable disadvantages such as ground damage, tyre wear, time and energy losses occur.

The possibilities of limiting slip or controlling slip have been considered for a long time. Electronics now offers an economic and reliable solution. The actual vehicle speed is recorded without contacting the ground using a Doppler radar sensor which sends out rays to the ground at an oblique angle. The theoretical, ie. the slip-less speed is measured with a speed sensor in the transmission. Slip can be calculated from both signals and used for control and regulating tasks.

Increasing slip acts on the controller in exactly the same way as increasing traction, ie. the hitch raises when the slip increases and thus reduces the traction of the equipment. Both values – traction and slip always act on the controller, the relationship of both values is permanently set in the electronics and cannot be changed manually.

Slip control is a 'mixed control' from traction and slip. It represents a compromise between agricultural and drive/physical criteria. Were only the slip to be used as a control parameter, large working depth fluctuations would have to be taken into account for significantly changing soil conditions. The Bosch solution results in a significant reduction in slip on wet ground, but produces lower depth fluctuations than a pure slip control.

The characteristics which define the effect of slip on the hitch can be selected so that above particular slip values the hitch is completely raised, thus avoiding the vehicle getting stuck in the ground.

The operation of a hitch with slip control differs from that with force control only in as much as the slip control has to be activated, which is indicated by a light-emitting diode. Lift and nominal value lever are identical with those for force control.

Slip control has the following advantages:

- Reductions in time and fuel cost;
- Reduction in tyre wear;
- The ground is protected;
- The driver has less to do;
- Driver can avoid getting stuck.

– Vibration Damping

When tractors are used for transporting with heavy rear mounted equipment,large dynamic front axle load changes occur at increasingly high speeds of travel which seriously impair steerability. The electronic hitch control can be used for damping these vibrations.

In the case of the Bosch EHR systems, the forces in the lower links of the three point linkage are measured at their pivot point on the tractor with the aid of force sensors. No additional sensors are required for recording the vibration condition for the purpose of vibration damping.

Theoretical vibration studies show that the damping effect is optimal if the active damping force is 90° ahead of the vibration angle of the tractor. This is achieved by the damping controller.

The damping controller is a pure force control circuit, which alone cannot meet all requirements. When transporting, the

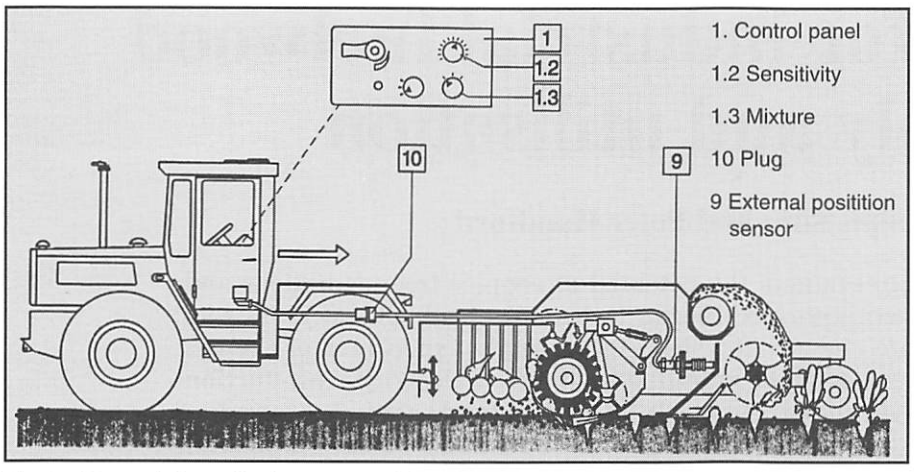


Fig 5. External Control allows mounted beet lifter to be maintained accurately at set depth.

equipment should be raised to the highest possible position. There is therefore a dynamically differently-tuned position control circuit superimposed on the damping control circuit which always returns the attached equipment to the specified position.

Manual intervention is in principle not necessary to activate the vibration damping. It is effective if the lift switch on the EHR operating unit is positioned on 'transporting' and a set vehicle speed is exceeded.

Fig 6 shows the measured curve of cylinder pressure and lower link force at 15 km/h with and without damping. The effect can be clearly seen.

The EHR-D can thus be used for active vibration damping simply by means of software changes without additional sensors. Hence the additional expense for this important function is very low. The essential advantages are:

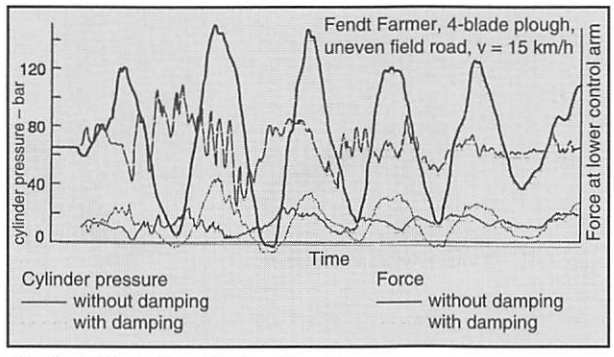


Fig 6. Effect of oscillation damping.

- Effective front axle load fluctuations can be reduced by up to 40%;
- Steering safety can be significantly improved;
- Seating comfort improved by up to 25%;
- The load peaks on equipment and attachment linkage considerably reduced.

System Diagnosis

Downtimes and workshop costs have to be minimised. In this context, digital electronics provides a very good approach for rapid detection of the causes of faults.

All EHR-D system faults which can be determined by the electrical input and output signals are detected. These faults are subdivided into three categories – serious, moderate and slight. A serious fault activates the Control 'Stop' and a new start can only be made via the ignition key; a moderate fault activates the 'Stop' but a new start is possible via reset button. There is no interruption for a slight fault. Currently faults are listed and coded and are displayed via a light-emitting diode which issues a flashing-light code. This is the most cost effective solution. An extension with an indication via a display is possible.

Potential for further innovation

The electronic/hydraulic hitch control has created conditions for a extension of the hitch functions hardly believed possible:–

- Extension of the application possibilities and limits of tractors in the field and on the road;
- Increase in driving safety;
- Protection of equipment and ground;
- Saving energy;
- Increased operating and driving comfort;
- Increased draft force in field operation;
- Reduction in downtime.

Development is not yet at an end to be sure. In the next development stage, the integration of the EHR into higher-order or allocated systems has to be solved. The introduction of the CAN bus system developed by Bosch is intended to do this. Certainly there will be further developments in the functions currently constructed and other additional tasks are conceivable.

The available potential for innovation has not yet been fully exploited.

A copy of the full text of this paper and of other papers presented at the Silsoe Conference, Fluid Power in Agricultural Machinery, may be obtained from the Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ. Tel: 071 973 1277 (Mr John Lawrence).

QUOTES/SHORTS

Sixty percent of world R & D expenditure into crop protection is conducted in Europe. Expenditure in research/development is 1.0 billion ECU/pa.

Grapevine, Dec, 1992

"Increased funding will allow for an expansion in numbers in Further Education Colleges on a dramatic scale – a 25 percent increase over the next three years."

John Patten, Education Secretary, 9 Dec, 1992

"The percentage of women taking engineering and technology degree courses in universities has doubled from seven percent in 1980 to 14 percent in 1990. The introduction of the National Curriculum in our schools and efforts of employers promise an even larger number of women entering the profession."

Emily Blatch, Education Minister, 11 Dec, 1992

In Africa 25 out of 43 countries produce less cereals per head of population than they need. In South America the situation is worse with 17 out of 23 countries not producing enough.

Farming Facts II

Organic farming is unlikely to account for more than 7% of the food produced in the UK because it takes too much land to obtain the yields, is too labour intensive, and organic produce does not store well.

Farming Facts II

Britain is now 75% self-sufficient in indigenous foods and over 60% self-sufficient in total food production. Fifty years ago we were only 30% self-sufficient in foodstuffs – a precarious situation to be in.

Farming Facts II

In the past 10 years the retail price index has gone up by 103%, food prices by 71% and farmgate prices by only 40%.

Farming Facts II

"The hard fact is that accidents cost money – a great deal more than many people imagine. In one company the costs amounted to 37% of annual profits."

Patrick McLoughlin, Under-Secretary of State for Employment, Nov, 1992

MAFF news

The Boxworth project explored the long-term effect of pesticides in intensive cereal production and compared the results of the high input farming of the late 1970s with reduced input systems. The book on the findings was launched by Earl Howe; it points the way forward towards safer, yet economically viable systems of arable farming.

From: HMSO 1992: 011 242876 2 'The Boxworth Project'. Price £45.

Prospects for industrial fuelwood supply and utilisation

Ralph Sims and Peter Handford

A research programme to evaluate the potential of coppice tree plantations and forest residues as an energy resource began in New Zealand several years ago. Public interest in climate change; the short-term supply expectancy of the gas and oil reserves; a recent drought resulting in reduced electricity production from the South Island hydro-lakes (normally 70-80% of total supply but for a few weeks as low as 40%); and a general increased awareness of environmental issues, has led to an expansion of the programme.

This paper outlines the results from several major feasibility studies with particular emphasis on engineering issues. It is the link between the trees and the boiler, say the authors, where the agricultural engineer has a major role to play if woody biomass is ever to become a significant energy source.

Wood, regardless of species and form, is a useful fuel containing 18-21 MJ/kg of oven dry material. Basic density varies with tree species; bulk density varies with piece size and form; and calorific value varies with moisture content. For industrial fuel use, air-dried hardwood in the form of logs is preferred, though comminution into chips or chunks is the more useful practice as drying rates, handling convenience, and combustion properties are improved with a smaller piece size.

Forest residue recovery for fuelwood following stemwood harvesting is often limited due to access, depletion of soil nutrients and cost. Integrated harvesting of whole trees for both timber and fuelwood may be a future option on the more fertile sites (Fig 1).

Energy plantations, probably highly mechanised, may become feasible depending on comparative returns from competing land-based enterprises and competing fossil fuels.

Many examples of small and large wood-fired boilers are in use but design changes are continually being sought to improve combustion efficiency, fuel handling systems, stack emissions, etc. Ash removal is a lesser problem with wood than coal. Dual combustion of both these solid fuels is feasible and may lead to certain benefits such as reduced sulphur emissions.

Survey of potential users

The handling, transport and storage of fuelwood should be planned as an integral system if it is to be cost effective. Well designed methods of storage are necessary to achieve the desired maximum fuel moisture content but with minimal decomposition of the fuel.

R E H Sims is a Senior Lecturer in Agricultural Engineering at Massey University, New Zealand. P Handford was a Research Officer at Massey University and is now a forestry consultant.

In a survey of 354 industrial companies (Sims *et al* 1990) it was found that factors relating to the relatively low energy density of fuelwood, compared with other fuels, gave considerable concern to potential users. Coal, lpg or oil users were more interested in the potential of using fuelwood than were diesel, gas or electricity users who valued convenience and tended to run smaller boilers. Organisations with total boiler capacities of 5-20MW were most interested in fuelwood use. Those with larger boilers envisaged technical difficulties when storing and handling large quantities of fuel.

The major perceived limitations to using fuelwood by the survey respondents were: storage and handling; additional labour; security of supply; control of stack emissions; boiler problems after conversion; suitability of present boilers; loss of convenience, and insufficient heat output after conversion of existing boilers.

Land area required

The survey indicated a potential national industrial demand for 17.4 PJ/annum of energy derived from fuelwood, assuming all organisations expressing an interest were actually to convert.

If air-dry wood (calorific value 14.7 MJ/kg) was burnt in wood-fired boilers which averaged 70% efficiency, this energy demand could be met from 1.3 million tonnes of air-dry fuelwood produced annually. A sustainable supply of this quantity could be produced from around 55000ha of land assuming recoverable biomass yields of 20 oven-dry tonnes (ODt)/ha/year were achievable on a large scale. This area is equivalent to 4–5% of that in New Zealand currently planted in exotic forest.

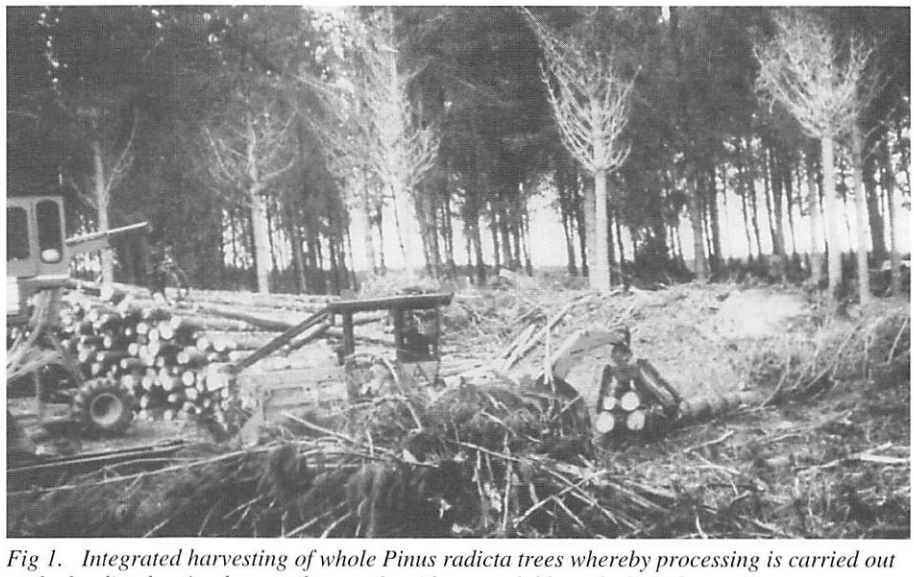


Fig 1. Integrated harvesting of whole Pinus radicta trees whereby processing is carried out at the landing leaving large volumes of residues available as fuelwood.

As a guideline, approximately 0.014ha of land is required to give sufficient sustained yield of fuelwood to provide 1MWh of average actual boiler output (assumed to be 60% of rated output). For wood-fired power generation 10% of land up to a 10km radius would need to be utilised for energy production in order to supply a 10MW

(electric) generator to avoid having excessive transport costs.

Harvesting systems – must be low cost

Due to the relatively low value of fuelwood, a low harvesting cost is essential to the overall economics of production.

Systems for harvesting forests in New Zealand generally involve motor manual felling using chainsaws, followed by extraction to a landing using mobile skidders on easier country or cable haulers on steeper country. These systems have been developed as the most economic method of recovering large piece size trees. Such conventional systems become increasingly expensive as piece size drops due to the extra handling involved (Vaughan and Shula, 1989) so are not well suited to harvesting close-planted coppice crops.

There is a general lack of information on the harvesting of small trees of around 150-200mm stem diameter, 10m tall and often multi-stemmed following coppicing. Systems are varied but can broadly be classified into conventional (Fig 2), chipper/forwarding or use of specialised harvesters.

Cost estimates of harvesting the standing trees and processing to chips delivered to the landing for these three systems are shown in Table 1.

Specialised harvesters

Development of highly mechanised equipment capable of harvesting coppice plantations at a low cost will be necessary if the production of industrial fuelwood and other biomass products is undertaken on a large scale.

A variety of harvesting machines have been developed to the prototype stage overseas to suit particular crops and growing conditions (for example, the Loughry willow coppice harvester, Hare *et al* 1989). Commercial equipment is not yet available and is unlikely to be developed until demand increases and is secure.

Harvesting of short rotation energy plantations is characterised by recovery of a high density of stems of small size. Work has been undertaken in the last 10-15 years developing specialised woody biomass harvesters for use in such plantations.

The major development work of specialised harvesters has been undertaken in Sweden, N Ireland, Canada, Germany and USA but none of the prototypes has been evaluated on young eucalyptus trees (see item on ETSU trials – foot of next page). Many of the prototype machines integrate cutting and bundling, cutting and loading, or cutting and processing of the stems to chip form in one continuous operation. This enables the machine to travel along the tree rows in an operation similar to conventional cereal crop harvesting which offers the potential for high machine throughput with consequent low harvesting costs.

Chipping at harvest does not permit transpirational drying of whole trees. Current trials indicate a reduction from 60% moisture content (wet basis) at harvest to 25% moisture content within 4-7 weeks dependent on the time of year (Fig 3).

Much research and development of specialised biomass harvesters is still required. Their development appears to be one of the major factors controlling the supply of fuelwood from energy plantations as a competitive source of industrial energy. Harvesting costs are likely to remain a significant proportion of the total cost of fuelwood production. An economic and reliable system of harvesting, integrated with drying, handling, transport and processing of large volumes of biomass material must be developed to give the cheapest cost of fuelwood.

Fig 2. Motor manual harvesting of field experiments. The 3 year old coppice regrowth of the 9 year old Eucalyptus trees, being harvested for the third time, is weighed and recorded.

Research project – coppice eucalyptus combined with effluent disposal

Towards this goal a joint research project has begun between Richmond Meat Packers and Exporters Ltd and Massey University.

For coppice tree crops, a series of field trials has led to the identification of preferred species, length of rotation, optimum tree planting density, best time of harvest, etc. Several commercial plantings are now being established, usually of eucalyptus planted at 5000 trees/ha and harvested every three years. The number of rotations possible is not known but one trial of twenty-three species is now well into the fourth rotation. Willows, poplars and acacias also show promise but are lower yielding than the eucalypts which appear to do best when grown in association with the land disposal of effluent.

Richmond Meats are planting 90ha of land with coppice eucalyptus as a means of controlling their effluent using land disposal on to the trees (Fig 4). This follows a successful four-year, 6ha, pilot trial. The

Table 1. Harvesting and processing costs for coppice trees cut and delivered as chips to the landing.

Harvesting system	*Description*	*Equipment*	*Suitable tree size (m^3)*	*Harvesting and processing cost (£/ODt)*
Conventional	Felling by chainsaw (motor manual) or feller/buncher. Skid or forward to landing for chipping	Chainsaw or feller/buncher; skidder or forwarder; portable chipper	> 0.25 0.1–0.25	15 21
Chipper/ forwarder	Felling by chainsaw (motor manual) or feller/buncher. Items recovered and fed directly to a chipper mounted on a forwarder which forwards chips to landing when bin is full	Chainsaw or feller/ buncher; forwarder with chipper and chip bin	0.1–0.25 < 0.1	18 23
Specialised harvester	Specialist machine cuts and recovers small stems in a continuous operation. Processing to chip or other form may also be directly integrated	Agricultural tractor with biomass harvester attached or self-propelled biomass harvester	< 0.1	11

Sources: Mead (1987), Ellingsen (1986), Stokes and Sirois (1983), Stokes *et al* (1986), Golob (1985).

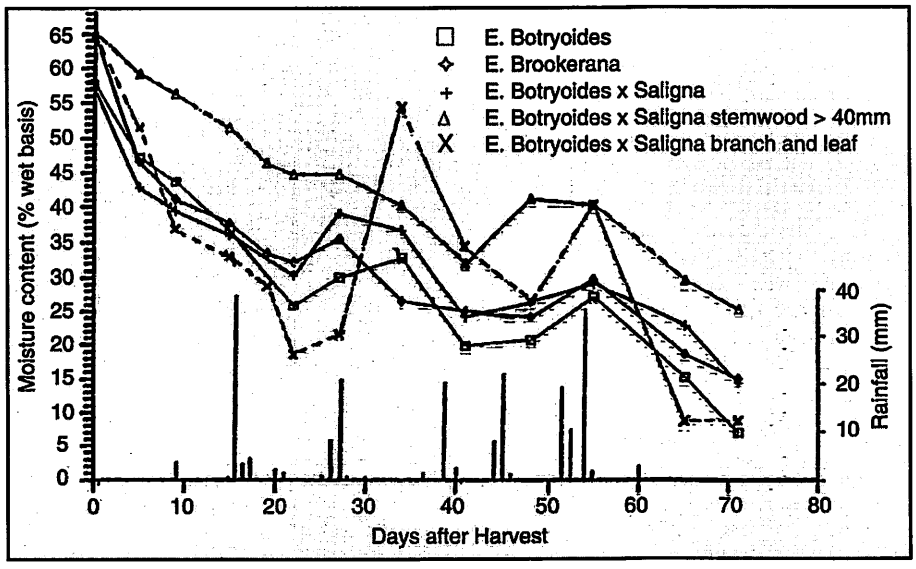


Fig 3. The drying rate of three species of 3 year old Eucalyptus coppice regrowth harvested in the spring 6 years after planting. The samples were placed outside in piles of 6-7 trees each with base stem diameter approximately 100-150mm. Rainfall recorded during the monitoring period is shown.

objective of the joint project is to use the biomass produced in their boiler to replace their annual coal demand costing over £100,000 and generating large volumes of CO_2. If fuelwood is substituted for coal, CO_2 is still produced but is in effect reabsorbed by the resprouting coppice trees. No net atmospheric gain in CO_2 results.

Disposal of industrial effluent and sewage on to the land is well understood. Using forests for stripping nutrients is showing promise and results in improved tree growth rates. However, the build up of trace elements in the soil over time must be carefully monitored. The combination of the disposal of effluent over land planted with trees and the utilisation of the biomass produced as an energy source merits further investigation. In particular, work is required to determine crop yields and renovation rates following several years of application. Lysimeter trials are planned to identify optimum loading rates and nutrient uptake by the trees.

The survey of industry showed over 75% of factories produce effluent with many having to dispose of more than 1000m^3/day. Discharge into sewer systems was the method of disposal for 63% of organisations surveyed. Discharge to rivers, lakes or sea was practised by 20% whilst 8% used land disposal on to pasture.

Three-quarters of those industries discharging into sewers were urban based, had little or no land area available and tended to have no interest in fuelwood. Conversely a large proportion of those discharging effluent into surface water had reasonable areas of land available (often in excess of 100ha), and were more interested in possibly using fuelwood. The few respondents already using a land disposal system mostly owned or leased the land and were interested in the concept of fuelwood production.

Under new legislation discharge of effluent to waterways will be more stringently controlled and sewer discharge costs are likely to increase. Land disposal could become the most suitable and economic alternative. Several development and demonstration projects are under way and being assessed to see whether fuelwood produced could be used on-site. Richmond Meats will be the first to link effluent disposal on to the trees with production of fuelwood, thereby obtaining a return on the disposal costs.

Economic feasibility study shows 'stand alone' project not viable

A computer model was developed to ascertain the economic potential for short rotation fuelwood (and fuelwood/pulpwood) production from biomass coppice plantations. Table 2 lists the base assumptions of cost used in the model to produce a discounted cash flow analysis. A mean annual increment (MAI) of growth was assumed at 20 ton/ha/year above-ground dry matter.

On the basis of these assumptions, it was shown that fuelwood production using each of three silvicultural regimes considered (5000 stems/ha, 3-year rotation; 4000 stems/ha, 4-year rotation; 2500 stems/ha, 8-year rotation) was not profitable at a 7% discount rate. A fuelwood price of at least £24/ODt delivered would be required to give the grower a 7% real return on investment whereas £17/ODt was considered the maximum price affordable if fuelwood was to compete with current coal prices and if the capital investment costs and additional running costs for a wood-fired boiler were included.

The need for low cost, harvesting/processing systems was highlighted by the model. Harvesting costs below £5.40/ODt were required to provide a 7% return on even the best silvicultural regime using the base assumptions. Increased yields would improve the return but the necessary break-even mean annual increment of 3-4 times the 20 ODt/ha/year achieved at present would be unrealistic.

Thus – as a stand alone enterprise – establishing short rotation plantations purely to supply biomass for industrial fuelwood is not economically viable unless significant reductions in inputs (particularly harvesting/processing) and/or increases in yield and fuelwood price can be obtained compared with the base assumptions used.

Fuelwood production as joint product with pulpwood or in combination with effluent disposal

When plantations are grown in association with the land disposal of effluent using irrigation techniques, the value of the fuelwood as a means of offsetting the cost of disposal could make it a viable venture.

Combining pulpwood production with fuelwood production could be an even more profitable option due to the higher value of the pulpwood component. Internal rates of return of 12-19% were obtained for all three silviculture regimes using the model assuming pulpwood fetched £50/ODt for chip price on wharf and fuelwood £21/ODt. A 7% return could still be realised if the pulpwood price fell to £26.60/ODt or if the

Table 2. Base cost assumptions used in a simple economic model to evaluate the cost for producing biomass.

Note: ODt = Oven dry ton

Item	*Cost assumption*
Site preparation costs	£70/ha
Tree seedling	£0.20/tree
Tree planting	£0.06/tree
Fertiliser application	£83/ha – once in every 3 years; zero if grown with effluent disposal
Herbicide spraying	£73/ha – once in every 3 years
Pest and disease control	£42/ha – once in every 3 years
Average maintenance costs	£70/ha/year
Harvesting costs	£11/ODt for 5-year rotation or less using specialised biomass harvester £21/ODt for 8-year rotation using chainsaw, skidder and portable chipper
Transport costs	£0.11/ODt/km

pulpwood price remained at £50/ODt and no fuelwood was sold.

The 4000 stems/ha, 4-year rotation regime was the most profitable of the three studied though the harvesting/processing costs for this option may have been underestimated due to insufficient data being available since no commercial harvester currently exists.

Thus production of fuelwood as a joint product with pulpwood or in conjunction with effluent disposal was a more attractive option than producing fuelwood alone. Sensitivity analyses of one fuelwood option and one pulpwood/fuelwood option (best case) showed mean annual increments, harvesting costs, and seedling costs had the largest effect on the equivalent annual annuities (£/ha). Site preparation costs, transport distances and maintenance costs had lesser effects.

Detailed case studies of 16 of the organisations surveyed, and representing a range of industries, showed that those with a high boiler utilisation, above average fuel costs, and land available nearby could expect a simple payback on capital investment of 3-5 years using the base case assumptions when producing fuelwood alone.

Fig 4. A flood irrigation system for applying effluent to fuelwood plantation. The trees on the right are 3 year old Acacia and those on the left show 6 month old coppice regrowth on Eucalyptus stems.

The future

A number of issues raised in this research programme will require further research if fuelwood production is to become a viable proposition.

Particular issues which should be studied as part of a major programme include:

- species selection;
- optimising yields;
- evaluating harvesting/handling/storage systems;
- developing improved combustion systems for wood at high moisture content;
- producing pulpwood from coppice plantations;
- disposing of effluent on to plantations over a prolonged period.

In essence we know how to grow the trees (though there is still much agronomic and breeding research to be undertaken). We also know how to burn the biomass produced, there being many examples around the world of wood-fired boilers and electricity generators ranging from the domestic to 50MW scale.

If New Zealand is to meet its stated target of reducing CO_2 levels by 20% of 1990 levels within eight years and if land disposal of waste water becomes an economically viable and environmentally acceptable practice, coppice fuelwood production is a promising option. The Richmond Meats plant project will prove to be an ideal way to develop and demonstrate such technologies and encourage their uptake, but if it is to prove successful it will require a significant agricultural engineering input.

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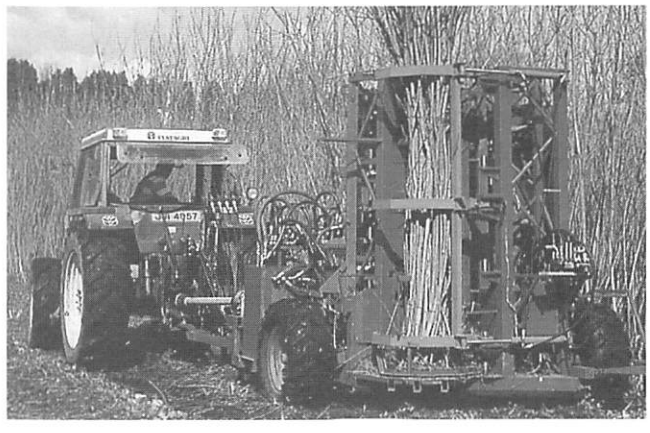
Arable energy forestry

ETSU organise on-farm trials

The production of fuelwood from willow and poplar trees coppiced on short rotation is a practical reality reports Silsoe Research Institute.

On-farm commercial trials are now taking place in a programme funded by the DTI and managed by the Energy Technology Support Unit (ETSU) at Harwell, Oxfordshire. Five farm sites – in Essex, Oxfordshire, Avon, Devon and Cornwall will each be planting 10ha to supply wood fuel to developing local markets.

ADAS are contractors to the project, and will be evaluating the economics of farm coppicing, looking at grant aid and diversification opportunities.



Silsoe Research Institute were invited by ETSU to evaluate the performance of the Loughry coppice harvester, developed at Loughry College of Agriculture, Northern Ireland.

Hydraulic load sensing for agricultural vehicles

Winfried Rüb and Garry Molton

The continual development of modern agricultural machinery has resulted in the demand for a greater quantity and quality of hydraulic utilities. Linked with this has been the ever-increasing trend towards higher installed engine power and consequently, higher installed hydraulic power. Tied in with this trend for more power has also been the requirement to provide increased flexibility in the facilities that are available. Load sensing technology is being seen by many as technically the best way to achieve these requirements.

In this paper the authors outline the most significant factors that should be considered when designing a load sensing system.

In Europe, tractor hydraulics have traditionally been in the form of open centre, constant flow systems. However, in the USA load sensing systems have been common for over 20 years and are now well established. This trend towards load sensing has recently become established here and the majority of the large European tractors are now fitted with load sense technology.

Consider, by way of example, the performance requirements for a tractor in the 100kW engine class range. Such tractors contain a large variety of different hydraulic consumers and will have a total installed hydraulic power in the region of 25% of the engine power. It is therefore obvious that the system efficiency must be optimised. The scope of these utilities can be seen in Fig 1 and includes internal working hydraulic cylinders, external power take off points, steering, brakes, lubrication, power shift, four-wheel drive, differential lock, and PTO actuators.

Performance demands of modern tractors

Looking in detail at the installed performance in the 100kW tractor one finds that the following figures are typical for demands of the hydraulic system:

Flow (Q):	5 < Q < 120l/min
Pressure (P):	2 < P < 200bar
Time Constant (T):	50 < T < 500msec
Power (p):	0.3 < p < 30kW

These demands come from a wide range of hydraulic consumers of which the most significant are:

Maximum flow: the maximum flow demand is often dictated by the size of lift cylinder installed. For example, with a cylinder volume of 3l and a minimum raise time of two seconds the pump will require a supply flow of at least 90l/min. Another factor that is very important is that at low speed, several functions may have to work together without any loss in performance. This 'corner performance' is particularly critical for the power steering and transmission control valves.

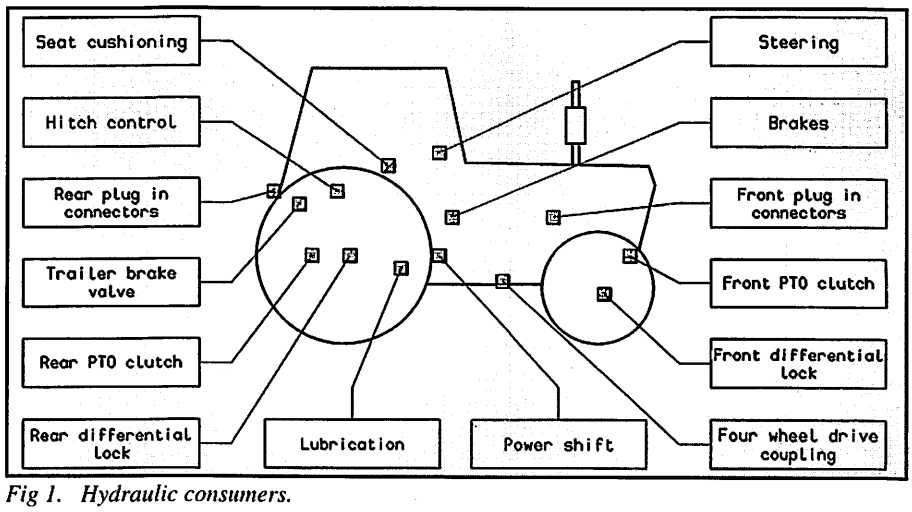


Fig 1. Hydraulic consumers.

System pressure: some system pressure limits are currently controlled by industrial standards with 200bar (DIN)/250bar (ISO) being set for external plug-in connectors. These limits are also a practical maximum level for the rest of the equipment as they correspond to current standard component ratings and consequently reduce the need to have additional pressure control valves in each section of the circuit.

Dynamic performance: the highest requirements for the dynamic performance of the tractor hydraulics are set by the steering system and transmission control valves. With a typical system where the response delay is more than 100msec it is likely that the steering will exhibit a distinct 'hard spot' and the power shift may be intermittently overloaded, possibly resulting in excessive clutch wear or torque interruption during power shift.

Traditionally these different requirements have been satisfied by using constant flow pump technology. The demands of steering, lubrication, pilot oil supply, and working hydraulics have been achieved by utilising several pumps and linking them together when required. The number of possible combinations for this is large and they often require additional specialised control valves to reduce the circulation losses.

Further complications arise when the suppliers wish to provide a wide range of system options and therefore require greater flexibility in their designs. Inevitably, as installed hydraulic power has increased so have the losses.

Consequently a growing number of manufacturers have switched away from the use of open centre, constant flow pump systems to the more flexible and efficient load sensing technology, with variable displacement pumps.

All hydraulics supplied by one pump – with priority to the power steering

The essential goal for a load sensing system should be to have all the hydraulic consumers supplied from one central pump, with a continuously variable, stepless flow.

Abridged text of a paper presented at the joint IMechE/IAgrE/Silsoe Link Conference 'Fluid Power in Agricultural Machinery' – Silsoe College, 4 November, 1992.

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An example of such a system, suitable for tractors with common transmission and working hydraulics, can be seen in Fig 2. Here the variable displacement pump supplies the power steering via a priority valve. Once the power steering demand has been satisfied then the priority valve directs the flow to the rest of the circuit. The heart of this system is the variable displacement pump which is regulated by the pressure and flow demand of the circuit.

The supply for the transmission control valves is regulated by a second priority valve. This valve has the additional requirement of reducing the pressure to a suitable level for the components to be supplied and more critically ensuring that this pressure level does not fall below the minimum level required, Pc. To fulfil this limit the standby pressure Ps must be set higher than the minimum required pressure; normally:

$$Ps = Pc + 5bar.$$

If this condition cannot be guaranteed; for example when too much flow is demanded by a lift cylinder, then it is possible that the drive couplings will not remain slip-free or may even be destroyed. A suitable control valve to overcome this problem must work as a pressure reducing valve at Ps > Pc and as a pressure maintaining valve at Ps = Pcmin.

The flow demand signal for the pump compensator is provided by the pressure drop across, for example, a directional control valve. This pressure drop plus the load pressure downstream of the valve, gives the pump supply pressure. On the one hand this pressure drop should be kept as low as possible so as to reduce the system losses and not restrict the maximum working pressure; however, on the other hand it must be high enough to ensure that the pump dynamic is sufficiently fast and that the maximum flow is always available to the critical consumers.

When determining the level of this pressure drop it must be remembered that the load sensing system can be very sensitive to varying air content and temperature conditions. Careful attention must be paid to the supply and load sense lines to ensure this sensitivity is kept to a minimum.

Additional priority valve for supply to trailer brakes

If the tractor is fitted with a trailer brake valve then an additional priority valve will be required. The sequence of operation for this system must be: (1) steering valve, (2) trailer brake valve, (3) working hydraulics. This structure can, however, be achieved by several different priority control valve layouts.

Additional charge pump if hydraulics and transmission share oil supply

When using a circuit layout as discussed, where the hydraulics must share the same oil as the transmission, there are several precautions that should be observed. In order to ensure that adequate flow is available at all temperatures and pump speeds an additional charge pump will be required. This can at the same time be used to provide the low pressure filtration and lubrication flow, thus compensating for some of its additional expense.

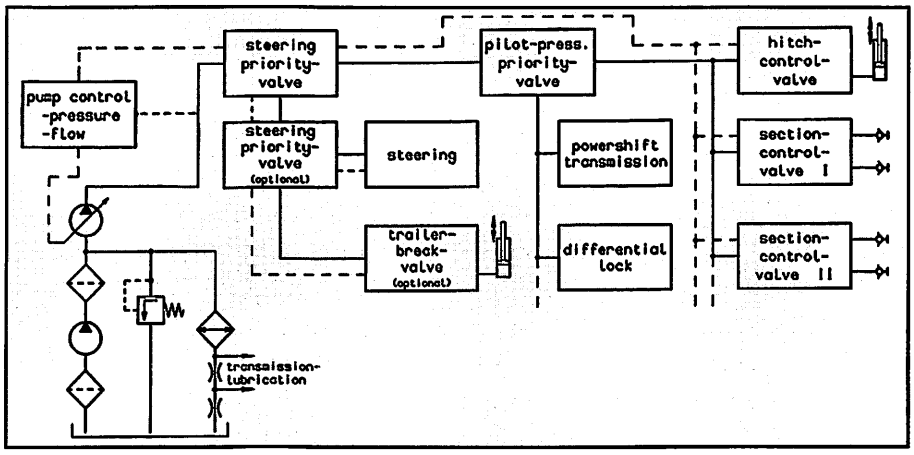

Fig 2. Load sensing – tractor hydraulics and transmission with single oil reservoir.

If the facility for separate transmission and working hydraulics is available then a circuit layout similar to that shown in Fig 3 becomes more appropriate. Here the suitable positioning of the tank, and the use of a low pressure return line filter makes the need for a charge pump less likely. The lubrication flow and transmission control valves must, however, be supplied by a separate low pressure oil supply in the transmission.

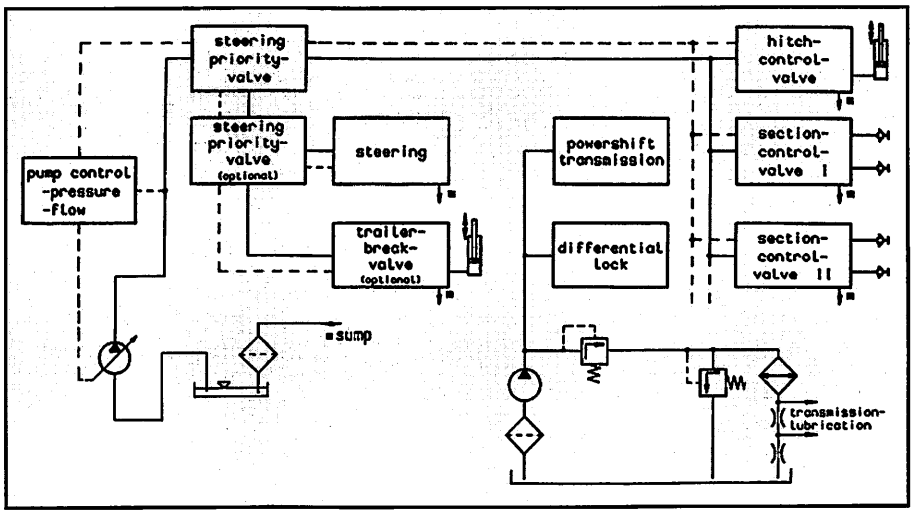

Fig 3. Load sensing – tractor transmission supplied from separate oil reservoir.

The maximum pressure protection in either of the load sensing circuits is provided by the pressure regulator on the variable displacement pump. With current technology there is normally no need for an additional pressure relief valve to be included, although for increased safety this is a good technical solution.

The power steering circuit

The use of LS technology is particularly beneficial when considering inclusion of the power steering circuit. Normally the flow demand for power steering falls below that for the working hydraulics, but when considering the system losses the steering is invariably the most significant factor. For the power steering it is also beneficial to have the supply flow independent of motor speed; this is both to achieve good 'dry scrub' performance at low engine speed as well as reducing the steering lightness at high road speeds. The dynamic performance of modern variable displacement pumps and priority valves is amply capable of responding to the demands of extreme steering movements, without exhibiting a noticeable 'hard spot'.

The control of steering performance provided by load sensing, throughout the engine speed range, allows the tractor designs to conform more easily with the relevant legislation on steering performance. This legislation covers both the maximum turning force required at the steering wheel and the minimum time to execute a controlled turning radius.

Power and cost savings

The realisable power savings from a load sensing system, compared to a constant flow, open centre system, are impossible to quantify. As with system cost comparisons, the vast number of circuit build possibilities and the range of conditions under which a machine will operate means that no standard figures can be given. However, from experimental work that has been published it

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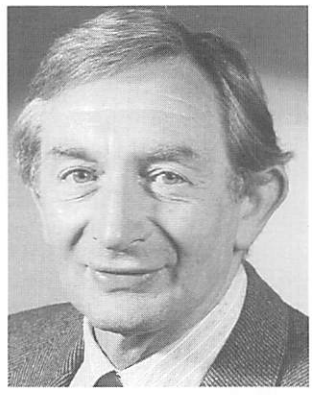
Robotic milking



Mike Street

Present milking operations are based upon the human working day and not on the cow's physiological or welfare requirements. The good high yielding cow is therefore uncomfortable on the limited twice a day milking and would benefit from more frequent milking opportunities. Robotic milking offers the potential for 24 hour round the clock milking on a voluntary basis.

The Silsoe team on Robotic Milking has been working on this concept since 1987. The present Mk2 system is designed to attach all four teat cups sequentially using a single robot arm. The robot is a new design and an attempt was made to keep the mass and inertia down, and the arm as simple as possible. All joints are simple pivots and cylinders are small to maintain short pneumatic time constants. The general design principle is shown in Fig 1. A rotation axis has been fitted in the base to rotate the robot from underneath the cow.

The cups are held inverted in a magazine at the opposite side of the stall to the robot. The robot end effector has the means of gripping and releasing the teat cups, a wrist action for inverting and shifting the cups to get the best orientation for attachment, and a means of local sensing that does not impede the mechanical operations.

The position of the cow in the stall is sensed using mechanical paddles pressed on the cow using air springs; potentiometers connected to the paddles provide the electrical signal outputs, Fig 2. The paddles are retracted by reversing the effect of the air springs. One split paddle is used on the rump of the cow for the *x* position and a pair of paddles on the flanks for the *y* position. The direct contact with the cow also allows the sensors to provide dynamic movement information.

Separate milking jar to each teat cup

The teat cups are held retracted into a magazine, Fig 3, by the tension applied to the milk and pulsator tubes using a roller and teat cup retrieval (TCR) cylinders. Each cup and milk tube assembly is independent and feeds a separate quarter milking jar. Information from load cells in each jar is used for yield measurements and to initiate the individual cup detachment and retraction to the magazine.

The robot end effector is open ended and can slot over the teat cup, a small pneumatic gripper holds the cup at pick up and whilst attachment takes place. The end effector is mounted on the robot arm using a 45° pivot (Fig 4), a 180° rotation on this pivot inverts the teat cup and also changes the direction of the end effector for best access to the teats. The cups are put on in the sequence shown in Fig 5 to avoid collisions and entangling of the milk tubes. Once cups are

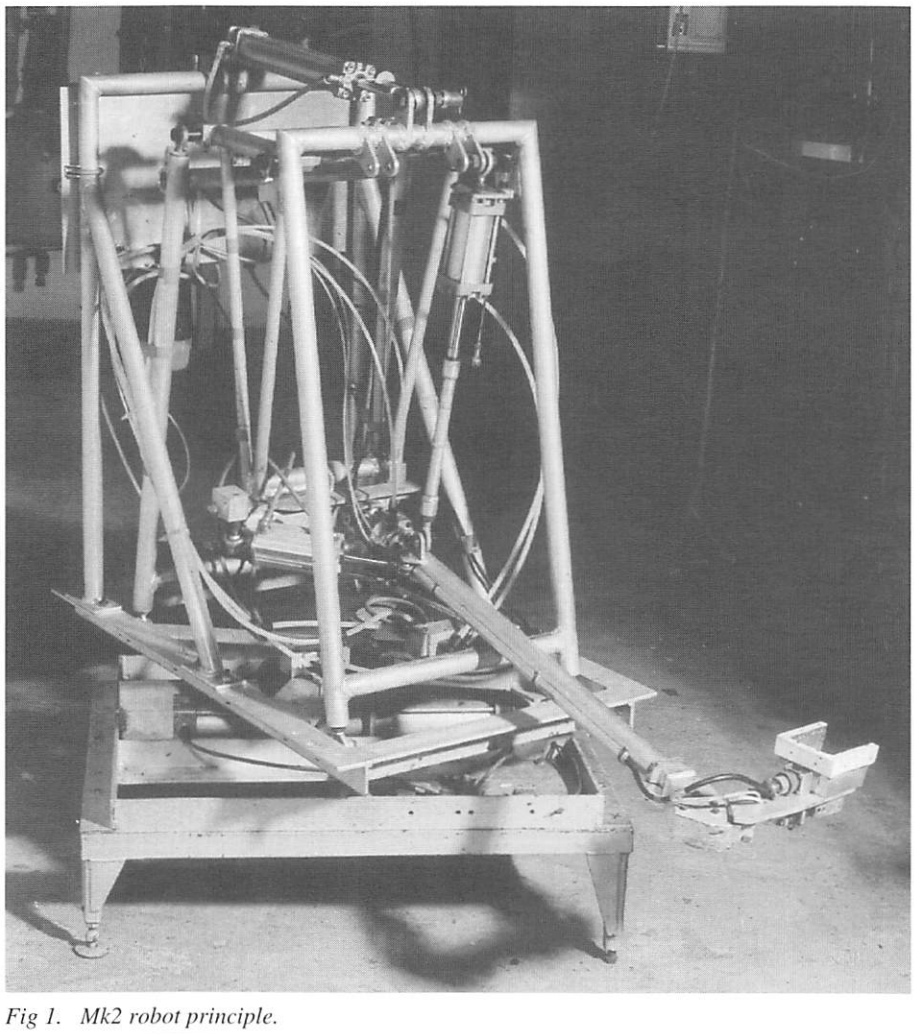


Fig 1. Mk2 robot principle.

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Abridged text of a paper presented at the joint IMechE/IAgrE/Silsoe Link Conference 'Fluid Power in Agricultural Machinery' – Silsoe College, 4 November, 1992.

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would appear reasonable to predict figures of the following magnitude:

a) 50% saving while working in hitch control mode;
b) 2kW less installed cooling required for front loader work;
c) An efficiency improvement from 11 to 70% for power steering.

The fact that an increasing number of manufacturers are producing machines with load sensing hydraulics is clear. Such decisions have been taken after considering the cost and performance of the complete hydraulic system including such areas as cooling requirements and build options.

By careful design of the complete system as one unit a high standard of overall performance can be achieved, and with this, the additional benefit of a significant reduction in power loss, to the end user.

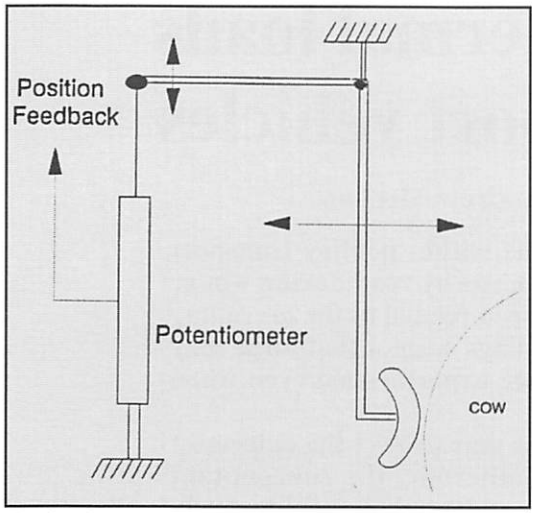


Fig 2. Cow position sensor.

on the teats then the gripper is released and the robot can proceed to pick up the next teat cup.

Each TCR cylinder is released as the gripper slots onto the teat cup, the cup and milk tubes are then pulled out by the robot. Milking vacuum is applied as the cup nears the teat and attachment is signified by sensing the vacuum level changes in the milk tube.

Centralising the cup on the teat

A matrix of 8 infra-red light beams is arranged across the top of the end effector to detect the teat and allow correction of the robot position to centralise the cup on the teat.

Co-ordinates for each teat on each cow are maintained in a database associated with the management system. The co-ordinates are initially generated by steering the robot to each teat using a joystick and then pressing a button. The data is automatically corrected for the cows position in the stall before being stored.

For attachment the co-ordinates from the database are combined with the cow position information to provide the approximate location for each teat. The robot then moves the cup to this position and if the teat is within the sensor area, 80 x 80mm, a correction can be made and the cup attached.

Corrected co-ordinates gathered during attachment are returned to the database to be used in an updating operation.

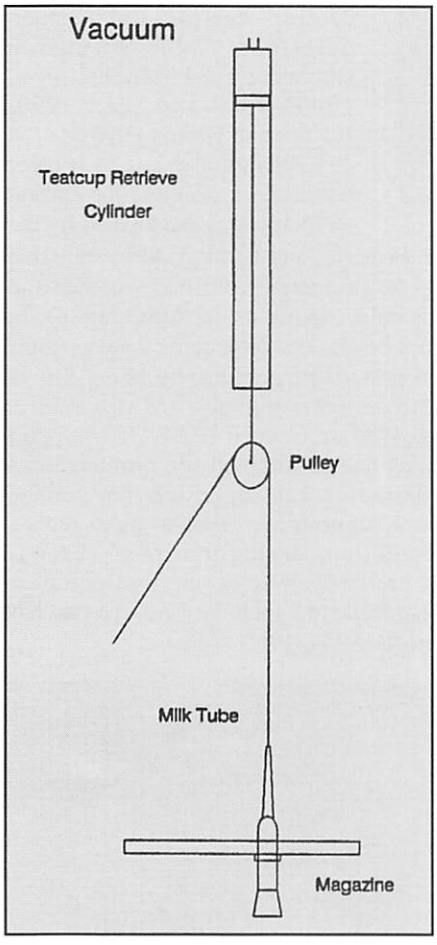


Fig 3. Milk tube and teat cup retraction.

Control of robot axes

Each axis is moved using a cylinder controlled from a Norgren Martonair modulating valve. Position feedback is from linear transducers mounted alongside the cylinder.

The modulated valve alternately connects each end of the cylinder to supply or atmosphere, and by varying the average position of the valve a pressure difference can be developed across the piston to support a load or cause a movement. The modulation also removes the stiction normally associated with pneumatic systems.

Robust construction combined with positional accuracy

Computer techniques are used to sense each axis position and control the valve at regular 5 millisecond periods. The control algorithms are more complex than for electrical or hydraulic systems in order to deal with the compressibility of the air.

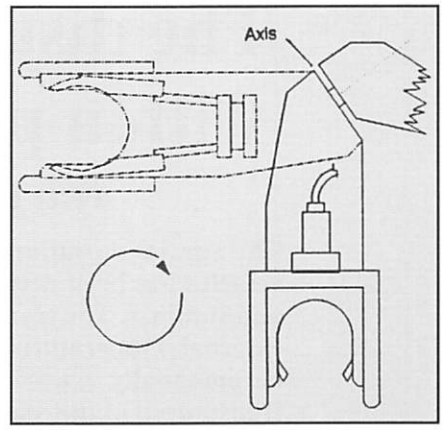


Fig 4. End effector.

The end effector has a positional accuracy of ± 2mm, a rate of approximately 1 metre/sec, and an acceleration of 15 metres/sec^2. The pneumatic activators provide a compliant system and permit kicks and collisions without damage. The robot arm can be trodden on by the cow and still spring back and perform a successful attachment when released.

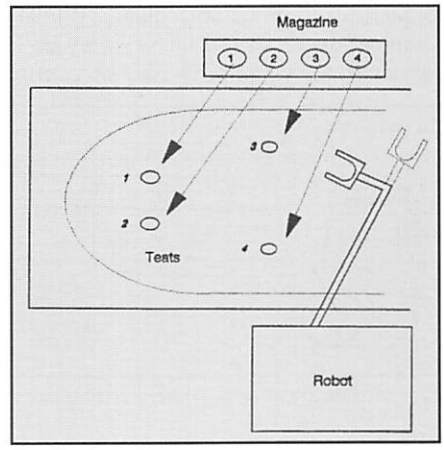


Fig 5. Attachment sequence.

Northern Ireland Branch meeting

Northern Ireland Branch Members and Branch Associates enjoyed a recent visit to Redrock Engineering. This thriving Northern Ireland firm manufactures a range of farm machinery including slurry tankers, diet feeders, silage grabs, trailers and slurry pumps. Pictured, from left on front row, are: Noel Stewart (Redrock), Peter Frost, Bertie Hunter (programme organisers), Frank Flynn (Redrock).

The distribution of thermal loads within poultry transport vehicles

Peter Kettlewell, Malcolm Mitchell, Andrew Meehan

The spatial variation of container micro-environments within poultry transport vehicles has been determined during the movement of birds by road during winter and summer. The transport micro-environments have been related to the prevailing external temperatures and relative humidities. The findings suggest that birds may be potentially exposed to thermal loads likely to induce hyperthermia even when transported in the 'cold' conditions of winter.

The results demonstrate that while the use of curtains may protect the outermost birds in the load from cold and thus becoming hypothermic, the concomitant reduction in internal air movement and heat dispersion may promote paradoxically conditions likely to cause hyperthermia in the centre of the load during winter.

Such characterisation of 'on-board environments' coupled to a knowledge of the physiology of thermoregulation in poultry and an understanding of vehicle ventilation must be prime considerations in the design of any poultry transport vehicles.

The annual production of broiler chickens (meat birds) within the UK is now around 600 million. Broiler chickens are reared on large geographically dispersed farms and transported live to centralised processing plants. Whilst the duration of many journeys from farm to factory may be less than 3 hours there are occasions when birds may be confined in the vehicle for a total period of up to 12 hours (Warriss *et al* 1990). With the present trend towards fewer, larger processing plants longer transport times may become the norm.

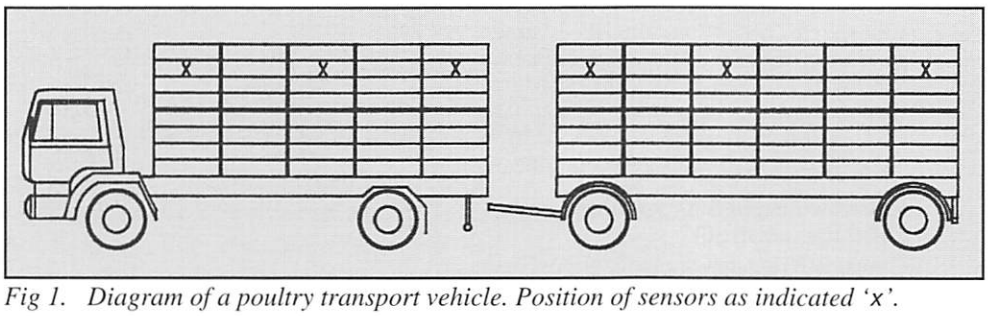


Fig 1. Diagram of a poultry transport vehicle. Position of sensors as indicated 'x'.

Annual transport loss (UK) in excess of 500,000 birds 'dead on arrival'

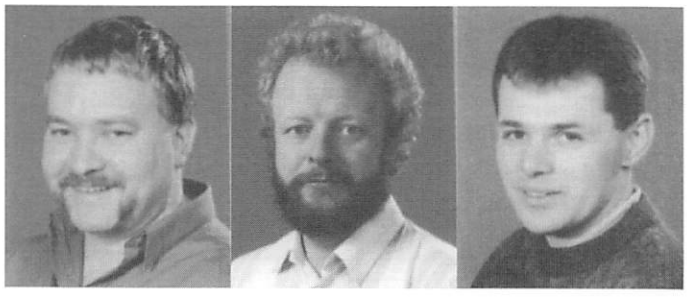
During transportation birds may be exposed to a number of stressors, including motion, acceleration, noise, restriction of behaviour and social disruption. A major source of potential stress, however, is the transport micro-environment in which high thermal loads may be imposed upon the birds particularly during hot weather. In the mildest form these factors may cause distress to the animals, but in more severe cases they may cause increased morbidity and mortalities.

The industry quotes a generalised figure of 0.1% for birds which are dead on arrival (DOA) at the factory, but it has been reported that mortality increases with journey length (Warriss *et al* 1990). Even at 0.1%, with an annual production of 600 million, this represents a total loss of 600,000 birds.

One survey has shown that 40% of the DOA's are a consequence of 'stress' (Bayliss and Hinton 1990), a major source of which may be adverse thermal micro-environments within the transport container. The role of thermal stress in reduced welfare of transported broilers has previously been described and discussed (Freeman 1984; Mitchell *et al* 1990; Nicol and Scott 1990; Bayliss and Hinton 1990).

Legislation exists to protect poultry in transit and the current welfare codes established by the Ministry of Agriculture, Fisheries and Food (MAFF) state that birds in transit "should be protected from bad weather and from excessively hot or cold conditions" (HMSO, 1988). In addition, "they should not be allowed to become distressed (as indicated by prolonged periods of panting) by being left in containers exposed to strong direct sunlight" (MAFF 1987 a, b, c). The Farm Animal Welfare Council (FAWC) in support of these recommendations has highlighted the problematical nature of broiler transportation and suggested that vehicle ventilation should be at an appropriate level so as to reduce the risk of 'adverse conditions during transport' (FAWC 1990). Optimisation of broiler welfare during transportation by controlling the thermal loads to which they are exposed has been emphasised (Swarbrick 1983, 1986).

P J Kettlewell (left) is Senior Scientific Officer and A M Meehan (far right) is Scientific Officer, both in the Welfare Science Division, Silsoe Research Institute, Silsoe, Bedford. M A Mitchell (centre) is Senior Scientific Officer, Department of Avian Biotechnology, AFRC Institute for Animal Physiology and Genetics Research, Edinburgh Research Station, Roslen, Midlothian (Refereed Paper).



Such generalised recommendations, whilst desirable, are clearly imprecise in that they are not based upon fundamental characterisations of the physical environments which birds may experience in transit and do not reflect the quantifiable physiological and behavioural requirements of the animals.

Study of transport micro-environment is an essential first step to proposing improvements

It has been suggested that transport practices and the thermal micro-environments prevailing in broiler transportation containers under moderate external climatic conditions may limit the birds' behavioural thermoregulatory capacity and impose unacceptable thermal loads upon the animals (Mitchell *et al* 1990). It is also recognised that, in hot weather, under commercial broiler transport conditions, mortalities may increase 10 fold from 0.1% to in excess of 1.0% on specific journeys with an associated adverse effect upon the welfare of the surviving birds.

Possible contributing factors to the thermal stress induced during transportation of broilers have been reviewed (Kettlewell 1989). It is clear, however, that in order to assess the welfare of broiler birds in transit and to propose potential improvements to vehicle design and transport practices it is first necessary to characterise precisely and fully the range of thermal micro-environments to which the chickens are exposed during commercial transportation.

The present study was therefore undertaken in collaboration with a commercial broiler producer.

Measurements of temperature/relative humidity – summer and winter journeys

Measurements of dry bulb air temperatures and relative humidities (RH) were made in the birds' immediate environment within transport containers at a number of locations in the vehicle. These measurements were made during journeys from the farm to the processing plant in different seasons of the year (summer and winter).

Moisture contents of the air surrounding the birds were derived from RH and dry bulb temperature and are expressed as water vapour densities (gm^{-3}). This is necessary as relative humidity is, by definition, temperature dependent and the vapour density gradient is the physical determinant of evaporative heat loss from the animals (Monteith 1973).

Measurements were made on commercial poultry transport vehicles operating a modular drawer container system (Kettlewell and Turner 1985). Each drawer (1.3m x 0.7m x 0.25m) was loaded with 21-22 birds in the summer and 21-23 birds in the winter. The drawer sides were perforated by vertical slats 10mm wide at 55mm centre spacing. Modules were loaded onto a curtain-sided vehicle which consisted of a lorry and trailer (Fig 1). The vehicles had solid headboards, solid roof and rear of both lorry and trailer always open.

Six specific locations (identical on every journey –three on the lorry and three on the trailer) were selected as being representative of the distribution of micro-environments within the vehicle. All the locations were on the mid-line of the lorry, on the upper layer of modules, and at positions near the front, middle and back of the lorry and trailer (see Fig 1).

Two journeys were studied on consecutive days in the summer (summer configuration – curtains open) and winter (winter configuration – curtains closed). Temperature and humidity were measured using a combined probe (Mitchell *et al* 1992). On all occasions data were collected using the same vehicle and driver, travelling by the same route from the same farm site. This approach was adopted to minimise the influence of the many uncontrolled variables which may prevail in commercial transport situations including those due to husbandry, transport practices, handling, road type, journey length and geographic location.

The results of these experiments are presented as the mean values of temperature and vapour density occurring during the total transport period (ie departure from farm to arrival at processing plant). This period averaged 216 minutes in the summer and 218 minutes in the winter. All journeys departed from the farm site at about the same time each day (08:30 to 09:30 hours).

Table 1. Temperatures (C) and vapour densities (gm^{-3}) during transport on summer journeys (curtains open). Data presented are mean values ± one standard deviation of the mean (n=216).

Journey			*Lorry*				*Trailer*	
		Ambient	*Front*	*Middle*	*Rear*	*Front*	*Middle*	*Rear*
1	Temperature (C)	17.4 ±1.3	21.1 ±0.9	21.0 ±1.2	20.4 ±1.1	22.6 ±0.9	–	20.5 ±1.2
	Vapour density (gm^{-3})	8.4 ±0.4	8.5 ±0.6	8.8 ±0.7	9.1 ±0.7	9.1 ±0.7	–	8.7 ±0.7
2	Temperature (C)	21.2 ±0.9	24.7 ±0.8	25.3 ±1.4	24.4 ±1.1	26.8 ±0.7	25.6 ±1.2	24.3 ±0.8
	Vapour density (gm^{-3})	10.4 ±1.0	10.5 ±1.1	10.7 ±1.1	10.9 ±1.1	11.2 ±1.1	11.0 ±1.2	10.4 ±1.1

Table 2. Temperatures (C) and vapour densities (gm^{-3}) during transport on winter journeys (curtains closed). Data presented are mean values ± one standard deviation of the mean (n=218).

Journey			*Lorry*				*Trailer*	
		Ambient	*Front*	*Middle*	*Rear*	*Front*	*Middle*	*Rear*
3	Temperature (C)	9.9 ±1.0	24.5 ±1.8	22.7 ±1.6	16.8 ±2.3	23.9 ±3.2	23.5 ±3.4	20.6 ±3.1
	Vapour density (gm^{-3})	8.8 ±0.4	13.7 ±2.3	11.3 ±2.0	8.6 ±1.3	15.8 ±3.8	14.5 ±3.5	13.1 ±2.1
4	Temperature (C)	9.8 ±0.7	25.7 ±1.2	23.9 ±2.3	17.2 ±2.9	25.5 ±3.7	24.9 ±3.3	22.5 ±2.9
	Vapour density (gm^{-3})	8.1 ±0.3	12.2 ±2.0	11.5 ±1.9	9.5 ±1.7	16.2 ±4.3	14.3 ±3.6	12.9 ±2.6

Winter transport shows large gradients of both temperature and vapour density

Data are presented, Tables 1 and 2, for the ambient environment and for each of the specific locations monitored.

There were marked differences in the ambient conditions between the two occasions studied and the range of ambient conditions was greater in the summer (17.4°C–21.2°C: 8.4gm^{-3}-10.4gm^{-3}) than the winter (9.8°C–9.9°C: 8.1gm^{-3}–8.8gm^{-3}).

Paradoxically perhaps, the ranges of conditions within the containers were greater in the winter (16.8°C–25.7°C: 8.6gm^{-3}–16.2gm^{-3}) than the summer (20.4°C–26.8°C: 8.5gm^{-3}–11.2gm^{-3}). During the summer journeys (open configuration) when the average ambient temperature and vapour density for both days were 19.3°C and 9.4gm^{-3} respectively, the average lorry temperature was 22.8°C and vapour density 9.8gm^{-3} and on the trailer the corresponding values were 24.0°C and 10.1gm^{-3}. This compares with the winter configuration when the corresponding values were 9.9°C and 8.5gm^{-3} for the ambient environment and, 21.8°C and 11.1gm^{-3} for the lorry and 23.5°C and 14.5gm^{-3} for the trailer.

Fig 2. Broiler chickens in modular transport drawer.

During the summer months, with the curtains open, there were no clear gradients of temperature within the lorry although the trailer did show a decreasing gradient from the front to the rear. Vapour density was lowest at the front of the lorry and increased towards the rear while on the trailer the converse was true.

In the winter configuration, with the curtains closed during transport, large gradients of both temperature and vapour density were evident, both decreasing from front to rear of the respective vehicle components. The temperature gradients, from front to back, on the lorry (average 8.1°C over the two journeys) and trailer (average 3.2°C over the two journeys) revealed very high temperatures behind the respective head-boards combined with elevated temperatures, with respect to ambient, even at the rear open faces of the lorry and trailer. Vapour densities showed similar trends.

Current commercial practice

The main objective of this study was to characterise the thermal micro-environments which may exist on commercial poultry transport vehicles under different ambient conditions. The limited number of reports relating to single journeys or external environments which have been published confirm that temperature gradients may be established between the inside and outside of the vehicle and that temperature and humidity may rise rapidly in the centre of stationary vehicles (Scholtyssek and Ehinger 1976; Gschwindt and Ehinger 1978). The present study has attempted to determine the range of micro-environments to which birds might be exposed in transit by studying on-board conditions in summer and winter with the appropriate curtain configurations and associated ventilation regimes. In this context the studies relate directly to current commercial practice.

Heat regulation mechanisms

– in the birds themselves

Heat regulation in birds is achieved by various control mechanisms (Freeman 1971; Kettlewell 1989) which operate at different levels dependent upon the perceived environmental conditions.

Heat loss from the body can be as sensible heat (conduction, convention and radiation) or as latent heat. The latter mechanism in poultry operates primarily via respiratory heat loss although cutaneous evaporation can occur but only to a limited extent. Behavioural thermoregulation (spreading the wings, separation from other birds, etc), is also another option available to the bird to increase heat loss, although during transport circumstances dictate that such mechanisms are severely limited.

As temperatures within the transport containers increase, sensible heat loss becomes less efficient and the bird depends more on evaporative cooling to maintain its body temperature (Richards 1976). It is therefore important to characterise the transport micro-environment with respect to both air temperature and moisture content to reflect the true total thermal load on the bird.

Respiratory evaporative cooling depends upon gradients, between the bird and its immediate surroundings, of temperature and/or moisture content. Increases in water vapour density will limit this mechanism of heat loss (Richards 1973, 1976; Dawson 1982; Mitchell 1986; McArthur 1987) and it has been suggested that maximal respiratory frequencies may be achieved at temperatures of 27°C in saturated air (Kettlewell and Moran 1992).

– curtain-sided vehicles for winter/summer transport

The use of curtain-sided vehicles allows the transport of poultry in either a closed (winter) or open (summer) mode. In the winter, the closing of the curtains ensures that water ingress from precipitation, road spray or condensation is minimised. This is important because if those birds in the outermost containers get wet during transport then their thermal insulation is greatly reduced and there is a risk of birds becoming hypothermic (Kettlewell 1989). Conversely in the summer the curtains are kept open to prevent the build up of temperature and water vapour within the vehicle and thus to reduce the risk of birds becoming hyperthermic.

During the summer, the uniform nature of the micro-environments within the containers at different locations suggests that by keeping the curtains open during transport there is sufficient air movement to ventilate the load uniformally whilst the vehicle is moving and thus to prevent the establishment of any significant 'on-board' gradients of temperature or moisture content.

In this study the gradients above ambient were less than 5°C for temperature and 1.0gm^{-3} for vapour density. In percentage terms, these gradients represent a 25% rise in temperature and less than a 10% rise in vapour density. The small gradients which are produced probably arise during stationary periods or immediately after the vehicle has left the farm before the ventilation has taken effect.

It should be emphasised, however, that these gradients *per-se* do not determine the heat exchange of the animals. It is the

absolute values of temperature and vapour density within the transport space and the gradients between the animal's exchange surfaces and these values which are important.

In the winter, while closing the curtains will keep the birds dry it also has a dramatic effect on the transport micro-environment. There are clear and large gradients of both temperature and vapour density throughout both the lorry and trailer. These large gradients suggest poor ventilation of the containers. The elevation of temperatures above ambient is in excess of 10°C for most of the vehicle representing a 100% rise. Vapour densities are also elevated by up to $4.0gm^{-3}$ behind the vehicle headboards. The rear of the lorry shows a greater equilibration with the ambient environment than does the trailer. The sometimes large standard deviations from the mean suggest that differences are occurring when the vehicle is stationary when conditions will show a rise in both temperature and vapour density.

Mean values disguise possible dangerous extremes

It may be suggested that the use of curtains to prevent water ingress in winter can actually create transport micro-environments, which may, in terms of heat exchange and thermoregulation, prove to be more adverse than those encountered in the summer configuration. Even when the vehicle is in motion, there may be insufficient ventilation to prevent the build up of large gradients of temperature and water vapour density in the 'thermal core' of the vehicle. The worst locations can be identified behind the respective headboards of the lorry and trailer.

The nature of the vehicle ventilation and how it is determined by the vehicle's aerodynamics is being addressed in complementary studies relating scale model wind tunnel tests to full scale measurements (Baker *et al* 1992). A mathematical model is being developed to predict those areas on the vehicle where ventilation may be inadequate and hence the thermal load greatest. Preliminary results from the model have demonstrated a good agreement with real data, especially in identifying the areas behind the respective headboards as the positions where the total thermal load on the birds will be greatest.

It is probable that the mean temperatures and vapour densities recorded in some of these locations would impose a substantial demand upon the thermoregulatory capability of the birds and may result in elevated deep body temperatures – the onset of hyperthermia. Parallel studies (Mitchell *et al* 1992) have shown that such transport conditions can precipitate physiological stress in transported birds.

It must be recognised that mean values of temperature and water vapour density do not reflect the stresses induced by the extremes which may occur during the journey. Mean values do, however, represent an index of the average thermal load.

If birds are exposed to high heat loads early in a journey then the consequent loss of water through thermal polypnea cannot subsequently be replaced. Any further episodes of high heat loads during that journey may then exacerbate the sequellae of profound heat stress. These considerations may not be reflected in mean values of thermal load.

The industry is aware that such problems can occur during transport and it does adopt subjective measures to reduce the likelihood of thermal stress during transport.

Vehicle thermodynamics holds key to improvement of thermal conditions during transport

Some processors reduce the number of birds in a transport container to reduce the total heat production in the container. It must be remembered though that if the birds are afforded too much space in a container then the risk of physical damage associated with birds sliding around will also increase.

It must be emphasised that the data presented in this paper were collected on days when the prevailing ambient conditions were representative of the norm for that time of the year. Because of the practical difficulties involved in fitting and removing curtains to/from the vehicle, once the decision to use curtains has been made the lorries are then operated with curtains throughout the winter period. This may be from the start of October through to the end of March. It is not feasible to keep taking curtains on and off on a daily, or even weekly, basis. Clearly then, on warm days in late autumn and early spring, when ambient conditions are 'better' than the norm, the thermal load imposed on the birds may be greater, with the consequent adverse effects on the birds.

Ironically the industry still believes that the summer offers the greatest risk of hyperthermia during transport. This study does not support this belief.

It is evident that an understanding of the vehicle aerodynamics and hence ventilation is of prime importance to the improvement of thermal conditions during the transport of poultry. This aspect of the work is now being addressed in ongoing research and it is envisaged that changes to the vehicle will be conceived which will effect a more uniform and acceptable transport micro-environment in all weather conditions.

Acknowledgments

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High velocity tines – from furrow to seedbed in one second?

To go into a field one morning with a plough and some seed and leave later in the day with it sown is the prospect held out by Brian Wilton and Shamseldin Elazhari. It is suggested that if each body is equipped with a hydraulically driven rotor and a seed dispenser, this is a distinct possibility.

B. Wilton. *S. E. M. I. Elazhari.*

Some 30 years ago one author was working in the UK on the effect of striking clods with tines travelling at up to 40 m/s (Wilton, 1963). The other lived in Northern Sudan, and like most boys he probably spent some time making mud pies and hitting things with sticks, unaware that his future colleague was also handling soils at various moisture contents, hitting them with wide and narrow tines, then collecting the pieces in an attempt to determine what had happened at the moment of impact.

The activity in Sudan was part of the normal growing-up process; the other was intended to provide information to assist in the design of a pto-driven machine that it was hoped might find a niche in the limited range of seedbed preparation equipment then available.

Following the laboratory work a 1.0 m wide field unit was made which had three main components, arranged as shown in Fig 1. The aim was to reduce the clods in the top layers of roughly-cultivated soils to seedbed proportions by the action of rapidly-moving tines. Dynamometers were fitted and experiments were planned, but unfortunately the unit would only work in very dry soil. In all other conditions the tines packed soil onto the share and no matter what adjustments were made a blockage developed. Removal of the share was considered but rejected because of the potentially harmful effects on the underlying soil.

The study of clod breakdown by high velocity impact was continued at Silsoe College in the late 1980s, with modern recording equipment that allowed a more precise understanding of the processes involved (Godwin R J, 1992). A field machine was then made which bore some resemblance to the earlier one; it ran into the same problem and an attempt to overcome it by presenting only the largest clods to the rotor was not entirely successful.

B Wilton is Lecturer in Agricultural Engineering at the University of Nottingham and S E M I Elazhari was one of his post-graduate students.

The challenge

At this stage the authors met and decided to make a further attempt to exploit the potential advantages of 'impact comminution' of clods.

If one excludes weathering, then in simple terms clods are broken conventionally either by:

- cutting or crushing or by
- loading horizontally
  – either process usually involving movement around among other clods.

Combinations of these processes obviously occur and all have their limitations, one being that in each case the reaction to the force applied by the working element has to be provided by adjacent soil. Another major problem is the influence of soil moisture content on each type of operation.

In contrast, impact loading utilises the target's inertia to provide the reaction and the effect of moisture content and other soil factors can be largely taken care of by altering tine velocity.

The problem faced was how to bring high velocity tines and limited volumes of soil into contact continuously in a way that would not damage the unworked soil and would leave the broken soil spread over the surface.

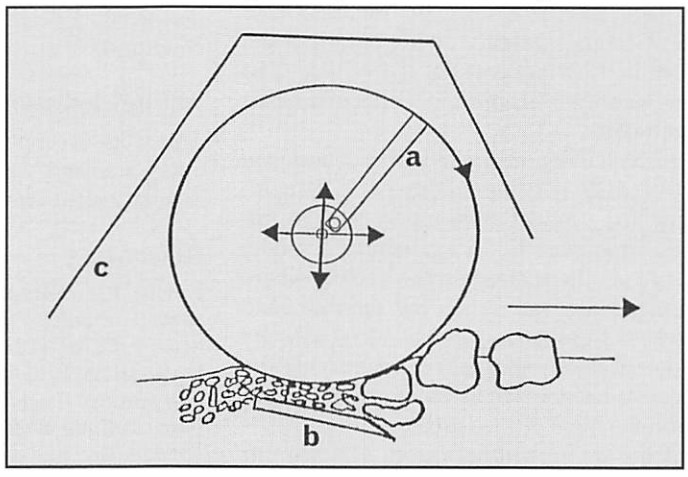

Fig 1. The original field unit showing (a) tines on a horizontal rotor (b) a full width share and (c) a hood.

A solution

The possibility of conveying clods lifted by a wide share to some form of rotor was considered first: stone separators operate in

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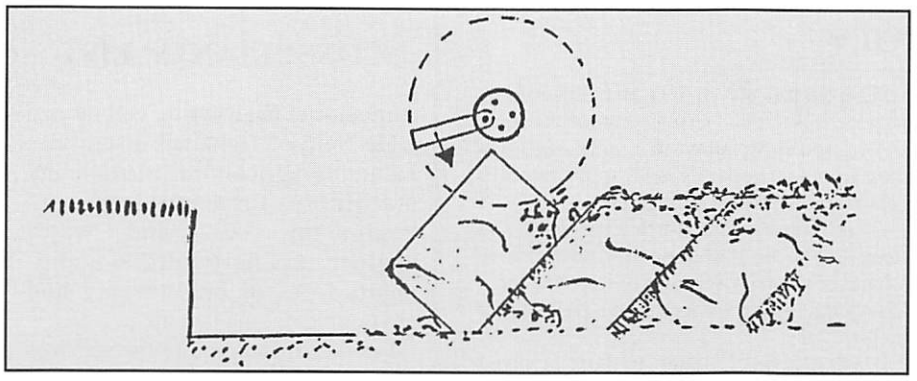

Fig 2. The position of the rotor (only one of the four tines shown) in relation to the furrow.

this way and in an experimental Swedish machine soil was elevated, sieved and had fertiliser and seed dispensers fitted in appropriate positions (Danfors, 1987). In the present work this approach was soon discarded as it would be slow, expensive and likely to be only a dry weather operation.

The exercise was useful, however, as it triggered the thought that instead of looking for ways to take a full-width bank of rotating tines through partly cultivated soil, it might be better to think of ways of moving soil past a rotor.

From this position it was a short step to the realisation that a mouldboard plough might almost have been designed for this task, and that with the addition of one small rotor per furrow, set to strike across the top of it in a more-or-less horizontal direction, the aim might be achieved.

At this stage a literature search and a review of patents in this area (the latter carried out by the British Technology Group) indicated that this was a novel approach, although several workers had described powered attachments to ploughs (Elazhari, 1992).

Two furrows were then removed from a conventional 3-furrow plough and a 0.58m diameter, hydraulically-driven rotor was mounted at the end of the mouldboard. The intention was to remove the crest of the furrow (some 20-25% of it) and throw the broken soil across several previously treated furrows (Fig 2).

During construction it was realised that by extending the rotor shaft forward a rotary skimmer (similar to a large countersink bit) could be incorporated.

Modifications

When first tried out on a fairly light soil the unit performed extremely well: the only problem was that the broken soil was thrown too far, but this was later overcome by fitting a small curtain of chains some 0.5m out from the furrow. However, on heavy soils performance was unsatisfactory. The problem was obvious: one moment the rotor was beating air, the next it could be overloaded, even though the motor was being run so that it delivered 3kW.

Three modifications were required to overcome this problem:

1. The semi-digger (SCN) body was replaced by a general purpose (YCN) one which gave a more uniform, less broken furrow;
2. A slightly more powerful hydraulic motor was fitted; and
3. The fixed position rotor was abandoned in favour of one that pivoted and followed the 'level' of the furrow.

The last of these changes was the most difficult to implement; at first it was mounted on a skid, pivoted on a shaft clamped to the plough leg so that the skid ran along the length of the furrow. This change, which involved discarding the rotary skimmer, was only partly successful as a large clod under the front of the skid would still lift the rotor out of work. The skid also had to be counterbalanced so it was replaced by two dished discs (220mm dia) located immediately in front of the rotor. The motor was also moved forward to reduce the weight on the discs and it drove the rotor by a shaft which ran through the hollow pivot arm (Fig 3).

A limited amount of work was then done on three soils, ranging from fairly light to fairly heavy, with satisfactory results. As a final step a seedbox was mounted on the plough so that it discharged onto the surface produced by the removal of the top of the previous furrow. The seed (barley) was immediately covered by soil arrested by the chain curtain and within two weeks it had germinated and emerged satisfactorily.

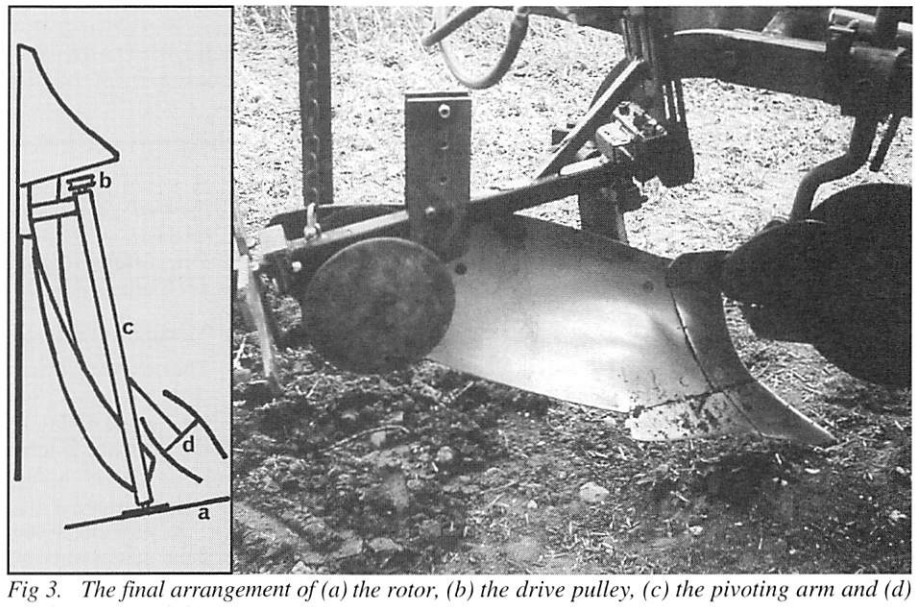

Fig 3. The final arrangement of (a) the rotor, (b) the drive pulley, (c) the pivoting arm and (d) the depth control discs.

Other considerations

It is particularly fortunate that the plough proved to be such a convenient platform for the rotor as it performs well on most soils over a wide range of moisture contents, usually only being defeated by heavy soils when they are very dry. It has been common to criticise the plough for being slow, and hence expensive to use, and for needing to be followed-up by other operations, but it seems to be staging a comeback with the aid of the straw and stubble burning ban and the emergence of some weed problems.

– plough and sow in one operation?

It is also fortunate that the arrival of the Minimat press drill – designed to be towed behind a plough and consisting of two corrugated rolls and a seedbox – has demonstrated that on light soils ploughing and seeding can be achieved in one pass. The current popularity of the rediscovered furrow press also shows that farmers are now keen to do more in one pass than simply turn soil over.

For widely-spaced row crops grown from seed the possibility of ploughing, preparing a seedbed and sowing in one pass seems remote, but for cereals, oilseed rape and one or two other crops it might be possible to do what the Minimat does, but on a wider range of soils and perhaps even in wet weather.

Consolidation, or rather lack of it, may be a problem, but this is obviously an area that would need to be investigated. Broadcast beans can be ploughed in, even on heavy soils in wet weather; how convenient it would be if other crops could be established in a similar way.

– guarding; power requirement

On the mechanical side, guarding would be a necessary but not impossible task and a multi-furrow version would cause problems, but not insurmountable ones.

A reversible unit is hard to visualise, but such considerations did not inhibit Krampe

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BOOK REVIEW

Farm Workshop: 2nd Edition
by Brian Bell
Farming Press Books, Ipswich
Price £12.95 (hardback)

A problem for practising farmers, advisers and educationalists, is to answer the vexed question "so what equipment do I require in a workshop?" Brian Bell's book certainly goes a long way to answering this problem as well as relating basic techniques of general repair work, such as, welding, metal working and plumbing.

With such a wide remit a criticism might be that the subject matter is dealt with in a rather superficial way. However, it is a tribute to the author and a great strength of the book that this is, in fact, not the case.

The careful use of text and illustrations provide a first class explanation of the tools and equipment required in a workshop, also how to select, operate and apply them to general maintenance and repair.

This is in essence a practical work and therefore to be recommended to those in whatever capacity wishing to improve their knowledge of the workshop as a basic repair facility.

It will also be of interest to those involved in setting up a workshop as part of a Maintenance Management Scheme in both the developed and developing world.

For this quality of presentation the price is refreshingly reasonable.

MJH

Top Scottish Recruiter gets his whisky

Ted Kernahan recruited more new members in 1992 than any other member of the Scottish Branch. His prize for this success was a bottle of Old Fettercairn malt whisky, presented by Roger Horner of Cariers Ltd, who had made this generous gesture to spur on the Scottish Branch recruitment competition.

The number of members in the Scottish Branch increased from 143 to 155 in 1992.

CONSULTANTS' LIST

Agricultural engineering embraces a wide field of technical disciplines including agricultural tractors and machinery, farm buildings and equipment, soil and water engineering, horticultural equipment, forestry engineering and environmental management.

For those who require the **services of an independent expert** in one of these fields **The Institution of Agricultural Engineers** maintains a **list of corporate members practising as consultant engineers.**

The list, recently updated, is available, free of charge, on application to:

The Secretary,
Institution of Agricultural Engineers,
West End Road, Silsoe, Bedford
MK45 4DU.
Telephone: 0525 861096.

Lifting awareness

Many thousands of man-hours are lost each year as a direct result of injuries and accidents involving the manual lifting and handling of loads.

In the light of new evidence uncovered about such injuries, and to bring the UK into line with other EC countries, the Health and Safety Commission have put new regulations into force as from 1st January 1993.

Gone are the old directives which concentrated on the weight of the load, that has been found to be only a contributing factor in the reported incidents. The new Regulations adopt a more ergonomic approach and apply to all workplaces.

The initial responsibility lies with the employer to take all reasonable steps to avoid the need for manual handling. Where manual handling cannot be avoided the employer must assess the risk of injury. If the assessment shows that there is a risk of injury then steps must be taken to minimise that risk.

Once a system of work has been devised that minimises that risk, employees will be required to adhere to that system.

The assessment of the risk must take into account the nature of the task – whether there is any twisting, bending or stretching involved; the work environment – any space constraints, extremes of temperature, slippery floors, etc; the worker's individual capability – is specialist expertise or extreme strength required; and, of course, the load – is it heavy, bulky, hot or sharp? Guidance on how to make this assessment is contained in a booklet entitled **'Manual Handling Operations Regulations 1992'** from HMSO bookshops or other booksellers, price £1.50.

Mechanical lifting . . .

The new manual handling regulations say, basically, if it can be lifted with a machine, use it. But that creates its own problems and the Health and Safety Executive have been increasingly concerned about the growing number of accidents involving lift trucks. In the five years 1986-91 some 112 people were killed by lift trucks and 20,000 injured. Many of the incidents involved the lift truck overturning.

In an effort to reduce these grizzly statistics the HSE have revised their guidance booklet: **'Safety in Working with Lift Trucks'.** It covers the use of these trucks in all workplaces from factories to farms, construction sites to warehouses. It is essential reading for all members of the workforce from senior management to the drivers themselves. The booklet costs £4.25 from the usual sources.

Complementing the booklet is a video showing the main causes of overturning accidents. **'Dangerous Manoeuvres'** costs £30 from the HSE's Public Information Centre, Broad Lane, Sheffield S3 7HQ.

continued from previous page

(1987) when patenting a design for an attachment to such a plough. MacIntyre (1972) also made a 2 furrow reversible plough in which each mouldboard was largely replaced by a powered rotor: his rotors carried relatively slowly moving blades which passed upwards through the furrow surface formed by the share.

In the work to date no attempt has been made to measure power requirements nor to establish the minimum tine velocities required in different situations. To date, the unit has usually been operated with pivoting tines made from 50 x 10mm bar striking the furrow edge-on; on the earlier machines pivoting tines were essential as they were working against soil passing over a rigid share – they are probably not necessary when striking against an unsupported furrow top.

A final point worth making is that in contrast to equipment such as a furrow press, the unit did not add markedly to the draught of the plough, indeed it may well have reduced it as the mouldboard was shortened (for convenience, at one stage) and the rotor could be seen to be both helping to turn the furrow over and easing it away from the mouldboard.

Any 'new' approach can be expected to have limitations and drawbacks that are not anticipated: at the time of writing no technical reasons have appeared to indicate that further development and investigation of this plough/cultivate/seed operation would not be worthwhile.

References

Danfors B (1987). Equipment for seed placement below a removed and replaced soil tilth. *J Agric Eng Res*, **38**, 167-172.
Elazhari S E M I (1992). The breaking-up of furrows formed by mouldboard ploughs. *Unpubl M Phil thesis*, Univ. of Nottingham.
Godwin R J (1992). *Personal communication.*
Krampe F (1987). Multi-share plough. European Patent Office, *Pub. No. 0222377.*
MacIntyre D (1972). A rotary plough. NIAE Scottish Station, Dept Note SSN 101.
Wilton B (1963). The use of high velocity tines in breaking clods. *J Agric Eng Res*, **8**, (2), 107-114.

DIARY

March
22 **Low cost unsurfaced roads** – Forestry Engineering Specialist Group, Heriot Watt University, Edinburgh.
Conference *Geoff Freedman, 231 Corstorphine Road, Edinburgh EH12 7AT. Tel: 031 334 0303. Fax: 031 334 3047.*

April
13-16 **Britain in the Gulf,** Dubai.
Exhibition *International Conferences and Exhibitions Ltd, 51-53 High St, Kings Langley, Herts WD4 9HU. Tel: 0923 261988. Fax: 0923 261669.*

21-22 **Muck '93,** National Agricultural Centre, Kenilworth.
Demonstration *Melanie Allen, RASE, National Agricultural Centre, Kenilworth, Warks CV8 2LZ. Tel: 0203 696969. Fax: 0203 696900.*

May
2-6 **Agritech, Spring '93,** Tel-Aviv.
Exhibition *Agritech Spring '93, Organising Committee, PO Box 50084, 61500 Tel-Aviv, Israel. Tel: 010972 3 5142830. Fax: 010972 3 5142881.*

10-13 **International Environment '93,** Wembley Exhibition Centre, London.
Conference *Labmate Ltd, Newgate, Sandpit Lane, St Albans, Herts AL4 0BS. Tel: 0727 855574. Fax: 0727 841694.*

12-13 **European Pig and Poultry Fair '93,** National Agricultural Centre, Kenilworth.
Exhibition *Melanie Allen, RASE, NAC (details above).*

12-14 **Royal Ulster Show,** Balmoral, Belfast.
Exhibition *W H Yarr, BSc, Chief Executive, Royal Ulster Agricultural Society, King's Hall, Balmoral, Belfast BT9 6GW. Tel: 0232 665225. Fax: 0232 661264.*

18 **IAgrE Annual Conference,** Silsoe College, Silsoe, Bedford.
Conference *Mrs D Bradshaw, IAgrE (see back cover).*

25-28 **AGROBALT '93,** Food and Packaging Industry Trade Fair, Vilnius, Lithuania.
Exhibition *Brigitte Ley, IFW Landfriedstr 1a, 6900 Heidelberg, Germany. Tel: 01049 6221 16 70 43. Fax: 01049 6221 181438.*

June	**20-23**	**ASAE International Summer Meeting.**
	24-27	**Royal Highland Show.**
July	**5-8**	**Royal Show.**
	19-22	**Royal Welsh Show.**
September	**11-12**	**West of England 4x4 Festival.**
October	**3-7**	**Saudi Agriculture '93.**

ADVERTISERS INDEX

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THE INSTITUTION OF AGRICULTURAL ENGINEERS

ANNUAL CONVENTION 1993

In a foreword to our 1992 conference it was suggested that: "the way out of difficulty today is not to produce greater outputs more efficiently. It is to change direction, hence the theme 'Alternatives'.
In 1993 we suggest that to help in changes of direction, and to achieve better results after changes have been made, it is essential to use the best available techniques, materials, management systems, hence the theme for this year of **'Better by Design'** in both meanings of the words.

'BETTER BY DESIGN'

10.00 – 10.25 Registration and Coffee
10.30 – 10.35 **OPENING OF ANNUAL CONFERENCE** – President, *J B Finney CBE*
10.35 – 11.20 **KEYNOTE ADDRESS** – *Mr R Friedlander*, Managing Director, New Holland Ford Ltd
11.20 – 13.00 **SPECIALIST GROUPS** (1) – 2 Parallel Sessions

VEHICLES

Integration of tractor and implement control systems
Andy Scarlett, Silsoe Research Institute
Dynamics and control of front mounted implements
Peter Cowell, Silsoe College

SOIL & WATER MANAGEMENT

Improving quarry restoration by better use and handling of soil resources
Malcolm Reeve, Land Research Association
Form invention of the soil Inverta
Peter Topham, Caldecote Manor Farm

13.00 **BUFFET LUNCH** – Junior Common Room
14.00 – 15.30 **SPECIALIST GROUPS** (2) – 2 Parallel Sessions

FORESTRY ENGINEERING

'Better by Design'
Ewen McLay, Forestry Commission
Perils and pitfalls when using imported machines
John Martin, Forestry Commission

MACHINERY MANAGEMENT

The Analysis of Machinery breakdown
Mats Bohm, Research Manager, Swedish Institute of Agricultural Engineering, Uppsala
Annual depreciation rates of farm machinery
Martin Turner, Investigation Officer in Agricultural Economics, Exeter University

16.00 – 17.30 **SPECIALIST GROUPS** (3) – 3 Parallel Sessions

OVERSEAS DEVELOPMENT

Tractor rehabilitation in developing countries
Ray Wainwright, Silsoe Research Institute
Whole Crop Harvesting: A Better by Design option for the Developing World
Nadeem Amjad, Silsoe College

ELECTRONICS & COMPUTING

The state of the art – presenting the missing link
Simon Blackmore, Silsoe College
Use of Geophysical information systems in agricultural decision support
Ian Bradley, Soil Survey & Land Research Centre, Silsoe

CROP DRYING & STORAGE

Computer aided drafting techniques for effective design of mechanical and electrical projects
Ken Spreadbury, T H White Installations Ltd
Design and application of efficient crop aeration systems in large bulk stores
Speaker to be advised

19.00 for 19.30 **ANNUAL DINNER AND PRESENTATION OF AWARDS**
Principal Guest – **EARL HOWE**, Parliamentary Secretary at the Ministry of Agriculture, Fisheries and Food